United States
Department of
Agriculture
Marketing and
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Programs
Animal and
Plant Health
Inspection
Service

Glyphosate-Tolerant H7-1 Sugar Beets: Request for Nonregulated Status

Draft Environmental Impact Statement—October 2011

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Draft Environmental Impact Statement – October 2011

Agency Contact:
Rebecca Stankiewicz Gabel, Ph.D.,
Biotechnology Regulatory Services
U.S. Department of Agriculture
4700 River Road, Unit 147
Riverdale, MD 20737-1236
301-734-5603
rebecca.l.stankiewicz-gabel@aphis.usda.gov

[1] [1] The applicant has described H7-1sugar beet as "herbicide tolerant" and historically APHIS has also referred to GE plants with diminished herbicide sensitivity as "herbicide tolerant". However, the phenotype would fall under the Weed Science Society of America's (WSSA) definition of "herbicide resistance" since H7-1 has an inherited ability to survive and reproduce following exposure to a dose of herbicide normally lethal to the wild type variety (WSSA, 2008). By the WSSA definition, "resistance [to an herbicide] may be naturally occurring or induced by such techniques as genetic engineering or selection of variants produced by tissue culture or mutagenesis." Herbicide tolerance, by the WSSA definition, only applies to plant species with an "inherent ability" to survive and reproduce after herbicide treatment.

Table of Contents

Executive Summary

The U.S. Department of Agriculture (USDA), Animal and Plant Health Inspection Service (APHIS) is considering alternatives in response to a petition from Monsanto/KWS SAAT AG seeking a determination of non-regulated status of its event H7-1 sugar beets. This sugar beet cultivar is genetically engineered (GE) to be resistant to the herbicide glyphosate and is marketed as a tool for managing weeds in sugar beet production. APHIS regulations at 7 Code of Federal Regulations (CFR) part 340, which were promulgated pursuant to authority granted by the Plant Protection Act, as amended (7 United States Code (U.S.C.) 7701–7772), regulate the introduction (importation, interstate movement, or release into the environment) of certain GE organisms and products. A GE organism is considered a regulated article if the donor organism, recipient organism, vector, or vector agent used in engineering the organism belongs to one of the taxa listed in the regulation (7 CFR 340.2) and is also considered a plant pest. A GE organism is also regulated under Part 340 when APHIS has reason to believe that the GE organism may be a plant pest, or APHIS does not have information to determine if the GE organism is unlikely to pose a plant pest risk. A GE organism is no longer subject to the plant pest provisions of the Plant Protection Act or to the regulatory requirements of 7 CFR part 340 when APHIS determines that it is unlikely to pose a plant pest risk.

APHIS received a petition in 2003 from the Monsanto Company of St. Louis, Missouri, and KWS SAAT AG of Einbeck, Germany (hereinafter referred to as Monsanto/KWS SAAT AG) seeking a determination of nonregulated status of H7-1 sugar beets. APHIS completed a Plant Pest Risk Assessment as well as an environmental assessment (EA) and announced a Finding of No Significant Impact (FONSI) that all supported a determination of nonregulated status on March 4, 2005. The Center for Food Safety et al. (CFS) filed a complaint in January, 2008, challenging APHIS' determination of nonregulated status of H7-1 sugar beets. The U.S. District Court for the Northern District of California in September, 2009, found in favor of CFS et al. holding that APHIS should have prepared an environmental impact statement (EIS) before making a determination on the regulated status of H7-1 sugar beets. On August 13, 2010, the Court vacated the APHIS decision to fully deregulate event H7-1 sugar beet varieties, making them subject to the Plant Protection Act of 2000 (PPA) and 7 CFR Part 340 once again. In doing so, the Court remanded the matter back to the agency to determine what regulatory actions, if any, should be imposed upon event H7-1 sugar beets in the interim, until the completion of the EIS and a new determination decision could be made by APHIS. On July 29, 2010, Monsanto and KWS SAAT AG submitted to APHIS a supplemental request to amend the petition submitted in 2003 requesting "Partial

Deregulation" or some similar administrative action under 7 CFR part 340 to authorize continued cultivation subject to carefully tailored interim measures and conditions. In response to that supplemental petition, APHIS prepared an EA and made a determination that it is appropriate to partially deregulate H7-1 sugar beets if grown under specific mandatory conditions. The purpose of this EIS is to present analysis of alternative responses to the 2003 petition in a manner that comprehensively informs the decisionmaker of the potential impacts to the human environment from the selection of a given alternative. The regulatory decision for this petition must be consistent with the requirements in 7 CFR part 340.

The United States has a well-established sugar beet and sugar cane industry. Since the mid-1990s, approximately 40 to 50 percent of the U.S. refined sugar has been produced from sugar beets (USDA-ERS, 2010b)). The acreage for sugar beet cultivation has not changed substantially over the past 50 years. Sugar beets are planted on about 1.1 million acres in the States of California, Colorado, Idaho, Michigan, Minnesota, Montana, Nebraska, North Dakota, Oregon, South Dakota, Washington, and Wyoming. Sugar beets are grown for root and seed production. The largest root production of sugar beets occurs in Minnesota and North Dakota, accounting for about 55 percent of production. The majority of the seed production occurs in the Willamette Valley of Oregon (just over 50 percent) and Eastern Washington (just under 50 percent). H7-1 sugar beets were planted in 2010 in all the above States except California. No H7-1 sugar beets were planted in California or South Dakota in 2011. The primary use of sugar beets is for production of sugar and, therefore, its production is closely coordinated with the factories that process the sugar. Most sugar beets are grown within 60 miles and up to 100 miles, in some cases, of the processing facilities. Other products derived from sugar beets include certain food additives, dietary supplements, and livestock feed. In the United States, other economically important species (*Beta* spp.) related to sugar beets include red table beets and Swiss chard/leaf beets.

A. Alternatives Analyzed

The three alternatives considered in detail by APHIS were selected based on their ability to fulfill the agency regulatory requirements and their ability to be implemented by APHIS in a reasonable manner. Alternative 1 involves denial of the petition seeking a determination of nonregulated status of H7-1 sugar beets. Alternative 2 involves making a determination of non-regulated status. Alternative 3 involves various levels of regulation that would allow large-scale cultivation of H7-1 sugar beets. The specific alternatives are as follows:

Alternative 1, No Action – Sugar Beets Regulated and Planted by Notification or Permit. APHIS would deny the petition seeking a determination of nonregulated status of H7-1 sugar beets. APHIS would continue to regulate the environmental release and movement of H7-1 sugar beets under 7 CFR part 340. Notifications or permits with conditions specified by APHIS would be required for planting or movement of any H7-1 sugar beets. No partial deregulation of H7-1 sugar beets would be allowed under this alternative.

Alternative 2, Full deregulation of H7-1 sugar beets (Preferred Alternative) – H7-1 sugar beets would no longer be regulated articles under the regulations at 7 CFR part 340. Permits and notifications from APHIS would no longer be required for commercial planting of H7-1 sugar beet seed and roots. APHIS would no longer regulate the environmental release and movement of H7-1 sugar beets. H7-1 sugar beets would be expected to be planted in all sugar beet root production areas, including Imperial Valley, California, and the seed production areas of the Willamette Valley and Eastern Washington.

Alternative 3, Partial Deregulation – APHIS would extend the partial deregulation of H7-1 sugar beets for the root crop, with mandatory conditions and restrictions. APHIS would continue permitting the seed crop via APHIS permits or notifications in accordance with 7 CFR part 340. The importation and interstate movements of the seed crop would not require any permits or notifications, but would be subject to measures specified in the compliance agreement. This regulatory approach is currently being applied during the preparation of this EIS as an interim measure. The partial deregulation conditions would not allow the planting of H7-1 sugar beets in California and Western Washington.

B. Environmental Consequences of Alternatives

The environmental consequences of the alternatives are broadly summarized by the potential impacts resulting from herbicide usage, from cultivation of H7-1 sugar beets, from socioeconomic effects on agricultural producers, and from effects on potential options for consumers. The impacts from some alternatives are similar based upon the degree of regulation, but the magnitude of effect may vary. Based on similar impacts, the description of potential consequences of each alternative are compared and contrasted. This summary of potential impacts and findings is designed to address specific court, regulatory, and scoping issues for the alternatives.

1. Production and Management Issues in Sugar Beets and Related Crops

Alternative 1 is expected to increase herbicide usage of 12 herbicides, many of which are more toxic than glyphosate, and decrease glyphosate use. Alternatives 2 and3 are expected to decrease the use of the 12 herbicides and increase the use of glyphosate. The total pounds of herbicide applied per acre is expected to be greater under Alternatives 2 and 3 than under Alternative 1.

Alternative 1 is expected to result in usage of herbicides that could have more environmental impacts than glyphosate, which is the predominant herbicide applied under Alternatives 2 and3. This includes impacts to animals, micro-organisms, non-target plants, human health, and environmental quality of the physical environment.

Because, many weeds that are present in sugar beet fields are resistant to the non-glyphosate herbicides, Alternative 1 is expected to decrease the effectiveness of chemical weed control. Weed resistance to non-glyphosate herbicides under Alternative 1 is expected to further increase as the spectrum of available herbicide mechanisms of action is decreased when glyphosate is no longer available for post-emergent weed control in sugar beets. In some areas where weed control is poor with non-glyphosate herbicides, growers may abandon growing sugar beets under Alternative 1.

Alternatives 2and 3 are expected to maintain the improved weed control sugar beet growers currently experience using glyphosate. Production practices for sugar beets include a 3- to 4-year crop rotation, which is expected to delay the selection of glyphosate resistant weeds. Glyphosate resistant weeds could become a problem for sugar beet growers under Alternatives 2 and 3 especially if glyphosate resistant weeds in rotation crops become prevalent in sugar beet fields. Industry and growers are aware of this situation and will likely take proactive measures aimed to reduce and delay the development and spread of glyphosate resistant weeds.

Cultivation of conventional sugar beets under Alternative 1 is expected to result in increased conventional tillage. Alternatives 2 and 3 are expected to result in more reduced tillage and strip-tillage, except in California where conventional tillage is required for fallow irrigation. As increased tillage leads to more soil erosion, it is expected that more soil erosion and associated impacts on water quality will result from Alternative 1 than from the other alternatives.

Alternative 1 could result in limited availability of non-glyphosate herbicides and limited availability of conventional sugar beet seeds needed for planting the root crop until at least 2014. Six of the non-glyphosate herbicides are used almost exclusively on beet crops. With the wide scale adoption of H7-1 sugar beets there has been very little demand for these herbicides and consequently their manufacture was curtailed. Similarly, with the widescale adoption of H7-1 sugar beets, there has been very little demand for conventional sugar beet seeds and production of conventional varieties has been limited. Seed and herbicide shortages would not be an issue for Alternatives 2 and 3.

In the United States, sugar beets can cross pollinate to vegetable beets (Swiss chard and table beets) and wild beets. Movement of genes between sugar beets and other related species requires flowering. Sugar beet roots and table beet and Swiss chard vegetables are harvested before flowering. Therefore no gene flow can occur to the vegetable crop under any of the alternatives.

For about half the vegetable beet seed produced in the U.S., no gene flow from sugar beet seed production is expected because the production fields are geographically isolated. For the other half of the vegetable seed, grown in the Willamette Valley, sugar beet seed is grown in proximity but separated by isolation distances established to ensure varietal purity and that reduce the likelihood of gene flow.

No gene flow is expected to occur from H7-1 sugar beets to wild beets. The only known place where sugar beets and wild beets coincide is the Imperial Valley of California where sugar beet root production and not seed production occurs. The root crop only occasionally flowers. The only confirmed species of wild beet in Imperial Valley is *Beta macrocarpa*. This wild beet is a different species than sugar beet and does not readily cross hybridize. It flowers earlier than sugar beet and is self fertile. Therefore it is much more likely to self hybridize than to cross pollinate with sugar beet. The potential gene flow of glyphosate resistance traits to conventional sugar beets, organic beets, and other *Beta* spp. would be greatly reduced under Alternative 1. However, gene flow of glyphosate resistance traits would also be minimized under Alternative 2, where H7-1 sugar beets are grown in compliance with voluntary industry practices, and in Alternative 3, where industry practices are mandatory. Among the voluntary industry practices are the use of 3- to 4-mile isolation distances between different *Beta* seed crops and infrequent use of male fertile lines containing the H7-1 trait for seed production in areas where other *Beta* seed crops are grown. In 2011, 15 percent of the sugar beet seed production acreage in Oregon used male fertile plants containing the H7-1 trait. The average and median distance between male fertile H7-1 sugar beet and vegetable beet seed production fields in 2011 is at least 8.7 and 7 miles, respectively.

2. Biological Resources

Under Alternative 1, use of non-glyphosate herbicides would increase. There could be a risk of sublethal or chronic effects on mammals from the application of pyrazon, cycloate, or quizalofop-p-ethyl. Chronic effects could occur on birds/reptiles from the use of pyrazon, sethoxydim, or trifluralin. Trifluralin is the herbicide of most concern for fish and aquatic amphibians because it is very highly toxic to these organisms. None of the herbicides are expected to pose risks of population-level effects when used within label limits. Potential impacts on aquatic species from tillage include impaired habitat conditions from soil erosion, which can result in harm to individual species, including individual mortality.

Under Alternatives 2and 3, glyphosate use would increase. Glyphosate is not expected to pose an acute or chronic risk to birds, reptiles, mammals, terrestrial and aquatic invertebrates, fish, amphibians, and micro-organisms when used within label limits.

Under Alternatives 2 and 3, potential impacts on aquatic species from tillage are expected to be less than Alternative 1 due to the expected adoption of conservation tillage practices such as reduced and strip-tillage.

The increased usage of glyphosate under Alternatives 2 and 3 and non glyphosate herbicides under Alternative 1 might adversely affect exposed non-target plants from herbicide drift. Herbicide drift is expected to be greater under Alternative 1 because non glyphosate herbicides are applied more frequently and are more likely to be applied through aerial applications. As a result the impacts to non-target plants from herbicide drift are expected to be greater under Alternative 1.

Several agronomic traits were evaluated and no biological differences between H7-1 sugar beets and conventional sugar beets were found. Therefore H7-1 sugar beets are not expected to become more invasive in natural environments or have any different effect on critical habitat than conventional sugar beets, which do not establish or persist in the environment. In addition, the nutritional profiles of H7-1 sugar beets is similar to conventional sugar beets. Therefore, any nutritional effects of H7-1 sugar beets on any animals that feed upon them would not be different than the nutritional effects associated with conventional sugar beets. H7-1 sugar beets are not expected to be toxic to animals or allergenic to humans. The 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS) protein from plants and from the CP4 *Agrobacterium* strain is not known to have pathogenic or toxic effects on humans, animals, or plants based on numerous laboratory and field studies with these purified proteins or plants expressing these proteins. H7-1 sugar beets are not sexually compatible with any threatened and endangered species. Therefore, the H7-1 trait is not expected to adversely affect plants and animals including threatened and endangered species.

APHIS has determined that the importation, interstate movement, and environmental release of H7-1 sugar beets, within and into the United States, would have no effect on listed threatened and endangered species or species proposed for listing and would have no effect on designated critical habitat or habitat proposed for designation.

3. Socioeconomic Effects on Agricultural Producers

Limited availability of conventional seed and more costly non-glyphosate herbicides needed for sugar beet production under Alternative 1 in 2013 would be expected to result in temporary reduction in income for sugar beet growers as a group and reduced payrolls for the sugar beet processing industry when compared to Alternatives 2and 3. Some processing plants could be forced to close, resulting in longer term reductions in processing capacity and job loss.

There is evidence that H7-1 sugar beets can lower producton costs of weed control in sugar beets. Sugar beet producers under Alternative 1 would no longer benefit from the reduced herbicide, weeding, and tillage costs associated with the H7-1 sugar beet varieties. However, they would not be subject to the technology fee costs for H7-1 sugar beet seed by using conventional varieties. Alternative 1 is expected to reduce overall sugar beet yields when compared to Alternatives 2and 3, especially in areas where conventional herbicides do not give good weed control.

Domestic sales and exports of sugar beets or beet sugar were not negatively impacted during the years when H7-1 sugar beet varieties were commercialized. There is, likewise, no evidence that selection of Alternatives 2 and 3 would affect commercial sales relative to Alternative 1.

Under Alternatives 2 and 3, production costs for vegetable beet producers in the Willamette Valley may increase as a result of testing costs for low level presence (LLP) of the H7-1 trait. Even if no cross pollination between H7-1 sugar beet and vegetable beet seed is ever detected, market perception, by the GE-sensitive market, may disadvantage Willamette Valley vegetable beet seed producers compared to their competitors in western Washington, California, and Arizona. If so, some vegetable beet seed production may relocate outside the Willamette Valley under Alternatives 2 and 3, though most have not relocated since commercial-scale H7-1 sugar beet seed production began in 2007. Only a fraction of the vegetable beet seed market is expected to be sensitive to this perceived potential LLP, so the bulk of vegetable beet seed production in the Willamette Valley should continue.

4. Consumer Options

Under Alternatives 2 and 3, consumers with a preference for non-GE products are not expected to be impacted by the availability of H7-1 sugar beets, given that half of the U.S supply of sugar is derived from non-GE sources. Sugar beet sugar that would be derived under Alternative 1 would be chemically identical to the sugar derived from H7-1 sugar beets under Alternatives 2 and 3.

Shortages of supply and increases in the cost of sugar would be anticipated for Alternative 1 until an adequate supply of conventional seed is produced, but sales of conventional sugar beets and their products would be expected to increase.

No impacts are expected to the supply or sales of organic sugar under any of the alternatives because organic sugar is not derived from sugar beets.

No impacts are expected to the supply or sales of conventional or organic vegetable beets under any of the alternatives as vegetable beet production is unaffected by sugar beet production.

No impacts are expected to the supply of conventional and organic vegetable beet seed under any of the alternatives as *Beta* seed production is largely concentrated, segregated, and isolated under all the alternatives. Alternatives 1–3 vary in the degree of segregation between H7-1 and vegetable beets where Alternative 1 has the most segregation and Alternative 2 has the least.

5. Human Health

The toxicological and nutritional profile of H7-1 sugar beets and the sugar produced from them indicates no substantive differences compared with non-transgenic sugar beets and sugar derived from them.

H7-1 sugar beets have been found to have no adverse effects on human health and worker safety beyond those of non-transgenic sugar beets. APHIS estimated that about 95 non-fatal injuries would occur each year to sugar beet growers from tillage and herbicide applications. Production of H7-1 sugar beets reduces the equipment use for both by about 70 percent and consequently a proportional decrease in non-fatal worker injuries is expected.

EPA has determined that the use in accordance with the labeling of currently registered pesticide products containing glyphosate and other herbicides will not pose unreasonable risks or adverse effects to humans or the environment, including its use on sugar beets. Under Alternative 1, workers will be exposed to more non glyphosate herbicides which are more toxic to humans than is glyphosate. For example, clethodim is a much more toxic skin irritant than glyphosate, clopyralid and desmedipham are much more toxic eye irritants, and EPTC, ethofumesate, and triflusulfuron-methyl are much more toxic by inhalation than is glyphosate. Worker exposure to herbicides will be greater under Alternative 1 because more field work is expected to be needed and herbicide applications are expected to be more frequent. Under Alternative 1, risks to Human Health are expected to be greater than under Alternatives 2 and 3.

I. Purpose and Need

A. Purpose of H7-1 Sugar Beets

The sugar beet (*Beta vulgaris* ssp. *vulgaris*) cultivars, designated as H7-1 sugar beets by developers Monsanto/KWS SAAT AG, are genetically engineered to be resistant to the herbicide glyphosate. H7-1 sugar beets are marketed to benefit sugar beet growers by providing a tool for managing weeds in sugar beet production. H7-1 sugar beets are genetically engineered to be resistant to gyphosate through the insertion of a gene (from *Agrobacterium* sp. strain CP4) that encodes the enzyme 5-enolpyruvylshikimate-3-phosphate synthase protein (EPSPS) into the sugar beet genome.

Weed management is one of the largest concerns and challenges in sugar beet production. Current herbicide programs injure sugar beets, decrease yields, and are often ineffective. With the insertion of the CP4 gene, H7-1 sugar beet farmers are able to apply glyphosate to weeds in the field without the concern for ancillary damage to the sugar beet crop.

B. Production History of H7-1 Sugar Beets

The United States is among the largest producers of sugar beets, and about half of the sugar refined in this country is produced from sugar beets (USDA-NASS, 2010d). The roughly 1.1 million acres of sugar beets grown in the United States includes seed production and root production (sugar production). Sugar beet root production is primarily localized in the Red River Valley area of Minnesota and North Dakota (57 percent of U.S. production), with smaller production areas in the Upper and Central Great Plains, and portions of Idaho, Michigan, Nebraska, Montana, Colorado, Wyoming, California, and Oregon (USDA-ERS, 2010c). Sugar beet seed production occurs primarily in Oregon and Washington where in 2011, about 50 percent of the total H7-1 U.S. sugar beet seed production occurred in each State. In Oregon, production is concentrated in the Willamette Valley in Oregon, located between the Coast Range and the Cascade Range (Stankiewicz Gabel, 2010).

In the United States, beet sugar is processed in most cases in local, farmer-owned processing cooperatives. Sugar beet producers and their cooperatives rapidly adopted H7-1 sugar beet varieties following the determination of the U.S. Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS) of nonregulated status of H7-1 sugar beets in 2005. Widespread cultivation began in 2008, with H7-1 sugar beet varieties being grown in 10 States. USDA’s Economic Research Service (ERS) estimates that adoption of the genetically engineered (GE) sugar beet varieties exceeded 95 percent of U.S. sugar beet production in 2010 (USDA-NASS, 2010d).

C. Regulatory History of H7-1 Sugar Beets

On November 19, 2003, USDA–APHIS received a petition request from Monsanto Company of St. Louis, Missouri, and KWS SAAT AG of Einbeck, Germany (hereinafter referred to as Monsanto/KWS SAAT AG) seeking a determination of nonregulated status of a GE variety of sugar beets designated as event H7-1 (hereinafter referred to as H7-1 sugar beets). H7-1 sugar beets and cultivars derived from it are genetically engineered to be resistant to the herbicide glyphosate. On October 19, 2004, APHIS published a notice in the *Federal Register* (see 69 *Federal Register* (FR) 61466–61467, Docket No. 04–075–1) announcing receipt of the petition from Monsanto/KWS SAAT AG requesting a determination of nonregulated status under 7 U.S. Code of Federal Regulations (CFR) part 340 The petition stated that APHIS should not regulate H7-1 sugar beets because they do not present a plant pest risk.

APHIS also announced in the 2004 FR notice the availability of a draft environmental assessment (EA) for sugar beets (USDA-APHIS, 2005)for the proposed determination of nonregulated status. APHIS received 44 comments on the petition and the draft EA during a 60-day comment period, which ended December 20, 2004. Following review of public comments, completion of the final EA, and the subsequent finding of no significant impact (FONSI), APHIS published another notice in the *Federal Register* on March 17, 2005 (see 70 FR 13007–13008, Docket No. 04–075–2), advising the public of the agency's determination decision, effective March 4, 2005, that H7-1 sugar beets posed no plant pest risk and would no longer be considered a regulated article under APHIS regulations codified at 7 CFR part 340. Pursuant to this regulatory determination decision, H7-1 sugar beet seed and root crops were fully deregulated, and could be grown without any APHIS-imposed conditions.

Before receiving the 2003 petition from Monsanto/KWS SAAT AG, APHIS had authorized approximately 35 notifications on 98 sites for H7-1 sugar beets in all sugar beet producing States(USDA-APHIS, 2011b). A USDA notification is an administratively streamlined alternative to a permit that is used if a GE plant meets specified eligibility criteria and the introduction meets predefined performance standards (7 CFR 340.3). APHIS had also authorized approximately 100 confined releases (i.e., planting outside in a field) for the field planting of all sugar beet varieties from 1998 to 2005. As part of the authorization process, the releases require seed developers to describe to USDA "the methods used to ensure that the regulated materials and any possible offspring remain confined to the release site and do not persist in the environment." Additionally, the seed developers must provide, among other data, descriptions of isolation distances, use of border rows or fallow zones, use of temporal isolation, cages, flower removal or bagging, and male sterility(USDA-APHIS, 2011b). The 100 authorizations for confined releases involved multiple planting locations with up to 270 acres being authorized under single notifications.

On July 29, 2010, Monsanto/KWS SAAT AG submitted a supplemental request to APHIS (Monsanto/KWS, 2010) to amend the original petition for nonregulated status that was submitted in 2003 (Schneider and Strittmatter, 2003) pursuant to the regulatory scheme of 7 CFR part 340. The 2010 Monsanto/KWS SAAT AG petition requested that APHIS approve their petition seeking a partial deregulation or similar administrative action to authorize the continued cultivation of H7-1 sugar beets subject to conditions proposed by APHIS. In November 2010, APHIS prepared a draft EA to evaluate the environmental impacts of the 2010 Monsanto/KWS SAAT AG petition seeking partial deregulation or similar administrative action for the continued cultivation of H7-1 sugar beets. The draft EA notice of availability (NOA) was published in the *Federal Register* on November 4, 2010 (see 75 FR 67945–67946, Docket No. APHIS-2010–0047) and indicated that the draft EA was available to the public for review and comment through December 6, 2010. The draft EA of the 2010 Monsanto/KWS SAAT AG petition evaluated several alternatives for responding to the request for partial deregulation or similar administrative action for the continued cultivation of H7-1 sugar beets, and those alternatives included specific production and management conditions proposed by APHIS.

APHIS received, reviewed, and considered public comments on the draft EA for partial deregulation of H7-1 sugar beets. APHIS then prepared a plant pest risk assessment (PPRA) for the root crop (USDA–APHIS 2011c), the final EA for partial deregulation of H7-1 sugar beets (USDA-APHIS, 2011a), and an accompanying FONSI. The FONSI includes a summary of the public comments received (see section I.H.2 of the FONSI). APHIS then issued the accompanying determination decision document on February 3, 2011, approving the petition for partial deregulation of H7-1 sugar beets with conditions for root crop production and to allow seed production under 7 CFR part 340 (USDA-APHIS, 2011a). The final EA, FONSI, PPRA, and determination decision were published in the *Federal Register* on February 8, 2011 (see 76 FR 6759-6761). However, it must be noted that the outcome of the EA process for the 2010 Monsanto/KWS SAAT AG petition is an interim measure set to expire in December 2012 and which will be superseded by the determination made in reliance on this environmental impact statement (EIS).

For the plant pest risk assessment, prepared in conjunction with the EA for partial deregulation of the H7-1 sugar beet root crop, APHIS concluded that H7-1 sugar beets are unlikely to pose a plant pest risk (USDA-APHIS, 2010b). based on the information provided by the applicant and the lack of any of the following—

- plant pest risk from the inserted genetic material,
- weedy characteristics,
- atypical responses to disease or plant pests in the field,
- effects on nontarget or beneficial organisms in the agro-ecosystem, and
- horizontal gene transfer (HGT).

D. Litigation History

1. First Lawsuit: Sugar Beets I

In March of 2005, APHIS approved a petition requesting a determination of nonregulated status for a GE variety of sugar beets (H7-1) after completing a PPRA and an EA pursuant to the National Environmental Policy Act of 1969 (NEPA) and issuing a FONSI.

The Center for Food Safety, Sierra Club, Organic Seed Alliance, and High Mowing Organic Seeds filed in the U.S. District Court for the Northern District of California on January 23, 2008, a lawsuit challenging the USDA determination of nonregulated status of H7-1 sugar beets (see *Center for Food Safety, et al. v. Vilsack, et. al., No3: 08-cv-00484*). The plaintiffs argued that wind-blown pollen from H7-1 sugar beets would contaminate conventional sugar beets and other closely related crops, such as Swiss chard and table beets, and that such gene flow from the H7-1 sugar beets to non-H7-1 sugar beets and other related crops could be economically detrimental to farmers and consumers of conventional and organic varieties. This is the first H7-1 sugar beet lawsuit and is referred to in this document as Sugar Beets I.

On September 21, 2009, the U.S. District Court for the Northern District of California ruled that the APHIS EA for H7-1 sugar beets failed to consider certain environmental and interrelated economic impacts. As a result, the court ordered APHIS to prepare an EIS before making a determination on the regulated status of H7-1 sugar beets (see *Center for Food Safety, et al. v. Vilsack, et al. No.3:08-cv-00484 Document139*). Specific findings of the court in its September 21, 2009 decision include:

(1) The Court found that the APHIS FONSI was “not supported by a convincing statement of reasons,” and that, therefore, APHIS is required to prepare an EIS.

(2) In particular, the court agreed with an earlier ruling (see *Geertson Seed Farms v. Johanns*, 2007 WL 518624, *7 (N.D. Cal. Feb. 13,

2007)) that “potential elimination of a farmer’s choice to grow non-genetically engineered crops, or a consumer’s choice to eat non-genetically [sic] engineered food, and an action that potentially eliminates or reduces the availability of a particular plant has a significant effect on the human environment” and therefore, requires analysis in an EIS.

(3) The court noted that economic effects of “transmission of the genetically engineered gene into organic and conventional” crops should be considered by APHIS in its environmental reviews when determining whether nonregulated status would cause significant environmental impacts.

(4) The court was critical of the APHIS analysis of existing coexistence measures used in Oregon seed production areas, noting that APHIS did not adequately consider that recommended isolation distances were voluntary, might not be followed, and might not be sufficient.

(5) The court concluded that APHIS did not provide support for the contention that non-transgenic seed would continue to be available for growers or that growers would discern that seed varieties derived from H7-1 sugar beets are transgenic because it is labeled as glyphosate tolerant.

On August 13, 2010, the court vacated the APHIS decision to fully deregulate event H7-1 sugar beet varieties, making them subject to the Plant Protection Act of 2000 (PPA) and 7 CFR part 340 once again. In doing so, the court remanded the matter back to the agency to determine regulatory actions, if any, that should be imposed upon event H7-1 sugar beets in the interim, until the completion of the EIS and a new determination decision could be made by APHIS. The plaintiffs’ request for a permanent injunction against the planting of H7-1 sugar beets pending completion of the court-ordered EIS was denied. Consistent with the court order, H7-1 sugar beets planted *before* August 13, 2010, are *not* treated as regulated articles and are not subject to the PPA of 2000 or 7 CFR part 340 for the duration of those plantings. Thus, H7-1 sugar beets planted for root production before August 13, 2010, may remain in the ground, be harvested, transported, processed, and sold as sugar. Based on the court order, H7-1 sugar beets planted for seed production before August 13, 2010, may continue to be grown until the seeds or seed stecklings are harvested, transported, and stored; and sugar beet seed producers that used direct seeding (seed plants that will not be transplanted during the steckling stage of seed production) before August 13, 2010 may allow their H7-1 sugar beet seed plants to flower and set seed with no restriction under 7 CFR part 340.

2. Second Lawsuit: Sugar beets II

Shortly after the Court's August 13, 2010 remedy ruling in Sugar Beets I, four sugar beet seed companies applied for permits pursuant to APHIS' Part 340 biotechnology regulations to plant H7-1 sugar beet seed crops. The requested permit applications sought to allow the immediate planting of H7-1 sugar beet seeds for nonflowering steckling production on up to 525 total acres in two States (450 acres in Arizona and 75 acres in Oregon).

On September 3, 2010, APHIS issued four "nonflowering" permits allowing the planting of the first phase of the 2010–2011 H7-1 sugar beet seed (steckling) crop, and expressly prohibiting the flowering of the H7-1 sugar beet plants. The permits were set to expire on February 28, 2011.

In response to APHIS' issuance of the four nonflowering steckling permits, on September 9, 2010, Center for Food Safety filed a new lawsuit alleging that APHIS violated NEPA. This is the second H7-1 sugar beet lawsuit and is referred to in this document as *Sugar Beets II* (see *Center for Food Safety, et al. v. Vilsack et al. No.: 4:10-cv-04038*).

On September 28, 2010, the court found that plaintiffs were likely to succeed on the merits in that APHIS violated NEPA in permitting steckling crops. On November 30, 2010, the court ordered that the stecklings planted under permit shall be removed from the ground (see *Center for Food Safety, et al. v. Vilsack, et al. No.: 4:10-cv-04038 document 221*).

On December 3, 2010, the court issued a preliminary injunction ordering APHIS to issue an Emergency Action Notification to each of the four permittees directing them to plow under (i.e., "destroy") the stecklings by December 14, 2010. The Ninth Circuit Court granted a stay of the District Court's order on December 6, 2010 and on February 25, 2011, the Ninth Circuit issued an opinion reversing and vacating the court's preliminary injunction of December 3, 2010. The four permits expired on February 28, 2011 and the district court dismissed the case as moot but plaintiffs have appealed the decision.

3. Lawsuits: Sugar Beets III and IV

On February 4, 2011, APHIS announced its new interim decision to partially deregulate H7-1 sugar beets after preparing an EA. The decision was made in response to a petition for partial deregulation submitted July 29, 2010 by Monsanto/KWS SAAT AG. APHIS approved the petition to partially deregulate H7-1 sugar beet root crop subject to mandatory mitigation conditions contained in APHIS-issued compliance agreements. APHIS further announced that H7-1 sugar beet seed crop planting would only be allowed through permits issued pursuant to the agency's 7 CFR part 340 regulations.

Immediately after this announcement, two new legal challenges were filed against APHIS. The first challenge was a new lawsuit filed by growers and other members of the sugar beet industry. This lawsuit, referred to in this document as *Sugar Beets III*, was filed in the U.S. District Court for the District of Columbia (see *Grant, et al. v. Vilsack, et. al. No.*11-cv-308). The complaint alleged that APHIS exceeded its authority under the PPA by mandating certain conditions for the planting of H7-1 sugar beets. In the alternative, plaintiffs seek a declaratory judgment that APHIS' February 4, 2011 interim decision complied with NEPA..

The Center for Food Safety also filed a motion to amend its *Sugar Beets II* complaint in the Northern District of California seeking to enjoin APHIS' interim partial deregulation decision. The court denied this motion and ordered that any new challenge would have to be filed as a new complaint. The Center for Food Safety responded by filing a new complaint on February 23, 2011, in the Northern District of California. This February 23, 2010 action is referred to in this document as *Sugar Beets IV* (see *Center for Food Safety, et al. v. Vilsack, et. al.* Nos. 11-cv—831; 11-cv-586; 11-cv-308. Sugar Beets IV was subsequently transferred to the U.S.District Court for the District of Columbia and consolidated with the *Sugar Beets III* case. Thus, *Sugar Beets III and IV* are proceeding in the District of Columbia.

E. Regulatory Authority

"Protecting American agriculture" is the basic charge of USDA–APHIS. APHIS provides leadership in ensuring the health and care of plants and animals. The agency improves agricultural productivity and competitiveness, and contributes to the national economy and the public health. USDA asserts that all methods of agricultural production (conventional, organic, or the use of genetically engineered varieties) can provide benefits to the environment, consumers, and farm income.

Since 1986, the United States government has regulated GE organisms pursuant to a regulatory framework known as the Coordinated Framework for the Regulation of Biotechnology (Coordinated Framework) (51 FR 23302, 57 FR 22984). The Coordinated Framework, published by the

Office of Science and Technology Policy, describes the comprehensive federal regulatory policy for ensuring the safety of biotechnology research and products and explains how Federal agencies will use existing Federal statutes in a manner to ensure public health and environmental safety while maintaining regulatory flexibility to avoid impeding the growth of the biotechnology industry. The Coordinated Framework is based on several important guiding principles: (1) agencies should define those transgenic organisms subject to review to the extent permitted by their respective statutory authorities; (2) agencies are required to focus on the characteristics and risks of the biotechnology product, not the process by which it is created; (3) agencies are mandated to exercise oversight of GE organisms only when there is evidence of “unreasonable” risk.

The Coordinated Framework explains the regulatory roles and authorities for the three major agencies involved in regulating GE plants: USDA–APHIS, the Food and Drug Administration (FDA), and the Environmental Protection Agency (EPA). In the case of H7-1 sugar beets, under the coordinate framework review, USDA reviews the plant. FDA considers the safety and regulatory status of food and feed derived from the plant. EPA did not review the H7-1 sugar beet plant, but does register the use of the glyphosate and other herbicides by farmers in H7-1 sugar beet production. EPA also established a tolerance for allowable glyphosate and other herbicide residues on harvested H7-1 sugar beets

1. USDA–APHIS

The USDA–APHIS Biotechnology Regulatory Service (BRS) mission is to protect U.S. agriculture and the environment using a dynamic and science-based regulatory framework that allows for the safe development and use of GE organisms. APHIS regulations at 7 CFR part 340, which were promulgated pursuant to authority granted by the Plant Protection Act, as amended (7 United States Code (U.S.C.) 7701–7772), regulate the introduction (importation, interstate movement, or release into the environment) of certain GE organisms and products. A GE organism is no longer subject to the plant pest provisions of the Plant Protection Act or to the regulatory requirements of 7 CFR part 340 when APHIS determines that it is unlikely to pose a plant pest risk. A GE organism is considered a regulated article if the donor organism, recipient organism, vector, or vector agent used in engineering the organism belongs to one of the taxa listed in the regulation (7 CFR 340.2) and is also considered a plant pest. A GE organism is also regulated under Part 340 when APHIS has reason to believe that the GE organism may be a plant pest or APHIS does not have information to determine if the GE organism is unlikely to pose a plant pest risk.

A person may petition the agency that a particular regulated article is unlikely to pose a plant pest risk, and, therefore, is no longer regulated under the plant pest provisions of the Plant Protection Act or the regulations at 7 CFR 340. The petitioner is required to provide information under § 340.6(c)(4) related to plant pest risk that the agency may use to determine whether the regulated article is unlikely to present a greater plant pest risk than the unmodified organism. A GE organism is no longer subject to the regulatory requirements of 7 CFR part 340 or the plant pest provisions of the Plant Protection Act when APHIS determines that it is unlikely to pose a plant pest risk. In such a case, APHIS authorizations (i.e., permits and notifications) would no longer be required for environmental release, importation, or interstate movement of the nonregulated article or its progeny.

It was pursuant to these APHIS regulations that Monsanto/KWS SAAT AG submitted a petition for a determination of nonregulated status of H7-1 sugar beets (Schneider and Strittmatter, 2003). H7-1 sugar beets are initially considered a regulated article because they contain noncoding DNA segments derived from plant pathogens and the vector agent used to deliver the transforming DNA is a plant pathogen (Monsanto/KWS, 2010; Schneider and Strittmatter, 2003; USDA-APHIS, 2005)

2. FDA

FDA regulates GE organisms under the authority of the Federal Food, Drug, and Cosmetic Act. FDA is responsible for ensuring the safety and proper labeling of all plant-derived foods and feeds, including those that are genetically engineered. To help developers of food and feed derived from GE crops comply with their obligations under Federal food safety laws, FDA encourages them to participate in a voluntary consultation process. Food and feed derived from GE crops currently on the market in the United States have successfully completed this consultation process. In 1992, FDA, which has primary regulatory authority over food and feed safety, published a policy statement in the *Federal Register* concerning regulation of food derived from new plant varieties, including those produced through biotechnology (U.S. FDA, 1992). FDA operates a voluntary, pre-market consultation process and encourages developers to consult with FDA to ensure that human food and animal feed safety questions are resolved before food from bioengineered crops is commercially distributed. The voluntary consultation process provides a way for developers to receive assistance from FDA when making a judgment about the regulatory status of a food prior to marketing. Monsanto/KWS SAAT AG participated in FDA's consultation program by submitting a food and feed safety and nutritional assessment summary for H7-1 sugar beets to FDA in April 2003. The consultation process was completed in August 2004 (Tarantino, 2004; U.S. FDA, 2004).

3. EPA

EPA regulates plant-incorporated protectants under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and certain biological control organisms under the Toxic Substances Control Act (TSCA). EPA is responsible for regulating the sale, distribution and use of pesticides, including pesticides that are produced by an organism through techniques of modern biotechnology. EPA is also responsible for regulating pesticides (including herbicides such as glyphosate) under FIFRA (7 United States Code (U.S.C.) § 136 et seq.). FIFRA requires all pesticides to be registered before distribution, sale, and use, unless they are exempted by EPA regulation. Before a product is registered as a pesticide under FIFRA, the product must be shown to not result in unreasonable adverse effects on the environment when used in accordance with the label. EPA granted the registration of glyphosate for use over the top of sugar beets on March 31, 1999.

Under the FFDCA, as amended (see 21 U.S.C. § 301 et seq.), pesticides added to (or contained in) raw agricultural commodities generally are considered to be unsafe unless a tolerance or exemption from tolerance has been established. EPA establishes residue tolerances for pesticides under the authority of the FFDCA. EPA is required, before establishing pesticide tolerance, to reach a safety determination based on a finding of reasonable certainty of no harm under the FFDCA, as amended by the Food Quality Protection Act of 1996 (FQPA). FDA enforces the pesticide tolerances set by EPA. EPA established a tolerance for glyphosate residue found on beets, including sugar, roots, tops, and dried pulp on April 14, 1999 (64 FR 18360).

4. Statutory Basis for Documentation

APHIS has prepared this EIS in compliance with the requirements of NEPA (42 U.S.C. § 4321 et seq.), the Council on Environmental Quality's (CEQ's) regulations implementing NEPA (40 CFR parts 1500–1508), and the USDA and APHIS NEPA implementing regulations and procedures (see 7 CFR part 1b and 7 CFR part 372). This EIS and a subsequent Record of Decision (ROD) are part of an independent NEPA process to make an informed decision on the petition request from Monsanto/KWS SAAT AG seeking a determination of non-regulated status of their H7-1 sugar beets.

F. Purpose and Need for APHIS Action

Under the authority of the plant pest provisions of the Plant Protection Act and 7 CFR part 340, APHIS has issued regulations for the safe development and use of genetically engineered organisms. As required by 7 CFR 340.6, APHIS must respond to petitioners that request a determination of the regulated status of genetically engineered organisms, including genetically engineered plants such as H7-1 sugar beets. When a petition for nonregulated status is submitted, APHIS must make a determination if the genetically engineered organism is unlikely to pose a plant pest risk. If APHIS determines, based on its Plant Pest Risk Assessment (PPRA), that the GE organism is unlikely to pose a plant pest risk, the GE organism is no longer subject to the plant pest provisions of the Plant Protection Act and 7 CFR part 340.

Any party can petition APHIS to deregulate an organism that is regulated under 7 CFR part 340. A petition must document the evidence that the GE organism is unlikely to pose a greater plant pest risk than the unmodified organism from which it was derived.

APHIS must respond to the November 2003 petition from Monsanto/KWS SAAT AG requesting a determination of nonregulated status of H7-1 sugar beets. APHIS prepared an EA and FONSI in February 2005 (USDA-APHIS, 2005) and subsequently approved the petition in March 2005. On September 21, 2009, the U.S. District Court for Northern California ruled that the APHIS EA failed to consider certain environmental and interrelated economic impacts and ordered APHIS to prepare an EIS before making a determination on the regulated status of H7-1 sugar beets. This EIS has been prepared in order to specifically evaluate the effects on the quality of the human environment that could result from a decision on the regulated status of H7-1 sugar beets.

G. Decisions to be Made

Based on the scope of this EIS, the specific decisions to be made are:

- Should APHIS deny the petition seeking a determination of nonregulated status of H7-1 sugar beets, allowing for no full or partial deregulation of H7-1 sugar beet seed and root, and continue to regulate the environmental release and movement of H7-1 sugar beets under 7 CFR part 340 (the No Action Alternative)?

- Should APHIS approve the petition seeking a determination of nonregulated status (the Full Deregulation Alternative) of H7-1 sugar beets, allowing for commercial planting of H7-1 sugar beet seed and root, and no longer regulate the environmental release and movement of H7-1 sugar beets under 7 CFR part 340?

- Should APHIS extend the partial deregulation of H7-1 sugar beets for root crop, with mandatory conditions and restrictions, and continue permitting seed crop via APHIS permits or notifications in accordance with 7 CFR part 340 (the Partial Deregulation Alternative)?

H. Scoping and Public Involvement

A determination of nonregulated status of H7-1 sugar beets raises several issues that are addressed in this EIS. APHIS identified these issues through a scoping process. Public scoping is required for an EIS under NEPA (see 42 U.S.C. §§ 4321–4327), CEQ regulations for implementing NEPA (40 CFR parts 1500–1508), the USDA regulations implementing NEPA (see 7 CFR part 1b), and the APHIS NEPA Implementing Procedures (see 7 CFR part 372).

1. Scoping: NOI

Scoping for this EIS began on May 28, 2010, when APHIS gave notice in the *Federal Register* (see 75 FR 29969–29972) of its intent to prepare an EIS. The notice listed several topics and questions that are addressed in this EIS:

(1) *Management practices for organic sugar beet, conventional sugar beet, and glyphosate tolerant sugar beet*. What are the management practices and associated costs of establishing, growing, harvesting, and marketing sugar beet, including selling prices and premiums for the various types of sugar beet? What crop rotation regimes are used with sugar beet?

(2) *Production levels of organic and conventional sugar beet, Swiss chard, and table beet by region, State, and county*. What is the acreage of cultivated, volunteer, or feral sugar beet? What is the acreage of Swiss chard and table beet? Which regions of the country may be affected as a result of a determination of nonregulated status for glyphosate tolerant sugar beet? What are the potential impacts on adjacent, nonagricultural lands such as natural areas, forested lands, or transportation routes that may result from the use of glyphosate tolerant sugar beet?

(3) *Potential impacts of glyphosate tolerant sugar beet cultivation on livestock production systems.* What are the potential impacts of glyphosate tolerant sugar beet cultivation on conventional and organic livestock production systems?

(4) *Potential impacts on food and feed.* Does glyphosate affect the socioeconomic value of food or feed or its nutritional quality? What are the impacts, if any, on food or feed socioeconomic value or its nutritional quality from the use of glyphosate?

(5) *Differences in weediness traits of conventional sugar beet versus glyphosate tolerant sugar beet.* What are the differences, if any, in weediness traits of conventional sugar beets versus glyphosate tolerant sugar beet under managed crop production systems, as well as in unmanaged ecosystems?

(6) *Occurrence of common and serious weeds found in organic sugar beet systems, in conventional sugar beet systems, and in glyphosate tolerant sugar beet systems.* What are the impacts of weeds, herbicide tolerant weeds, weed management practices, and unmet weed management needs for organic and conventional sugar beet cultivation? How may the weed impacts change with the use of glyphosate tolerant sugar beet?

(7) *Management practices for controlling weeds in organic sugar beet systems, in conventional sugar beet systems, and in glyphosate tolerant sugar beet systems.* What are the potential changes in crop rotation practices and weed management practices for control of volunteer sugar beet or herbicide tolerant weeds in rotational crops that may occur with the use of glyphosate tolerant sugar beet? What are the potential effects on sugar beet stand termination and renovation practices that may occur with the use of glyphosate tolerant sugar beet?

(8) *Cumulative impact on the development of glyphosate resistant weeds.* What glyphosate resistant weeds have been identified and what is their occurrence in crops and in non-crop ecosystems? How would the addition of glyphosate tolerant sugar beet impact the occurrence of glyphosate resistant weeds in sugar beet, in other crops, and in the environment? Which are the most likely weeds, if any, to gain glyphosate resistance and why would they gain such resistance with the use of glyphosate tolerant sugar beet? What are the current and potentially effective strategies for management of glyphosate tolerant or other herbicide tolerant weeds in glyphosate tolerant sugar beet stands or in subsequent crops? What are the potential changes that may occur in glyphosate tolerant sugar beet as to susceptibility or tolerance to other herbicides?

(9) *Current or prospective herbicide tolerant weed mitigation options.* What are the potential impacts of current or prospective herbicide tolerant weed mitigation options, including those addressed by the EPA-approved label for glyphosate herbicides?

(10) *Potential for gene flow from glyphosate tolerant sugar beet to other Beta species, including gene flow between seed fields, root crops, and feral plants.* To what extent will deregulation change hybridization between cultivated and feral sugar beet, sugar beet

introgression or establishment outside of cultivated lands, and sugar beet persistence or weediness in situations where it is unwanted, unintended, or unexpected? What are the potential impacts associated with feral glyphosate tolerant sugar beet plants? Will the removal of glyphosate tolerant sugar beet, in situations where it is unwanted, unintended, or unexpected, result in adverse impacts? In such situations, how will glyphosate tolerant sugar beet be controlled or managed differently from other unwanted, unintended, or unexpected sugar beet?

(11) *Economic and social impacts on organic and conventional sugar beet, Swiss chard, and table beet farmers.* What are the economics of growing organic sugar beet, conventional sugar beet, or glyphosate tolerant sugar beet as well as the economics of growing organic or conventional Swiss chard and table beet? What are the potential impacts of the presence of glyphosate sugar beet caused by pollen movement or seed admixtures? What are the potential impacts of commingling sugar beet seed with glyphosate tolerant sugar beet seed? What are the potential changes in the economics of growing and marketing organic and conventional sugar beet that may occur with the growing of glyphosate tolerant sugar beet? What are the potential changes in production levels of other crops that may occur with the growing of glyphosate tolerant sugar beet? Will the cultivation of glyphosate tolerant sugar beet result in more or fewer acres of other crops? What are the potential changes in growing practices, management practices, and crop rotational practices in the production of sugar beet seed for planting purposes that may occur with the use of glyphosate tolerant sugar beet? What are the potential changes in the choice of seeds available for organic and conventional sugar beet farmers that may occur with the use of glyphosate tolerant sugar beet?

(12) *Cumulative impact of potential increased glyphosate usage with the cultivation of glyphosate tolerant crops.* What are the past, present, and future impacts of glyphosate usage on soil quality, water quality, air quality, weed populations, crop rotations, soil micro-organisms, diseases, insects, soil fertility, food or feed quality, crop acreages, and crop yields as a result of the introduction of glyphosate tolerant crops? Does the level of glyphosate tolerance within glyphosate tolerant sugar beet plants have an impact on the amount of glyphosate applied on the glyphosate sugar beet crop on a routine basis?

(13) *Impacts on threatened or endangered species.* What are the potential impacts of glyphosate tolerant sugar beet cultivation on listed threatened or endangered species or on species proposed for listing? What are the potential impacts of glyphosate use on listed

threatened or endangered species or species proposed for listing, including glyphosate used on glyphosate tolerant sugar beet? What impacts does the addition of glyphosate tolerance in sugar beet cultivation have on threatened and endangered species as a result of displacing other herbicides?

(14) *Potential health impacts.* What are the potential health impacts to farmers or others who would be exposed to glyphosate tolerant sugar beet?

(15) *Can any potential negative environmental impacts of the action be mitigated and what is the likelihood that such mitigation measures will be successfully implemented and effective?* What is the likely effectiveness of the stewardship measures, outlined in the petition, which are designed to reduce inadvertent gene flow to negligible levels as well as to monitor and minimize the potential development of glyphosate tolerant weeds? Are there reasonable alternative stewardship or monitoring measures that may avoid or minimize reasonably foreseeable environmental impacts of a deregulation decision?

(16) *Impacts of the mitigation measures on coexistence with organic and conventional sugar beet production and on export markets.* What are the potential impacts of mitigation measures on coexistence with organic and conventional sugar beet production and on export markets? Are there reasonable alternative measures that may avoid or minimize reasonably foreseeable impacts on organic and conventional sugar beet production and on export markets that may be associated with a deregulation decision?

(17) *Consideration of reasonable alternatives.* The EIS will consider a range of reasonable alternatives. These could include continued regulation of H7-1 sugar beets, deregulating H7-1 sugar beets, or deregulating H7-1 sugar beets in part with geographic restrictions and required separation distances from sexually compatible crops.[2]

The notice solicited public involvement in the form of written comments regarding the above issues and alternatives for regulatory action. Written comments were accepted from the public during a 30-day comment period, which lasted until June 28, 2010.

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[2] The alternatives included in the May 28, 2010, *Federal Register* listing have since been revised and currently include: Alternative 1 – deny the petition seeking a determination of nonregulated status and continued regulation of H7-1 sugar beets by notification (no action), Alternative 2 – full deregulation of H7-1 sugar beets, Alternative 3 – partial deregulation of H7-1 sugar beets for root crop and continued permitting of seed crop

2. Scoping: DEIS

APHIS seeks public comment on this draft EIS through publication of a NOA in the *Federal Register*. The NOA explains how interested agencies, organizations, and individuals can access this EIS for review and comment. The NOA also explains the process for submitting comments on the draft EIS to APHIS. The draft EIS is available for public comment for 60 days. At the end of the 60-day comment period, APHIS will analyze and consider comments in preparing a final EIS.

3. Scoping Analysis and Documentation

In total APHIS received 70 comments from 64 respondents during the comment period for the May 28, 2011, NOI, including multiple comments from the same individual or organization. There were 46 respondents opposed to deregulating H7-1 sugar beets, of which 3 were nongovernmental organizations. Two of those organizations sought to extend the comment period, while not providing substantive input on the scope of the EIS. The Center for Food Safety submitted a comment germane and in opposition to APHIS' positions on the specific issues previously identified for scoping.

There were 18 respondents supporting deregulating H7-1 sugar beets, of which 17 were from industry or trade groups seeking an expeditious EIS and approval process. An analysis of the comments did not identify additional broad issues outside those in the NOI, but highlighted important issues within the present list of issues to be analyzed by the agency in the EIS. There was substantive information provided in public comments that will be considered in the analysis for this draft EIS.

The following is a general summary of the comments received.

In opposing the deregulation of H7-1 sugar beets, Center for Food Safety (CFS) provided a source for an approach for promoting cover crops as an alternate weed control strategy. CFS further suggested that APHIS break out crop rotation regimes by region as a means of assessing the rate at which glyphosate-resistant (GR) weeds will emerge. CFS stated that the use of glyphosate may make plants more susceptible to disease and mineral deficiencies, adversely impact soil bacteria, and reduce yield. CFS provided references supporting their position. In addition to reducing feed quality due to glyphosate-induced lower mineral content, CFS suggested that glyphosate residues may render GR crops toxic to livestock and increase the presence of mycotoxins and other disease-related toxins due to increased susceptibility to fungal diseases such as Fusarium yellows (also called Fusarium wilt). CFS suggested H7-1 sugar beets and the associated use of glyphosate to control weeds will contribute to the development of GR weeds which may spread to neighboring crops, as well as development of weeds resistant to multiple herbicides. CFS also suggested that mandatory weed resistance requirements may be necessary if H7-1 sugar beets are deregulated. One such weed CFS cited is kochia, which "has the ability to propagate long distances to infest other fields." CFS also urged APHIS to consider the negative effect "inert" ingredients present in glyphosate formulations may have on wildlife, such as the California red-legged frog.

Forty-five other commenters, including the Sierra Club and the Organic Seed Growers and Trade Association, submitted generally anti-GE comments opposing deregulation of H7-1 sugar beets and requesting additional time to respond to the scoping of the EIS. A citizen in opposition of H7-1 sugar beets posted a copy of the June 14th, 2010, "Organic and non-genetically modified organism (GMO) Report" interview with Don Huber that also referenced a similar previous interview with Robert Kremer warning of the impacts of glyphosate use on soils and plant health.

There were 17 respondents from industry or trade organizations,[3] citing a number of agronomic and economic benefits to sugar beet growers and submitting similar comments in support of deregulation of H7-1 sugar beets. These expressed benefits include reduced weed pressure; improved disease treatments; increased sugar beet yields; less manual cultivation; reduced use of "harsher" (more toxic and/or less environmentally benign) herbicides and less complex herbicide regimens which improve worker safety, reduce environmental effects, and are less harmful to the crop; less tillage, which decreases erosion, reduces carbon release, and allows for more cover crops; and fewer tractor emissions. Associations urged the USDA to return H7-1 sugar beets to nonregulated status, since most sugar beet growers have adopted equipment and rotation plans suitable for the GR varieties that are unsuitable for a return to conventional methods. These commenters also expressed concerns that a return to conventional varieties would cause an unbearable financial hardship for growers, who would lose several years' worth of revenue in the process of reverting back to pre-GR equipment and technology; that growers would rather abandon growing sugar beets altogether than resume conventional sugar beet cultivation; and that no longer growing sugar beets would cause wide-ranging economic impacts.

[3] American Sugar Beet Association, Beet Sugar Development Foundation, Red River Valley Sugar Beet Growers Association, Nyssa-Nampa Beet Growers Association, Idaho Sugar Beet Growers Association, California Beet Growers Association, Montana Dakota Beet Growers Association, Big Horn Basin Beet Growers Association, Michigan Sugar Company, United States Beet Sugar Association, Minn-Dak Farmers Cooperative, Wyoming Sugar Co., LLC, Colorado Sugarbeet Growers Association, Southern Minnesota Beet Sugar Cooperative, Nebraska Sugarbeet Growers Association, Biotechnology Industry Organization (BIO), and the U.S. Soybean Export Council.

The California Beet Growers Association stated that GR technology is needed to address the severe weed control problem in their State, and although H7-1 sugar beets are currently unavailable in California because of possible gene flow between wild and engineered beets, the industry has developed protocols for reducing cross-pollination between the two. The U.S. Beet Sugar Association, in addition to the above general comments supporting deregulation, stated that after processing, sugar derived from H7-1 sugar beets contains no DNA fragments, and its molecular structure is identical to that produced from conventional sugar beets. The Minn-Dak Farmers Cooperative states that "Roundup Ready® sugar beets have provided a safety net that does not exist with conventional sugar beets when the crop has been injured from excessive spring rains." The Nebraska Sugarbeet Growers Association commented that spring rains prevent growers from timely herbicide spraying, but with H7-1 sugar beets, growers can control larger weeds.

The Biotechnology Industry Organization (BIO) "strongly encourages APHIS to also utilize EPA's human health risk assessments of glyphosate to be used on the glyphosate-tolerant sugar beet." BIO urged APHIS to include facts contained in the report "The Impact of Genetically Engineered Crops on Farm Sustainability in the United States," which details the benefits to U.S. farmers who grow crops developed through biotechnology experience, such "substantial economic and environmental benefits – such as lower production costs, fewer pest problems, reduced use of pesticides, and better yields – compared with conventional crops" and these benefits should be taken into account when undergoing a NEPA process for biotech crops.

The U.S. Soybean Export Council (USSEC) supports deregulation, stating that like bioengineered soybean, economic coexistence between GE sugar beets and conventional sugar beets is possible, provided the appropriate stewardship plans are in place and that risks posed by conventional breeding methods are manageable without Federal oversight. They also stated that the development of other non-GT crops will reduce the selection pressure in developing GR weeds; biotech crops provide substantial health and environmental benefits (see reports from National Academy of Sciences, Council for Agricultural Science and Technology) and do not pose unique risks; and that the use of biotechnology-derived crops will soon be necessary to feed a population approaching 9 billion people. The USSEC opposes the use of consumer preferences and marketing standards as a significant decision-making factor in the EIS, and does not believe that these preferences should trigger an EIS. It recommends that the USDA examine coexistence strategies in *Gene Flow in Alfalfa: Biology, Mitigation, and Potential Impact on Production.* Special Publication 28, published by Council for Agricultural Science and Technology, as well as glyphosate stewardship in statements made by M. Owen and C. Boerboom, National Glyphosate Stewardship Forum, (November 17, 2004) available at www.weeds.iastate.edu/weednews/2006 /NGSFpercent20finalpercent20report.pdf. USSEC warns that [w]ere the USDA…[to] “protect” non-GMO or organic exports, it could be seen overseas as implicitly endorsing creation of similar restrictions on biotech crops in overseas markets and points out that the National Organic Program (NOP) does not guarantee the complete absence of genetic material from GE plants in certified organic crops.

APHIS considered all comments received in response to the *Federal Register* notice to ensure that all pertinent issues are addressed, and that this EIS examines any environmental impacts that could result from a decision on the regulatory status to H7-1 sugar beets.

II. Alternatives

A. Introduction

This environmental impact statement (EIS) analyzes in detail four alternative approaches to respond to the petition from Monsanto Company and KWS SAAT AG (Monsanto/KWS SAAT AG) seeking a determination of nonregulated status of H7-1 sugar beets. This EIS informs the Animal and Plant Health Inspection Service (APHIS) Administrator of the potential impacts on the human environment from the selection of each alternative. Each of the alternatives poses environmental impacts that differ in context and intensity. Additional alternatives (described in section II.F) were considered but eliminated from further consideration because they were either unreasonable or they failed to meet program need.

B. Alternative 1 – No Action Alternative: Sugar Beets Regulated and Planted by Notification or Permit

Under Alternative 1, APHIS would deny the petition seeking a determination of nonregulated status of H7-1 sugar beets. All movements and environmental releases for H7-1 sugar beets would be subject to the regulations in 7 Code of Federal Regulations (CFR) part 340. Notifications or permits with conditions specified by APHIS would be required to move viable plant material and to plant it outdoors. This Alternative 1 would only allow movements and environmental releases of H7-1 sugar beets pursuant to notifications or permits. No partial deregulation of H7-1 sugar beets would be allowed. When H7-1 sugar beets were released under notification prior to 2005, the yearly acreage of authorized plantings varied from 45 to just over 500 acres. Under Alternative 1, the environmental release of H7-1 sugar beets would not be expected to exceed 1,000 acres as explained below.

If neither full nor partial deregulation of H7-1 will be allowed, research and development activities associated with H7-1 are expected to diminish because developers would receive no return on investment to support such activities. If the reason for denying the petition was event specific for H7-1, it is possible that other herbicide-tolerant sugar beets would be developed in the future. Glyphosate-tolerant sugar beets, GTSB77, developed by Novartis (now Syngenta) and Monsanto were determined to have nonregulated status on January 8, 1999, and glufosinate-tolerant sugar beets, T-120-7, developed by AgrEvo (now Bayer) were determined to have nonregulated status on May 7, 1998. According to regulatory staff at both Monsanto and Bayer, neither trait is being bred into commercial sugar beet varieties (H.Keith Reding and Ali Bayer, personal communications). Monsanto informed APHIS that “there is no intent to reintroduce GTSB77, even if Event H7-1 is not fully deregulated"(Reding, 2011). Therefore, it is unlikely that development of sugar beets with previously approved events would resume if Alternative 1 is selected.

For genetically engineered (GE) crops that are regulated under 7 CFR part 340, the importation, interstate movement, or release into the environment requires authorization from APHIS. During the development of the GE crop, field trials are conducted by companies and organizations to select high performing plants and to collect data needed to petition APHIS for nonregulated status. For H7-1 sugar beets, 98 field trials were conducted from 1998 to 2002. All of these field trials as well as all movements and importations into the United States were authorized under APHIS' notification system in accordance with 7 CFR § 340.3. They could have also been authorized under the permit system as described in section II.D.1.a. Notification is an administratively streamlined alternative to the permit process to allow the introduction of a certain subset of GE plants (see APHIS notification guidance at http://www.aphis.usda.gov/ biotechnology/downloads/notification_guidance_0810.pdf). The goal of the notification procedure is the same as the permit system: preventing the unintended release of the regulated article. The notification procedure for introduction of GE plants may be used if the introduced plant meets all of the six eligibility criteria specified in the guidance and in 7 CFR § 340.3, and the introduction (the importation, interstate movement, or environmental release) will meet all of the six specified performance standards. By submitting a notification to APHIS, the applicant certifies to APHIS that the regulated article and introduction will meet the specified eligibility criteria and performance standards, respectively. The submission document contains information, including design protocols, that helps APHIS determine the appropriateness of the notification process for the proposed introduction. Each notification is individually assessed for meeting confinement standards by review of design protocols submitted as part of the application.

The No Action Alternative would return sugar beet production to the status quo from 2005, before a determination of nonregulated status of H7-1 sugar beets was made and when all environmental releases of H7-1 sugar beets were conducted under notification. It is expected that under Alternative 1, all H7-1 sugar beets that were planted for commercial seed and root production would be phased out of U.S. agriculture. Sugar beet growers would need to either replace H7-1 varieties with conventional sugar beet varieties, grow other crops, use the land for other purposes, or allow the land to become fallow. The environmental release of H7-1 sugar beets would no longer be expected to be field tested for commercial development but might be used for research purposes such as gene flow studies. The planting acreages are expected to be well under 1,000 acres per year. Field testing would be limited to sites that have been in agricultural production for a minimum of 3 years.

C. Alternative 2 – Full Deregulation of H7-1 Sugar Beets

Under Alternative 2 (Preferred Alternative), H7-1 sugar beets and progeny derived from them would no longer be regulated articles under the regulations at 7 CFR part 340. APHIS Biotechnology Regulatory Service (BRS) permits or notifications would no longer be required for introductions of sugar beets derived from the H7-1 event. Under this alternative, growers could freely move and plant H7-1 sugar beet seed and stecklings and any harvested seeds and roots without further oversight from APHIS. Under Alternative 2, in the short term, H7-1 sugar beets would be expected to be adopted at 2010 levels where it represented 95 percent of the sugar beet crop. Although the rate of adoption of H7-1 sugar beets is very high, it can still increase as varieties continue to be developed for specialized areas or circumstances. For example, California, which represents 2 percent of the sugar beet production area, uses different varieties than are grown in the more northern States. Varieties suitable for California that contain the H7-1 trait are being developed and are undergoing variety testing. Similarly, certain growers have special needs for disease resistance and H7-1 is still being bred into these varieties. This EIS expects that H7-1 sugar beets will eventually be developed for California and other areas of the United States such that adoption would approach 100 percent. APHIS expects that growers will continue to be subject to contract restrictions imposed by Monsanto's technology use agreement and the grower cooperatives that necessitate certain stewardship requirements because all commercial sugar beets are produced under contracts with the grower-owned cooperatives.

D. Alternative 3 – Extend Partial Deregulation of H7-1 Sugar Beets for Root Crop and Continue Permitting of Seed Crop

In response to a request for partial deregulation during the interim period for the preparation of this EIS, APHIS has partially deregulated the H7-1 sugar beet root crop until December 31, 2012. In accordance with7 CFR part 340, the seed crop has continued to be regulated under permits for environmental release while movements could be made under either permit or notification. The partial deregulation of the root crop was subject to conditions proposed by APHIS to the Court in the lawsuit challenging APHIS' determination of nonregulated status of H7-1 sugar beets (see Litigation Summary in chapter 1). Specifically, the conditions required for cultivating and handling H7-1 sugar beet root crop under the deregulation in part with conditions was articulated in that deregulation in part decision; implemented by seed companies, grower cooperatives and growers; and enforced through seed companies and grower cooperatives, respectively, under the direct oversight of APHIS. The regulatory mechanism for imposing such conditions under the partial deregulation was carried out through APHIS administered compliance agreements similar to APHIS' oversight of permits. Monsanto also identified that they will, for education and emphasis, place all of the APHIS-imposed conditions in its Technology Use Guide (TUG), which is implemented through Monsanto Technology Stewardship Agreements (grower agreements), to reinforce the measures imposed by APHIS as conditions of the partial deregulation.

Under Alternative 3, APHIS would extend the partial deregulation of the root crop indefinitely. The root crop could be used for commercial production, processing, and sale of sugar. Seed production activities such as breeding and production of commercial seed for the planting of the root crop would be allowed. Seed production activities would continue to be regulated under permits in accordance with 7 CFR part 340. However, pursuant to and in compliance with 7 CFR § 340.6, APHIS would partially deregulate H7-1 root production activities as long as certain specific mandatory conditions are complied with. If commercial root production activities are conducted under these mandatory conditions, they would no longer be subject to the procedural and substantive requirements of 7 CFR part 340. If, however, commercial root production activities are not conducted pursuant to these mandatory conditions, the APHIS Administrator has the regulatory authority and discretion to return such root production activities to regulation under 7 CFR part 340.

The mandatory conditions pertaining to the root production activities would be imposed and enforced pursuant to written APHIS compliance agreements or other authorization instrument authorized under the Plant Protection Act (PPA). Similar to a permit, the compliance agreements would be used to authorize the movement and release into the environment of H7-1 root crop and would impose certain mandatory conditions on the movement and environmental release of the H7-1 sugar beet root crop and root production activities. These legally binding and enforceable compliance agreements would specify the mandatory conditions for partial deregulation of the root production activities and would formalize and impose the mandatory conditions under which the root crop and root production activities would be considered partially deregulated; i.e., no longer subject to the procedural and substantive requirements of the 7 CFR part 340 regulation. APHIS would employ these required compliance agreements to authorize movement and release of H7-1 sugar beets and to impose and enforce the mandatory conditions on the import, movement, or environmental release of the root crop and root production activities and the compliance agreements would be a formal, written, and signed agreement between APHIS and a person who wants to import, move, and/or do an environmental release in conjunction with the H7-1 sugar beet root crop production activities (note that movement and the environmental release includes the entire production cycle of H7-1 sugar beet root crop – referred to collectively as all the "root production activities"; and the terms person, import, or move have the meanings as they are so defined in the PPA, as amended).

Alternative 3 would lead to lower H7-1 sugar beet adoption rates than Alternative 2 because the sugar beet root crop would not be permitted in California, which currently represents 2 percent of the acreage and 3 percent of U.S. sugar beet production. Adoption under Alternative 3 may be further diminished compared to Alternative 2 because Alternative 3 would impose additional regulatory burdens on growers, seed developers, and sugar beet processors. Alternative 3 requires compliance with mandatory conditions, reporting requirements, inspections, and audits. It is possible that some growers will elect not to grow H7-1 sugar beets due to the increased costs and time required to meet the regulatory burden. Depending on regional production costs, the additional expense may make H7-1 sugar beets less attractive to grow than conventional sugar beets.

1. Seed Production Activities- APHIS Permits and Notifications

The environmental release (planting), interstate movement, and importation of H7-1 sugar beets associated with seed production activities would be authorized under APHIS permits in accordance with conditions imposed by APHIS. APHIS would authorize the environmental release and movement of H7-1 sugar beet seeds and stecklings under APHIS permits and notifications in accordance with 7 CFR part 340. APHIS would impose conditions (described in II.D.1.h) consistent with conditions proposed to the Court and required for partial deregulation.

a. Permit Program

APHIS' permitting and notification process for the environmental release and movement of H7-1 sugar beets associated with seed production activities would be carried out in accordance with 7 CFR part 340. As specified in 7 CFR § 340.4, applicants must request permits for a field release (planting) in advance of the proposed planting date. Required data for the permit would include the responsible person, description of the regulated article and differences between it and the nonmodified parental crop, locations and distribution of the regulated article, size of the field release site(s), confinement procedures and safeguards employed, and methods to dispose of residues or reproductive materials. For movement of sugar beet seeds or stecklings, the quantity of the regulated H7-1 article would be identified in the applications. APHIS would provide States and Tribes, where the release is planned as appropriate, copies of its review of permit applications. APHIS would individually review each application. Specific permit conditions assigned by APHIS to each permit would be designed to prevent the escape, dissemination, and persistence of the regulated article and greatly limit the risk of any potential for inappropriately introducing or disseminating H7-1 sugar beets into the environment.

Importation or interstate movement of H7-1 sugar beet seed or stecklings would occur under an APHIS permit or acknowledged notification. H7-1 sugar beet seed or stecklings could be imported or moved interstate under notifications acknowledged by APHIS BRS as long as they meet the requirements found in §340.3 "Notification for the introduction of certain regulated articles." These include §340.3(c)(1) "Performance standards for introductions under the notification procedure," which require shipment in such a way that the viable plant material is unlikely to be disseminated while in transit and must be maintained at the destination facility in such a way that there is no release into the environment. Permits for importation and interstate movement would meet the requirements identified in 7 CFR §§ 340.4, 340.7, and 340.8, including specific permit conditions assigned by APHIS that would prevent inadvertent release of H7-1 sugar beets into the environment.

APHIS maintains a Web site, http://www.aphis.usda.gov/biotechnology/status.shtml, which automatically updates information about the status of a permit application on the next weekday morning after such information is entered into the system. Information about APHIS' receipt of a permit can be obtained by anyone accessing the APHIS Web site and searching for information about the status of a permit. APHIS would use this Web site to inform the public in a timely manner on the status of all permit applications for H7-1 sugar beets.

b. Scope

The Willamette Valley is the principal area where sugar beet seeds are grown and where Swiss chard and table beet seeds are also grown in proximity. However, there are other areas where Swiss chard and table beet seed are grown where no sugar beet seed is presently produced. Under Alternative 3, one of the mandatory conditions would be the creation of zones outside the Willamette Valley where the growth of H7-1 sugar beets is prohibited in order to eliminate the potential for gene flow from H7-1 sugar beets to non-GE Swiss chard and table beet production. In evaluating where these H7-1-free zones should be, APHIS considered where most of the seed production for Swiss chard and table beet takes place. APHIS identified California and western Washington as two areas where major production of Swiss chard and table beet seed occurs but where no sugar beet seed is produced. The H7-1 sugar beet-free zones would create mandatory isolation conditions far in excess of what has been scientifically determined to be adequate.

Permits with specific permit conditions would be issued for each of the following sugar beet production systems in any State except California and western Washington: nonflowering steckling production and seed production from flowering stecklings or directly from seed. The environmental release of H7-1 sugar beets would be limited to sites that have been in agricultural production for a minimum of 3 years. In addition, importation and interstate movement of seed and steckling shipments within and into the United States would require a notification acknowledged by APHIS. For each type of sugar beet production system for which APHIS receives an application, APHIS would issue a permit to any organization, association, corporation, institution, or any other entity that is in the business of growing and/or producing H7-1 sugar beets. This includes, but is not limited to seed companies producing H7-1-derived sugar beet seed. These entities then would allow farmers/transport drivers to plant and/or move H7-1 sugar beets under their APHIS issued permit or acknowledged notification.

APHIS has knowledge of five seed companies (American Crystal Sugar Company, Betaseed, Inc., Holly Hybrids, SES Vanderhave Sugar Beet Seeds, and Syngenta Seeds, Inc.) that produce H7-1 sugar beet seed, either directly or through a seed production cooperative (West Coast Beet Seed, WCBS). APHIS could issue permits to any of these five seed companies for steckling and direct seed production activities upon receipt and review of a completed permit application. All growers and the locations of their H7-1 sugar beets would be identified in the permits issued to the seed company.

c. Chronology of Permitting

Upon receipt of a complete permit application and after a thorough evaluation and review, APHIS would make a decision on whether or not to authorize the planting of flowering stecklings in seed production fields in late winter/early spring; the planting of seeds for direct seeding (flowering) for seed production in seed production fields in late summer/early fall; and the planting of seeds for nonflowering stecklings in nursery fields in late summer/early fall. Exact planting dates would vary dependent upon geographic location and local conditions. Subsequent seasons would follow a similar permitting scheme for the duration of the interim action.

d. Enforcing Permit Conditions

An applicant's compliance with APHIS permit conditions would be carried out using the following approaches.

(1) Seed Production

The following permit conditions would apply to seed production:

(1) H7-1 beet seed producers (permit holders) would assign a responsible person pursuant to 7 CFR part 340 to oversee the permit for beet seed production; this individual would oversee the performance of the sugar beet seed growers under the permits. The responsible person, likely an agronomist, would oversee the standard procedures of seed production and would monitor and assess compliance with the conditions assigned by the APHIS permit. Total acreage for all seed production permits is estimated to cover approximately 3,000–5,000 acres.

(2) APHIS would directly inspect the seed production fields to ensure compliance with all mandatory permit conditions and such inspection(s) will be completed prior to any possible pollen shed. APHIS would use the standard inspection process that it uses for inspecting permits under 7 CFR part 340.

(2) Import and Movement under Notification

Site visits by APHIS inspectors would also involve monitoring and assessing compliance with regulations for seed and steckling movement, such as secure storage sites, allowable containers, and vehicle containment devices when used in the movements.

e. **Uniformity of Assigned Conditions**

All mandatory permit conditions identified under this alternative would be required and applicable to all permit applications that APHIS may receive for H7-1 sugar beets associated with seed production activities. Details of the respective assigned permit conditions for each of the specific production systems (nonflowering steckling production, seed production from flowering stecklings, or directly from seed) are described below.

f. Evaluation of Permit Application for Consistency with the EIS

Upon receipt of a complete permit application or notification, and prior to issuing the permit or acknowledging the notification, APHIS would evaluate and make a determination about whether the permit application or notification corresponds with all of the required conditions and provisions as described in the EIS to mitigate a plant pest risk. In addition, APHIS would review the applicant's Standards of Practice (SP) for adhering to the requirements set forth in 7 CFR part 340. If APHIS determines that approving the permit is not consistent with any mitigations deemed necessary in the EIS, APHIS would deny the permit.

g. Information for Non-GE *Beta* Seed Producers Regarding Male Fertile H7-1 Seed Production Locations

Under the requirements of Alternative 3, APHIS would have a record of the location of each field release, including an address, global positioning system (GPS) coordinates, and a diagram of the site. A similar requirement was imposed as an interim measure during the preparation of the court ordered EIS for Roundup Ready® alfalfa. The Privacy Act of 1974 5 USC 552a states that "No agency shall disclose any record which is contained in a system of records by any means of communication to any person, or to another agency, except pursuant to a written request by, or with the prior consent of, the individual to whom the record pertains." As it is against the law to disclose or publish any private information that identifies an individual or business such as names and addresses including GPS coordinates without the written consent of those individuals, APHIS cannot provide exact information on the locations of specific fields. To provide information on the whereabouts of flowering sugar beets that produce pollen containing the H7-1 trait while still protecting the privacy rights of individuals cultivating flowering H7-1 sugar beets, APHIS would set up a toll-free number that growers of non-GE *Beta* seed crops may use to request from APHIS the approximate distances from the nearest male fertile H7-1 sugar beet plantings to their non-GE *Beta* seed crops. Upon calling this number, the caller would certify to APHIS that the caller is a grower of non-GE *Beta* seed crops or intends to grow non-GE *Beta* seed crops. APHIS would provide the approximate distance from the location of the nearest male fertile H7-1 sugar beet planting to the caller's location of a non-GE *Beta* seed crop.

h. Mandatory Permit Conditions Imposed on Seed Production

Under this alternative, the following mandatory permit conditions, which are additional conditions that APHIS would impose beyond those required under 7 CFR § 340.4, would be imposed on plantings of H7-1 sugar beets intended for seed production activities via permit conditions where the seed producer (permit holders) would acknowledge and adhere to these mandatory conditions:

(1) Planting of H7-1 sugar beets is not allowed in the State of California and the following counties in Washington State: Clallam, Clark, Cowlitz, Grays Harbor, Island, Jefferson, King, Kitsap, Lewis, Mason, Pacific, Pierce, San Juan, Skagit, Skamania, Snohomish, Thurston, Wahkiakum, and Whatcom.

(2) A 4-mile separation distance shall be maintained between male *fertile* H7-1 sugar beets and all other commercial Beta seed crops (i.e., table beets, Swiss chard) throughout the United States.

(3) An inventory of H7-1 male *fertile* planting locations shall be provided to APHIS within two weeks of planting.

(4) A 4-mile separation distance shall also be maintained between male *sterile* H7-1 sugar beets and all other commercial *Beta* seed crops throughout the United States. During flowering, fields shall be scouted for male *sterile* H7-1 plants that shed pollen and such plants shall be destroyed.

(5) A visual identification system, such as labeling, that accompanies the regulated material (e.g., basic seed, stock seed, stecklings, and commercial seed) throughout the production system, is required.

(6) A companion seed-lot based tracking and tracing system that is fully auditable shall be maintained. Records must be retained for five years.

(7) Other than non-GE *Beta* seed material used in the production of hybrid-seed, all H7-1 material shall be physically separated from nonregulated material to prevent commingling at all points throughout the production process.

(8) Planting, cultivation, and harvesting equipment shall be cleaned to prevent H7-1 stecklings or seed from being physically transferred out of production areas or mixed with non-GE *Beta* material by inadvertent means.

(9) All unused H7-1 stecklings shall be treated as regulated articles until devitalized and discarded.

(10) All H7-1 seed and steckling material shall be moved in contained transport systems to avoid inadvertent release into the environment. Vehicles or movement containers shall be thoroughly cleaned after transport and any regulated material recovered shall be devitalized.

(11) Sexually compatible varieties (e.g., Swiss chard/red beet) cannot be planted or produced in the same location (the same field) as H7-1 in the same growing year.

(12) Planting/cultivating/harvesting equipment that might be used in Swiss chard/red beet seed production shall not be used for regulated GE material in the same growing year.

(13) Measures to force same year sprouting of H7-1 seed left in production fields are required. Any seeds that sprout from such leftover seed shall be destroyed. Fields shall be monitored for three years and any volunteer beet plants shall be destroyed. If the same land is used for crop cultivation during the 3-year volunteer monitoring period, that crop shall be visually distinct from sugar beets or the fields left fallow.

(14) A management plan shall be submitted and followed. The management plan will set forth best practices for oversight of the movement, transportation, and confined field production of H7-1 seed. The management plan shall include, but not be limited to, required resources, training of relevant personnel, monitoring of growers, recordkeeping, and verifying compliance with the permit conditions. The applicant shall also provide the standard operating procedures (SOPs) that will be utilized to conduct the field trials and comply with the permit and permit conditions.

(15) No H7-1 seed shall be cleaned or processed in any processing facility that also cleans and processes table beet or Swiss chard seed.

(16) Interstate movement of H7-1 sugar beet stecklings and seed may only be authorized with a movement notification or permit consistent with regulations described in 7 CFR part 340.

(17) The applicant shall ensure that all site cooperators/growers have received the permit conditions and are trained in all the processes and procedures.

(18) The applicant shall maintain records of all the activities authorized under the permit to demonstrate adherence to 7 CFR part 340, the permit, and the permit conditions. These records shall be made available to APHIS BRS.

2. Root Production Activities – Not Considered a Regulated Article under 7 CFR part 340 with Compliance Agreement Conditions/ Restrictions

Pursuant to and in compliance with 7 CFR § 340.6, the H7-1 sugar beet root crop, when grown under specific mandatory conditions imposed by APHIS, would not be subject to the procedural and substantive requirements of 7 CFR part 340. The H7-1 sugar beet root crop and root production activities would be considered partially deregulated provided that there is compliance with mandatory conditions on the environmental release and movement of the H7-1 sugar beet root crop. These mandatory conditions would be enforced and required pursuant to APHIS compliance agreements authorized under the PPA, and would restrict the movement and environmental release of the H7-1 sugar beet root crop and root production activities. The compliance agreement system, outlined below, for root crop production and root production activities is comparable in rigor and enforceability to the permitting scheme. Like the requirements imposed on permittees, the compliance agreement system requires the responsible parties to give APHIS notice of the locations of the crops, to agree to APHIS oversight, and to be subject to suspension, revocation, and possibly civil and/or criminal penalties in the event of noncompliance.

a. Compliance Agreements

Under Alternative 3, any person who wants to import, move, and/or do an environmental release in conjunction with the H7-1 sugar beet root crop (root production activities) must first contact APHIS BRS at Regulatory Operations Programs in Riverdale, MD at (301) 734-5301 and enter into a compliance agreement in advance of the shipment (import/movement) and/or planting (environmental release) of H7-1 sugar beets (seeds and roots) associated with the H7-1 sugar beet root crop production activities. These required compliance agreements would be formal, written, and signed agreements between APHIS and a person who wants to import, move, and/or do an environmental release in conjunction with the H7-1 sugar beet root crop. For the environmental release of H7-1 sugar beets associated with the root crop production activities, any organization, association, corporation, institution or any other entity that is in the business of growing and/or producing H7-1 sugar beets (i.e., sugar beet cooperatives or processors) must first request and then enter into a signed compliance agreement in advance of the proposed planting date. APHIS expects that sugar beet cooperatives and processors (or other associations or entities that conduct H7-1 sugar beet root crop activities) would be the only entities that would enter into compliance agreements and will do so on behalf of their respective members/farmers. Required information for the compliance agreement would include: identifying the Responsible Entity, contact information, location of the environmental release(s), and total number of acres to be planted. For the movement and/or importation of H7-1 sugar beets associated with the root crop production activities, any organization, association, corporation, institution or any other entity that is in the business of growing and/or producing H7-1 sugar beets (i.e., seed company, sugar beet cooperatives or processors) must first request and then enter into a signed compliance agreement in advance of the movement and/or importation. Required information for the compliance agreement includes identifying the Responsible Entity, contact information, and point of origin and final destination(s). The industry is familiar with compliance agreements as they were used by APHIS to ensure compliance with mandatory conditions during the interim period during the preparation of the EIS. The compliance agreement includes a training component to ensure that all persons conducting root crop production activities under the compliance agreement receive a copy and are trained in the processes and procedures necessary to comply with its terms. A sample compliance agreement is included as appendix D.

b. Scope

Compliance agreements with mandatory conditions and restrictions can be issued for the environmental release (planting) of H7-1 sugar beets associated with root production activities in any State within the United States. Currently sugar beet root production is primarily located in ten States: Minnesota, North Dakota, Nebraska, Wyoming, Colorado, Michigan, Idaho, Montana, Oregon, and California. The environmental release of H7-1 sugar beets would be limited to sites that have been in agricultural production for a minimum of 3 years. APHIS can issue a compliance agreement to any organization, association, corporation, institution, or any other entity that is in the business of growing and/or producing H7-1 sugar beets. This includes, but is not limited to, seed companies producing H7-1-derived sugar beet seed, and sugar beet cooperatives or processors. These entities would then enter into a compliance agreement with APHIS on behalf of all its members/farmers. Because of the logistical impossibilities of dealing with the huge number of potential individuals involved in growing and transporting H7-1 sugar beets, APHIS does not envision issuing compliance agreements to individual farmers or transport drivers.

As mentioned previously, APHIS has knowledge of five seed companies (American Crystal Sugar Company, Betaseed, Inc., Holly Hybrids, SESVanderhave Sugar Beet Seeds, and Syngenta Seeds, Inc.) that produce

H7-1 sugar beet seed, either directly or through a seed production cooperative (West Coast Beet Seed (WCBS)), and nine sugar processors, including American Crystal Sugar Company, Michigan Sugar, Minn-Dak Farmers Cooperative, Sidney Sugars Incorporated, Snake River Sugar Company, Southern Minnesota Beet Sugar Cooperative, Spreckels Sugar Company, Western Sugar Cooperative, and Wyoming Sugar Company in the United States, with a tenth, Rogers Sugar Company, located in Alberta, Canada. One company, Spreckels Sugar, is in California and owned by Southern Minnesota Beet Sugar Cooperative. Under Alternative 3, no compliance agreements for root production activities would be granted in California where conventional sugar beets, but no H7-1 sugar beets, are currently grown, or in western Washington, where no sugar beet industry currently exists in this region.

c. Chronology of Compliance Agreements

Upon receipt of a request to enter into a signed compliance agreement in conjunction with the H7-1 sugar beet root crop and after a thorough evaluation and review, APHIS would make a decision on whether or not to authorize the planting of H7-1 sugar beet seed in root production fields in the spring. Exact planting dates would vary dependent upon geographic location and local conditions. The compliance agreement is valid from the date of issuance (i.e., the date signed by APHIS BRS) until revoked or superseded by APHIS–BRS to allow changes in conditions as deemed necessary.

d. Enforcing Compliance Agreements

The oversight of APHIS compliance agreements would be carried out using the following approaches:

- Prior to planting H7-1 sugar beets, any person who wants to do an environmental release in conjunction with the H7-1 sugar beet root crop shall have a signed compliance agreement in place that identifies the responsible party, contact information, location of the environmental release(s) (county/State), total number of acres to be planted, and applicable restrictions that will be followed to ensure confinement. The compliance agreement may be signed by the responsible entity or an authorized representative on behalf of the responsible entity and all persons engaging in root crop production activities.

- The responsible entity confirms its understanding of the requirements/conditions set forth in the agreement and confirms that the responsible entity and all persons conducting root crop production activities under this compliance agreement will comply with the requirements/conditions of the agreement.

- Prior to moving H7-1 sugar beets, any person who wants to import and/or move seed or roots in conjunction with the H7-1 sugar beet root crop shall have a signed compliance agreement in place that identifies the responsible entity, contact information, point of origin and final destination(s), and applicable restrictions that will be followed to ensure confinement.

- Within 28 days after planting H7-1 sugar beet root crops under the compliance agreement, the responsible entity shall provide APHIS a report that includes the names and addresses of all growers, the county and State where each release occurred, at least one GPS coordinate for the release site, the location of the GPS coordinate (e.g., the northwest corner of the field), confirmation that the release site has been in agricultural production for at least the past three years, the exact planting date(s) for each release site, and the actual acreage planted at each site. Each report shall include plantings occurring during the prior 28 days (to the extent such information is reasonably available at the time of the report) and information for plantings occurring in prior reporting periods for which information was not available at the time the prior report was submitted.

- The responsible entity through its authorized representative shall notify APHIS within 48 hours of any change in the information provided to APHIS BRS, either upon application for a compliance agreement or at anytime thereafter, regarding planting and/or movement/importation activities (e.g., changes/updates to planting locations, GPS coordinates, shipping addresses for seed and/or root movement).

- The responsible entity through its authorized representative shall notify APHIS verbally and in writing via email within 24 hours, after becoming aware of unauthorized releases and/or movements. In addition, the responsible entity through its authorized representative shall notify APHIS, verbally and in writing via email within 48 hours, after becoming aware of any instance of noncompliance with the conditions of the compliance agreement. In incidents involving unauthorized releases and/or noncompliance, growers shall give notice immediately to the responsible entity so that the responsible entity may notify APHIS. When contacting APHIS, the authorized representative shall describe the incident, the date it occurred, the location (including county and State and GPS coordinate(s) of release site), name and address of grower, and field personnel associated with the incident. The authorized representative shall also provide immediate or short-term corrective actions and, if necessary and available, long-term plans to return the situation to compliance and prevent similar incidents from occurring in the future. APHIS will review the information provided by the authorized representative and request additional information, if necessary, within 24 hours of the receipt of the notice. APHIS may require additional corrective actions if APHIS deems it necessary. The responsible entity and all persons engaged in root crop production activities in association with or on behalf of the responsible entity must cooperate with APHIS until the situation is resolved and the incident brought back to compliance. APHIS will record the incident and submit a response in writing, summarizing the incident and corrective measures, as per APHIS standard procedure in handling noncompliance incidents, to the authorized representative, no later than 10 days of the receipt of the notice.

- APHIS will conduct some direct inspections to ensure that persons importing, moving, and/or doing an environmental release (planting) in conjunction with the H7-1 sugar beet root crop comply with all conditions and restrictions identified in the compliance agreements.

- For the root crop production activities, APHIS will require third-party inspectors to conduct the majority of the inspections. APHIS will evaluate the third-party inspectors' credentials provided by the responsible entity through its authorized representative in the request for the compliance agreement. The credentials will be evaluated for information, such as prior experience with biotechnology inspections, general experience in conducting inspections, and overall experience/background in agriculture. After evaluating the inspectors' credentials, APHIS will notify the authorized representative which third-party inspectors it believes are qualified to conduct H7-1 sugar beet root crop inspections on behalf of the agency. The responsible entity will have 15 business days from the date of the notice to retain the services of the third-party inspector(s). The responsible entity may choose to retain the services of one or more of the APHIS approved inspectors. Upon retaining the services of the third-party inspector(s), the authorized representative shall supply the name(s) of the third-party inspector(s) to APHIS. APHIS officials will contact the third-party inspectors to schedule inspection training. (APHIS will provide an inspection form to be used by inspectors to capture inspection data.) The third-party inspectors will schedule and conduct inspections according to APHIS' instructions. APHIS will coordinate with a third-party inspector to randomly choose a statistically representative sample of fields, from those fields designated by APHIS to inspect, to conduct inspection for bolters. The third-party inspectors will submit inspection reports directly to APHIS and APHIS will work directly with the inspectors if the reports require additional information. A large number of the root production fields and facilities will be inspected by the third-party inspectors, sufficient to give statistically significant conclusions ($p = 0.05$) on overall compliance. If the compliance agreement only covers seed movements, no third-party inspectors are required. Total acreage for all root production is estimated to cover approximately 1–1.4 million acres.

- For the root crop production activities, APHIS will require third-party audits to review grower records. APHIS will evaluate the third-party auditors' credentials provided by the responsible entity through its authorized representative in the request for the compliance agreement. The credentials will be evaluated for information, such as prior experience with biotechnology inspections, general experience in conducting inspections, and overall experience/background in agriculture. After evaluating the auditors' credentials, APHIS will notify the authorized representative which third-party auditors it believes are qualified to conduct H7-1 sugar beet root crop audits on behalf of the agency. The responsible entity will have 15 business days, from the date of the notice, to retain the services of the third-party auditor(s). The responsible entity may choose to retain the services of one or more of the APHIS-approved auditors. Upon retaining the services of the third-party auditor(s), the authorized representative shall supply the name(s) of the third-party auditor(s) to APHIS. APHIS officials will contact the third-party auditors to schedule audit training. APHIS will provide an audit form to be used by auditors to capture audit information. The third-party auditors will schedule and conduct audits according to APHIS' instructions. APHIS will require third-party auditors to review shipping records and/or grower records and to submit auditing reports directly to APHIS for review. APHIS will work directly with the auditors if the reports require additional information.

- Activities conducted by growers to comply with compliance agreement conditions and restrictions may be either audited or inspected by APHIS or third-party auditors or both. APHIS will provide detailed inspection forms for the information to be supplied by processors/growers, and the subsequent records will be made available to APHIS for audit. Growers must keep records of these compliance activities and make them available to APHIS and/or third-party auditors upon request. APHIS will carefully examine a representative sample of these records to ensure compliance with all conditions and restrictions identified in the compliance agreement. The responsible entity shall ensure that all persons conducting root crop production activities under the compliance agreement provide access to all records required to be maintained under the compliance agreement and provide access, during regular business hours, to inspect planting locations, facilities, and transport vehicles, upon request by APHIS or its authorized representative(s).

- The responsible entity shall ensure that all persons conducting root crop production activities under the compliance agreement receive a copy of the compliance agreement and are trained in the processes and procedures necessary to comply with the terms of the compliance agreement. In addition, the responsible entity shall ensure that written documentation of the training is maintained and that all training records are maintained for the duration of the compliance agreement.

- For importation and interstate movement, APHIS inspections and/or third-party inspections/audits will be required to ensure that persons importing and/or moving H7-1 sugar beet seeds or roots in conjunction with the H7-1 sugar beet root crop comply with all conditions and restrictions identified in the compliance agreements. APHIS will carefully examine these records to ensure compliance with all conditions and restrictions identified in the compliance agreement.

- In the event of a finding of noncompliance or violation of the terms of a compliance agreement, APHIS may revise, suspend, revoke, or otherwise withdraw the compliance agreement and/or the partial deregulation of any and all root crop grown under the compliance agreement. APHIS may also, at its discretion, use the full range of PPA authorities to seek, as appropriate, criminal and/or civil penalties, and to take remedial measures including seizure, quarantine, and/or destruction of any H7-1 sugar beet root crop production that is found to be in violation of the conditions set forth in the compliance agreements.

e. Uniformity of Conditions and Restrictions

Conditions and restrictions identified in the compliance agreement would be required and applicable to all persons utilizing this partial deregulation authority. These mandatory conditions imposed and required pursuant to the partial, conditional deregulation of the root crop would be enforced and required pursuant to APHIS compliance agreements authorized under the PPA. Details of the specific conditions and restrictions are described below.

f. Evaluation of Compliance Agreement for Consistency with the EIS

Prior to issuing the compliance agreement, APHIS would evaluate and make a determination about whether the compliance agreement corresponds with all of the required conditions and provisions as described in the EIS and, if so decided, in any subsequent final decision. If APHIS determines that approving the compliance agreement is not consistent with any mitigations deemed necessary in the EIS, APHIS would not issue the compliance agreement.

g. Mandatory Conditions/Restrictions Imposed on Root Production Activities

Under Alternative 3, the following mandatory conditions and restrictions would be imposed on H7-1 sugar beets intended for root production via compliance agreements:

(1) Planting of H7-1 sugar beets is not allowed in the State of California, and the following counties in Washington State: Clallam, Clark, Cowlitz, Grays Harbor, Island, Jefferson, King, Kitsap, Lewis, Mason, Pacific, Pierce, San Juan, Skagit, Skamania, Snohomish, Thurston, Wahkiakum, and Whatcom.

(2) Root growers shall ensure that root crop fields are surveyed to identify and eliminate any bolters before they produce pollen or set seed. Fields shall be surveyed every 3–4 weeks beginning April 1. Root growers shall ensure that field personnel maintain records of their field observations and removal of bolters. Reports where bolters are not observed must be maintained as well. Root growers shall notify APHIS BRS within 48 hours after finding bolters, with the location and action taken by the field personnel. Root growers shall maintain all records of inspection and bolter removal and records must be made available to APHIS BRS and/or to authorized third-party inspectors upon request.

(3) Third-party inspectors procured by beet processors (usually a cooperative) shall randomly choose a statistically representative

sample of fields and conduct inspection for bolters. If bolters are identified, field personnel shall be notified immediately and those bolters must be removed. APHIS will provide an inspection form to be used to capture these data.

(4) Planting/cultivating/harvesting equipment that might be used in Swiss chard/red beet production shall not be used or shared for regulated GE material in the same growing year.

(5) Root crop fields shall be monitored for 3 years following harvest for volunteers and any volunteer plants must be destroyed. If the same land is used for crop cultivation during the volunteer monitoring period, that crop shall be visually distinct from sugar beets or the fields must be left fallow. Records of observations must be maintained and provided to APHIS BRS or third-party auditors upon request.

(6) All root crop growers and field personnel must receive all conditions and restrictions identified in the compliance agreements and must be trained in all processes and procedures necessary to comply with the terms of the agreement.

(7) Root growers shall maintain records of all the activities being carried out under the compliance agreements to demonstrate adherence to the mandatory conditions and restrictions. These records shall be made available to APHIS BRS and/or to authorized third-party inspectors/auditors upon request.

h. Mandatory Conditions/Restrictions Imposed on Importation and Interstate Movement

Under Alternative 3, the following mandatory conditions and restrictions would be imposed on the interstate movement and importation of H7-1 seeds and roots associated with root production activities via compliance agreements:

(1) The responsible party shall ensure that all personnel have received all conditions and restrictions identified in the compliance agreements and are trained in all the processes and procedures necessary to comply with the terms of the agreement.

(2) The responsible party shall maintain records of all the activities being carried out under the compliance agreements to demonstrate adherence to the mandatory conditions and restrictions. These records shall be made available to APHIS BRS and/or to authorized third-party inspectors/auditors upon request.

(3) During transport, chain of custody and records shall be maintained. Records shall be made available to APHIS BRS and/or to authorized third-party inspectors/auditors upon request.

(4) Trucks used for the movement of root crop from field to storage/processing shall be loaded in a manner to minimize loss of beets during transport or equipped with a retaining device.

(5) Sugar beet seeds shall be transported in a sealed plastic bag, envelope, or other suitable container (primary container) to prevent seed loss.

(6) The primary container for transporting seeds shall be placed inside a sealed secondary container that is independently capable of preventing spillage or loss of seed during transport.

(7) Each set of containers (primary and secondary) for transporting seeds shall then be enclosed in a sturdy outer shipping container constructed of corrugated fiberboard, corrugated cardboard, wood, or other material of equivalent strength. Each container shall clearly identify that the seed contents within shall only be used for the planting of sugar beet root crop.

(8) The shipping containers for transporting seeds shall be transported in enclosed trucks or trailers with closed sides.

E. Alternatives Considered but Eliminated from Further Consideration

APHIS assembled a comprehensive list of alternatives that might be considered for H7-1 sugar beets as part of the decision process for this EIS. The agency individually evaluated each alternative based on legality, environmental safety, efficacy, and practicality to identify which alternatives would be further considered during the decision process. Based on this evaluation, APHIS rejected a number of alternatives. In the interest of transparency, these alternatives are discussed briefly below along with the specific reasons for rejecting each.

- APHIS considered a No Action Alternative where no H7-1 would be allowed to be released into the environment or moved even under permitting or notification. APHIS considered but rejected this alternative because GE organisms may be released into the environment or moved subject to the regulations in 7 CFR part 340 under conditions specified by APHIS and designed to confine the regulated article. This alternative does not meet the purpose and need of the agency to authorize the safe introduction of GE organisms in accordance with 7 CFR §§ 340.3 and 340.4.

- APHIS considered an alternative where both the seed and root crop would be subject to partial deregulation using compliance agreements instead of regulating the seed crop under the permitting procedure. This alternative was rejected from further analysis because the conditions for seed production imposed under permitting would not differ from the conditions imposed using compliance agreements under a partial deregulation. Therefore, this alternative is not materially distinct from Alternative 3.

- APHIS considered an alternative where root production would no longer be under regulation but environmental releases of H7-1 sugar beets associated with seed production would be prohibited. Under this alternative, H7-1 seed could be imported from outside the United States but that would be the only source for such seed and most likely foreign H7-1 seed would not provide an adequate supply for root production in the United States. APHIS considered but rejected this alternative because GE organisms may be released into the environment or moved subject to the regulations in 7 CFR part 340 under conditions specified by APHIS and designed to confine the regulated article. This alternative does not meet the purpose and need of the agency to authorize the safe introduction of GE organisms in accordance with 7 CFR §§ 340.3 and 340.4.

- APHIS considered an alternative where H7-1 sugar beet seed production is no longer under regulation but all importation, interstate movements, and environmental releases of H7-1 sugar beets associated with root production activities would continue to be regulated under 7 CFR part 340. APHIS determined that this alternative is not appropriate because a determination of nonregulated status of the seed crop would mean that APHIS determined that H7-1 is unlikely to pose a plant pest risk, and as the seed crop includes the entire lifecycle of the root crop, it is not possible for the root crop to pose a plant pest risk if the seed crop does not. So if APHIS determined that the sugar beet seed production did not pose a plant pest risk and would therefore no longer be under regulation, then APHIS would have to likewise conclude that the root production did not pose a plant pest risk and would also no longer be under regulation.

F. Comparison of Impacts by Alternative Matrix

CEQ NEPA regulations (40 CFR § 1502.14) state that agencies should compare the impacts of the alternatives proposed to provide a clear basis for decision making. Table 2–1 provides a comparison of the impacts under each alternative.

Table 2- 1: Alternatives

Alternative 1: No Action (Regulated by Permit/Notification)	Alternative 2: Full Deregulation	Alternative 3: Extend Partial Deregulation
Potential Impacts on Production and Management of Beet Crops		
H7-1 Sugar Beets Adoption		
In the short term, adoption of H7-1 sugar beets would be limited to research done under permit. Acreage would be expected to be less than the amount historically done under research and development permits (<1,000 acres) and each plot location would be approved by APHIS. In the long term, H7-1 sugar beet acreage would be expected to approach zero. Conventional seed varieties available to farmers in the short term (~1–10 years) would likely not contain the most desirable trait combinations for each region due to the breeding lag. As the State of California has not yet adopted H7-1 varieties, farmers in that state are not expected to have a shortage of conventional sugar beet seeds. Patent expiration would have no impact on how H7-1 sugar beet seed plots would be handled	In the short term, adoption of H7-1 sugar beet for seed and root production would be 95%. In the long term, adoption is expected to approach 100 %. Location of H7-1 sugar beet seed production would not be restricted but is not expected to substantially move from the current seed production areas due to climatic conditions and limitations on land availability imposed by pinning mechanisms aimed at establishing priorities for the use of land. Similarly, location of root production areas are not expected to change from the current root production areas due to the need for proximity to sugar processing plants. H7-1 sugar beets would be expected to be adopted by California root farmers, and use of H7-1 in the other regions would continue. In the next 10 to 15 years while H7-1 sugar beets are under patent, APHIS assumes that growers would continue to be subject to contract restrictions imposed by Monsanto's Technology Stewardship Agreement (MTSA). In the long term, APHIS assumes that there might be no binding enforcement mechanism to ensure that farmers follow the Technology Use Guide (TUG), which does not allow seed saving and requires bolters to be removed. However, because the Grower Cooperatives would maintain control of which sugar beet varieties are allowed to be planted and all sugar beets are produced from hybrids anyway, APHIS concludes that patent expiration would not lead to seed saving and stewardship practices would still be followed .	In the short term, H7-1 sugar beet adoption in the Great Lakes, Midwest, Great Plains, and Northwest would be 95%. In the long term, sugar beet root production would be expected to approach 100 % outside of California. H7-1 sugar beets would not be grown in California. Alternative 3 also excludes production in western Washington, although there is currently no production in this area, nor would any be expected. Under Alternative 3, patent expiration would have no impact on how H7-1 sugar beet seed fields would be handled. Mandatory measures imposed on H7-1 sugar beet production would still be required in compliance agreements and permits..

Table 2–1. (continued)

Alternative 1: No Action (Regulated by Permit/Notification)	Alternative 2: Full Deregulation	Alternative 3: Extend Partial Deregulation
Control of Weeds and Volunteers		
No changes to weed control in sugar beet seed production have occurred as a result of H7-1 sugar beets, so no impact would be expected in seed production by a return to conventional varieties. For the root crop, weed control measures would likely return to similar practices used prior to the adoption of H7-1 sugar beet. Overall, the northern regions would increase the use of non-glyphosate herbicides and decrease the use of glyphosate. In the Great Lakes, there would be a decrease in stale seed bed and an increase in hand hoeing and in-crop mechanical cultivation compared to current practice. In the Midwest, rotary hoeing, hand hoeing, and mechanical cultivation would return to levels used prior to the adoption of H7-1 sugar beets. In the Northwest and Great Plains it is likely that a return to in-crop mechanical cultivation and hand hoeing, and a reverse in the trend of increasing strip tillage for seed bed preparation, would occur.	Alternative 2 would not impact weed control measures in seed production because glyphosate is rarely used on the H7-1 sugar beet seed crop All regions would continue the predominant use of glyphosate and sparse use of other herbicides. In the Midwest, the use of H7-1 sugar beets would not be expected to alter tillage practices. An increase in conservation tillage in root fields in the Great Lakes, Northwest, and Great Plains would be expected. If adopted in the Imperial Valley, there would be shifts from non glyphosate herbicides to glyphosate and a reduction in hand hoeing and mechanical cultivation. Conventional tillage would be expected to remain unchanged. The use of cover crops and planting into crop residue is expected to become more common (except in California). H7-1 sugar beet volunteers from the root crop are not a concern because the crop rarely if ever produces seed and leftover roots do not survive the winters of the north or the summers of the south.	Alternative 3 would impact weed control measures in the same way as described for Alternative 2, except in the Imperial Valley. Under Alternative 3, H7-1 sugar beets would not be permitted in California or western Washington, so weed control measures in those locations would remain as they are today. Alternative 3 requires surveying and removal of bolters from root production fields planted in H7-1-derived varieties to ensure that no seeds are produced from H7-1 sugar beet root crops. Volunteer sugar beet plants are rarely a problem in sugar beet root production fields.

Table 2–1. (continued)

Alternative 1: No Action (Regulated by Permit/Notification)	**Alternative 2: Full Deregulation**	**Alternative 3: Extend Partial Deregulation**
	Swiss Chard and Table Beet (Vegetable Beets)	
There would be little to no potential for unintended gene flow from H7-1 sugar beet seed production into vegetable beet seed production. Isolation distances between vegetable beet seed production and other *Beta* ssp. would be expected to revert to distances used before the introduction of H7-1 sugar beet. There would be no impact on vegetable beet vegetable producers.	There would be very low potential for unintended gene flow from H7-1 sugar beet seed production into vegetable seed production. The only counties that have potential impact of gene flow are those in which both crops are grown. For commercial seed operations, this currently occurs only in seven counties in Oregon and no where else in the U.S. To date, no gene flow from H7-1 sugar beet seed production into vegetable beet seed production has been detected. Vegetable beet seed producers perceived to be "too close" to H7-1 sugar beet seed producers might be required by customers to test for Low-Level Presence (LLP) of the H7-1 trait. LLP of the H7-1 trait could affect sales to their normal markets and the value of their product. Even if no LLP of the H7-1 trait occurs, the perception that it could occur may disadvantage vegetable beet seed producers in the Willamette Valley. No impacts on vegetable beet vegetable producers would be expected because an ample supply of seeds with no LLP of the H7-1 trait is expected to be available and no gene flow can occur to the vegetable crop.	There would be very low potential for unintended gene flow from H7-1 sugar beet seed production into vegetable seed production in Oregon. Vegetable beet seed producers in California and western Washington would be isolated from H7-1 sugar beet seed production in excess of the isolation distances used in the Willamette Valley. Vegetable beet seed producers in Willamette Valley could be required by their GE-sensitive customers to test their seed lots for LLP despite the likelihood of detection being low. LLP of the H7-1 trait could affect sales to their normal markets and the value of their product. Even if no LLP of the H7-1 trait occurs, the perception that it could occur may disadvantage vegetable beet seed producers in the Willamette Valley. There would be no impacts on vegetable beet vegetable producers because an ample supply of seeds with no LLP of the H7-1 trait is expected to be available and no gene flow can occur to the vegetable crop. .
	Fodder Beets	
There would be no impact. There is currently no domestic fodder beet. Even in the long term, there would be no impact because there would be no H7-1 sugar beet.	There is currently no fodder beet commercial seed and little if any root production. In the long term, no seed production is expected but there is potential for root production for ethanol. No impacts are expected under Alternative 2. Fodder beets are harvested as a vegetable crop so potential for gene flow is not likely.	No change from Alternative 2.

Table 2–1. (continued)

Alternative 1: **No Action (Regulated by Permit/Notification)**	**Alternative 2:** **Full Deregulation**	**Alternative 3:** **Extend Partial Deregulation**
Gene Flow and *Beta* Species		
Under Alternative 1, isolation distances for planting *Beta* seed would follow the WVSSA guidelines in the Willamette Valley, which is 1 mile from hybrids of the same color and group, 2 miles between hybrids and open pollinated plants of the same color and group, 3 miles between unlike hybrids, and 4 miles between unlike open pollinated plants and hybrids. As no full or partial deregulation of H7-1 sugar beet seed production would take place, isolation guidelines between GE sugar beet and other *Beta* species would be moot in the short term. No gene flow is expected between H7-1 sugar beet and other *Beta* species because H7-1 sugar beet seed production is expected to cease.	Under Alternative 2, isolation distances for *Beta* planting seed would follow the WVSSA guidelines in the Willamette Valley, which is 1 mile from hybrids of the same color and group, 2 miles between hybrids and open pollinated plants of the same color and group, 3 miles between unlike hybrids, and 4 miles between unlike open pollinated plants. All GMO plants would need to be at least 3 miles from any other *Beta* species. These conditions are expected to result in non-detectable levels of gene flow (<1 seed in 10,000) between H7-1 sugar beets and other *Beta* species in Oregon, the only state where *Beta* seed crops are grown in proximity. No gene flow from the root crop to the seed crop is expected because the root crop rarely flowers and is not grown near a seed crop, Root bolters in California could potentially hybridize with *B. macrocarpa* but desynchronized flowering time, partial hybrid sterility barrier, and self fertility of *B. macrocarpa* all reduce the potential to negligible levels. Wild *B. vulgaris* occurs in California but has not been confirmed in the Imperial Valley where sugar beet production occurs. Best management practices prevent sharing of harvesting, cleaning, and storage equipment between sugar beets and other *Beta* crops. Therefore seed admixture between *Beta* crops is not expected.	Under Alternative 3, isolation distances for H7-1 sugar beet seed from other *Beta* seed crops would be 4 miles in all cases including male sterile H7-1 sugar beet crops and hybrid crops These conditions are expected to result in non-detectable levels of gene flow (<1 seed in 10,000) between H7-1 sugar beets and other *Beta* species. H7-1 sugar beet planting would be prohibited in California and western Washington. This planting restriction would ensure that certain areas of vegetable beet seed production remain isolated from H7-1 sugar beet seed production by geographic barriers and isolation distances that vastly exceed those used in the Willamette Valley. Because H7-1 sugar beet would not be allowed in California, it could not cross pollinate with wild beets. Best management practices to minimize seed admixture between *Beta* seed crops would be mandatory.

Table 2–1. (continued)

Alternative 1: No Action (Regulated by Permit/Notification)	Alternative 2: Full Deregulation	Alternative 3: Extend Partial Deregulation
Potential Impacts on Biological Resources		
Animals		
There would be no impacts on animals from exposure to the H7-1 gene and its product. Under Alternative 1, the expected increase in non glyphosate herbicides in sugar beet production increases the risk of animal exposure to herbicides more toxic than glyphosate. Potential toxic effects from these herbicides on animals include impaired growth, development, reproduction, and long-term survival. Cycloate, pyrazon, glyphosate (single application high pre emergent usage), and quizalofop-p-ethyl could be used at rates that pose concern for chronic effects to individual mammals. Birds and reptiles could be subject to chronic effects from high application rates of sethoxydim and trifluralin. Trifluralin is very toxic to fish and aquatic-phase amphibians though it is not expected to be used at levels that raise unreasonable concerns. Herbicide use could cause indirect effects on aquatic organisms by adversely impacting habitat by drift and runoff. As spraying is more frequent and more likely to be applied aerially under Alternative 1 than Alternatives 2 and 3, the impacts on habitat from drift are expected to be greatest under Alternative 1. Potential impacts on aquatic species from tillage include impaired habitat conditions from soil erosion, which can result in harm to individual species, including individual mortality.	There would be no impacts on animals from exposure to the H7-1 gene and its product. Under Alternative 2, there would continue to be increased use of glyphosate in sugar beet production. Glyphosate is expected to be used primarily for post emergent applications at about three fold lower rates than the maximum allowed rate for pre-emergence. At this lower rate, there is no concern for chronic effects to mammals as noted under Alternative 1. Glyphosate is practically nontoxic to mammals and terrestrial invertebrates, practically nontoxic to slightly toxic to birds and fish, and slightly toxic to aquatic invertebrates. The potential toxic effects include impaired growth or development. Glyphosate is not expected to pose an acute or chronic risk to birds, mammals, terrestrial and aquatic invertebrates, and fish when used within label limits. Potential impacts on aquatic species from tillage would be less than Alternative 1 due an expected increase in conservation tillage practices such as reduced and strip tillage. Glyphosate could have indirect effects on aquatic organisms through habitat destruction as a result of drift and runoff, however these effects are expected to be less than for Alternative 1 because sprayings are expected to be less frequent and are less likely to be applied aerially.	There would be no impacts on animals from exposure to the H7-1 gene and its product. In California where conventional sugar beets are grown, potential impacts from conventional herbicide use and conventional tillage would be similar to Alternative 1. Depending on the herbicide used, individual adverse impacts on species could occur. Conventional tillage could result in harm to individual species, including individual mortality. In all other areas where H7-1 sugar beets are grown, potential impacts from herbicide use and conservation tillage would be similar to Alternative 2. Glyphosate is not expected to pose an acute or chronic risk to birds, mammals, terrestrial and aquatic invertebrates, and fish when used within label limits. Conservation tillage would minimize impacts on aquatic species. Western Washington, where H7-1 would also not be allowed, would not be impacted.

Table 2–1. (continued)

Alternative 1: **No Action (Regulated by Permit/Notification)**	**Alternative 2:** **Full Deregulation**	**Alternative 3:** **Extend Partial Deregulation**
	Micro-organisms	
There would be no impacts on micro-organisms from exposure to the H7-1 gene and its product. Potential adverse or beneficial impacts on microbial communities might occur from herbicide use, depending on the herbicide used. Several of the non-glyphosate herbicides are considered more toxic to micro-organisms than glyphosate. Conventional tillage practices associated with conventional sugar beet production and removal of crop residues could result in decreased microbial biomass and activity.	There would be no impacts on micro-organisms from exposure to the H7-1 gene and its product. Adverse impacts on microbial communities from glyphosate use might occur, but no acute or chronic risk is expected if label directions are followed. Conservation tillage practices expected to increase with H7-1 sugar beet production would lessen impacts on micro-organisms relative to Alternative 1.	There would be no impacts on micro-organisms from exposure to the H7-1 gene and its product. In California where conventional sugar beets are grown, potential impacts from herbicide use and conventional tillage would be similar to Alternative 1. Depending on the herbicide used, adverse or beneficial impacts on micro-organisms could occur. Conventional tillage could result in decreased microbial biomass and activity. In all other areas where H7-1 sugar beets are grown, potential impacts from herbicide use and conservation tillage would be similar to Alternative 2. No acute or chronic risk to micro-organisms is expected from glyphosate use if label directions are followed. Conservation tillage practices expected to increase with H7-1 sugar beet production would lessen impacts on micro-organisms relative to Alternative 1. Western Washington, where H7-1 would also not be allowed, would not be impacted.

Table 2–1. (continued)

Alternative 1: **No Action (Regulated by Permit/Notification)**	**Alternative 2:** **Full Deregulation**	**Alternative 3:** **Extend Partial Deregulation**
	Resistant Weeds (Target Plants)	
Biotypes resistant to non glyphosate herbicides are expected to resurge in the four regions that currently use H7-1 (Great Lakes, Great Plains, Midwest, Northwest) following the return to the use of non-glyphosate herbicides. In Imperial Valley, where H7-1 sugar beets have not yet been adopted, the selection of biotypes resistant to non glyphosate weeds would continue. Selection of biotypes resistant to non glyphosate weeds would be accelerated relative to Alternative 2 because one less mechanism of action would be available for post emergent herbicide use.	Under Alternative 2, selection of herbicide resistant biotypes is expected to be delayed by the use of an additional mode of action for weed control. H7-1 sugar beet root production would be expected to contribute to the spread and persistence of glyphosate resistant weeds that disperse from rotation crops or other crop types. The impact would be low due to the small acreage of H7-1 relative to other Roundup Ready® crops. Rotation to other crop types would be expected to reduce persistence through altered tillage and herbicide practices. In states that utilize rotations with multiple Roundup Ready® crops, impacts are expected to be higher than in states where sugar beets are the only Roundup Ready® crop. Incremental selection of glyphosate resistant biotypes would not be expected as a result of H7-1 sugar beet seed because post emergent use of glyphosate is rarely used in H7-1 seed production. Selection of new glyphosate resistant biotypes would not be expected as a result of H7-1 sugar beet root production. Resistant weeds most often are selected under repeated use of a single herbicide in a single continuous cropping system whereas sugar beets are nearly always grown in a three to 4-year crop rotation.	Impacts would be as in Alternative 2 for the regions currently producing H7-1 sugar beets. No impacts would be expected in western Washington because no sugar beets are grown there. In Imperial Valley, selection of biotypes resistant to non glyphosate herbicides would be accelerated relative to Alternative 2.

Table 2–1. (continued)

Alternative 1: **No Action (Regulated by Permit/Notification)**	**Alternative 2:** **Full Deregulation**	**Alternative 3:** **Extend Partial Deregulation**
	Nontarget Plants	
The non-glyphosate herbicides used on conventional sugar beets target specific groups of plants (monocots or dicots). Incidental exposure to these herbicides could result in impaired plant growth or death. Non-target plants adjacent to sugar beet fields would experience the greatest risk of effects from spray drift under Alternative 1.Drift is expected to be greater under Alternative 1 comparred to Alternative 2 and 3 because sprayings and the use of aerial applications are expected to be more frequent than under the other Alternatives. No unreasonable effects on non target plants are expected.	Glyphosate targets all types of plants (monocots and dicots). Incidental exposure to glyphosate could result in impaired plant growth or death. Non-target terrestrial plants (monocots and dicots) adjacent to sugar beet fields would experience the greatest risk of effects from spray drift under Alternative 2. Because herbicide applications are less frequently applied to H7-1 than to conventional sugar beets and the use of aerial spraying is less frequent with glyphosate compared to non glyphosate herbicides, less drift is expected under Alternative2 compared to Alternative 1. No unreasonable effects on non target plants are expected.	In California where conventional sugar beets are grown, effects would be similar to Alternative 1. In other areas,effects would be similar to Alternative 2. .
	Sugar Beet Weediness	
No impact –Sugar beets are not considered weedy and feral populations of sugar beet have not been identified.	No impact – H7-1 sugar beets have no altered traits associated with weediness. Sugar beets are not considered weedy and feral populations of sugar beet have not been identified.	No impact – H7-1 sugar beets have no altered traits associated with weediness. Sugar beets are not considered weedy and feral populations of sugar beet have not been identified.

Alternative 1: No Action (Regulated by Permit/Notification)	Alternative 2: Full Deregulation	Alternative 3: Extend Partial Deregulation
Potential Impacts on Socioeconomics		
U.S. Sugar and Sugar Beet Markets		
The sugar beet industry could continue to consolidate with reduction in the number of sugar beet farmers and number of processing plants. If conventional sugar beet seed or herbicide for conventional sugar beet production is not sufficient to address demand, a temporary reduction in domestic sugar production could occur resulting in increased sugar prices.	Sugar beet root growers would continue to benefit from an increase in the overall economic return to sugar beet root production with adoption of H7-1 sugar beet varieties, particularly outside the Midwest. Processing plants would likely continue operations. Opportunities for agricultural workers in hand weeding in sugar beet production would be reduced, when compared to Alternative 1.	Sugar beet root growers would continue to benefit from an increase in the overall return to sugar beet root production with adoption of H7-1, although there would be a minor cost to comply with regulatory restrictions on production. These benefits would not occur in California, where no H7-1 adoption would be allowed. Western Washington, where H7-1 would also not be allowed, would not be impacted because it is not a sugar beet producing area, nor expected to be-come one. Processing plants outside California would likely continue operations. Opportunities for agricultural workers in hand weeding in sugar beet production would be reduced, when compared to Alternative 1.

Table 2–1. (continued)

Alternative 1: No Action (Regulated by Permit/Notification)	**Alternative 2: Full Deregulation**	**Alternative 3: Extend Partial Deregulation**
	U.S. Sugar Beet Seed Market	
Sugar beet seed producers would need to discard H7-1 seed inventory estimated to be worth $110 million for 2013 alone. Substantial losses would be incurred for R and D efforts that resulted from the investment in resources to develop sugar beet varieties that could not be used. Substantial resources would need to be invested to develop new varieties to replace the H7-1 varieties. Returns to past investments in the development of H7-1 varieties that depend on production in the United States would no longer be realized. To the extent that there is a shortage of domestic conventional seed in 2013, sugar beet seed growers would temporarily experience decreased sales of seed. Future investments in genetically engineered varieties of sugar beets might be reduced if expectations of regulatory approval are diminished.	If sugar beet seed growers produced conventional sugar beet seed for 2013 due to uncertainty from the litigation, they may accrue losses if they are unable to sell that seed. Seed companies would not lose the heavy investment made in the H7-1 seed inventory. Past investments in development of H7-1 varieties would be preserved as well as incentives for future development of genetically engineered sugar beets.	If sugar beet seed growers produced conventional sugar beet seed for 2013 due to uncertainty from the litigation, they may accrue losses if they are unable to sell that seed. Seed companies would not lose the heavy investment made in the H7-1 seed inventory. Past investments in development of H7-1 varieties would be preserved as well as incentives for future development of genetically engineered sugar beets. California would continue to demand conventional sugar beet seed and there would continue to be no production of sugar beet seed in California or western Washington. Enforcement of seed production regulatory requirements could slightly increase costs to H7-1 sugar beet seed production, but would unlikely substantially affect supply or seed prices. To the extent that the enforcement of isolation distances in seed production affect any current sugar beet seed producer, the seed grower might be forced to relocate his/her seed production, produce conventional seed, or abandon the production of sugar beet seed.

Alternative 1: No Action (Regulated by Permit/Notification)	Alternative 2: Full Deregulation	Alternative 3: Extend Partial Deregulation
Organic and Non-GE Sugar Beets and Sugar Markets		
All sugar sold in the domestic market would be conventional or organic. Sales of organic sugar would likely continue to increase. Organic sugar is expected to be derived from imported cane sugar. Consumers would have the option of choosing between conventional and organic sugar. Sugar beet seed and root growers and processors would not have the option of growing and processing H7-1 varieties of sugar beets.	Sugar from cane sold in the domestic market would be conventional or organic, while beet sugar would be expected to be predominantly from genetically engineered sugar beets. Consumers of sugar are expected to have the option of obtaining conventional or organic sugar. Sugar beet growers and processors would have the option of producing and processing conventional or H7-1 varieties of sugar beets.	Sugar from cane sold in the domestic market ia expected to be conventional or organic, while beet sugar is expected to be predominantly from genetically engineered sugar beets, with the exception of California beet sugar production. No production in western Washington is expected. Consumers of sugar are expected to have the option of obtaining conventional or organic sugar. Sugar beet growers and processors would have the option of producing and processing conventional or H7-1 varieties of sugar beets, with the exception of California producers, for which H7-1 varieties would not be available. Sugar beet seed production is not expected to occur in California or western Washington but would not have the option of adopting H7-1 sugar beet varieties if it did occur.
Vegetable Beet Markets		
U.S. production and consumption of vegetable beets would likely continue to be between 100,000 tons and 150,000 tons a year. Exports would likely remain few and mostly destined to Canada. Because the demand for vegetable beet seed is derived from the demand for vegetable beet, vegetable beet seed production would not be expected to grow. Foreign demand might remain stable at around 700 tons to 800 tons a year.	No impacts would be expected to vegetable beet root growers or consumers as gene flow is not possible to the vegetable crop.	No impacts would be expected to vegetable beet root growers or consumers as gene flow is not possible to the vegetable crop

Table 2–1. (continued)

Alternative 1: **No Action (Regulated by Permit/Notification)**	**Alternative 2:** **Full Deregulation**	**Alternative 3:** **Extend Partial Deregulation**
	Vegetable Beet Markets	
Vegetable beet seed production would likely continue to be concentrated in the western States of Washington, Oregon, and California, with a strong concentration in Western Washington	Vegetable beet seed growers in Oregon could be impacted by the perceived possibility of presence of GE material in vegetable beet seed fields. These impacts could include increased testing costs and loss of clients. Some vegetable beet seed farmers could cease production of vegetable beet seed. Vegetable seed production intended for a GE sensitive market might diminish in Oregon and become more prevalent in Western WA, California, and Arizona. Consumers would still have the choice to consume conventional or organic vegetable beet.	Vegetable beet seed growers in Oregon could be impacted by the perceived possibility of presence of GE material in vegetable beet seed fields. These impacts could include increased testing costs and loss of clients. Some vegetable beet seed farmers could cease production of vegetable beet seed. Vegetable seed production intended for a GE sensitive market might diminish in Oregon and become more prevalent in Western WA, California, and Arizona. To the extent that production practices enforced under Alternative 3 reduce the market perception of potential presence of GE material in vegetable beet seed, any negative impacts could be reduced. Because H7-1 sugar beet production would not be allowed in California or western Washington, vegetable seed producers in these areas would not be negatively impacted. Consumers would still have the choice to consume conventional or organic vegetable beet.
	Environmental Justice	
There would be no disproportionate impacts on minority or low-income populations	There would be no disproportionate impacts on minority or low-income populations	There would be no disproportionate impacts on minority or low-income populations

Table 2–1. (continued)

Alternative 1: **No Action (Regulated by Permit/Notification)**	**Alternative 2:** **Full Deregulation**	**Alternative 3:** **Extend Partial Deregulation**
Potential Impacts on Physical Environment		
Land Use		
The unavailability of H7-1 sugar beets is expected to result in most growers producing conventional sugar beets; however, some growers might not go back to planting conventional sugar beets and opt for alternative rotation crops. Over the short term, a decrease in sugar beet acreage could occur due to a potential shortage of conventional sugar beet seed. If conventional sugar beet seed is available, and growers choose to plant conventional sugar beets, the acreage would be expected to be similar to 2010 sugar beet planted acreage .	H7-1 sugar beets adoption would be expected to continue at 95 percent in the short term, and to approach 100 percent in the long term, including planting of H7-1 sugar beet crops in California when suitable varieties of H7-1 sugar beets become available. An increase in the prevalence of H7-1 sugar beets would be expected but the overall acreage under sugar beet production would not be expected to change notably with the adoption of H7-1 sugar beets.	The acreage of H7-1 sugar beets would be less than under Alternative 2 due to the mandatory exclusion of California. The mandatory exclusion of western Washington would be expected to have no impact on land use because there is no sugar beet production in that area, nor would any be expected under any of the alternatives. Adoption of H7-1 sugar beets would be expected to range from 95 percent to 97 percent in the long term and the overall acreage of sugar beet production would not be expected to change notably with the adoption of H7-1 sugar beets. The mandatory conditions imposed by Alternative 3 on H7-1 sugar beet growers would generally not be expected to diminish overall H7-1 sugar beet adoption behavior across sugar beet growing regions. To the extent that it does, impacts would be more likely to affect growers in the Midwest region where differential returns of H7-1 might be less than in other growing regions
Swiss chard and table beet seed production is not expected to relocated from the Willamette Valley	Some Swiss chard and table beet seed production could possibly relocate from the Willamette Valley to other areas of seed production such as California and western Washington, if the continued presence of H7-1 sugar beet production in the Willamette Valley has a negative impact on the marketing of Swiss chard and table beet seed to markets sensitive to the presence of GE material.	Some Swiss chard and table beet seed production could possibly relocate from the Willamette Valley to other areas of seed production such as California and western Washington, if the continued presence of H7-1 sugar beet production in the Willamette Valley has a negative impact on the marketing of Swiss chard and table beet seed to markets sensitive to the presence of GE material.

Table 2–1. (continued)

Alternative 1: No Action (Regulated by Permit/Notification)	Alternative 2: Full Deregulation	Alternative 3: Extend Partial Deregulation
Soil Quality		
Micro-organism Contribution to Soil Quality Sugar beet growers would be expected to primarily use conventional tillage practices, which would reduce organic matter build-up, increase tillage activities, and increase soil disturbances. This would be expected to lead to a limited micro-organism diversity or elimination of some micro-organisms.	*Micro-organism Contribution to Soil Quality* Sugar beet growers would continue to use more conservation tillage practices, which would increase organic matter buildup, reduce tillage activities, and reduce soil disturbances relative to Alternative 1, favoring higher micro-organism diversity.	*Micro-organism Contribution to Soil Quality* Micro-organism impacts from the increased use of conservation, reduced, and strip-tillage methods would be similar to those described under Alternative 2 in all areas of production except California, where no H7-1 adoption would be allowed. Western Washington, where H7-1 would also not be allowed, would not be impacted because it is not a sugar beet producing area, nor expected to become one.
Sugar beet growers would shift to more non-glyphosate herbicides, which could lead to applying herbicides that are more toxic to micro-organisms in soil. This could limit micro-organism diversity or eliminate some micro-organisms	Sugar beet growers would continue to apply more glyphosate-based herbicide and less non-glyphosate herbicides on sugar beets. The reduction in non-glyphosate herbicides that might be more toxic to micro-organisms could result in less impact than Alternative 1.	Sugar beet growers would continue to apply more glyphosate-based herbicide and less non-glyphosate herbicides on sugar beets. The reduction in non-glyphosate herbicides that might be more toxic to micro-organisms could result in less impact than Alternative 1 but slightly more than Alternative 2 because H7-1 sugar beets would not be grown in Imperial Valley.
Manganese in Soil Sugar beet growers would predominantly use non-glyphosate herbicides. No impacts are expected on soil manganese..	*Manganese in Soil.* Sugar beet growers would predominantly use glyphosate on sugar beets. No impacts of herbicide use on soil manganese is expected. If manganese became limiting for sugar beet production, however, growers could rectify the situation through foliar application of manganese.	*Manganese in Soil* Manganese availability in the soil from the increased use of glyphosate would be similar to those described under Alternative 2 in all areas of production except California, where no H7-1 adoption would be allowed. Western Washington, where H7-1 would also not be allowed, would not be impacted because it is not a sugar beet producing area, nor expected to become one

Table 2–1. (continued)

Alternative 1: **No Action (Regulated by Permit/Notification)**	**Alternative 2:** **Full Deregulation**	**Alternative 3:** **Extend Partial Deregulation**
Air Quality and Climate		
Alternative 1 is expected to have emissions of criteria pollutants, greenhouse gases (GHGs), and airborne herbicides, with associated potential impacts on air quality and climate that are comparable to pre-2005 conditions when more machinery was used and more soil was disturbed under conventional farming. These impacts are expected to be greater than under Alternative 2.	Alternative 2 is expected to lead to the adoption of more conservation tillage practices, which would decrease machinery usage and reduce soil disturbances relative to Alternative 1. Furthermore, less tractor passes are expected from the reduced tillage and fewer applications of herbicide.Therefore, Alternative 2 is expected to have lower emissions of criteria pollutants, GHGs, and airborne herbicides, with associated reductions in potential impacts on air quality and climate, compared to Alternative 1.	Tillage practices, machinery and herbicide use associated with H7-1 sugar beet farming would be expected to be similar to Alternative 2 except in Imperial Valley where it would be similar to Alternative 1. Alternative 3 is expected to have levels of emissions of criteria pollutants, GHGs, and airborne herbicides, with associated potential impacts on air quality and climate, that are similar to or slightly higher than under Alternative 2 but lower than Alternative 1.
Water		
Tillage and Water Infiltration and Runoff Sugar beet growers would be expected to primarily adopt conventional tillage practices, which would expose more soil to the erosive forces of wind and water, increase sedimentation and turbidity in nearby surface waters during rain and irrigation.	*Tillage and Water Infiltration and Runoff* Alternative 2 is expected to lead to the adoption of more conservation tillage practices, which would expose less soil to the erosive forces of wind and water,decrease soil erosion, and sedimentation and turbidity in nearby surface waters.	*Tillage and Water Infiltration and Runoff* Soil impacts from the increased use of conservation, reduced, and strip tillage methods would be similar to those described under Alternative 2. In California, conventional tillage is expected to be used.
Herbicides and Water Infiltration and Runoff Sugar beet growers would shift from a glyphosate dominated herbicide use to a wider array of other herbicides, which have a greater potential to leach into groundwater than glyphosate. During erosion events, most non-glyphosate herbicides would have a lower potential than glyphosate to move in surface water runoff in solution and when attached to soil particles, which could lead to a reduced potential for herbicides reaching surface waters.	*Herbicides and Water Infiltration and Runoff* The expected increase in conservation tillage practices is expected to reduce erosion and the corresponding movement of herbicide coated soil particles. Under Alternative 2, the increased use of glyphosate and decreased use of non glyphosate herbicides is expected to to reduce the risk of herbicides leaching into groundwater but increase the risk of herbicide adsorbed onto soil particles moving from erosion. It is not known which impact on water quality would be greater.	*Herbicides and Water Infiltration and Runoff* The effect of herbicides on surface and groundwater would similar to those described under Alternative 2.

Table 2–1. (continued)

Alternative 1: No Action (Regulated by Permit/Notification)	**Alternative 2: Full Deregulation**	**Alternative 3: Extend Partial Deregulation**
Potential Impacts on Human Health and Safety		
Public Health and Safety		
Sugar beet sugar would remain substantively identical with recent H7-1 sugar beet sugar and thus would continue to provide a readily available high energy carbohydrate and have the potential to contribute to obesity, diabetes, and other adverse effects when consumed in large quantities, within the context of the diet, for extended periods of time.	Sugar beet sugar would remain as practically all H7-1 sugar beet sugar and would continue to provide a readily available high energy carbohydrate as well as contribute to obesity, diabetes, and other adverse effects when when consumed in large quantities, within the context of the diet, for extended periods of time.	Sugar beet sugar would remain as primarily H7-1 sugar beet sugar and provide a readily available high energy carbohydrate and contribute to obesity, diabetes, and other adverse effects when when consumed in large quantities, within the context of the diet, for extended periods of time.
Increased exposure to fugitive soil particulates and engine exhaust could result from increased use of cultivation and other equipment; herbicide toxicity to humans would be higher and there would be more aerial spraying	Use of cultivation and other equipment would be expected to continue to decrease, decreasing adverse health effects from exposure to engine exhaust and fugitive soil particulates; health risks from herbicides would be expected to be lower and there would be less aerial spraying of herbicides	Use of cultivation and other equipment would decrease compared to previous conventional sugar beet practices decreasing adverse health effects from exposure to engine exhaust and fugitive soil particulates, but risks could be slightly higher than Alternative 2. Health risks from herbicides would be lower and aerial spraying of herbicides would be less, when compared to Alternative 1, except in California, where no H7-1 adoption would be allowed.
Sugar beet pollen would remain substantively identical and thus would continue to cause seasonal allergies near sugar beet seed farms.	Sugar beet pollen would continue to cause seasonal allergies near sugar beet seed farms..	Sugar beet pollen would continue to cause seasonal allergies near sugar beet seed farms.
Other products, genes, gene products, nutrients, and other components would remain substantively identical and thus would continue to be a source of fiber, human and livestock nutritional supplements, pharmaceuticals, and other products.	Other products, genes, gene products, nutrients, and other components would continue to be a source of fiber, human and livestock nutritional supplements, pharmaceuticals, and other products	Other products, genes, gene products, nutrients, and other components would continue to provide fiber, human and livestock nutritional supplements, pharmaceuticals, and other products

Table 2–1. (continued)

Alternative 1: No Action (Regulated by Permit/Notification)	Alternative 2: Full Deregulation	Alternative 3: Extend Partial Deregulation
	Worker Health and Safety	
Sugar beet pollen would remain nearly identical with H7-1 pollen and would continue to cause seasonal allergies to workers at sugar beet seed farms.	Sugar beet pollen would remain as predominantly H7-1 pollen and would continue to cause seasonal allergies to workers at sugar beet seed farms.	Sugar beet pollen would remain as nearly all H7-1 pollen and continue to cause seasonal allergies to workers at sugar beet seed farms.
Risks to workers from herbicides could be higher compared to the recent H7-1 practices due to higher worker toxicity of some conventional herbicides, and while use restrictions would be in place, accidents or misuse could have greater impact. For example Clethodim is a much more toxic skin irritant than glyphosate, clopyralid and desmedipham are much more toxic eye irritants, and EPTC, ethofumesate, and tirflusulfuron-methyl are much more toxic by inhalation than is glyphosate.	Risks to workers from herbicides are expected to be lower compared to Alternative 1)due to lower worker toxicity of H7-1 herbicides (mostly glyphosate) compared to some of the conventional herbicides and less potential impact of accidents or misuse. For example Clethodim is a much more toxic skin irritant than glyphosate, clopyralid and desmedipham are much more toxic eye irritants, and EPTC, ethofumesate, and tirflusulfuron-methyl are much more toxic by inhalation than is glyphosate.	Risks to workers from herbicides could be lower compared to conventional practices (and Alternative 1) due to lower toxicity of H7-1 herbicides compared to some conventional herbicides and less potential impact of accidents or misuse, except in California. Risks would be slightly higher than Alternative 2
Emissions of engine exhaust and soil particulates due to equipment use would increase compared to recent H7-1 practices, which could increase adverse worker health effects	Emissions of engine exhaust and soil particulates due to equipment use are expected to be less than those of conventional sugar beet practices, which could decrease adverse worker health effects.	Emissions of engine exhaust and soil particulates from equipment use are expected to be less than those of conventional sugar beet practices, except in California. This could decrease adverse worker health effects, although risks would be expected to be slightly higher than Alternative 2.
Equipment accidents are expected to result in an average of about 95 non-fatal injuries each year and about 0.7 fatal injuries each year to workers	Equipment accidents are expected to average about 66 non-fatal injuries each year and about 0.5 fatal injuries each year to workers	Equipment accidents are expected to average about 66 non-fatal injuries and about 0.5 fatal injuries to workers annually, although there is a potential for these rates to be slightly higher than Althernative 2 because of the slightly higher use of equipment
The number of workers in the field would increase, which could increase the numbers exposed to equipment emissions, soil particulates, and pesticides.	The number of workers in the field would decrease compared to Alternative 1, which could decrease the numbers exposed to equipment emissions, soil particulates, and pesticides.	.The number of workers in the field would decrease compared to Alternative 1, except in California. This could decrease the numbers exposed to equipment emissions, soil particulates, and pesticides, although not quite as much as Alternative 2.

III. Affected Environment

A. Introduction

For the purpose of this EIS, the affected environment for H7-1 sugar beets grown in the United States is described in the context of the production practices used to farm and process sugar beets, specifically the practices related to weed control and the genetic environment that could be influenced by gene flow from H7-1 sugar beets. These practices and conditions are described in this chapter to set the stage for the chapter IV discussion of how the different action alternatives may change activities and cause impacts on the human environment. The production practices under each alternative also determine how the various "resource areas" of the affected environment are affected by the decisions of the growers and producers. Those resource areas have been grouped into the biological environment (wildlife and ecosystems), socioeconomic environment, physical environment (land use, air, water, soil), and human health and safety.

This chapter describes key aspects of the affected environment in terms of two scenarios: (1) pre-2005 when production practices were based on the exclusive use of conventional sugar beet seeds and roots; and (2) from March 2008 to August 2010 when production practices switched almost exclusively to the use of H7-1. This distinction is especially relevant because the production practices used to farm sugar beets are different under those two scenarios. These differences are important to understand when comparing the various alternatives, which represent varying degrees and combinations of pre-deregulation and deregulation conditions. This chapter also describes key regional differences in the affected environment based upon differences in production practices.

The remainder of the chapter is organized into five main sections, as follows.

Section III.B, *Production and Management of Beet Crops*, describes how sugar beets are farmed, including an overview on how the crop is used (e.g., sugar, feed). It also discusses weed management practices in sugar beet farming because the H7-1 trait influences the weed management options. An analysis of herbicide quantities applied to total acres used on sugar beets that represent pre-deregulation and deregulation conditions is also included. Section III.B also describes Swiss chard, table beet or red beet, hereafter referred to as table beet, and fodder beet production practices and uses, as well as the potential for gene flow between beet crops and gene flow to and from wild beets, where they occur. Finally, section III.B discusses H7 1 sugar beet volunteers (crop plants that grow in a field after they have been rotated out of the field because of leftover seed in the soil) in agricultural systems and estimates the quantity of herbicides used for sugar beets.

Section III.C, *Biological Resources,* describes how sugar beets and the practices related to sugar beet production interact with living organisms in ecological and agricultural settings. The biological resources are divided into animals, micro-organisms, and plants. Section III.C discusses selection of weeds resistant to herbicides and weed shifts due to herbicide usage patterns (e.g., application method and timing), the potential for sugar beet weediness in ecosystems, the H7-1 sugar beet traits (including disease resistance with and without glyphosate application), and horizontal gene transfer (HGT).

Section III.D, *Socioeconomics,* describes the supply and demand for sugar beets and vegetable beets including foreign markets and suppliers as well as organic and conventional segments. These markets are described from seed to consumer and the role of sugar beets in the U.S. sugar market is discussed. Section III.D also discusses the presence of minority and low-income populations in the affected area to support analysis of potential environmental justice impacts in chapter IV.

Section III.E, *Physical Environment,* describes how sugar beets and farming practices (e.g., tillage and herbicide usage) interact with soil, air, and waterbodies.

Section III.F, *Human Health and Safety,* describes both consumer and worker health and safety with respect to the: (1) production and use of sugar beets and their products; and (2) use of pesticides that are applied before or during the production of sugar beets. The direct ingestion of the products of sugar beets, such as sugar, food additives, and dietary supplements, is addressed, as is the inhalation of sugar beet pollen and the indirect exposure via the consumption of meat, dairy, and other products derived from livestock that are fed sugar beet pulp.

B. Production and Management of Beet Crops

Sugar beets (*Beta vulgaris* L. subsp. *vulgaris* var. *altissima)* are in the Chenopodiaceae, or goosefoot, family (OECD (Organization for Economic Cooperation and Development)). The Chenopodiaceae family includes approximately 1,400 species divided into 105 genera (CFIA, 2002). The genus *Beta* comprises 15 recognized species that are divided into four sections: *Beta* (formerly *Vulgares*), *Corollinae*, *Procumbentes* (formerly *Patellares*), and *Nanae* (see table 3–1). As shown in table 3–1, *Beta* ssp. grow in various locations throughout the world and vary with regard to the number of sets of chromosomes (their ploidy level), existing in diploid, tetraploid, and hexaploid forms with a base chromosome number of nine (OECD (Organization for Economic Cooperation and

Development)). The center of origin of beet (*Beta*) is believed to be the Middle East, near the Tigris and Euphrates Rivers (CFIA, 2002). Beets have been grown for their tops and roots since Greek and Roman times and historically, have been used for both livestock and human consumption.

In Europe, wild sea beet, *B. vulgaris* ssp. *maritima* L., occurs as a wild plant. As shown in table 3–1, wild *B. vulgaris* ssp.*maritima* is distributed along the border zones of the Mediterranean from southern Russia, the Near East, and Syria to the Canary Islands and Madeira. It is also found along the European Atlantic coasts near the Gulf Stream. *Beta. vulgaris* has been introduced into the Baltic and Central and South America. In North America, the species has become naturalized in parts of California, resulting from the introduction of plants, thought to be Swiss chard, for cultivation (OECD (Organization for Economic Cooperation and Development)). There are no native beet species in North America.

Important economic cultivars of *B. vulgaris* include sugar beets, primarily grown for sugar; fodder beet/mangolds, an important cattle feed in Europe; red table beet, grown for the root and leaves; and Swiss chard/leaf beet grown for the leaves (Duke, 1983; OECD (Organization for Economic Cooperation and Development)). All cultivated beets are biennial and require two years to complete their lifecycle. During the first year, beets grow as a rosette (a circular arrangement of leaves often at the same height) and in the case of sugar and table beets, develop a swollen storage root. In the second year, the energy contained in the storage root is used to produce a seed stalk, completing the lifecycle. Exposure to a period of cool temperatures (39.2–44.6 °F) and long nights, referred to as vernalization, triggers the transition from the vegetative to reproductive phases of growth (CFIA, 2002). Under certain environmental conditions, however, such as low, vernalizing temperatures early in the growing season of the first year, sugar beets can “bolt” (produce a flowering stalk that elongates, or bolts, from the root) and act as an annual by flowering the first year (CFIA, 2002).

The tall seed stalk can produce hundreds of flowers, each releasing a large quantity of wind-borne pollen. The female flowers can remain receptive for more than two weeks (Kockelmann and Meyer, 2006). A complex system of self-incompatibility promotes cross-pollination. In most cases, the fruits, sometimes referred to as seed balls, are multiple (multigerm) such that each typically contains from two to four true seeds (Milford, 2006). However, commercial sugar beet seed takes advantage of a

Table 3- 1. Taxonomic Division and Distribution of the Genus Beta (based on De Bock, 1986)

Species	Chromosome Number	Distribution
Section 1: *Beta* (syn: *vulgares*)		
B. vulgaris ssp. *vulgaris* L.	18	Global (cultivated)[1]
B. vulgaris ssp. *maritima* L.	18	N. Africa, Portugal, Spain, Egypt, Israel, Jordan, Syria, Turkey, Albania Belgium, Bulgaria, Denmark, France, Germany, Greece, Ireland, Italy, Netherlands, Sweden, U.K., Yugoslavia[1]
B. atriplicifolia (Rouy)	18	Europe[1]
B. patula (Ait.)	18	Portugal[1]
B. orientalis (Roth.)	18	India (cultivated)[1]
Section 2: *Corollinae*		
B. macrorhiza (Stev.)	36	Turkey, Iran, Caucasus Mountains [3]
B. lomatogona (Fish et Mey.)	18, 36	Caucasus, Western Asia[2]
B. corolliflora (Zos.)	18	Turkey, Iran, Caucasus Mountains[3]
B. trigyna (Wald et Kit.)	36, 45, 54	Caucasus, Western Asia, Eastern Europe, Southeastern Europe[2]
B. intermedia (Bunge)	18	Turkey[3]
B. foliosa (Hausskn.)	Unknown	No data available
Section 3: *Nanae*		
B. nana (Bois. Et Held.)	18	Greece[3]
Section 4: *Procumbentes* (syn. *Patellares*)		
B. procumbens (Chr. Sm.)	18	Canary Islands, Southern Spain, Northwest Africa[3]
B. webbiana (Moq.)	18	Canary Islands, Southern Spain, Northwest Africa[3]
B. patellaris (Moq.)	36	Macaronesia, Northern Africa, Southeastern Europe, Southwestern Europe[2]

[1] Source: (CFIA, 2002).
[2] Source: Wiersema and León, 1999.
[3] Source: USDA–ARS, 1996.

naturally occurring trait that causes the fruit to be monogerm, containing a single seed per fruit.

Although beets are biennial, all of the agricultural commodities are produced from beets grown as summer or winter annuals depending on the region. That is, they are harvested during the first year when growth is vegetative prior to vernalization and flowering. Flowering and seed formation will ruin the quality of the vegetable. In contrast, beet seed production requires the completion of the natural biennial lifecycle; namely the roots must be exposed to low temperatures over the winter to induce flowering that occurs in the spring. Commercial seed producers can produce a seed crop over a 12-month period by sowing seeds in the late summer to generate young plants that are vernalized over the winter and produce a seed crop the following summer.

The following sections describe production and management of each of the economically important "*Beta* species" in turn: sugar beets (section III.B.1), Swiss chard (section III.B.2), table beets (section III.B.3), and fodder beets (section III.B.4).

This section starts with a general introduction to sugar beets. It then describes sugar beet seed crop production, sugar beet root crop production, and weeds in seed and root crops.

1. Sugar beets

a. General Introduction to Sugar Beets

This general introduction to sugar beets provides useful background information and context before getting into the more detailed production and gene flow issues that follow. It provides an overview of the uses of sugar beets, sugar beet production levels and locations, sugar production processes, United States approvals for GE sugar beets, and international regulatory approvals for H7-1 sugar beets.

(1) Uses of Sugar Beets

Because sugar beets contain from 13 to 22 percent sucrose or sugar, they are primarily grown for sugar for human consumption and are rarely used as a raw commodity (CFIA, 2002). A typical sugar beet root consists of 75.9 percent water, 2.6 percent non-sugars, 18.0 percent sugar, and the remainder pulp (CFIA, 2002). In the sugar fraction, 83.1 percent is recovered as crystalline sucrose and 12.5 percent is recovered as molasses (CFIA, 2002). During the sugar refining process, sugar beet roots are processed into white sugar, beet pulp, and molasses that are used for food, feed, and industrial applications (CFIA, 2002).

Beet pulp is produced in wet (pressed shreds) or dry (shreds or pellets) forms. Pressed beet pulp is a valuable feed – high in energy (85 percent of the energy value of corn) and low in protein (7–10 percent crude protein). Pressed beet pulp is considered a non-forage fiber source(Dalton and Norell, 2005). Conversely, wet pulp contains approximately 75 percent moisture, which limits the distance it can be transported economically. Wet pulp also can be ensiled (placed in silos) with other dry feeds to extend its shelf life and improve storage characteristics (Sugar Knowledge International, 2010). Additionally, high-fiber dietary food additives for human consumption have been manufactured from sugar beet pulp (Cattanach et al., 1991).

Sugar beet molasses is a viscous liquid containing about 48 percent saccharose, a sugar related to sucrose but which cannot be as easily crystallized. In contrast to molasses derived from sugar cane, beet molasses is used mainly for livestock feed. It is sprayed onto dried beet pulp shreds or pellets to enhance palatability (Cattanach et al., 1991). Beet molasses is also used for production of baker's yeast, chemical manufacturing, and pharmaceuticals (CFIA, 2002; SMBSC (Southern Minnesota Beet Sugar Cooperative), 2010a). In addition, sugar beet molasses is used in the production of monosodium glutamate (MSG), a food flavor enhancer (Khan and Abourashed, 2009). Sugar beet molasses can also be mixed with salt brine and applied to roadway surfaces and other areas to prevent the accumulation of snow or ice or the deicing of surfaces on which snow or ice has already accumulated (Maryland DOT (Maryland Department of Transportation), 2010).

Sugar beet tops can be used for livestock feed or as silage. Sheep and cattle can graze beet tops in the fall and can eat small beets left in the field after harvest (Cattanach et al., 1991). Recent advancements in defoliator technology have limited the usefulness of beet tops because the beet tops essentially are mulched as they are removed (Sugar Knowledge International, 2010).

Generally with silage, sugar beets that produce 20 tons per acre of roots also produce about 5 tons per acre of total digestible nutrients (TDN) per acre in the tops. Tops are an excellent source of protein, vitamin A, and carbohydrates (Cattanach et al., 1991). Beet tops also contain oxalic acid, which, depending on the digestive system of the animal and the amount eaten, can cause diarrhea and may bind to calcium in the animals' diet (FAO (Food and Agriculture Organization of the United Nations), 2002). Ruminants, such as beef cattle and sheep, can tolerate larger quantities of oxalic acid and can be fed limited amounts of beet tops whereas pigs and horses do not tolerate oxalic acid as well and generally are not fed beet top silage (OSU (Oregon State University), 2010). For more information on sugar beet use in animal feed, see section III.C.1.a.

Occasionally, regional sugar processors must dispose of whole sugar beets due to spoilage. Whole beets can be fed successfully to cattle. Some producers use manure spreaders to spread whole beets on stubble or stalk fields and allow cows to have access to the beets on the field (Sugar Knowledge International, 2010).

Sugar beets are also planted, sometimes as part of a mix with other plants, to attract deer in wildlife plot habitats (BuckLunch, 2011; Frigid Forage, 2011).

Beet tailings are a specific type of whole beet that can be used for feeding. Beet tailings consist of small beets, broken or damaged beets, soil, and other foreign material not suitable for sugar production. Due to the high moisture content, transportation is a major expense with beet tailings (Lardy and Anderson, 2009).

Additionally, subspeciesof *Beta vulgaris*, including sugar beets, table beets, and Swiss chard, have traditionally been used for complementary and alternative medicine. For example, boiled and extracted seeds have historically been used to treat tumors of the intestines and genital tumors. The juice or other parts of the plant purportedly help tumors, leukemia, and other forms of cancer, for example, cancer of the breast, esophagus, glands, head, intestines, leg, lip, lung, prostate, rectum, spleen, stomach, and uterus (Duke, 1983). Recent studies indicate that compounds in *Beta* species members, table beet and Swiss chard in particular, can antagonize (reduce growth of) certain types of cancer development (Kapadia et al., 1996; Lechner et al., 2010) Waste lime from the processing of sugar beets is an excellent soil amendment to increase soil pH levels. Waste lime is a good source of phosphorus and potassium, two essential plant nutrients. Waste lime is created through the treatment of the sugar juice solution. Solid lime is separated from the juice and pumped to a lime pond where it can be recovered and delivered to farms (Schaetzl, 2008). Treated process wastewater also can be used for irrigation (Schaetzl, 2008). .

Sugar beets can also be used to produce ethanol.. Although there has been production of sugar beet ethanol in the United Kingdom since 2007 (British Sugar, 2010), there is currently no production of sugar beet ethanol in the United States. However, there are several efforts underway to develop sugar beet ethanol plants as early as 2012 (Austin, 2010; Iowa State University, 2009; U.S. EPA 2010a).

(2) **Sugar Beet Production**

Sugar beets are grown in temperate regions around the world, and beet sugar accounts for about 30 percent of global sugar production (Sugar Knowledge International, 2010). The largest sugar beet producing countries are France, Germany, the United States, and Russia, in that order (FAO (Food and Agriculture Organization of the United Nations), 2010). It is estimated that in 2009, more than 229 million tons of sugar beets were produced globally (FAO (Food and Agriculture Organization of the United Nations), 2010).

The United States has large and well-developed sugar beet and sugar cane industries. Since the mid-1990s, more than half (approximately 55 percent) of U.S. refined sugar has been produced from sugar beets (USDA-ERS, 2009a). Sugar beet production acreage in the United States has remained relatively constant since 1961. Production has ranged from a low of 1.1 million acres in 1982 to a high of 1.6 million acres in 1975 (USDA-NASS, 2010d). For the 2009-2010 production year, approximately 1.18 million acres of sugar beets were planted and approximately 1.15 million acres were harvested (USDA-ERS, 2009b). Annual cash receipts for sugar beets in the United States in the past few years have ranged up to 1.5 billion U.S. dollars (USD) (USDA-ERS, 2009a) .

When discussing sugar beet production, it is necessary to distinguish between sugar beet seeds and sugar beet roots; seeds are used to grow the roots and roots are used to produce the sugar. Sugar beet seed production and sugar beet root production occur in various, non-overlapping areas throughout the United States. Primary sugar beet root production States, in order from most to least acres planted, are: Minnesota and North Dakota (57 percent of U.S. production), Idaho, Michigan, Nebraska, Montana, Colorado, Wyoming, California, and Oregon (USDA-ERS, 2010b). States with minor production (less than 1 percent of U.S. production) are Washington (about one tenth of 1 percent) and South Dakota (about one one-hundredth of 1 percent) (Stankiewicz Gabel, 2010).

In general, sugar beet roots are produced in five regions: Great Lakes, Midwest, Great Plains, Northwest, and Imperial Valley (California). Sugar beet seed production occurs on a much smaller scale in the United States than sugar beet root production. Sugar beet seeds are produced mainly in Oregon andWashington with additional breeder plots in Idaho and Colorado. These production locations are discussed in more detail for seeds in section III.B.1.b, and for roots in section III.B.1.c.

Although sugar beets have been adapted to a very wide range of climatic conditions, they are primarily a temperate zone crop produced in the Northern Hemisphere at latitudes of 30 to 60 °N. The sugar beet plant grows until it is harvested or growth is stopped by a hard freeze. Sugar beets primarily grow tops until the leaf canopy completely covers the soil surface in a field, about 70 to 90 days after planting. Optimal daytime temperatures are 60–80 °F for the first 90 days of growth. Regions with long day length are most suitable for sugar beet growth. The most favorable environment for producing a sugar beet crop from 90 days after emergence to harvest is bright, sunny days with temperatures of 65–80 °F followed by night temperatures of 40–50 °F. These environmental conditions maximize yield and quality in a sugar beet crop. Sugar beets are successfully produced under irrigation in areas with very low rainfall and in regions relying on natural rainfall (Cattanach et al., 1991). During the first growing season – the vegetative stage – the sugar beet plant typically has glabrous, or smooth, oval and dark green leaves that form a rosette from an underground stem. A white fleshy taproot develops, prominently swollen at the junction between the leaves and the root (CFIA, 2002).

Most cultivars of sugar beets require 90–110 days of exposure to vernalizing temperatures to initiate reproductive development or the flowering process. The bolt or seed stalk forms an inflorescence (a cluster of flowers growing on a stalk) and grows to approximately 1.2–1.8 meters (3.9–5.9 feet) tall. Sugar beets produce a perfect flower meaning that the flowers have both male and female organs. These flowers are small and sessile (grow directly from the stalk) and do not have petals (CFIA, 2002). Flower formation commences on the top shoot and flowers mature from the base upward, with secondary shoots following. The sugar beet plant flowers for about 4 weeks. Flowers open primarily in the morning, but continue throughout the day, with the stigmas (female reproductive parts of the flower) remaining receptive or fertile for more than 2 weeks (OECD (Organization for Economic Cooperation and Development)).

The pollen grains produced are round and have numerous indentations. Approximately 17,000 pollen grains are produced per anther (male reproductive part of the flower), resulting in approximately one billion pollen grains produced per plant (OECD (Organization for Economic Cooperation and Development)). Pollen is viable for a maximum of 24 hours, depending on environmental conditions, especially moisture. Pollen is transported primarily by wind currents and, to a much lesser extent, by insects such as bees (OECD (Organization for Economic Cooperation and Development)).

The fertilized ovary forms a fruit, which is embedded in the base of the flower. Each fruit contains a single seed, which varies in shape from round to kidney-shaped. A monogerm seed is formed when a flower occurs singly. Multigerm beet seed is formed by an aggregation of two or more flowers (CFIA, 2002). Sugar beet seeds currently sold on the market in the United States are monogerms and contain only one seed (OECD (Organization for Economic Cooperation and Development)).

Most of the sugar beet varieties grown since the 1970s have been diploid or triploid hybrids. The development of hybrid sugar beets was made possible by the discovery of cytoplasmic male sterility (CMS) (CMS is a maternally inherited form of genetic male sterility in which plants fail to produce pollen resulting in a functionally “female” plant) used in conjunction with polyploidy. For more information on CMS and seed production, see the sections below (III.B.1.b(8)). Breeding programs using the CMS lines to form diploid or triploid hybrids have enabled the development of superior sugar beet varieties with higher root yield and higher sugar content, better extraction yield (juice purity), higher seed germination percentages, lower tendency to bolt, physical attributes of the root well adapted to mechanical harvesting, and higher resistance to leaf and root diseases (OECD (Organization for Economic Cooperation and Development)). The current trend is towards diploid hybrids because it is easier to generate strains resistant to beet necrotic yellow vein virus in the diploid compared to the triploid (Bosemark, 2006) (Betaseed, 2011b).

(3) Sugar Production

As stated previously, sugar beets are primarily grown for sugar for human consumption and are rarely used as a raw commodity (CFIA, 2002). Sugar beet processing to make sugar is composed of six steps: harvesting, extraction, pressing, carbonation, boiling, and production of final products (Sugar Knowledge International, 2011). Each of these steps leading up to final production step is summarized below. While typically just called “sugar,” the type of sugar extracted from sugar beets is sucrose. To avoid confusion, the word “sucrose” is used below in describing the sugar production process.

Harvesting. Harvesting dates and procedures are strictly regulated and vary between the sugar beet root production regions and the harvesting facilities. For the Great Lakes, Midwest, Great Plains, and Northwest, harvesting generally begins around September and ends around November (McDonald et al., 2003) (Mikkelson and Petrof, 1999). In California’s Imperial Valley, sugar beet roots are harvested between April through July (California Beet Growers Association, 1999; Lilleboe, 2010) L. (For more information on root harvesting see section III.B.1.c(2) below). Throughout the harvest in the northern states, growers transport their sugar beets by truck to the designated receiving station where sugar beets are stored until processing (American Crystal Sugar Company, 2011). In California where it is too hot to store sugar beets, sugar beets are harvested on a schedule to meet the demands of the processing plant. Sugar beets are thoroughly washed and separated from any remaining beet leaves, stones, and other trash material before processing (Sugar Knowledge International, 2011).

Extraction. Sugar beet processing starts by slicing the cleaned beets into thin strips, called cossettes, to increase the surface area of the beet to make it easier to extract the sucrose (Sugar Knowledge International, 2011). The cossettes are submerged into hot water (usually between 122 and 176 °F) to extract the sucrose by diffusion (U.S. EPA 1997). The resulting sucrose-enriched water that flows from the diffuser is called raw juice and contains 10–15 percent sugar (U.S. EPA 1997).

Pressing. The wet beet slices from the diffuser are further pressed to remove any remaining water and sucrose (Sugar Knowledge International, 2011). The juice is sent back to the diffuser and the leftover cossettes, or pulp, are conveyed to the dried-pulp manufacture operations to make animal feed and other products (Sugar Knowledge International, 2011); (U.S. EPA 1997).

Carbonation. The raw juice must be purified to remove non-sucrose impurities, such as other molecules and small cossette particles, so that the pure sucrose can be crystallized (U.S. EPA 1997). Purification is done by a process known as carbonation where the mixture is heated and chalk or "milk of lime" [$Ca(OH)_2$] is added to the juice and carbon dioxide (CO_2) gas is bubbled through the mixture to precipitate the lime. The "clumps" of lime adsorb to the majority of the non-sucrose and can be easily filtered out from the raw juice. The resulting juice is very dilute (U.S. EPA 1997); (Sugar Knowledge International, 2011). Therefore the sucrose mixture is put through a series of evaporators to increase the sucrose concentration to approximately 50–65 percent (U.S. EPA 1997). The resulting solution is known as standard liquor.

Boiling. To form sucrose crystals, the standard liquor is boiled and powdered sugar is added to seed (initiate) crystal formation. After the crystals grow to the desired size, the mixture of crystals and liquor is spun in a high-speed centrifuge to separate the crystals from the liquid (known as syrup). The crystals are then dried with hot air. Once cooled, the sugar is either packaged or stored for future packaging (U.S. EPA 1997); (Sugar Knowledge International, 2011).

(4) U.S. Approval of GE Sugar Beets

The Animal and Plant Health Inspection Service (APHIS) originally approved a petition seeking a determination of nonregulated status of H7-1 sugar beets in March 2005 (see chapter I for more information). Following deregulation, widespread seed production began in 2006 as did the multiyear breeding programs to develop appropriate varieties for growers in all sugar beet production States. To date, varieties have been released and adopted in all areas except California (Colacicco, 2010b). See section III.B.1.b(3) for more information on sugar beet breeding. According to the U.S. Department of Agriculture Economic Research Service (USDA–ERS), H7-1 sugar beets accounted for about 60 percent of sugar beet-planted areas in the 2008 crop year and 95 percent in the 2009 and 2010 crop years (USDA-ERS, 2009a) . California is the only sugar beet production State that did not grow H7-1 sugar beets in those three crop years (Colacicco, 2010b). To provide a clear context for the comparison of potential environmental impacts for the alternatives analyzed in this EIS, this chapter describes the affected environments for both pre-deregulation (pre-2005) and after widescale adoption post deregulation (after March 2009).

APHIS previously deregulated two other GE traits in sugar beets which were never produced commercially as a root crop:

- AgrEvo (now Bayer) glufosinate -tolerant sugar beet event T120-7 (97-336-01p) approved in United States on May 7, 1998 (USDA-APHIS, 1998a) also approved in Canada and Japan (CERA, 2011) and

- Novartis Seeds (now Syngenta) and Monsanto glyphosate-tolerant sugar beet line GTSB77 (98-173-01p) approved in United States on January 8, 1999 (USDA-APHIS, 1998b) (also approved in Australia, Japan, New Zealand, the Philippines and the Russian Federation) (ISAAA (International Service For the Acquisition of Agri-biotech Applications), 2011).

Neither of these traits is evaluated in or affected by this EIS. APHIS does not anticipate that industry will begin commercial production of sugar beets containing these events (Reding, 2011). Neither Monsanto nor Bayer has plans to stack T120-7 with H7-1 to make a sugar beet resistant to both glufosinate and glyphosate.

(5) International Regulatory Approvals for H7-1 Sugar Beets

Multiple countries that regulate the importation of biotechnology-derived crops and derived products have granted regulatory approval to H7-1 sugar beets. Each country independently determines for which type of use the crop or derived product is approved. Categories or types of approval typically include food, animal feed, imports, processing, and planting. For example, the Canadian Food Inspection Agency (CFIA) approved H7-1 sugar beets for livestock feed in 2005. As summarized in Decision Document DD2005-54, the CFIA "determined that this PNT and novel feed does not present altered environmental risk nor does it present livestock feed safety concerns when compared to currently commercialized sugar beet varieties in Canada" (CFIA, 2005). H7-1 sugar beets were also approved for planting in Canada in 2005. As another example, the European Food Safety Authority (EFSA) has also concluded that food and feed from H7-1 sugar beets are as safe as food and feed from conventional sugar beets (EFSA, 2006). In response to EFSA information requests, Monsanto/KWS SAAT AG conducted a 90-day toxicity study, feeding processed pulp to rats, which did not indicate any adverse effects. The Genetically Modified Organism (GMO) Panel reported additional studies of sugar beet pulp to sheep, also with no adverse effects (EFSA, 2006).

In alphabetical order, other countries besides the United States, and the uses for which H7-1 sugar beets or derived products are approved, include the following: Australia (food and import); Canada (food, feed, and planting); Columbia (feed and import); European Union (EU) (food, feed, and import); Japan (food, feed, import, and processing); South Korea (food and import); Mexico (food, feed, and import); New Zealand (food and import); Philippines (food, feed, and import); Russian Federation (food and import); and Singapore (food, feed, and import) (ISAAA (International Service For the Acquisition of Agri-biotech Applications), 2011). These diverse regulatory authorities have all reached the same conclusion, that food and/or feed derived from H7-1 sugar beets are as safe and healthy as food and feed derived from conventional sugar beets.

H7-1 sugar beets have received regulatory approval from more countries than the other two herbicide-resistant sugar beet seed varieties derived through genetic engineering, GTSB77 and T120-7. For more information on GTSB77 and T120-7 see section III.B.1.a(4). As stated above, H7-1 has received regulatory approval from 12 countries, event GTSB77, has been approved by six regulatory bodies (ISAAA (International Service For the Acquisition of Agri-biotech Applications), 2011), and T120-7has received regulatory approval from just three countries: Canada, Japan, and the United States (ISAAA (International Service For the Acquisition of Agri-biotech Applications), 2011). Neither GTSB77 nor T120-7 has been approved by the EU. The fact that both GTSB77 and T120-7 lack many of the regulatory approvals attained for H7-1 makes it extremely unlikely that these traits will ever be stacked with H7-1.

b. Seed Crop

(1) Sugar Beet Seed Production

In 2011, all of U.S. H7-1 sugar beet seed production (including commercial, foundation, breeder, and research seed) is occurring on a total of less than 5,000 acres in Oregon, Washington, Idaho, and Colorado (APHIS proprietary data). Table 3–2 (U.S H7-1 Sugar Beet Seed Production by State) below shows the percentage of total seed production that is grown in each State.

Table 3- 2. 2011 U.S. H7-1 Sugar Beet Seed Production by State

State in which H7-1 Planted	Percent of Total U.S. Production (%)
Oregon	50
Washington	49
Idaho	<0.5
Colorado	<0.1
Total	**100**

Source: APHIS proprietary data

As part of the permitting requirements, all producers growing H7-1 seed were required to submit planting reports that specified the location and acreage of their seed production activity in the United States. From these planting reports, APHIS determined that as of May 15, 2011, H7-1 sugar beet seed production is occurring in the following counties: Eastern Washington (Adams, Franklin, and Grant counties), Idaho (Cassia, Canyon, Gooding, Payette, Twin Falls, and Washington counties), and Oregon (Benton, Clackamas, Douglas, Jackson, Josephine, Lane, Linn, Malheur, Marion, Polk, and Washington counties) (APHIS proprietary data) Data compiled from planting reports submitted to APHIS- APHIS to provide reference). There is also a small amount of seed production in Boulder County, Colorado. See figure 3–1 below for a map of the H7-1 sugar beet seed producing counties listed above.

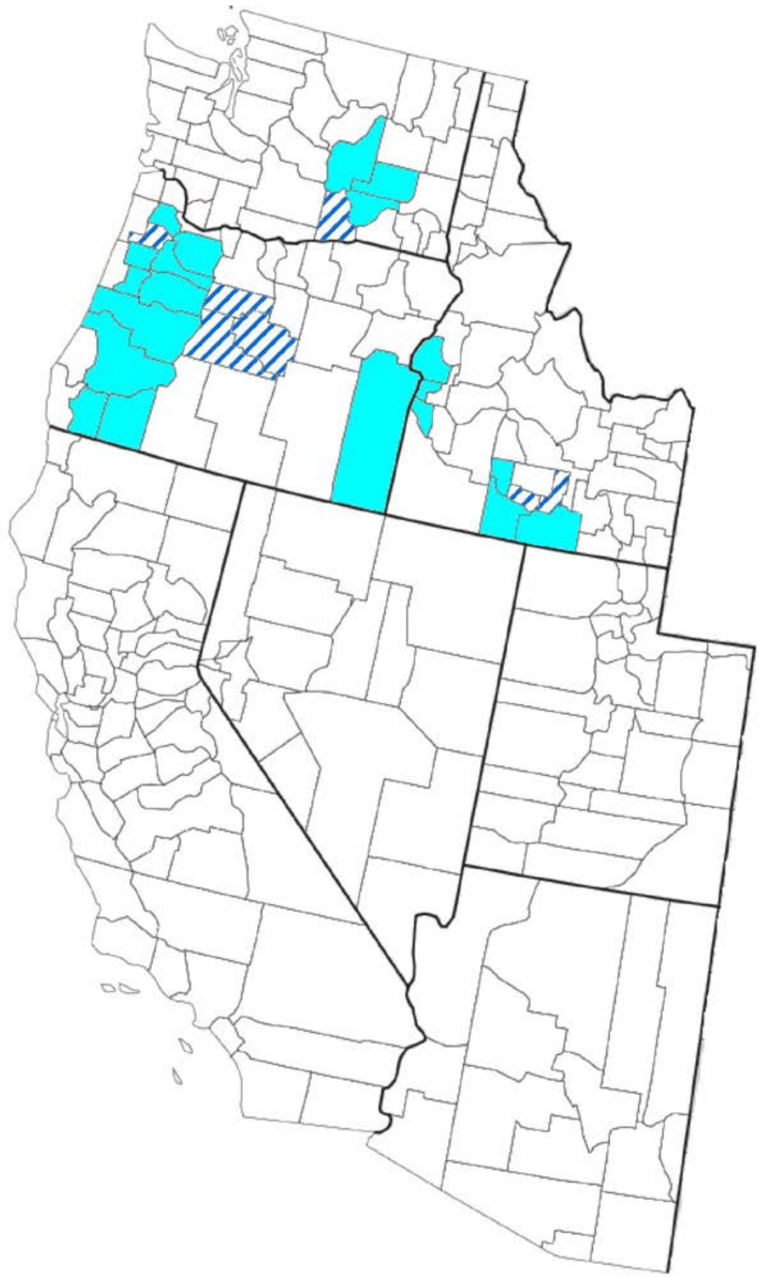

Figure 3- 1. Counties where H7-1 sugar beet seed is being produced in 2011 shown in solid color. Striped counties indicate counties in which permits to plant H7-1 sugar beet seeds in 2011 were applied for, but seeds were ultimately not planted. Planting in a single county in Colorado is not shown. (APHIS proprietary data);

As non-H7-1 sugar beet seed is not regulated, APHIS does not have any permit or other information as to where these seed crops may be grown. Given that the same five seed companies that produce H7-1 sugar beet seed also produce conventional seed, it is assumed that non-H7-1 sugar beet seed is grown in the same counties as H7-1 sugar beet seed (for more information on sugar beet seed production companies see section III.B.1.b(2).

Additionally, small fields of breeder's seed (both H7-1 as listed above and non-H7-1) are included in the States listed in table 3–2. Small breeder seed fields have occurred in Minnesota in the past. but were not planted in 2011 (APHIS, proprietary data).

Small acreage production of stecklings–sugar beet roots that are grown in plant nurseries from seed for less than a full season, are dug up, and are replanted in a different location for seed production–occurs in Oregon, Arizona, and eastern Washington (USDA-APHIS, 2011b).

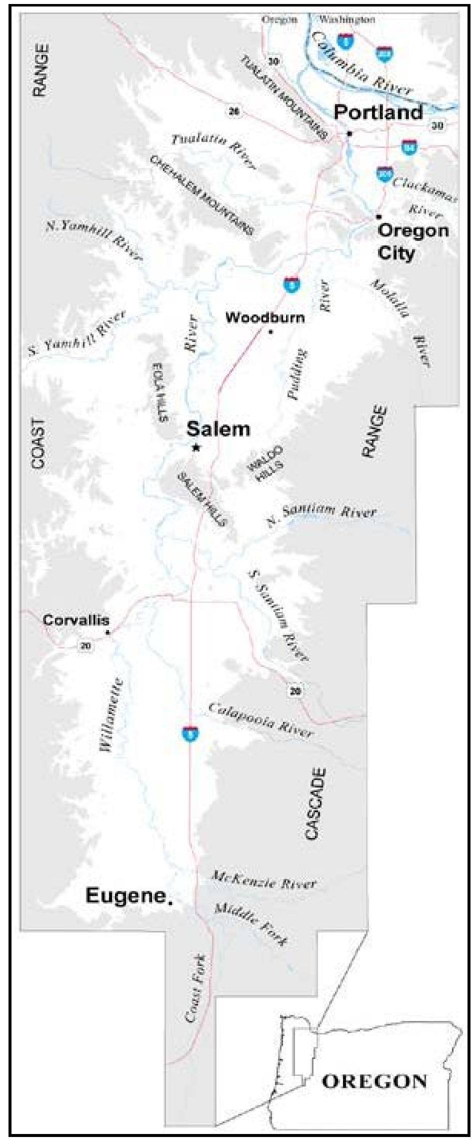

Figure 3- 2. Willamette Valley. (Source: (Givler and Wells, 2001)

At least 98 percent of all Oregon H7-1 sugar beet seed production (equal to about 50 percent of the total U.S. H7-1 production), is in the Willamette Valley (APHIS proprietary data), located between the Coast Range and the Cascade Range. The remainder occurs in Jackson and Josephine counties in the south and Malheur county in the east. The Willamette Valley runs through parts of the following counties: Benton, Clackamas, Douglas, Lane, Linn, Marion, Multnomah, Polk, Washington, and Yamhill (see figures 3–2 and 3-3). The Willamette River Basin contains more counties as it contains all lands that drain in to the Willamette River. The Willamette River Basin contains the above counties in addition to the following counties: Columbia, Lincoln, and Tillamook (Oregon Explorer, 2010). The Willamette River Basin is about 180 miles long and 100 miles wide (290 by 161 kilometers), and encompasses 11,478 square miles (29,728 square kilometers), or 12 percent of the State of Oregon(Oregon Explorer, 2010). The climate in the valley is cool enough for winter vernalization but warm enough for most roots to survive an average winter. Summers are very dry, producing ideal conditions for seed harvesting.

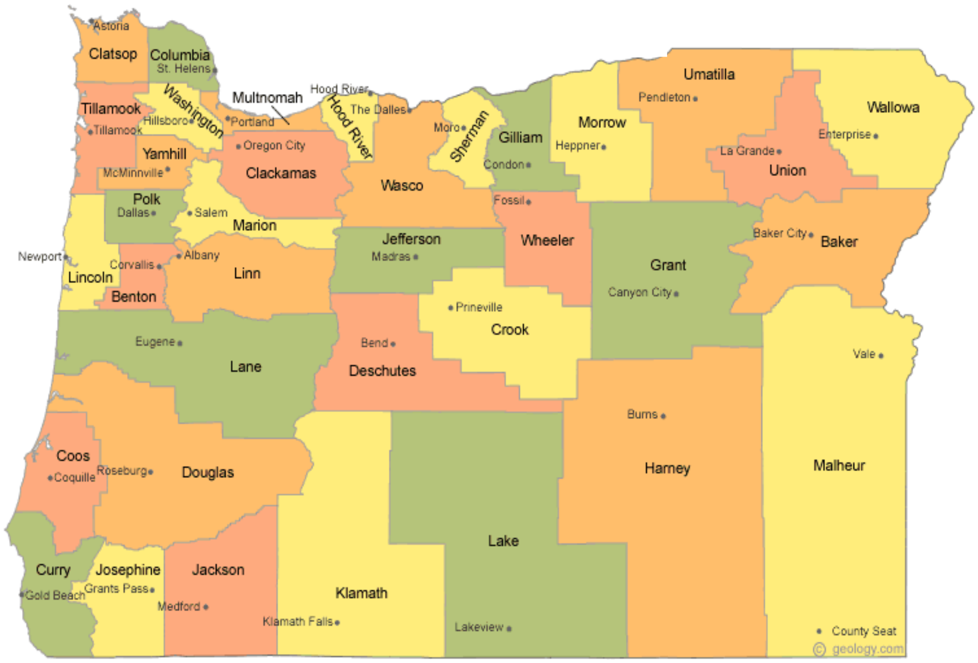

Figure 3- 3 County map of Oregon. The Northern edge of the Willamette Valley includes parts of Washington and Clackamus county and extends south through Douglas county. Source: http://geology.com/county-map/oregon.shtml

(2) Seed Crop Producers

Sugar beet seed production consists of developing, growing, and processing the seed that commercial sugar beet growers use to plant their crop. As mentioned previously, sugar beet seed production and sugar beet root production occur in different locations in the United States. Sugar beets planted for seed production make up less than 0.5 percent of the total acreage of beet cultivation (Miller, 2010).

Commercial sugar beet seed in the United States is produced, processed, and marketed by five private entities:

(1) American Crystal Sugar Company is a grower-owned cooperative based in Moorhead, Minnesota, which markets seed to its shareholders in the Red River Valley.

(2) Betaseed, Inc., based in Shakopee, Minnesota, is a wholly owned subsidiary of the German seed company, KWS SAAT AG.

(3) Syngenta Seeds, Inc., with sugar beet seed operations based in Longmont, Colorado, is a division of Syngenta.

(4) SES Vanderhave Sugarbeet Seed, based in Fargo, North Dakota, is a subsidiary of the French company, Florimond Desprez SES.

(5) Holly Hybrids, with beet seed operations based in Sheridan, Wyoming, is owned by Southern Minnesota Beet Sugar Cooperative and shares an alliance with SESVanderHave Sugarbeet Seed.

As stated above, most Oregon sugar beet seed production (approximately 50 percent of U.S. production), takes place in the Willamette Valley of Oregon. There are two commercial beet seed production entities in the Willamette Valley: West Coast Beet Seed (WCBS) and Betaseed. West Coast Beet Seed, based in Salem, Oregon, is a cooperative, producing seed for its member companies, which include American Crystal Sugar, Syngenta, Holly Hybrids, and SES VanderHave. Betaseed has seed production and processing facilities based in Tangent, Oregon. Although there is some degree of overlap, the seed production operations of these two seed producers are geographically separated: Betaseed is located in the southern and southeastern fringes of the Willamette Valley, and WCBS produces seed to the north in the Salem area. Betaseed accounts for approximately half of all sales of sugar beet seeds in North America (Lehner, 2010).

The Willamette Valley produces seed for a wide variety of crops, including vegetable beets. Sections III.B.2 through III.B.4 present more information on production of seed for other *Beta* species. In addition to seeds, many vegetables are also grown in the valley, which is a major area for production of "most temperate vegetables, herbs and vegetable seeds" (Mansour, 1999). Because high quality and seed purity are important to many growers, and because the valley is the site of varied seed production, sugar beet seed production companies have worked cooperatively to develop and implement protocols for maintaining the purity and quality of seed. Most seed companies in the Willamette Valley, including WCBS and Betaseed, belong to the Willamette Valley Specialty Seed Association (WVSSA) and follow the guidelines for isolation and minimum separation distances between fields. Additionally, WCBS and Betaseed have both developed explicit standard operating procedures (SOPs) and grower guidelines intended to minimize or eliminate the possibility of pollen movement between seed fields and inadvertent seed mixing. Isolation distances and grower guidelines are discussed further in sections III.B.1.b(10) and III.B.1.b(11), respectively, below.

(3) Seed Variety Development

The development of sugar beet varieties is a competitive, technological, and expensive multi-year activity. Seed companies develop varieties with the combination of agronomic and quality traits desired by both growers and processors. Up to 12 years is required to develop and bring to market a new sugar beet variety (Syngenta, 2010). This includes the time required for the initial breeding of parent lines, development of hybrid seed varieties , and the 3 years of variety testing required by processors as described below. Information about seed breeding and developing hybrids is described in more detail in section III.B.1.b(6).

Sugar beet seed produced outside the United States may not be suitable for commercial production in the United States, and this lack of suitability varies by region. For example, some European varieties might perform well in the Red River Valley, the market with the least severe disease pressure. Sourcing varieties with sufficient *Cercospora* resistance for production in Michigan; however, would be difficult, and no European varieties could provide the beet curly top virus (BCTV) resistance required for production in Idaho. Furthermore, due to concerns about importing wild beets from Europe, some sugar processors (e.g., American Crystal Sugar) have policies that prohibit the use of seed not produced in North America (Colacicco, 2010b). Wild beets occur across regions of Europe, including in sugar beet root and seed production fields. Wild annual forms of beet can cause crop failure and complicate the harvest and processing of sugar beets. Wild beets are difficult to eradicate due to their similar morphology and physiology to sugar beets which renders conventional control methods for annual wild beet less effective (Mücher et al., 2000).

(4) Variety Approval

Each sugar processor conducts official variety trials to generate a list of approved varieties, and growers are obligated to grow only varieties that appear on this list. To achieve full approval, new varieties must be tested in the official trials for 3 years and must generate data that meet or exceed the specific performance criteria established by each company's seed committee. Criteria include how well each variety tolerates exposure to particular diseases and pests known to infest the growing region, adverse growing conditions, and the variety's ability to deliver acceptable tons/acre and sugar content. Approved variety lists are updated annually with new varieties added that were approved the previous year. Although seed policies vary by region, seed companies are generally obligated to "enter" approved varieties in the official trials to maintain approval for unlimited sales. When sales of a given variety decline, the seed company must decide whether it is worth the cost of the official trial entry fees needed to support the declining market share of that specific variety. The approval systems are designed to enforce continuous improvement, so the lifespan of any given variety in the market is relatively short.

The approved variety list denotes only those sugar beet varieties that may be delivered to the processor for sugar production. Sugar beet varieties that do not qualify to be included on the approved variety lists cannot be delivered to the processor for sugar production because they do not meet the standards set forth by the processor. Growers may only plant seed of approved varieties for sugar beet production. As a cooperative member, a grower is contractually obligated to deliver sugar beets from a specified number of acres. Sugar cooperatives are described in section III.D.1.

In early 2009, the American Crystal Sugar Company Seed Committee exempted approved conventional varieties from continued variety testing (Niehaus, 2010) Since the seed industry was no longer entering these older varieties in the official trials, this policy change was enacted to allow these varieties to continue to be sold without testing fees assessed to the seed companies. Based on this decision, there were 31 conventional varieties available to American Crystal Sugar Company growers in 2010, but only 7 of these were tested in the 2009 official variety trials.

(5) Planting and Lifecycle

For seed production, sugar beet plants are sown in the late summer or early fall in regions with mild winter climate that reach the required vernalizing temperatures of 4–7 °C (39.2–44.6 °F). These direct seeded plants will produce seed in the following summer (OECD (Organization for Economic Cooperation and Development)). In the United States, sugar beet seed plants are planted around July to September and harvested the next summer about the same time (Meier, 2010). This cultivation technique for sugar beet seed crops is known as the overwintering method and eliminates the need for two spring/summer growing seasons for production of this biennial crop. After seed germination and emergence, vegetative growth and development of the crop occurs during the fall. The crop enters dormancy in the winter when it is vernalized by the low temperatures. Once vernalized, the crop switches from vegetative development to reproductive development in spring (Chastain, 2005). The overwintering method is only suitable in mild climates such as found in the Pacific Northwest, which is why the majority of sugar beet production occurs in this area. The winters are too cold for sugar beets to survive in areas where most sugar beet root production occurs with the exception of the Imperial Valley. In the Imperial Valley, late summer temperatures become too hot for sugar beet seed production, with soil temperatures reaching 115 °F (2011).

(6) Breeder Seed

The breeding process involves selection of the desired genetic traits and backcrossing those traits through several plant generations to ensure consistent reproduction in subsequent generations. This process culminates in what is called pre-basic seed (also known as breeder seed). Pre-basic seed is the purest form of seed and is always retained by the commercial breeder in sufficient quantities to ensure that it can be replicated to recreate the variety. Pre-basic seed is multiplied (planted, grown, allowed to set seed, and harvested) into basic seed, which is then planted and crossed to create the hybrid seed required for commercial production (Meier, 2010).

(7) Monogerm vs. Multigerm

Plants in the *B. vulgaris* species produce perfect flowers, meaning that the flowers have both male and female organs, and polygerm fruits or seed balls, meaning that each fruit contains multiple seeds and can develop into multiple plants (CFIA, 2002). Plants in the *B. vulgaris* species are strongly self-incompatible, meaning that a flower cannot fertilize itself or other flowers on the same plant. For fertilization to occur, self-incompatible plants must outcross with individuals that do not contain identical copies of self-incompatibility genes (Larsen, 1977). Despite this strong self-incompatibility, sugar beets can be “selfed” or inbred to a breeding population which contains a range of self-incompatibility genes (Bosemark, 2006).

Due to genetic manipulation and complex breeding programs, all of the sugar beet varieties grown in the United States since the 1970s have been diploid or triploid, monogerm hybrids. Monogerm means that the fruit contains just a single sugar beet seed which will give rise to a single plant. A monogerm beet seed is formed when a flower occurs singly on the “seed parent” and multigerm beet seed is formed by an aggregation of two or more flowers on the “seed parent” (CFIA, 2002).

Each hybrid seed is derived from two genetically different parents of the same (diploid) or different (triploid) ploidy levels (have different numbers of chromosome sets) (Bosemark, 2006). Hybrid seeds are produced by crossing “male” pollen parents with male sterile “seed parent” plants. In hybrid seed production, to produce a phenotypically monogerm seed, the female “seed parent” must be monogerm. The male parent, however, is typically polygerm as polygerm plants produce more pollen and have fewer undesirable vegetative plant growth traits than monogerms. The resulting hybrid seed is phenotypically monogerm (only one seed per seed ball) and genotypically polygerm (if allowed to flower, it would produce seed balls with multiple seeds) (Panella and Lewellen, 2007). These seeds are superior to previous types of seeds for the reasons previously described (OECD (Organization for Economic Cooperation and Development)).

(8) Cytoplasmic Male Sterility

The development of hybrid sugar beets was made possible by the discovery of CMS. CMS allows the breeder to develop male-sterile (nonpollen producing) “female” parental lines from which the seed is harvested (CFIA, 2002). CMS female seed parents are developed and maintained through a complex breeding program requiring two generations of crosses, as the gene required for CMS is maternally inherited and the monogerm trait is recessive (Bosemark, 2006).

Because of the number of specialized traits that must be combined, the development of a new female parental line takes 10–12 years, about twice as long as required to develop a new male parent line (Miller, 2010). The CMS female lines generally produce no pollen, ensuring that any seed produced will be hybrid. There are rare cases, however, where a CMS female plant does produce pollen. Seed production fields are routinely inspected prior to pollen release to identify and rogue (remove) these rare individuals to eliminate inadvertent pollination (Lehner, 2010; Miller, 2010).

The CMS female parent is itself a single cross produced by pollinating a monogerm CMS line with a monogerm O-type (or maintainer) line. An O-type maintainer line, by definition, is able to produce pollen (Hovland, 2010). The purpose of the maintainer line is to make more of the female parent while maintaining the cytoplasmic male sterility in the resulting seed. When crossed, the resulting progeny will be homozygous for the monogerm and H7-1 traits, will be male sterile, and will contain the desired genetics for the female parent, including disease resistance and yield characteristics (see figure 3–4). The offspring then is used as the female seed parent in crosses with polygerm diploid or tetraploid pollinator lines (CFIA, 2002). The cross will result in either a diploid or triploid hybrid monogerm seed. Because triploids are sterile, when triploid seed is used to produce the root crop, little to no fertile pollen will be produced from bolters should they arise.

Figure 3–4 provides a graphic representation of genetics used to produce H7-1 hybrid seeds using CMS. Part A of the figure shows crosses used when the H7-1 gene is on the CMS female parent. Part B shows crosses used when the H7-1 gene is on the male pollen producing parent. The genetic crosses used to produce hybrid H7-1 seed are identical in both cases with the exception of which parent carries the H7-1 gene.

The first cross shown in either case is used to produce more of the female parent. In the early stages of breeding when only small amounts of breeder seed are needed and the goal is to produce a highly inbred line, both the CMS line and the maintainer line are from the same cultivar (Cultivar A). When the goal is to produce commercial hybrid seed, larger quantities of the female parent are needed. Highly inbred lines do not have as much vigor and do not produce as much seed. For the cross used to produce the female parent for commercial seed production, the maintainer line is typically derived from a different Cultivar (B) than the CMS line, as shown in figure 3–4, so as to increase the vigor and seed production in the F1 hybrid used as the female parent. This female parent hybrid (Cultivar A x B), is then crossed to a third cultivar used as the pollen parent (Cultivar C).

In the crosses shown in figure 3–4A where H7-1 is on the female parent the first cross to generate the female parent (Cultivar A xB) requires an H7-1-pollen parent. If the O-type maintainer pollen producing lines did not carry the H7-1 trait, the CMS female sterile lines would only pass on the H7-1 trait to half of the offspring. A cross to produce the parent lines is typically planted on less than one acre. The second cross used to produce the commercial seed constitutes the bulk of hybrid seed production, may be planted on 50–60 acres, and utilizes a pollen parent that does not produce H7-1 pollen. In (B), just the opposite occurs: the significant hybrid seed production utilizes a pollen parent that produces H7-1 pollen.

In Willamette Valley in 2011, 85 percent of the H7-1 hybrid seeds are produced with the H7-1 gene on male sterile plants (APHIS proprietary data) and where the pollen parent lacks the H7-1 gene. In 2010, about 78 percent of the hybrid seed was produced using H7-1 on the male sterile lines. While the trend to use H7-1 on the male sterile lines is increasing, there are two reasons why pollen parents producing H7-1 pollen are still used. First, as described above, a small percentage of the seed production requires use of H7-1 pollen parents in order to produce the CMS line (female parent) containing the H7-1 gene. Second, because the female parent lines take twice as long to develop as the male parent lines, companies sometimes prefer to produce commercial seed from pollen parents having the H7-1 gene so they have the flexibility needed to respond quickly to develop new and improved hybrid varieties demanded by its customers as growing conditions change and disease pressures evolve and emerge (Meier, 2010). Except in very rare cases, no H7-1 pollen is produced by the H7-1 female parent. Fields are routinely inspected and these plants are destroyed by seed producers to remove inadvertent pollination that would otherwise occur (Lehner, 2010; Miller, 2010). As such, H7-1 pollen movement and potential for pollen gene flow is limited to just 15% of the sugar beet seed acreage in Oregon in 2011 (see section III.B.5 for further discussion on gene flow).

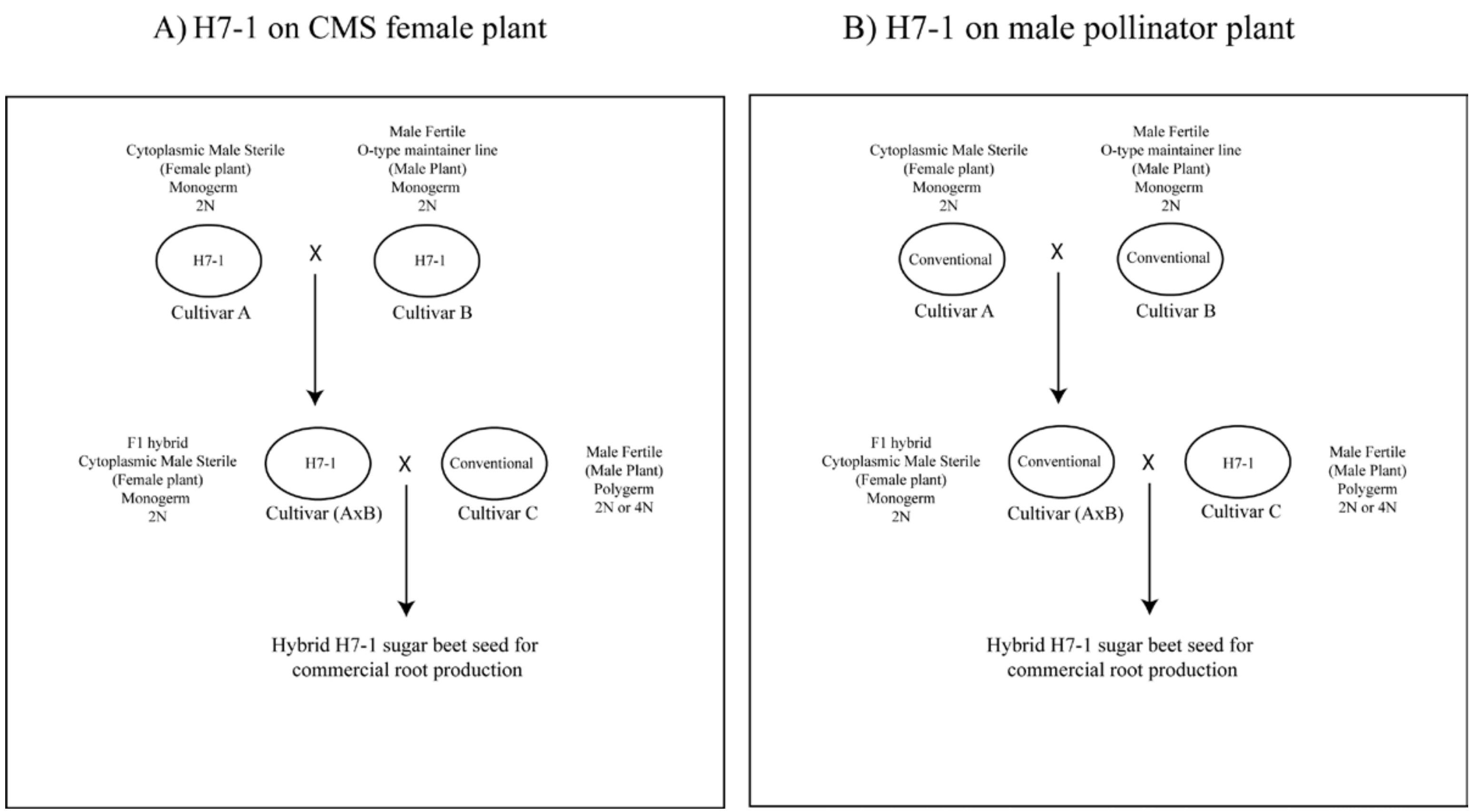

Figure 3- 4. Sugar beet hybrid seed production using cytoplasmic male sterility (CMS). (Source: Modified from (Bosemark, 2006).)

(9) Hybrid Crosses in the Field

Hybrid crosses occur in fields that have been planted with specific ratios of genetically distinct male “pollen parents” and CMS female “seed parents.” Pollination typically takes place from late May through June (Chastain, 2010). The two types of parents are typically grown in blocks (Kockelmann and Meyer, 2006). For example, in the Willamette Valley, typical plantings include 4 rows of pollen parents for every 12–14 rows of seed parents (Kockelmann and Meyer, 2006; Meier, 2010). Spacing between and within rows vary, but 61 cm (24 inches) between rows and 5 cm (2 inches) between plants within rows are common for Oregon, although there is currently a trend towards 30 inches between rows (Chastain, 2010; Kockelmann and Meyer, 2006). Fertile plants are rogued from the female rows to minimize unwanted pollination. Seed mixture and volunteers are the main sources of rogued fertile plants in the female rows (USDA-APHIS, 2011b). Sugar beet seed crops are managed intensively throughout the growing season with special attention paid during the pollination period. For example, staff members of WCBS are in the field approximately three times a week during pollination (Loberg, 2011).

Figure 3–5 illustrates hybrid sugar beet crosses for commercial production in the field. Part A of the figure shows a 1:4 ratio of pollen (male fertile) to seed (CMS) parents. Pollen parents are shaded in grey. Part B of the figure shows a field of seed parents after the pollen parents have been removed following pollination.

After the males have completed pollinating CMS seed parents and 2–3 weeks before harvest, the male pollinator rows are removed to ensure that only hybrid seed matured on the female plants is harvested (Kockelmann and Meyer, 2006) (see figure 3–5). The tall (3.9–5.9 feet) flower stalks on the seed parent plants and the male pollinator plants can become tangled given that rows are typically only 24 inches apart. Custom-built machines called separators are used to separate the plants to ensure that the seed parents are preserved during the removal of the pollen parents. Pollen parents are destroyed by flailing or tilling prior to harvest (Chastain, 2005).

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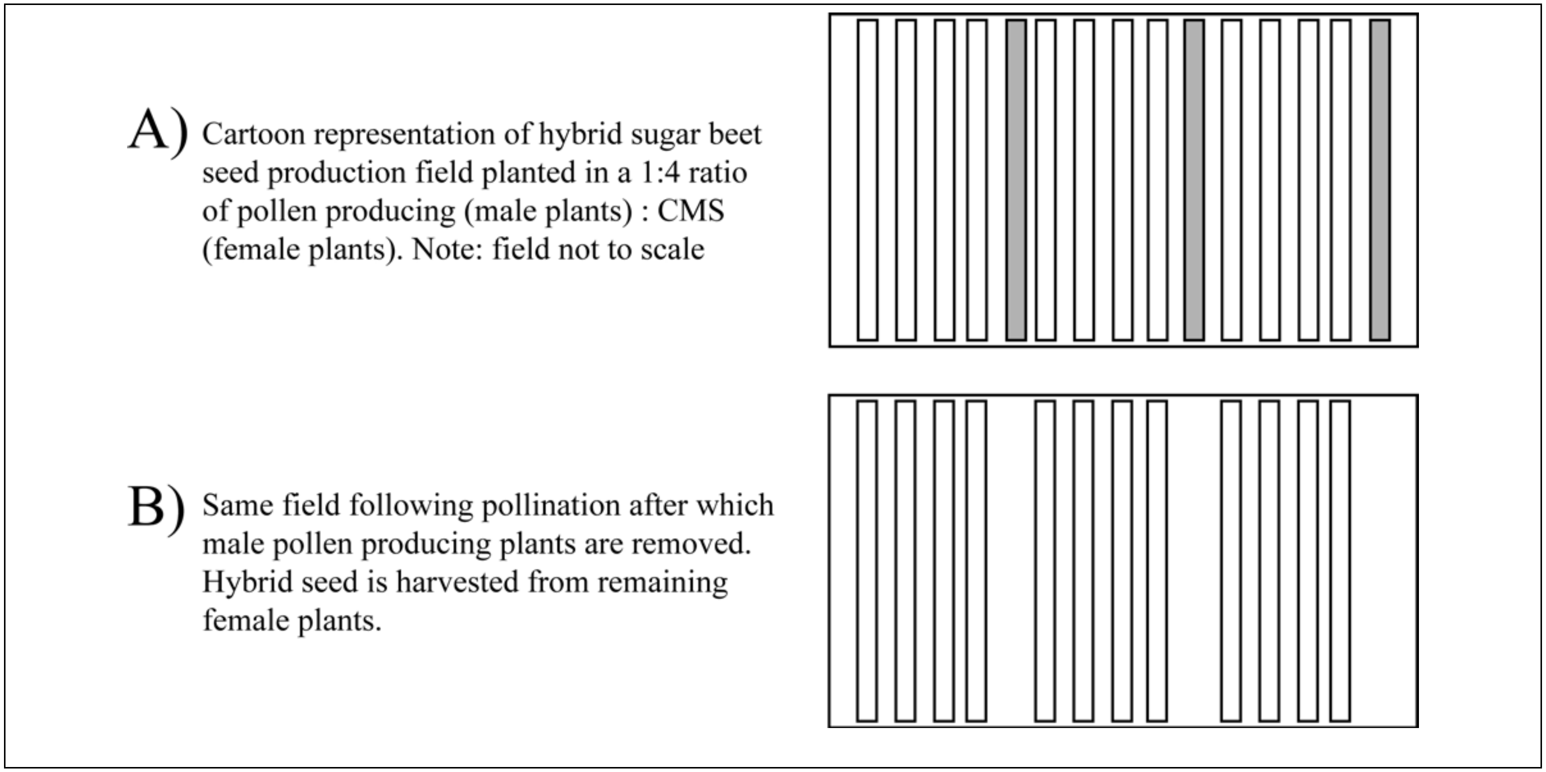

Figure 3- 5. Illustration of hybrid sugar beet crosses for commercial production in the field (Source: Modified from (Bosemark, 2006)

Seed is harvested from mid-July through mid-August. Irrigation must cease 10 days prior to swathing (swathing is the process of cutting the stalks) (Chastain, 2005). Then the seed is cut with a swather and left in the field to dry after which it is harvested by a combine that separates the seed from most of the stalk (Holly Hybrids, 2007b). Seed yields for sugar beet seed crops range from 2,000–3,000 pounds per acre (Chastain, 2005).

Post-harvest management practices of sugar beet seed crops are focused on controlling and destroying any remaining seeds in the soil. After harvest, post-harvest residue remaining in the field is irrigated to germinate volunteers, which are then destroyed by tillage and/or herbicides (Chastain, 2005).

(10) Isolation Distances

As described above, production of high-quality hybrid seed requires that the "correct" genetic cross take place; the pre-determined pollen donor must fertilize the pre-determined seed parent for the desired pre-determined cross to occur. The main way in which seed producers ensure that the desired pollen fertilizes the desired seed donor is to use isolation distances. As described in detail below (see section III.B.5 on gene flow), pollination rate, or gene flow, decreases rapidly as distance from the pollen source increases (Darmency et al., 2009; Eastham et al., 2002). In general, the farther a pollen source is from a seed production field, the less likely it is to cross pollinate plants in the seed production field. Therefore, seed producers follow strict isolation distances when producing sugar beet seed as described below.

As an example of isolation distances used to increase seed purity for sugar beets, the Oregon Seed Certification Service (OSCS) has established standards for certified seed and corresponding isolation distances. Note that most sugar beet seed is not certified (Chastain, 2010) (Betaseed, 2011a). OSCS has set the following standards for those items for certified sugar beet seed (OSCS (Oregon Seed Certification Service), 1993):

- Pure seed, minimum: 99.00 percent;
- Other crops, maximum: 0.10 percent;
- Inert matter, maximum: 1.00 percent; and
- Weed seed, maximum: 0.10 percent.

Minimum isolation distances required for certified seed are as follows:

- From sugar beet pollen of similar ploidy or between fields where male sterility is not used – 2,600 feet (0.49 mile); and
- From other pollinator or genus *Beta* that is not a sugar beet – 8,000 feet (1.5 miles).

The maximum specified OSCS required isolation distance, for "stock" seed that has a maximum allowable concentration of "other crop" seed of 0.00 percent, is 10,200 feet (1.9 miles) from other, non-sugar beet *Beta* species (OSCS (Oregon Seed Certification Service), 1993).

The following information on seed production practices and isolation distances are specific to the Willamette Valley, where 50 percent of the total U.S. H7-1 seed production takes place. While there are other areas that are known to use isolation distances and/or pinning maps for *Beta* species (Yuma, Arizona, Parma, Idaho, and at Washington State University (WSU) Mount Vernon NWREC (McReynolds, 2011) Wild West Seed, 2011), Willamette Valley is the only region in which sugar beet seed (H7-1 and non-H7-1), Swiss chard seed, and table beet seed are known to be grown within the same counties (see figure 3–12 in section III.B.5).

All growers of commercial specialty seed in the Willamette Valley, including all commercial companies producing sugar beets or vegetable beet seed, are members of the WVSSA. WVSSA has strict (although not mandatory) isolation distances and pinning guidelines for growers to follow (pinning is the process growers use to coordinate their plantings-growers put a pin on a map to show the specific location of where they intend to grow a crop that is sexually compatible with a nearby crop) (see table 3–3). WVSSA's guidelines for isolation of *Beta* species are summarized in table 3–3.

The pinning maps enable growers to see where sexually compatible crops are being grown so that they may take steps to ensure that the seed isolation distances are met. Pinning rules are required to be followed by all members of the WVSSA. These rules help growers maintain seed purity standards. There are specific rules on when pinning can occur, which seed producers have priority in pinning, and methods for arbitration if agreement between producers cannot be reached (WVSSA, 2007).

Female basic seed production is different from commercial seed production. It occurs on a much smaller scale and is typically done in more remote locations, with isolation distances in excess of 10 miles (Hovland, 2010). The WVSSA does not specify increased isolation distances for basic seed production.

Table 3- 3. WSVVA Specialty Seed Production Isolation Guidelines.

1 mile	2 miles	3 miles	4 miles
Between one O.P.[1] and another of the same color and group	Between hybrid and O.P. of the same color and group	Between different colors within a group	Between hybrid and O.P. of different groups
Between hybrids[2] of the same color and group	Between stock-seed and a hybrid within a group	Between stock-seed and O.P. within a group	–
–	–	Between GMOs[3] and any other *Beta species*[4]	–

Source: (WVSSA, 2008).

[1] Open Pollination (O.P.) a population of plants that intermate randomly without human intervention to produce seed; typically done for table beets, fodder beets and Swiss chard but not for sugar beets.

[2] Hybrid plants are a cross between two or more genetically distinct plants.

[3] Genetically Modified Organisms (any plant developed through the use of genetic engineering- including H7-1 sugar beet).

[4] Must be no closer than 3 miles and is excluded from exception to lessen this distance.

(11) H7-1 Sugar Beet Seed Guidelines

Since the approval of H7-1 sugar beets in 2005, the two commercial beet seed production entities, Betaseed and WCBS, have developed strict guidelines for H7-1 seed production to further maximize seed purity and minimize low level presence (LLP). These guidelines include all steps from basic crosses to produce hybrid seed through seed processing. Guidelines from each company are presented below.

Seed Production by West Coast Beet Seed. WCBS produces the commercial sugar beet seed for the U.S. beet seed providers, Syngenta, SES Vanderhave, Holly Hybrids, and American Crystal in Willamette Valley, Oregon.

Key features of their seed tracking system include the following (Loberg, 2010a):

- Fields and planting locations are controlled with a tracking and tracing system. The system distinguishes seed lots of basic seed from the moment of initial delivery to WCBS through subsequent planting and harvest.
- Management continues until the delivery of pre-cleaned seed to member companies.
- Some member companies further incorporate various computerized and digital tracking systems designed to manage real-time seed batch movement and quality testing.

- Many of these companies have sealed packaging and specified color coding designations to further identify seed batches/lots (Meier, 2010).

Key features of WCBS's production practices include the following:

- WCBS contracts to individual growers for seed production. As stated above, all commercial seed growers in the Willamette Valley, including WCBS, are members of the WVSSA.
- WCBS prohibits production of a vegetable beet seed crop by any WCBS grower in a year in which that grower is producing sugar beet seed, whether GE (which would currently only include H7-1 derived varieties) or conventional.
- WCBS prohibits the sharing of planting, cultivation, and harvesting equipment for vegetable beet seed, whether they are producing GE or conventional sugar beet seed.
- Since 2006, WCBS has followed a comprehensive stewardship and best management practices (BMP) Protocol for Genetically Modified (GM) Seed Production.
- WCBS requires its growers, by contract, to adhere to minimum isolation distance within a 3-mile radius of any GE field.
- WCBS maintains control of all material, whether GE or conventional, from point of origin to return of the seed to the member seed company.
- WCBS controls the disposal of any excess GE stecklings that are not used for seed production, including those that are removed from, or remain in, the nursery field.
- The prevailing method of disposing of stecklings is destruction through standard agricultural practices (physical destruction with tillage and chemical destruction in the subsequent crop) (Loberg, 2010a).

Key features of WCBS's seed processing procedures include the following:

- WCBS pre-cleans the seed prior to shipment to the seed provider. The pre-cleaning takes place in a dedicated WCBS facility. This process removes sticks, chaff, weeds, and the like that might be contained in the seed when initially harvested.
- WCBS does not handle vegetable beet seed. Its seed pre-cleaning operations present no opportunity for mechanical mixing of sugar beet seed, whether conventional or GE, with table beet or Swiss chard seed.
- When WCBS produces both GE and conventional sugar beet seed, physical separation requirements and cleaning protocols protect against inadvertent mixing.
- After pre-cleaning, WCBS ships each seed lot to the member companies in sealed containers with color-coded labeling and shipping documents.

Key features of WCBS's volunteer removal practice include the following:

- The WCBS BMP has requirements for monitoring, within a 3-mile radius of any H7-1 field, and removal of any volunteer seedlings for a minimum of 5 years or until no volunteers are observed, whichever is later.
- WCBS contracts also require seed growers to diligently control volunteer plants after H7-1 sugar beet seeds are harvested by tilling and monitoring fields (Loberg, 2010a).

Seed Production by Betaseed. Betaseed produces commercial sugar beet seed in Willamette Valley, Oregon.

Key features of their seed tracking system include the following (Lehner, 2010):

- Betaseed has adopted Standards of Practice (SOPs) that require all materials to be adequately identified and tracked through a computerized, bar-coded system. This system is in place from basic seed production to commercial seed production to final processing and shipping.
- All Betaseed personnel involved in seed production are trained in the SPs and required to sign an acknowledgement that they have read, understood, and will comply with the SOPs.
- According to the SOPs, Betaseed personnel are present for the beginning of every harvest by a commercial grower. Betaseed provides barcoded tote boxes into which the harvested seed is placed for transport to Betaseed's processing facility (Lehner, 2010).

Key features of Betaseed's production practices include the following:

- Betaseed contracts commercial seed production to individual growers.
- Betaseed requires its growers, by contract, to use the WVSSA's pinning information and isolation procedures.
- Betaseed is a member of WVSSA and pins all of its commercial seed fields in compliance with the WVSSA's rules to ensure that isolation distance guidelines are followed.
- Betaseed requires its growers, by contract, to adhere to isolation distances of 4 miles from other crops that could cross-pollinate with sugar beets.
- Betaseed supervises its commercial seed growers' practices for conformance with Betaseed's stewardship requirements. Betaseed's grower contracts provide for such supervision, as well as Betaseed's right to enter the grower's fields and take remedial action if the grower does not comply with Betaseed's instructions.

- Starting in 2010, for all commercial seed production, sugar beet plants carrying the glyphosate-tolerance gene were on the CMS male sterile seed-producing parent (Lehner, 2010). This reduces the possibility of gene flow of H7-1 pollen to close to zero, as approximately 1 CMS plant per 16,000 plants produces pollen (Lehner, 2010).

Key features of Betaseed's seed processing procedures include the following:

- Betaseed requires growers to clean their equipment before and after harvesting a sugar beet variety, and to monitor for and eliminate volunteer sugar beets.

Key features of Betaseed's volunteer removal practice include the following:

- Betaseed has a regime in place for controlling volunteers.
- Betaseed informs farmers about when and where volunteers could appear and instructs farmers to remove them.
- Betaseed knows the locations of all fields where its plants are grown, and inspects those fields for volunteers each year.
- When personnel find a small amount of volunteers, they destroy them.
- If Betaseed finds a larger quantity of volunteers, it alerts the grower and instructs him or her to destroy them (Lehner, 2010).

In addition to practices designed to minimize seed admixture and loss of purity in seed lots, BMP have also been implemented to prevent the unintentional mixing or release of stecklings. In May 2009, an incident was reported involving H7-1 steckling disposal. In or around May 2009, peat moss acquired by the Pro Bark garden store in Corvallis, Oregon from the seed producer Betaseed was reported to contain some stecklings and steckling materials. Following repossession of the peat moss, Betaseed reported that the stecklings found in the mixture were not likely to survive and produce pollen. Because of this incident, Betaseed subsequently revised its SOPs to provide for proper disposal of the peat moss in which it transports stecklings (Lehner, 2010). Now stecklings that are removed from the nursery, but are not used, are destroyed or securely disposed. The prevailing method is returning unused stecklings to the nursery field of origin and subsequent destruction through standard agricultural practices (physical destruction with tillage and chemical destruction in the subsequent crop) (Loberg, 2010a).

(12) Land Preparation

A 4- to 8-year rotation with non-*Beta* crops is required to avoid contamination from volunteer plants that might grow from fallen seeds from previous crops (American Crystal Sugar Company, 2010; Desai, 2004). Different seed producing companies may have different requirements for the number of years between rotations. For more on crop rotations see section III.B.1.b(16) below. Land is prepared by plowing, two or three harrowings (to break up clumps of soil and to provide a finer finish to the soil), and leveling to bring it to the desired tilth (soil structure suitable for seeding) (Desai, 2004). Seed beds are frequently irrigated prior to planting (Chastain, 2010).

Once the soil is prepared, hybrid sugar beet seed crosses from breeder seed are initiated by one of two methods: the direct-seeded method and the steckling (transplant) method. Most sugar beet seed production in the United States uses the steckling method. Although both methods rely on the same breeding practices to produce hybrid seed, there are differences in when and how the parental lines are planted. Regardless of which method is used, seed producers in Willamette Valley, Oregon plan which seed crops they will plant in which fields before August of the year in which the seeds will be planted to meet the August 1 WVSSA field pinning deadline for field isolation priority (Loberg, 2010a).

(13) Direct-Seeded Method

When the direct-seeded method is used, seeds for the male and female parents are planted in blocks in the same field (usually in August/September). As the weather becomes colder, the plants become dormant and are vernalized in the ground. Plants begin to bolt to form a flowering stalk in April, produce pollen in late May through June, and seeds in July and August (Chastain, 2010; Kockelmann and Meyer, 2006). Most cultivars of sugar beets require 90−110 days of exposure to vernalizing temperatures to initiate reproductive development or the flowering process. The direct seeded method saves labor costs from transplanting individual plants but uses more seed. It is primarily used when the basic seed supply is ample.

(14) Steckling Method

Stecklings are young beet plants that have a small tap root. When the steckling (transplant) method is used, the vegetative phase of the seed production cycle is considered as a separate crop in specialized steckling nurseries. Seeds for CMS male sterile and pollinator stecklings (described in more detail above) are planted in August/September and grown in separate plots, where each can be treated according to its individual requirements. Stecklings are harvested between January and March when roots are large enough to withstand the stress of replanting. During its growth, the steckling may have received some vernalization in the field. If needed, vernalization may be supplemented by additional cold treatment, which is accomplished by storing the stecklings in cold storage. Transplants are replanted in seed fields before late March to allow transplants to have an adequate root system so that seed production is robust (Kockelmann and Meyer, 2006; Lehner, 2010; Loberg, 2010a) (Chastain, 2010).

Although more expensive, the steckling method of seed production provides an additional opportunity for seed companies to flexibly manage product inventory and allows for increased production when stock seed is limited. Historically, the vast majority of U.S. sugar beet seed was produced by the direct seeded method; however, an almost complete shift to the steckling method has occurred during the past decade.

(15) Fertilization

Fertilizer application is done according to soil analysis, taking into account the preceding crop and regional experiences in production (Kockelmann and Meyer, 2006). Beet seed crops require 125–150 percent of the fertilizer nutrients that root crops require (Desai, 2004). Generally, two applications of fertilizer are made during production of sugar beet seed crops. The first application is made prior to planting (mid-August to mid-September) and is incorporated into the seed bed (Chastain, 2010). This application consists of a balanced fertilizer containing nitrogen, phosphorus, potassium, sulfur, and sometimes boron. The second application is made during the spring, and is often split between early spring (late February) and late spring. The early spring application contains nitrogen, sulfur, and boron, whereas the late application only contains nitrogen. The availability of nutrients during seed development can affect seed quality and nitrogen availability can affect seed germination (Chastain, 2010). Lime is applied when pH declines below 6 (Chastain, 2005).

(16) Crop Rotation

Sugar beet crops grown for seed are usually grown on a 5- to 8-year rotation with other crops (American Crystal Sugar Company, 2010). Rotation crops for seed and steckling production are highly variable but suitable crops include cereals such as wheat, vegetable crops, and grasses (USDA-APHIS, 2011b); (Kockelmann and Meyer, 2006). WCBS requires a minimum of five crops between sugar beet seed crop rotations, and does not allow sugar beet seed producers to grow other *Beta* crops (Loberg, 2010b). Selection of crops preceding seed production must consider the following: (1) time of harvesting to allow for sufficient time for field preparation, (2) whether the crop might result in an increase in sugar beet pathogens, and (3) whether the crop might result in detrimental or prohibited herbicide residues (Kockelmann and Meyer, 2006).

(17) Disease Management

Similar to sugar beet root crops, sugar beet seed crops are often infested with a variety of diseases and pests. Seed fields must be protected systematically against pests and diseases to ensure healthy crops that produce hybrid monogerm seed of the high-quality demanded by root-crop growers (Kockelmann and Meyer, 2006). (See table 3–4 below for the typical pests or diseases that attack sugar beet seed plants and the timing and possible treatment methods.) Seeds are coated with fungicides and insecticides to minimize diseases and early infestations with aphids (Kockelmann and Meyer, 2006). One way to reduce infestations, especially aphid-transmitted viruses, is to ensure that steckling and seed production plots are isolated from other nearby *Beta* species (Kockelmann and Meyer, 2006). Control of diseases carried by aphids and other pests depends on effective control of insect pests acting as vectors. Diseased plants should be removed and destroyed (Desai, 2004).

(18) Post-harvest Processing

After harvest, the seed is pre-cleaned, a process in which seed is run across round-hole screens to remove sticks and other undesirable material (American Crystal Sugar Company, 2011). Pre-cleaned seed is generally shipped from the Willamette Valley to processing facilities elsewhere, depending on the seed company. As stated above in the seed production methods section for Betaseed and WCBS, both companies have strict protocols to track the seed from the field to the final delivery at the processing facility in order to minimize the possibility of accidental mixing with other seeds (Lehner, 2010; Loberg, 2010a). These procedures include grower training, careful monitoring of seed production, prohibiting seed growers from growing other *Beta* species, cleaning equipment before and after harvesting a sugar beet variety, and monitoring for and eliminating volunteer sugar beets after harvest (Lehner, 2010; Loberg, 2010a).

Table 3- 4. Plant Protection Measures in Sugar Beet Seed Crops

Pests or Diseases (Scientific Name)	Pests or Diseases (Common Name)	Time of Attack	Possible Treatment
Conorhynchus sp. *Lixus* sp. *Cassida* sp.	Sugar beet weevil Cabbage weevil Beet tortoise beetle	Bolting to beginning of flowering (end of April to end of May)	Synthetic pyrethroids
Aphis fabae *Myzus persicae*	Bean aphid Green peach aphid	Bolting to maturation (May to July)	Carbamates, synthetic pyrethroides
Peronospora farinose	Downy mildew	Vegetative development to beginning of bolting (April to beginning of May)	Acylalanine types
Alternaria sp. *Ramalaria beticola* *Phoma betae* *Uromyces betae*	Leaf spot disease Ramularia leaf spot Phoma leaf spot Sugar beet rust	Bolting (end of April to mid-May)	Triazoles, strobilurines, copper fungicides, thiocarbamates, dicarboximides
Cercospora beticola	Cercospora leaf spot	Beginning of flowering to end of flowering (end of May to June)	Triazoles, strobilurines
Erysiphe betae	Beet powdery mildew	Maturation (June to July)	Morpholines, strobilurines, sulfur

Source: (Kockelmann and Meyer, 2006).

Once the seeds reach the individual processing facilities, they are further processed. Steps include:

Cleaning and Polishing. Seeds are further cleaned to remove any remaining debris. Polishing machines remove the pericarp (the outside of the seed) to remove the natural chemical inhibitors that interfere with germination (Betaseed, 2011b; Holly Hybrids, 2007c; Kockelmann and Meyer, 2006).

Sizing. Seeds are then sorted by size and separated into different size products (small, medium, large, and extra large). Seed sizing separates out seed by thickness and diameter, while gravity tables separate by weight (Betaseed, 2011b; Holly Hybrids, 2007b).

Coating and Coloring. Seed is coated with a colored film enhanced with emergence enhancing fungicides that allow for easier visibility when planting. Coated seed is the irregular shaped seed evenly covered with a colorful film. Pelleted seed is the result of a specialized seed treatment process that creates a sphere out of the irregular shaped seed. Similar to coated seeds, pelleted seeds are also coated with fungicides and/or insecticides that might otherwise be phytotoxic to the seed (Holly Hybrids, 2007c). More germination tests are conducted after coatings are applied (Betaseed, 2011b; Holly Hybrids, 2007b).

Packaging. Seed is packaged and shipped to distribution warehouses (Betaseed, 2011b; Holly Hybrids, 2007a).

The post-harvest processing procedure takes from mid-September to the end of March. This process is time consuming because of the volume of seed and the degree of processing required prior to sale. Seed is sold concurrently with processing, with 90–95 percent of sales completed by the end of December or early January. The selling period for the remainder of the seed used for late planting and replants continues through early June. Seed shipments to the sugar cooperatives begin in January and can continue through June in some areas. Planting of the sugar beet root crop begins in March and continues through May, except for in the Imperial Valley where it is planted in September and October as described below (Meier, 2010).

(19) Testing for Low Level Presence

Sugar beet seed producers have a strong economic incentive to maintain genetically pure seed in both their breeder and commercial seed. While

sugar beet seed is not typically certified (Chastain, 2010); (Betaseed, 2011a), sugar beet seed companies utilize internal purity thresholds. Maintaining high levels of seed purity is important because impure seed lots will not produce plants with the desired yield, sucrose concentration, disease resistance, resistance to bolting, and other important agronomic traits as demanded by growers and grower cooperatives. As a result, impure seed lots will likely lead to grower dissatisfaction and ultimately loss of business to the seed producer.

As described previously, sugar beet root growers can only use seeds that have been approved by their grower cooperative variety trials. (See section III.B.1.b(3) for more information on variety trials.) Variety trials provide an opportunity to evaluate whether varieties have superior agronomic characteristics. They also provide an opportunity to evaluate whether individual seed lots contain visible offtypes and are unsuitable for sale because they do not meet the customer's needs for varietal purity.

As a result of customer demand for high levels of genetic purity, seed genotype is tested using a wide range of molecular markers at several stages during production. It is standard protocol to test for any low level presence (LLP) of all potential sources of undesired seeds or traits (Anfinrud, 2010). Depending on the specific tests done, this type of testing can detect whether varieties are the intended mix of genetic traits and can also detect if the H7-1 trait is present in conventional lines (Anfinrud, 2010). LLP of undesired seeds or traits is the result of unintended pollen movement between flowering fields of compatible *Beta* species and/or through admixtures of seeds (accidental mixing of seeds) if equipment is shared or if seeds are not properly isolated from each other during the post harvesting process. Seed producers are aware of these potential avenues for seed impurities and have preventative protocols in place to keep LLP to a minimum (Lehner, 2010; Loberg, 2010a). (For more information on sugar beet seed production and gene flow, see sections III.B.1.b and III.B.5, respectively.)

The main way to detect LLP is by testing the seeds at multiple points during the breeding and seed production process (Anfinrud, 2010). For example, breeder seed (the seed that is produced through plant breeding with the goal of developing lines to use to make hybrid seeds) is tested prior to distribution to seed producers (who will use the lines to make commercial hybrid seed) and it is tested again when the seed is planted for hybrid seed production. Additionally, hybrid seed is tested following harvest from commercial seed fields prior to storage and sale to sugar beet root growers (Anfinrud, 2010). Finally, genetic purity is assessed by growouts and visible inspection in variety trials as described above.

The testing described above is done either through molecular means by testing for DNA and proteins, or through grow-outs. Grow-outs (planting of a representative sample of seeds, followed by visual screening) are used to evaluate the amount of LLP in different seed crops. Morphological traits can be visually identified to detect the presence of table beet or Swiss chard LLP, help identify the potential source(s) of LLP, and determine the percent of LLP in the seed lot.

In terms of the H7-1 trait, LLP is assessed by using protein strip tests or Polymerase chain reaction (PCR) tests designed to detect the specific protein or DNA sequence of the H7-1 trait (Anfinrud, 2010). Additionally, since the H7-1 trait confers glyphosate tolerance, LLP of H7-1 sugar beet seeds in non-H7-1 sugar beet seeds can be examined by conducting spray tests. In spray tests, a representative sample of non-H7-1 sugar beet seeds are planted, germinated, grown, and then sprayed with glyphosate. The percentage of plants that survive the glyphosate reveal the percent of H7-1 sugar beet seeds in the seed lot as non-H7-1 sugar beet seeds will not survive the glyphosate application.

Seed companies test for all potential sources of LLP including the presence of regulated traits (GE traits that have not been deregulated but are being grown in test plots) and all currently deregulated traits (Anfinrud, 2010). The tolerance limits for regulated traits are zero percent. As described previously, the main U.S. sugar beet seed export market—Canada—has approved H7-1 sugar beet seed for planting.

For deregulated traits in conventional sugar beets, LLP tolerances are below 1 percent but companies prefer to keep levels below 0.1 percent to assure customers of seed with greater than 99 percent purity (Anfinrud, 2010). If seed lots exceed tolerance limits, they are not sold.

c. Root Crop

(1) Sugar Beet Root Production

The 10 primary sugar beet root production States, in order from most to least acres planted, are: Minnesota and North Dakota (57 percent of U.S. production), Idaho, Michigan, Nebraska, Montana, Colorado, Wyoming, California, and Oregon (USDA-ERS, 2010b). States with minor production (less than 1 percent of U.S. production) include Washington (about one tenth of 1 percent) and South Dakota (about one one-hundredth of 1 percent) (Stankiewicz Gabel, 2010)These States can be grouped into five regions as shown in figure 3–5 below. These regions include: Great Lakes – Michigan and Ontario; Midwest– Minnesota and Eastern North Dakota; Great Plains – Montana, Wyoming, Colorado, Nebraska, and western North Dakota; Northwest – Idaho, Oregon, and Washington; and Imperial Valley – California. These regions are described in greater detail below.

Great Lakes. Great Lakes sugar beet production, now entirely in Michigan in the United States, occurs in the flat area around Saginaw Bay. The Great Lakes region also includes Ohio, where sugar beets were last produced in 2004. Michigan sugar beets are generally not irrigated and

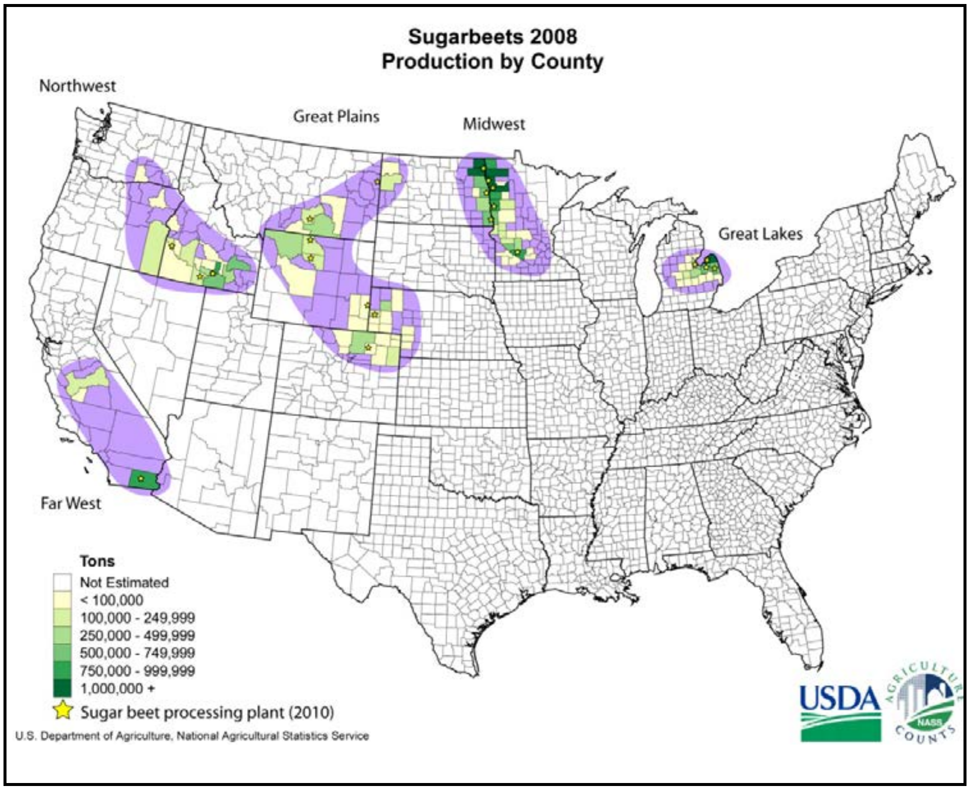

Figure 3- 6. Sugar beet production areas in 2008 and processing facilities, 2010.

Note: As shown in table 3–5, sugar beet production in California has decreased from 40,000 acres in 2008 to 25,000 acres in 2010–2011. The only area in California in which sugar beets are currently produced is in the Imperial Valley in Southern California. Source: (USDA-NASS, 2011c)

the varieties must have a high level of resistance to *Cercospora* leaf spot. Sugar beets are also grown in Ontario, Canada, and then trucked to Michigan for processing.

Midwest. The Midwest is the largest sugar beet production region in the United States, with the majority of this production in the Red River Valley. The Red River, flowing north into Canada and forming most of the North Dakota/Minnesota border, is all that remains of glacial Lake Agassiz, which dried up 10,000 years ago, leaving a broad, flat valley with highly fertile soils. The Minnesota River Valley, another broad, flat glacial valley that crosses southern Minnesota to the south of the Red River Valley, is also a large production area. Irrigation is uncommon in the Red River/Minnesota River Valleys (Ali, 2004). A moderate level of resistance to *Cercospora* leaf spot is required to achieve variety approval in the Red River Valley, while Southern Minnesota requires a high level of resistance. *Rhizomania* can also be a problem in the Midwest, but rarely as severe as in the irrigated regions to the west.

Great Plains. The Great Plains production region includes areas in northern Wyoming and southern Montana as well as western North Dakota. The major sugar beet growing areas in the Northern Great Plains are the sandy loam soils along the Yellowstone River and its tributaries (Mikkelson and Petrof, 1999). There is another, much smaller Great Plains production area along the border between Montana and North Dakota, in the valley of the Yellowstone River and its tributaries. The Southern Great Plains production sub-region includes growing areas in western Nebraska, southeastern Wyoming, and northeastern Colorado, primarily in the valley of the Platte River and its tributaries. All Great Plains sugar beet production requires irrigation (Mikkelson and Petrof, 1999; Thomas et al., 2000); (McDonald et al., 2003). The Great Plains region previously included New Mexico and Texas, where sugar beets were last harvested in 1997. Variety approval in the Great Plains region requires a moderate level of resistance to BCTV. Resistance to *Rhizomania* is also essential.

Northwest. Most production in the Northwest region is in the sandy loam soil of the Snake River Valley in Idaho. This area also requires irrigation (Traveller and Gallian, 2000). In addition, production occurs in south central Washington, east of the Cascade Mountains. Variety approval in the Northwest region requires a high level of resistance to BCTV. Resistance to *Rhizomania* is also essential.

Imperial Valley. The only remaining sugar beet root production in California is in the Imperial Valley at the far southern end of the State, where the only operating sugar processing plant in California is located. Production occurred in the Central Valley (near the middle of the State) through 2008; however, the last processing plant in this area closed that same year. As recently as the 1990s, nearly 30 percent of sugar beet root production was in the Central Valley; there were also small areas of production in coastal counties in the past (California Beet Growers Association, 1998). This area requires irrigation (Hembree, 2010).

See table 3–5 below for the number of acres planted by State and region for production years 2000–2010, and projected production areas for 2010–2011.

As sugar beet roots are primarily grown for the purpose of processing them into sugar, transportation costs of this bulky crop limit profitable production to about 100 miles from one of the 22 U.S. beet sugar processing facilities (Western Sugar Cooperative, 2006). As stated previously, figure 3–6 above is a map of U.S. sugar beet production, by county, from the U. S. Department of Agriculture (USDA) 2007 census data (most recent year available). Stars on the map indicate the location of sugar processing plants. For the 2009–2010 production year, approximately 1.18 million acres of sugar beets were planted (USDA-

NASS, 2010e). Data from selected years in table 3–5 are presented graphically by State in figure 3–7. This figure presents the acres of beets planted in each state at five year intervals and demonstrates that from 2000 to 2010 the relative sugar beet acreage between states is fairly consistent. The acreage from eastern and western North Dakota has been added to arrive at a total for the state.

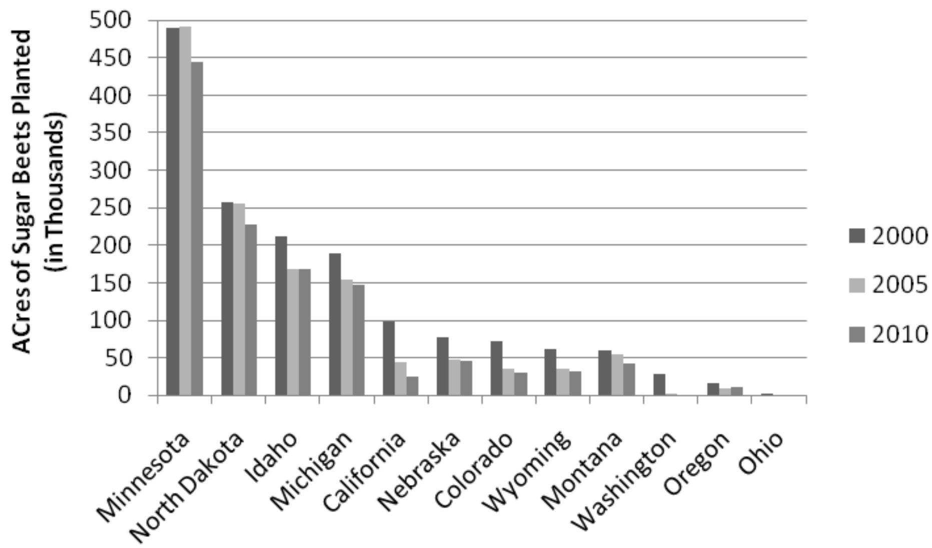

Figure 3- 7. Acres of sugar beets planted by State in 2000, 2005, and 2010. (Source: (USDA-NASS, 2011c).)

Data from selected years in table 3–5 are presented graphically by region in figure 3–8. Figure 3–8 shows that from 2000–2009, the Midwest region has consistently grown the largest acreage of sugar beets and the Imperial Valley has grown the smallest acreage.

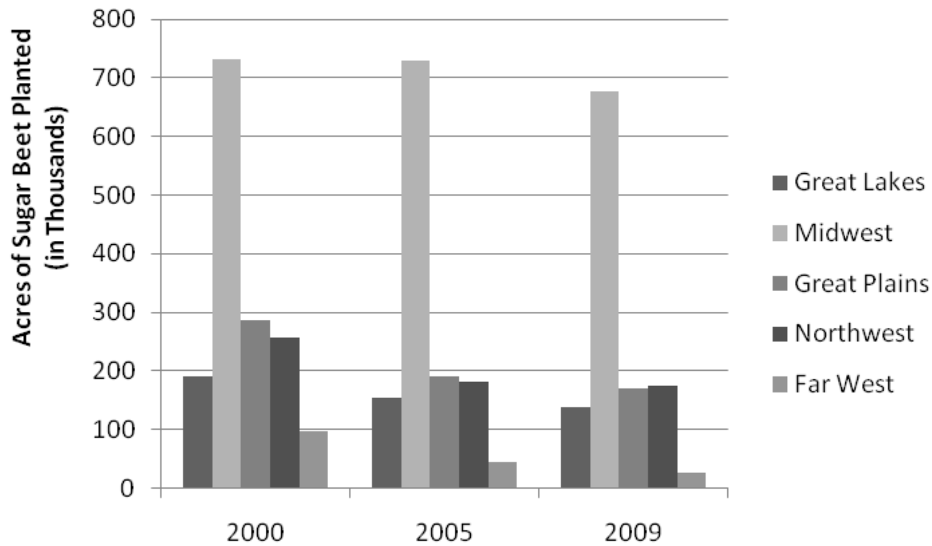

Figure 3- 8. Acres of sugar beets planted by region in 2000, 2005, and 2009. (Source: (USDA-NASS, 2011c).)

Table 3- 5. U.S. Sugar Beet Crop Area Planted by State and Region

State and Region	Year[1]										
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
	Area planted in 1,000 acres										
Great Lakes:											
Michigan	189.0	180.0	179.0	179.0	165.0	154.0	155.0	150.0	137.0	138.0	147.0
Ohio	1.2	0.8	1.9	2.0	1.9	0.0	0.0	0.0	0.0	0.0	0.0
Total	190.2	180.8	180.9	181.0	166.9	154.0	155.0	150.0	137.0	138.0	147.0
Midwest:											
Eastern North Dakota	242.4	245.7	249.1	243.3	240.7	239.3	245.7	237.4	199.7	213.2	172.6
Minnesota	490.0	468.0	505.0	492.0	486.0	491.0	504.0	486.0	440.0	464.0	449.0
Total	732.4	713.7	754.1	735.3	726.7	730.3	749.7	723.4	639.7	677.2	621.6
Great Plains:											
Colorado	71.5	41.5	43.9	28.6	36.0	36.4	42.1	32.0	33.8	35.1	28.9
Montana	60.7	57.4	58.0	51.7	53.7	53.9	53.6	47.5	31.7	38.4	42.6
Nebraska	78.2	48.6	57.0	45.3	49.8	48.4	61.3	47.5	45.2	53.0	50.0
Western North Dakota	15.6	15.3	15.9	15.7	15.3	15.7	15.3	14.6	8.3	11.8	44.4
Wyoming	61.0	48.5	40.0	35.0	36.4	36.2	42.8	30.8	29.7	32.4	30.5
Total	287.0	211.3	214.8	176.3	191.2	190.6	215.1	172.4	148.7	170.7	196.4
Northwest:											
Idaho	212.0	199.0	212.0	208.0	195.0	169.0	188.0	169.0	131.0	164.0	171.0
Oregon	16.2	11.9	11.3	10.0	12.9	9.8	13.1	12.0	6.7	10.6	10.3
Washington	28.4	7.2	4.0	4.0	3.8	1.7	2.0	2.0	1.6	0	0
Total	256.6	218.1	227.3	222.0	211.7	180.5	203.1	183.0	139.3	174.6	181.3
Imperial Valley:											
California	98.0	46.6	50.2	50.8	49.1	44.4	43.3	40.0	26.0	25.3	25.0
Total	98.0	46.6	50.2	50.8	49.1	44.4	43.3	40.0	26.0	25.3	25.0
U.S. Total	**1,564.2**	**1,370.5**	**1,427.3**	**1,365.4**	**1,345.6**	**1,299.8**	**1,366.2**	**1,268.8**	**1,090.7**	**1,185.8**	**1,171.4**

Source: (USDA-NASS, 2011c). (Note: the data reported in this table are survey data.)
[1] Relates to year of intended harvest except for overwintered spring-planted beets in California.
Abbreviations: N/A = Not available

At the county level, 2010 data from the U.S. Department of Agriculture's (USDA) Farm Service Agency (FSA) indicate that in the states that grow vegetable beet and sugar beet root crops (Minnesota, Michigan, Colorado, Oregon, Montana, California, North Dakota, Nebraska, Washington, and Idaho) fields of vegetable beet and sugar beet root crops can be found in adjacent fields. Where crops were adjacent, in no cases was one or more of the crops grown for seed. The distances between crops change each year as these crops are rotated. It should be noted that FSA data do not include hobby farmers or home gardeners. Additionally, pursuant to section 1619 of the Food, Conservation, and Energy Act of 2008, the data collected by FSA are generally protected from disclosure, unless the information is transformed into a statistical or aggregate form without naming any individual owners or specific data gathering site (Stankiewicz Gabel, 2010). For more information on Swiss chard and table beet vegetable production see sections III.B.2 and III.B.3, respectively.

(2) Planting/Harvesting Cycle/Bolting

Planting. Sugar beet growers choose seeds for planting based on a variety of criteria. Different growing regions have different needs and preferences in terms of disease resistance, pest resistance, and agronomic characteristics (Miller, 2010). See above for a description of some of the differences between the five growing areas. Additionally, as described earlier, growers may only grow approved varieties as determined by the local sugar beet cooperative, and growers can only deliver a specific quantity of sugar beets to a processor based on a pre-determined contract. Therefore, growers select approved seed varieties that they believe will provide the highest yield in their given location.

In addition to choice of variety, growers purchase seed by size and by shape. Size choices include small, medium, large, extra large, and pelleted. The size fractions result from the natural variability in a beet seed production field. Some growers have planting equipment (e.g., plate planters) that requires a specific seed size. In terms of shape, seed is either coated or pelleted. For more details on seed coatings, see section III.B.1.b(18) above.

With the exception of California, sugar beet root crops are typically planted in the early spring, between March and May, and harvested in fall, between September and November (McDonald et al., 2003); (Mikkelson and Petrof, 1999). Ensuring that the planting date falls within the early spring period is crucial for maximizing sugar beet yield (Yonts et al., 2005). In the Imperial Valley, this planting and harvesting cycle is reversed. In California's Imperial Valley, sugar beets are planted in September and October and harvested between April and early August (California Beet Growers Association, 1999); (Lilleboe, 2010).

The two key factors that affect planting date and sugar beet growth are soil temperature and soil moisture (Yonts et al., 2005). Soil temperature determines how fast sugar beets germinate and emerge, whereas soil moisture determines the quantity of plants that germinate and emerge. These factors combined with the number of acres available for planting determine the length of time needed for planting. For farms with fewer than 100 acres, growers need approximately 4 or 5 days to plant. For farms around 500 acres, planting typically takes about 2 weeks. This planting schedule is also dependent on the weather. For example, 0.50 inch of rain can delay the planting schedule by 1 or 2 days (Yonts et al., 2005).

Because it takes about two months for sugar beet foliage to cover the rows, early season weed control is a critical component of optimizing sugar beet production. Prior to the introduction of herbicide-tolerant sugar beet hybrids, sugar beet farmers typically employed a combination of tillage, hand labor, and chemical weed control, requiring multiple passes through the field with equipment. More information on other types of weed control can be found in section III.B.1.d.

Field selection and seedbed preparation are critical to establishing sugar beet crops. Objectives are to manage crop residues from previous rotations effectively, minimize erosion, improve soil structure to meet needs of the crop, and eliminate early season weeds (Cattanach et al., 1991).

Conventional sugar beet tillage (which can be performed in fall and spring) can help improve soil structure and eliminate early weeds (Häkansson et al., 2006). Conventional fall tillage is primary tillage (using moldboard plows or heavy disks) followed by one or more secondary tillage(s). Fall tillage systems should maintain enough residue on the soil surface to prevent erosion or be compatible with cover cropping systems for erosion control. Spring tillage should be kept to an absolute minimum (Cattanach et al., 1991). Objectives of spring tillage are to preserve seedbed moisture, maintain enough crop residues on the soil to stop erosion, and reduce the chance of wind damage to sugar beet seedlings as they emerge. The spring seedbed should be as level as possible and firm to well-packed to allow good seed-to-soil contact when planting. Common spring tillage tools are light harrows, multi-weeders, and combination Danish tine, harrow, rolling basket tillage tool systems. Spring tillage should be only 1–2 inches deep. Planting should be done as quickly as possible after spring tillage before seedbed drying can occur. Sugar beets are typically planted only 0.75–1.5 inches below the surface (Cattanach et al., 1991). Conventional tillage results in 100 percent soil disturbance (USDA-NRCS, 2008). Conventional tillage is typically used under conditions where weeds cannot be effectively controlled though chemical or other methods.

Sugar beets have also been successfully planted with no till, with strip tillage in previous crop residues, and other conservation tillage systems.

The USDA–ERS defines conservation tillage as cultural operations that maintain at least 30 percent cover of the soil surface by plant residue at the time of planting (Anderson and Magleby, 1997). Conservation tillage can encompass a range of management practices, from no-till to ridge- and strip-till cultivation to minimum tillage systems that restrict equipment traffic to dedicated zones. Special tillage field equipment can often perform the equivalent functions of several standard implements, reducing the necessity for multiple passes through the field. No till, as defined by USDA–ERS, leaves previous crop residue undisturbed from harvest to planting except for nutrient injection or narrow strips, and planting or drilling is accomplished in a narrow seedbed or slot (Anderson and Magleby, 1997). Weed control is primarily accomplished with crop protection products and cultivation may be used for emergency weed control.

Conservation tillage practices have seen increased use throughout the United States in recent years, especially in the Midwest where wind and water erosion are more problematic concerns. The percentage of conservation tillage managed land in the United States increased from 26 percent in 1990 to 41 percent in 2004 (Sandretto and Payne, 2006). The conservation tillage systems described above require more planning and better management than conventional tillage (Cattanach et al., 1991). The use of conventional tillage has decreased in sugar beets since the widespread adoption of H7-1 sugar beets in 2008. This is thought to be largely due to improved weed control through the use of glyphosate applications (NRC (National Research Council), 2010); (Duke and Cerdeira, 2007); (Wilson Jr, 2009). Some growers planting H7-1 sugar beets are now using conservation tillage practices, including strip tillage, which is described in more detail below.

Strip tillage involves tilling the soil in strips as opposed to the entire field. Strip tillage only disturbs approximately half of the inter-row area, creating strips 7–10 inches wide (with 22-inch row spacing) with the rest of the soil remaining undisturbed (Overstreet and Cattanach, 2008; USDA-NRCS, 2008) Strip tillage is associated with multiple environmental benefits that include: reduced wind erosion, less release of carbon into the air, maintaining higher levels of soil organic matter, conservation of soil moisture and shedding of excess water, and maintaining larger soil pores as compared to conventional tillage. Additionally, strip tillage has the agricultural benefits of resulting in yields equal to those of conventional tillage and cultivated strips warm up and dry faster than no-till systems in the spring, which is desirable for early-seeded crops (Franzen et al., 2008(Overstreet and Cattanach, 2008). Additional advantages include reduced fuel expenditures and expenses by eliminating some primary and secondary tillage; less labor, time, and machinery use; and the potential for conservation payments through Federal programs, such as the Natural Resources Conservation Service (NRCS), if certain criteria are met (Overstreet and Cattanach, 2008).

A national survey conducted in 2000 (the most recent survey of its kind) found that use of conventional tillage for sugar beet production varied by region (Ali, 2004). Conventional tillage (with and without moldboard plow) was used on 73 percent of farms in the Great Lakes, 64 percent of farms in the Midwest, 94 percent of farms in the Great Plains and 96 percent of farms in the Northwest (Ali, 2004). In Imperial Valley, all farms use conventional tillage. In the same survey, conservation tillage (reduced tillage and mulch tillage) were used on 28 percent of farms in the Great Lakes, 36 percent of farms in the Midwest, and on from 0.1 to less than 5 percent of farms in Great Plains and the Northwest (Ali, 2004). Additionally, the size of the farm (the number of acres of sugar beets planted) affected the type of tillage used in all regions. Twenty percent or greater of farms growing 150 acres or more practiced conservation tillage while conservation tillage was only practiced on 0.1 to less than 5 percent of farms growing 149 acres or less (Ali, 2004). Changes in tillage practices associated with H7-1 are described in greater detail below.

Sugar beet tillage practices in the Imperial Valley differ from those of the other four production areas due to differences in environmental conditions. Conventional tillage practiced prior to planting followed by between row cultivation(s), combined with band applications of an herbicide in the crop row, forms the mainstay of a sugar beet weed management program (Hembree, 2010). Hand hoeing is also used, but can be cost prohibitive (Hembree, 2010(Meister, 2004b). Pre-plant tillage involves building furrows for preplant irrigation, which is necessary in the Imperial Valley to manage salt buildup and supply water during the growing season (2011). Pre-irrigation is also frequently used to control weeds (Meister, 2004b). Fields are generally disked twice and pre-irrigated twice before planting; once through flat flood irrigation, which is followed by further disking, triplaning, then listing beds after which a second pre-irrigation occurs (Meister, 2004a, 2004b). After planting, crops are cultivated and irrigated (usually) 15–17 times during the growing period as needed (Meister, 2004b).

Several methods have traditionally been used to plant sugar beet root crops. Before the development of monogerm seed, many more plants per acre than desired would germinate and growers would thin the emerged plants until the target population was reached. Since the development of monogerm seeds, most growers “plant-to-stand,” meaning that growers plant roughly the amount of seeds they want to have germinate (CFIA, 2002). In the plant-to-stand method, the grower plants enough seeds per acre to compensate for those seeds that do not emerge (Yonts et al., 2005).

Growers generally count on 60–90 percent of planted sugar beets germinating (Cattanach et al., 1991; Hirnyck et al., 2005). This method decreases the need for thinning and the need for hand labor in sugar beet production. Most sugar beet seed currently planted in the United States, including H7-1 sugar beets, are planted using the plant-to-stand procedure (CFIA, 2002).

Changes in the production methods have occurred since the introduction of H7-1 sugar beets in 2005. Since 2008 when H7-1 varieties became widely available, growers have rapidly adopted H7-1 sugar beets with some areas, such as western North Dakota and eastern Montana, converting to nearly100 percent H7-1 varieties (Stachler et al., 2009a).

Herbicide usage patterns for sugar beets have changed with adoption of H7-1 sugar beets. Analysis of these differences is presented in section III.B.1.f. In brief, non-glyphosate herbicides usage decreased and glyphosate usage increased. Additionally, because weeds can be effectively controlled with glyphosate applications, H7-1 sugar beets usually require less tillage than conventional varieties (NRC (National Research Council), 2010); (Duke and Cerdeira, 2007); (Wilson Jr, 2009).

Differences in tillage, farm machinery use, and labor have been observed with the adoption of H7-1 sugar beets. These differences are described for each growing region below. However, not all differences are described for all regions due to lack of data. Additionally, as stated previously, H7-1 sugar beets have not been grown in the Imperial Valley region so that region is not discussed below.

- **Great Lakes.** Michigan Sugar Company recommends conservation tillage practices to help control erosion resulting from strong early spring winds in the Great Lakes region (Michigan Sugar Company, 2009). In 2010, nearly 25 percent of Michigan's sugar beet fields were planted into stale seedbeds (where fields are tilled in the fall and then left untouched the following spring when planting begins) as compared to less than 5 percent in 2006–2007 (Lilleboe, 2011). The introduction of H7-1 has allowed farmers the option of implementing varying methods of reduced tillage systems.

- **Midwest.** Recent studies by North Dakota State University (NDSU) have found that since the introduction of H7-1, strip tillage can be an effective, productive, and cost-saving tillage alternative to conventional full-width tillage for sugar beets, corn, and soybean production in the Red River Valley (Overstreet et al., 2011; Overstreet et al., 2009). Despite this, ridge tillage has only been used on a limited number of acres (less than 1000) in the region, strip tillage is only used on 1,800–2,500 acres in North Dakota and Minnesota combined, and no tillage is rarely used (Overstreet, 2011; Overstreet et al., 2010).

There have been changes in the amount of postemergence herbicide applications, however. For example, a member of the Minn-Dak Farmers Cooperative, who farms about 1,100 acres of sugar beets annually, has found that instead of three postemergence tillage trips across the fields, with H7-1 he now needs “little to no tillage postemergence” (Mauch, 2010). In Red River Valley trials, cultivation (conventional tillage) with H7-1 beets caused stand reduction and yield loss in two soil types (American Crystal Sugar Company, 2009).

In terms of the rotary hoe, row crop cultivation (mechanical weeding between rows), and hand weeding, a 2010 survey of sugar beet growers in Minnesota and North Dakota farms found changes in all of these weed control methods as compared to the survey conducted in 2000. The rotary hoe or harrow were only used on 2.8 percent of all acres of sugar beet production in 2010 when 93 percent of the sugar beets were H7-1 as compared to 62 percent of all acres in 2000.The main reason for the decline in the use of the rotary hoe or harrow is the introduction of H7-1 sugar beets (Stachler et al., 2011).

Row crop cultivation, including both the percentage of acres cultivated as well as the average number of times rows are cultivated, has also decreased with the adoption of H7-1 sugar beets. In 2010, 11 percent of H7-1 sugar beet acreage was row crop cultivated as compared to 74 percent of the conventional sugar beet acreage (Stachler et al., 2011).

In addition to the reduction in acres being row crop cultivated, the average number of row crop cultivations per field has decreased with the adoption of H7-1 sugar beets. On average, farmers growing H7-1 sugar beet row crop cultivated their fields once as compared to 1.5 cultivations reported by conventional sugar beet growers. In 2000, on average farmers growing conventional sugar beet row crop cultivated their fields twice (Stachler et al., 2011).When looking at the number of row crop cultivations per acre of sugar beets planted, the survey results show an even greater decrease in the amount of row crop cultivation with H7-1 sugar beets. The average number of row crop cultivations per cultivated acre for H7-1 sugar beets is 0.11 as compared to an average of 1.11 row crop cultivations for conventional sugar beets (Stachler et al., 2011).These data cannot be compared to the 2000 survey as the data were not collected in the 2000 survey (Dexter and Luecke, 2001).

Hand weeding has also decreased since the introduction of H7-1 sugar beets. The percentage of all sugar beet acres that were hand weeded was 1 percent in 2010 (93 percent H7-1 and 7 percent conventional) as compared to 25 percent in 2000 (100 percent conventional) (Stachler et al., 2011).

- **Great Plains.** In much of the Great Plains region, conventional sugar beets were cultivated using conservation tillage systems. However, deep tillage was utilized to improve drainage and help reduce the risk of soil borne diseases (mainly the beet necrotic yellow vein virus causing *Rhizomania*) (McDonald et al., 2003). A study conducted in Worland, Wyoming in 2007 compared H7-1 sugar beet production to similar, nearby fields of conventional sugar beet production (Kniss, 2010b). In crop tillage was reduced by 50 percent in the H7-1 sugar beet fields as compared to the conventional sugar beets (Kniss, 2010b). The same study found that none of the H7-1 sugar beet fields required hand weeding whereas all of the conventional sugar beet fields required hand weeding (Kniss, 2010b). Generally, farmers in the Great Plains have reported that strip tilling and H7-1 are compatible, resulting in reduced wind erosion and reduced irrigation requirements, along with fuel and time savings (Lilleboe, 2010).

- **Northwest.** As stated above, conventional tillage was used on 96 percent of farms in this region prior to glyphosate-tolerant sugar beets (Ali, 2004; Traveller and Gallian, 2000). Since the introduction of H7-1, some farmers have switched to strip tillage and have reported reduced fuel and labor costs and reduced wind erosion (Lilleboe, 2008). Researchers in Idaho found that while conventional tillage was necessary for weed control with conventional beets, the practice has little to no benefit with glyphosate-tolerant sugar beets (Miller and Miller, 2008).

Harvesting. Sugar beet processors ensure that beet harvesting is systematic and maintain stringent protocols. As previously stated, harvesting sugar beet crops occurs from September through November in the Great Lakes, Midwest, Great Plains, and the Northwest. According to Smith (2006), if crops actively grow during September and October, sugar content increases by 0.1 percent per day; however, growth can slow significantly by the third week in October as temperatures become more frigid. Delays in harvest caused by low or high temperatures or precipitation may occur (Smith, 2006). In the Imperial Valley, the harvest season typically stretches from April until early August to ensure that the sugar beet factory does not receive more beets than it can process in a 12-hour period (Lilleboe, 2010). During harvest, a mechanical defoliator is used to remove all the foliage from the beet root prior to lifting.

Growers are typically assigned to deliver a portion of their production, about 10 percent, during the pre-pile period. The pre-pile period allows the processing facility to begin manufacturing sugar prior to the full harvest. During the full harvest, growers transport sugar beets to multiple piling sites where they are stored outdoors prior to delivery at the processing facility. The processing facility hires truckers to move sugar beets from the piling sites to the processing facility as needed. In northern states, storage occurs during the winter where cold temperatures prevent the beets from spoiling. In California, harvest occurs during warm weather and beets cannot be stored. Instead they are harvested at a rate that meets the capacity of the processing plant.

Bolting. As described above, sugar beets are a biennial plant that produces an enlarged root the first year and then flowers in the second year. Nevertheless, sugar beets can bolt in their first year of production under certain environmental conditions, such as low temperatures (OECD (Organization for Economic Cooperation and Development)). Much effort has gone into breeding sugar beet varieties that do not bolt, and today's varieties bolt very infrequently, typically at a rate of about 0.01 percent or 4 plants per acre (Darmency et al., 2009; OECD (Organization for Economic Cooperation and Development)).

For bolting to occur, the plants first require exposure to temperatures below 40 °F in the 4- to 5-leaf stage followed by exposure to increasing day length (12 hours or more). Varieties differ in their sensitivity to bolting, with easy bolting lines requiring only a few to 1,000 hours of exposure to low temperatures, and bolting-resistant lines requiring 2,000 hours or more. Beets can devernalize, or return to the vegetative state, when exposed to high temperatures (OECD (Organization for Economic Cooperation and Development)).

Bolting is undesirable to sugar beet root producers as it depletes the root of sugars, making them woody and worthless. Additionally, the woody roots that result from bolters can damage harvesting and processing equipment (Ellstrand, 2003). As bolters are much taller than the rest of the crop, they are easily detected and can be removed by growers. The combination of the low frequency of bolting and the requirement of several weeks for the bolters to develop pollen-producing flowers allows for successful stewardship in minimizing pollen production from bolters.

As described above, in the Imperial Valley in California, sugar beets are planted in September, grow through the winter months, and are harvested the following April through July. Bolting occurs more frequently in the Imperial Valley than in the other U.S. sugar beet regions due to the growth through the winter which can expose plants to vernalization temperatures. Furthermore the longer growing season provides the plants the opportunity to flower before harvest(California Beet Growers Association, 1998(Bartsch et al., 2003). Consequently varieties with a high level of bolting resistance are used in California to minimize the frequency of bolting (Biancardi et al., 2010).

(3) Fertilization and pH Adjustment

Fertilization. Fertilization is important for sugar beet growth as it provides the necessary nutrients often lacking in soils. The three main nutrients typically applied to sugar beets are nitrogen, phosphate, and potassium (Jaggard and Qi, 2006).

Nitrogen is a key nutrient for sugar beets as it has both positive and negative impacts on yield, sugar content, and juice purity (Cariolle and Duval, 2006). For example, too little nitrogen can result in decreased sugar beet yield whereas too much nitrogen can injure beets, reduce sugar content, and affect juice purity. Therefore, sugar beet growers carefully control the amount of nitrogen available to their crops. This includes testing the soil for the amount of nitrogen present before adding fertilizer as few soils contain sufficient amounts of available nitrogen required for optimal growth. Additionally, the preceding crop grown in the rotation affects the amount of nitrogen available in the soil (different plant species increase or decrease the amount of available nitrogen in the soil depending on their specific biology)(Lamb et al., 2008); see Crop Rotation below for more information). Therefore, it is recommended that farmers check soil for the amount of nitrogen present and apply nitrogen fertilizer as required (SMBCB, 2011). Different sugar beet cooperatives may have specific recommendations as to application amount, timing of application, and method(s) of application depending on the amount present in the soil (SMBCB, 2011).

Phosphate and potassium are also important for sugar beet growth. Similar to nitrogen, different sugar beet cooperatives may also have specific recommendations as to application amounts, timing of application, and method(s) of application for these depending on the amount present in the soil (SMBCB, 2011).

In recent decades, the use of nitrogen-based fertilizer on sugar beet crops has declined globally. In France, fertilizer use on sugar beets has decreased from 180 pounds nitrogen per acre (lb N/acre) in 1977 to approximately 107 lb N/acre in 2003. During this time, sugar beet yields increased from 3 to 5 tons per acre (7 to 11 metric tons per hectare) (Cariolle and Duval, 2006) (Draycott and Martindale, 2000). Similar nitrogen-based fertilizer decreases have also occurred in Minnesota and eastern North Dakota over the past 25 years (Sims, 2009).

Cariolle and Duval (2006) suggest that the H7-1 sugar beet varieties are capable of both substantially higher yields and more efficient recovery and utilization of available nitrogen. To date, no conclusive studies demonstrate a significant difference between conventional sugar beets and H7-1 in nitrogen recovery and utilization.

The University of Minnesota recommends a one-third rate reduction for potassium and phosphorus when band applied on sugar beets. Band application is more commonly used with strip tillage than conventional tillage. No changes in nitrogen application are recommended with band application (Overstreet, 2011). Additionally, banding fertilizer with strip-tillage may provide enhanced plant availability of phosphorus in phosphorus-fixing soil environments, which are common in the Midwest region (Overstreet et al., 2010)

pH Adjustment. In addition to fertilization, sugar beets grow best in soils with pH levels near neutral to slightly alkaline (Kockelmann and Meyer, 2006). Soil amendment practices such as the application of lime and lime slurries on cropland can be useful in adjusting pH levels, where needed. Sugar beet factory "spent lime" is a byproduct of the sugar production process where juice that has been extracted from the pulp is mixed with lime and spread on farmland. The seven sugar beet processing factories in North Dakota and Minnesota produce approximately 500,000 tons (dry weight basis) of spent lime annually (Sims et al., 2005).

Generally, spent lime has about 86 percent of the acid neutralizing potential as an equivalent quantity of fresh lime (Sims et al., 2005). Most soils in eastern North Dakota and western and central Minnesota, however, are naturally alkaline. Although there are isolated areas where soil pH can be acidic and require lime application as part of the management practice, most of the soils in the sugar beet factory areas of North Dakota and Minnesota are at pH levels of 7.5 or above and do not require lime. Studies have shown that sugar beet spent lime application to both acidic and alkaline pH soils resulted in higher sugar beet yields, apparently due to the increased ability of sugar beets to resist the effect of *Aphanomycetes cochlioides* root rot as a result of the spent lime (Franzen, 2002); (Sims et al., 2005).

(4) Crop Rotation

Sugar beets are usually grown with other crops in 2- to 5-year rotations to improve the soil (by adding nutrients) and reduce the types and presence of weeds, diseases, and pests (Dewar and Cooke, 2006). The impact of certain soil borne diseases, nematodes (parasitic, microscopic worms) and weeds can be minimized through crop rotations (Mikkelson and Petrof, 1999); (Hirnyck et al., 2005; USDA-ERS, 2009b). For more information on pest management, see section III.B.1.c(5) below.

The length of rotations used and the type of crops that are rotated with sugar beets are summarized below on a regional basis. Rotation crops listed below are listed in random order and are not listed in order of rotation. In summary, the length of the rotation, often dictated by contract, and the type of crops that are rotated with sugar beets vary by region, and may include other glyphosate-tolerant crops, such as corn or soybeans.

However, in no regions are sugar beets rotated to other *Beta* crops such as Swiss chard or table beet.

Great Lakes. Sugar beets are usually grown in a 3–4 year rotation. Other crops grown in rotation typically include soybeans, corn, dry beans, and wheat (MSU (Michigan State University), 2011).

Midwest. Sugar beets are usually grown in a 3 or more year rotation, typically with small grain before sugar beets. Other crops grown in rotation include sweet corn, field corn, soybean and wheat (SMBSC (Southern Minnesota Beet Sugar Cooperative), 2010b).

Great Plains. Sugar beets are grown in 2–4 year rotations depending on the specific location within the region. Other crops grown in rotation include barley, dry beans, corn, and potato, and wheat.

Northwest. Sugar beets are grown in 2–5 year rotations depending on the specific location within the region. This region has the largest variety of crops grown in rotation; the crops grown in a given rotation are highly dependent on the location of the field within the region. Other crops grown in rotation include corn (sweet and field), wheat, barley, alfalfa, and dry beans.

Imperial Valley. Sugar beets are grown in 4–7 year rotations. Other crops grown in rotation include alfalfa, , Durum wheat, , vegetable crops such as lettuce, carrots, sweet corn, onions for dehydration, and Bermuda grass. In fields where sugar beets are harvested early-Sudan grass may be planted and grown till the fall(2011). Although the practice is discouraged, sugar beet farmers in the Imperial Valley may grow two consecutive crops of sugar beet. However, no more than 4 sugar beet crops can occur in a given 10 years (2011).

In general for all U.S. sugar beet crop rotations, yields and quality are highest when sugar beets follow barley or wheat in a crop rotation. Yields are also high when sugar beets follow corn, potatoes, or summer fallow in rotation; however, high levels of residual nitrogen in the soil can reduce sugar beet quality (Cattanach et al., 1991). According to the American Crystal Sugar Company, sugar beet cropping systems averaged over 2003–2007 had wheat preceding sugar beets in crop rotation for 1.75 million acres and barley was the preceding crop for 96,000 acres. Together, wheat and barley accounted for 83 percent of the total rotated acreage (Overstreet et al., 2008). Soybean (as the preceding crop) increased from 6,000 acres in 2003 to 20,400 acres in 2008 (Overstreet et al., 2008).

Table 3–6 below shows crops used in rotation after sugar beets and the percentage that are glyphosate-tolerant by state.

Key points from table 3–6 are:

- Crops that follow sugar beets in rotation include alfalfa, barley, corn, dry beans, onions for dehydration, carrots, lettuce, sweet corn, Bermuda grass, durum wheat, oats, potato, soybean, spring wheat, sugar beets, and winter wheat.
- Other *Beta* species, such as Swiss chard and table beet, are never planted in rotation after sugar beets.
- Corn is grown in rotation after sugar beets in all five regions.
- In all states that grow sugar beets with the exception of California, there is the potential for at least one Roundup Ready® crop in rotation besides sugar beets.
  - Michigan, Minnesota, and North Dakota potentially have two other Roundup Ready® crops in their rotations besides sugar beet.
  - Just under 50 percent of all land cultivated to sugar beet can be followed by a Roundup Ready® crop.

Table 3- 6. Rotational Crops Following U.S. Sugar Beet Production and an Estimation of Rotational Crops as an Estimation of Rotational Crops as Glyphosate-tolerant (GT) Crops[1]

A	B	C	D	E	F	G	H
State	Sugar Beet Acres[2]	Rotational Crop	Rotational Crop Acres[3]	% Rotational Crops[4]	% GT Crop Varieties[5]	GT Rotational Crop Acres[6]	% GT Crops in Rotation[7]
California[8]	**25,000**	Sudan grass	3,750	15	0	0	0
		Alfalfa	12,500	50	0	0	0
		Durum Wheat	7,500	30	0	0	0
		Sugar Beet	1,250	5	100	1,250	5
		Dehydrated onions, carrots, lettuce, sweet corn, or Bermuda grass	3,750	15	0	0	0
		TOTAL for California	25,000			1,250	5
Colorado	**29,000**	Barley	2,900	10	0	0	0
		Corn	20,300	70	61	12,383	43
		Dry Beans	4,350	15	0	0	0
		Potato	1,450	5	0	0	0
		TOTAL for Colorado	29,000			12,383	43
Idaho	**173,000**	Alfalfa	8,650	5	50	4,325	2.5
		Barley	25,950	15	0	0	0
		Corn	5,190	3	61	3,166	1.8
		Dry Beans	3,460	2	0	0	0
		Spring Wheat	129,750	75	0	0	0
		TOTAL for Idaho	173,000			7,491	4.3
Michigan	**147,000**	Corn	95,550	65	69	65,930	45
		Dry Beans	14,700	10	0	0	0
		Soybean	36,750	25	85	31,237	21
		TOTAL for Michigan	147,000			97,167	66

Table 3–6. (continued)

A	B	C	D	E	F	G	H
State	Sugar Beet Acres[2]	Rotational Crop	Rotational Crop Acres[3]	% Rotational Crops[4]	% GT Crop Varieties[5]	GT Rotational Crop Acres[6]	% GT Crops in Rotation[7]
Minnesota	**451,000**	Corn	67,650	15	74	50,061	11
		Barley	45,100	10	0	0	0
		Soybean	248,050	55	93	230,687	51
		Spring Wheat	90,200	20	0	0	0
		TOTAL for Minnesota	451,000			280,748	62
Montana	**43,000**	Barley	21,500	50	0	0	0
		Corn	10,750	25	61	6,558	15
		Dry Beans	6,450	15	0	0	0
		Spring Wheat	4,300	10	0	0	0
		TOTAL for Montana	43,000			6,558	15
North Dakota	**228,000**	Corn	34,200	15	71	24,282	11
		Durum Wheat	11,400	5	0	0	0
		Soybean	125,400	55	94	117,876	52
		Spring Wheat	57,000	25	0	0	0
		TOTAL for North Dakota	228,000			142,158	62
Nebraska	**50,000**	Corn	25,000	50	69	17,250	35
		Dry Beans	20,000	40	0	0	0
		Winter Wheat	5,000	10	0	0	0
		TOTAL for Nebraska	50,000			17,250	35
Wyoming	**3,000**	Barley	1,650	55	0	0	0
		Corn	750	25	61	458	15
		Sugar beet	300	10	100	300	10
		Dry Beans	300	10	0		0
		TOTAL for Wyoming	3,000			758	25

Table 3–6. (continued)

A	B	C	D	E	F	G	H
State	Sugar Beet Acres[2]	Rotational Crop	Rotational Crop Acres[3]	% Rotational Crops[4]	% GT Crop Varieties[5]	GT Rotational Crop Acres[6]	% GT Crops in Rotation[7]
Total	**1,177,000**	Alfalfa	21,150	1.8		4,325	0.4
		Barley	97,100	9.06		0	0
		Corn	259,390	22.58		180,088	16
		Dry Beans	49,260	4.68		0	0
		Durum Wheat	18,900	1.69		0	0
		Dehydrated onions, carrots, lettuce, sweet corn, or Bermuda grass	3,750	0.48		0	0
		Potato	1,450	0.13		0	0
		Sugar beet	1,550	0.03		1,550	<0.1
		Soybean	410,200	35.70		379,800	33
		Spring Wheat	281,250	24.48		0	0
		Winter Wheat	5,000	0.44		0	0
		OVERALL TOTAL	**1,149,000**			**565,763**	**49**

[1] USDA–NASS (see footnote 5 below) data included herbicide-tolerant crop acres but not specifically glyphosate-tolerant crop acres. As a conservative estimate, these data were used to represent glyphosate-tolerant crops.

[2] Sugar beet acres (Column B) obtained from the USDA–NASS (2010a).

[3] The rotational crop acres (Column D) were calculated by multiplying the % Rotational Crops (Column E) by the Sugar Beet Acres (Column B).

[4] The % Rotational Crops (Column E) that follow sugar beets is based on communications from individual local experts, i.e., university agronomists, USDA–ARS and Monsanto field personnel as discussed in Table VII-13 of USDA Petition 03-323-01p (Schneider and Strittmatter, 2003)

[5] The % GT Crop Varieties (Column F) was obtained from the USDA–NASS (2010d). For corn in MT, WY, CO, ID we used the average value for “other states” as individual state adoption rates were not available. For alfalfa, we used an estimated adoption rate of 50% for ID and 0% for the Imperial Valley, CA based on industry projection. (USDA–APHIS 2010b).

[6] The GT Rotational Crop Acres (Column G) was calculated by multiplying the % GT Crop Varieties (Column F) by the Rotational Crop Acres (Column D).

[7] The % GT Crops in Rotation (Column H) was calculated by dividing the GT Rotational Crop Acres (Column G) by the Rotational Crop Acres (Column D).

[8] In CA, sugar beets are planted in September and harvested from April to July. Sudan grass may be planted in the spring in those fields where sugar beet is harvested early (April-May) and harvested in the summer and fall. The remaining rotation crops (totaling 100%) are planted in the fall.

(5) Pest Management

Disease. Sugar beet yield loss results from a variety of causes, including seedling blights, root rots, and foliar diseases. The primary diseases that affect U.S. sugar beet production are *Cercospora* leaf spot, *Rhizoctonia* root rot, *Aphanomyces* root rot, rhizomonia, and BCTV. The level of resistance required for each disease varies by production region and the disease resistance profile is what distinguishes the regional varieties. For additional description of which diseases are associated with each region please, see section III.B.1.c(1).

The most common sugar beet seedling pathogens are soil-borne fungi. Of particular concern are *Aphanomyces cochlioides* and *Rhizoctonia solani,* as well as several *Pythium* and other species (Dewar and Cooke, 2006). These fungi, particularly *A. cochliodies* and *R. solani* , are the primary fungi that cause root rots. Many of these fungi survive in the soil for extended periods of time and can cause symptoms ranging from minor lesions to complete destruction of the root by dry or wet rots (Cattanach et al., 1991). Control methods for severe root rot and seedling disease problems caused by these fungi include varietal resistance, fumigation, crop rotations, seed treatments, and fungicide application. Commercial sugar beet seed is usually pretreated with one or more protectant fungicides (Cattanach et al., 1991).

Surveys conducted by NDSU in September, 2009 stated that *Rhizotonia/Aphanmyces* were consistently shown to be growers' most serious production problem at approximately 30 percent of all surveyed farms in Montana, North Dakota, and Minnesota (Stachler et al., 2009a; Stachler et al., 2009b).

Cercospora leafspot, caused by the fungus *Cercospora beticola,* is the most serious foliar disease for the sugar beet crop in the north-central United States. A moderate to severe outbreak can cause losses of recoverable sucrose per acre of 30 percent or greater (Cattanach et al., 1991). Crop rotation is one of the best methods to control the disease using at least a 3-year rotation between sugar beet crops in order to reduce the disease inoculum (Cattanach et al., 1991). Fungicides can also be applied, such as triphenyl tin hydroxide (most effective) and copper fungicides. *Cercospora* is not a problem for sugar beet crops in the Imperial Valley region (2011).

Maintaining proper crop hygiene is important to avoid or ameliorate potential disease problems. This includes eliminating overwintering sites for pests and sources of disease. In addition, the removal of infested residues of previous crops, the eradication of weed hosts between beet crops, and the removal of disease sources are important (Dewar and Cooke, 2006).

Table 3- 7. Fungicides Used in Sugar Beet Production

Active Ingredient	Percent Total Sugar Beet Acres Treated (%)	Number of Applications	Amount per Application (lb a.i./acre)	Amount per Year (lb a.i./acre)	U.S. Total in 2000 (lb a.i./year)	Total Acres Treated
Azoxystrobin	–	1.0	0.120	0.120	–	–
Benomyl	4	1.0	0.240	0.250	15	62,400
Mancozeb	4	1.0	1.440	1.530	99	62,400
Maneb	1	1.2	1.290	1.640	32	15,600
Sulfur	11	1.8	25.130	45.700	7,595	171,600
Thiophanate , methyl	6	1.1	0.230	0.260	25	93,600
Triadimefon	–	1.0	0.230	0.240	1	–
Triazole	55	1.6	0.100	0.160	136	858,000
Triphenyltin hydrox.	44	1.4	0.230	0.340	238	686,400

Source: (USDA-NASS, 2010d).

Table 3–7 below provides a complete list of fungicides used for U.S. sugar beet root production in 2000 (the most recent year of National Agricultural Statistics Service (NASS) data). The proportion of total sugar beet acres treated (as percent of total sugar beet acres), number of applications, and amount of the fungicide active ingredient (a.i.) are also shown. Overall, fungicide options and applications vary regionally according to disease pressure and needs, but APHIS expects that they do not vary between conventional sugar beets and H7-1 sugar beets.

Insects. Insects are another pest that can reduce sugar beet yields. The sugar beet root maggot (*Tetanops myopaeformis*) is the most destructive insect pest of sugar beets in Minnesota, North Dakota, and Idaho and secondarily in Nebraska, Colorado, Montana, and Wyoming. Approximately 49 percent of U.S. sugar beet acreage is infested at economic levels (USDA-APHIS, 2011b). The organophosphates terbufos, phorate, and chlorpyrifos, and the carbamate aldicarb are the mainstay control insecticides for the root maggot and are applied at planting because the insect larvae are underground (USDA–ARS, 2010). Other destructive insects found in the United States include: false root knot nematodes (*Nacobbus aberrans*), beet cyst nematode (*Heterodera schachtii*), symphylids (*Scutigerella immaculata*), millipedes (*Blaniulus guttulatus* and *Brachidesmus superus*), wireworms (*Agriotes lineatus*), cutworms and other caterpillars (*Agrotis* spp., *Euxoa* spp., *Peridroma saucia*, *Crymodes devastator*, *Amathes cnigrum*, *Feltia ducens*), root aphids (*Pemphigus* spp.), and lygus bugs (*Lygus elisus*, *L. hesperus*) (Dewar and Cooke, 2006).

Table 3–8 below lists the insecticides used in sugar beet production, from the most recent (2000) NASS data. (Note that the aldicarb registrant recently agreed to a voluntary cancellation of this insecticide, 75 FR 194 (October 7, 2010)). The percentages of total sugar beet acres treated, number of applications, and amount of a.i. are also shown. Overall, insecticide options and applications can vary regionally according to insect pressure and needs, but APHIS expects that they do not vary between conventional sugar beets and H7-1 sugar beets.

Table 3- 8. Insecticides Used in Sugar Beet Production

Active Ingredient	Percent Total Sugar Beet Acres Treated (%)	Number of Applications	Amount per Application (lb a.i./acre)	Amount per Year (lb a.i./acre)	U.S. Total in 2000 (lb a.i./year)	Total Acres Treated
Aldicarb[1]	7	1	1.840	1.870	198	109,494
Carbofuran	–	1	0.54	0.54	4	0
Chlorpyrifos	12	1.2	0.92	1.11	204	187,704
Diazinon	2	2.4	0.73	1.78	67	31,284
Esfenvalerate	5	1.9	0.02	0.05	3	78,210
Methomyl	2	1.1	0.46	0.52	17	31,284
Phorate	2	1	1.31	1.31	45	31,284
Terbufos	41	1	1.81	1.82	1,168	641,322

Source: (USDA-NASS, 2010d).
[1] The registrant recently requested a voluntary cancellation of all products containing Aldicarb.

d. Weeds in Sugar Beet Seed and Root Crops

(1) Weed Overview

The sugar beet plant is a poor competitor against weeds, especially from emergence until sugar beet canopy closure. Emerging sugar beets are small, lack vigor, and require approximately 2 months before canopy closure. Thus, weeds have ample opportunity to become established and compete. To avoid yield loss from weed competition, weeds need to be controlled during the 8 weeks after sugar beets emerge and weed control needs to be maintained throughout the season (Cattanach et al., 1991) (California Beet Growers Association, 1999); (McDonald et al., 2003); (Mikkelson and Petrof, 1999). If the crop stands are poor or under stress from pests or lack of nutrients, sugar beets may not be able to suppress late emerging weeds, and additional weed control measures may be necessary (Wilson et al., 2001).

Some disadvantages of weeds in crops include (Hirnyck et al., 2005; Stachler and Zollinger, 2009):

- Crop yield is reduced. Uncontrolled weeds that emerge with the crop can cause from 30- to 100-percent yield losses (California Beet Growers Association, 1999); Sprague, 2007).
- Weeds may lower the sugar content of the harvested product (Mesbah et al., 1994).
- Weed seed produced in any given year increases future weed problems.
- Root crops are subject to harvesting problems (smaller beets missed, harvesting equipment damage).
- Processors pay growers less for the harvested sugar beet crop when weeds are present
- Weeds can act as alternate hosts for insect pests and plant diseases.
- Increased tillage may be needed for weed control.
- Weeds that make it into the beet pile after root harvest can restrict air movement through the pile, generate and trap heat, and contribute to storage rot.
- Sugar beet seed crops must be free of noxious weed seed and have limited other weed seed (e.g., 0.10 percent weed seed in stock seed and certified seed) (OSCS (Oregon Seed Certification Service), 1993). Weeds in sugar beet seed crops can cause the seed lot to fail certification and not be useable for commercial sugar beet planting.

Though a detriment to the grower, weeds in agricultural fields can provide habitat and nourishment for insects and animals and in this way promote biodiversity (May and Wilson, 2006; Strandberg et al., 2005) (Graef et al., 2010). Weeds are classified as annual or perennial. An annual is a plant that completes its lifecycle in one year or less and reproduces only by seed. Perennials are plants that live for more than 2 years. Weeds are also classified as broadleaf (dicots) or grass (monocots). Weeds can reproduce by seeds, rhizomes (underground creeping stems), or other underground parts.

Some of the more important weeds in sugar beet are briefly described below (USDA-APHIS, 2011b):

- **Kochia** (*Kochia scoparia*), an annual broadleaf plant, is a member of the goosefoot family, the same family as sugar beets.
- **Pigweed** (*Amaranthus* spp.) is a broadleaf annual that is a weed problem in many crops. There are several species, with redroot pigweed being the most common (Hembree, 2005a).
- **Common lambsquarter** (*Chenopodium album*) is an annual broadleaf in the same family as sugar beets. With its rapid growth and large size, it quickly removes soil moisture (McDonald et al., 2003).
- **Nightshade** (*Solanum* spp.) is a broadleaf annual that grows 6–24 inches tall (McDonald et al., 2003).

- **Common mallow** (*Malva neglecta*) and **cocklebur** (*Xanthium strumarium*) are widespread broadleaf annuals.
- **Barnyardgrass** (*Enchinochloa crus-galli)*, **foxtail** (*Setaria*), **wild millet** (*Panicum miliaceum*), and **wild oats** (*Avena fatua*) are annual grasses.
- **Sowthistle** (*Sonchus* spp.) is a perennial plant that reaches a height of 3–7 feet and reproduces by seed and underground roots.
- **Canada thistle** (*Cirsium arvense*) is a perennial that reproduces by seeds and underground roots and grows 2–5 feet tall. The roots extend several feet deep and some distance horizontally. Canada thistle is the most prevalent and persistent nongrass weed in Minnesota and is the number one noxious weed in Colorado. It is a problem weed in all growing regions (Colorado Department of Agriculture, Undated; Durgan, 1998; McDonald et al., 2003).
- **Nutsedges** (*Cyperus* spp.) are among the most problematic weeds of agriculture in temperate to tropical zones worldwide. They are difficult to control, often form dense colonies, and can greatly reduce crop yields. Nutsedges reproduce primarily by rhizomes (Hembree, 2005).
- **Dodder** (*Cuscuta* spp.) is an annual parasitic weed that grows only by penetrating tissues of host plants to obtain water and nutrients. Each plant produces thousands of seeds that can remain dormant in the soil for years (Hembree, 2005).
- **Velvetleaf** (*Abutilon theophrasti*) is a broadleaf annual that grows 2–7 feet tall (McDonald et al., 2003).
- **Ragweed** (Ambrosia spp.) are annual broad leaf weeds that can be very competitive with crops.
- **Wild beet** *(Beta macrocarpa*) is an annual plant that is a problem weed only in the Imperial Valley. It is difficult to control due to its morphological and physiological resemblance to sugar beet.

An important concept in weed control is the seed bank, which is the reservoir of seeds that are in the soil and have the potential to germinate. Agricultural soils contain reservoirs of weed seeds ranging from 4,100 to 137,700 seeds per square meter of soil (May and Wilson, 2006). Climate, soil characteristics, cultivation, crop selection, and weed management practices affect the seed bank composition and size (May and Wilson, 2006).

(2) Weed Management Nonchemical Methods

In addition to crop rotation and tillage, growers of conventional sugar beets have other nonherbicide means to manage weeds, such as cover crops and hand hoeing. Narrow row widths (22–24 inches) are commonly used for quicker canopy closure (Cattanach et al., 1991; McDonald et al., 2003); (Mikkelson and Petrof, 1999). Growers also use weed-free seed. Additionally, nearly all growers scout their fields for weeds (Ali, 2004).

Rotation. Weed control should be considered over the entire rotation to keep weed seed banks in check year to year (May and Wilson, 2006). Although traditional fallow (land is rested for an entire year) is seldom practiced for economic reasons, inter-crop fallow (land is rested through fall and winter) is more common (May and Wilson, 2006). For inter-crop fallow, cultivation can be used to control weeds that germinate in the fall and winter.

The Southern Minnesota Sugar Beet Cooperative (SMSBC) indicates that for many years sugar beet rotation after soybean or wheat was not recommended, so sugar beets most commonly followed field corn. However, sugar beet production following soybeans has recently become more popular due to the easier management of residue following soybeans, compared to corn, and introduction of sugar beet varieties with greater rhizoctonia tolerance (pathogenic fungi). Nutrient management following soybeans is easier than corn as well. More recent data indicate that the ranking of crops to produce before sugar beets is wheat, sweetcorn, soybean, then field corn (SMBSC (Southern Minnesota Beet Sugar Cooperative), 2010b). SMSBC now recommends that, when possible, sugar beet production should follow wheat (SMBSC (Southern Minnesota Beet Sugar Cooperative), 2010b). For more information on typical rotations in the various regions see section III.B.1.c(4)

Although rotation is a nonchemical method for controlling weeds, rotation is often used combined with herbicides. Rotations are useful for weed control because different crops are sensitive and resistant to different sets of herbicides, so herbicide selection can vary from year to year and therefore control a wider variety of weeds (May and Wilson, 2006). Also, crop rotation presents the opportunity to vary cultural practices between crops such as planting date, harvest date, tillage practices, etc. This variation of cultural practices leads to weed shifts which help to minimize the dominance of a particular weed species from year to year. Both corn and soybean have Roundup Ready® varieties that are in widespread use. This means that when sugar beets are in rotation with corn or soybean, that most likely the corn and soybean in rotation are also Roundup Ready®.

In general for all U.S. sugar beet crop rotations, yields and quality are highest when sugar beets follow barley or wheat in a crop rotation. Based on information from the American Crystal Sugar database of sugarbeet cropping systems averaged over years 2003-2007, wheat preceded sugarbeet in the crop rotation on 1.75 million acres and barley was the preceding crop for 96,000 acres (Overstreet et al., 2008). Of all the preceding crops represented in the database, wheat and barley accounted for 83% of the total acreage (Overstreet et al., 2008). So whereas as much as 2/3 of the crop that precedes sugar beet in Minnesota and North Dakota may be Roundup Ready® based on the adoption rates of Roundup Ready® crops and total acreages planted in these states(see table 3-6), in practice a much lower percentage (<20%) of the preceding crop is expected to be Roundup Ready®.

Mechanical Cultivation (Tillage). Tillage in general and with respect to regional practices is discussed in section III.B.1.c(2)

One of the main purposes of tillage is weed control. One type of tillage is stale seedbed, which is a technique where a field is tilled well before the crop is sown to encourage weed seed germination and again just prior to sowing the crop (May and Wilson, 2006). In the United States and northern Europe, sugar beets have better yield if they are sowed as early as possible, but not before the risk of cold periods that could kill seedlings or induce bolting. In countries where there is less pressure to sow early or organic farming is practiced, stale seedbed can be used to control weeds (May and Wilson, 2006).

Tractor hoes are used to control weeds between sugar beet rows. Some examples include (May and Wilson, 2006):

- Where herbicides have been sprayed in bands over the rows, and weeds between the rows still need to be controlled;
- To replace a late herbicide application, especially when weed infestations are low or some weeds are too far advanced to be properly controlled by the herbicide; and
- To control difficult weeds such as weed beet and perennials.

Hand Hoeing. Hand hoeing for weed removal is associated with higher yields (Odero et al., 2008). Stachler and Zollinger (2009) provide advantages of hand weeding:

- Hand weeding will reduce losses due to weed competition. Losses due to weed competition are proportional to weed density. At some low weed density, the value of the increase in yield from weed control will be equal to the cost of the weed control. This economic threshold is very difficult to predict because many factors impact yield loss due to weed competition. Weed density, weed species biology, date of crop and weed emergence, rainfall, soil temperature, row width, date of weed removal, previous herbicide use, and the planned method of weed control, can all affect the economic threshold for the use of hand hoeing to control weeds in sugar beets. However, competition experiments in sugar beets suggest that one or fewer weeds per 100 feet of sugar beet row will be less than the economic threshold regardless of other factors. The economic threshold weed density often will be greater than one weed per 100-foot row but a lower economic threshold is unlikely.

- Hand weeding will prevent weed seed production and reduce weed densities in the future. Hand weeding densities of weeds that are below the economic threshold can be beneficial if the field has a relatively low level of weed seed in the soil. However, a few more weed seeds produced in a field already loaded with seed would be of little consequence.

- Hand weeding can prevent seed production by weeds that are resistant to the applied herbicides and slow the buildup of herbicide-resistant weeds.

- Stachler and Zollinger (Stachler and Zollinger, 2009) also provide a formula developed by Dr. Steve Miller at the University of Wyoming for calculating labor hours for hand weeding. The time for hand weeding in hours per acre equals 2 hours per acre for walking and looking plus 0.5 hour per 1,000 weeds. The formula was developed using student labor, so skilled labor might work faster. Hand weeding also results in removal of some sugar beet plants depending on weed density. For example, starting with 200 weeds and 150 sugar beets in a 100-foot row will result in 125 sugar beet plants per 100-foot row remaining after hoeing (Stachler and Zollinger, 2009). Hoeing weed populations greater than 200 weeds per 100-foot row would result in less than desirable sugar beet density (Stachler and Zollinger, 2009).

Hand weeding is used to control bolters and, in locations where they occur, wild beets (e.g., California, Europe). If plants begin setting seed, the hand-hoed plants must be carried from the field to limit the spread of weed seed (May and Wilson, 2006).

Cover Crops. In minimal or no-till crop systems with cover crops, mechanical cultivation may not be needed for weed control and herbicide spraying can be minimized. Organic mulches (green manure) form living, dying, or killed covers that hold soil, stop soil splashing, and protect crops from injury. Spraying and cultivation passes can damage the leaf cuticle (waxy covering on the leaf) and make the crop more susceptible to infection (Clark, 2007). Dusty and dirt splashed leaves can protect weeds from herbicides (Stachler, 2009).

The organic matter in cover crops stimulates soil biological activity. Soil organic matter and cover crop residues improve soil physical properties, which results in (Clark, 2007):

- greater water infiltration, due to direct effects of the residue coverage or to changes in soil structure;
- protecting the soil surface by dissipating raindrop energy and reducing the velocity of water moving over the soil;
- less surface sealing, because residue intercepts rain drops, reducing the dispersal of clay particles during a rainfall or irrigation event;
- greater soil aggregation or tilth, resulting in better nutrient and moisture management; and
- greater soil porosity, due to the macropores that are formed as roots die and decompose.

Cover crops reduce soil erosion and protect small sugar beet plants from wind damage. They compete with weeds and with the crop. Cover crops can also provide other benefits such as cutting fertilizer costs, reducing the need for herbicides and other pesticides, improving yields by enhancing soil health, preventing soil erosion, conserving soil moisture, protecting water quality, and helping safeguard personal health through reduced herbicide use (Clark, 2007).

Barley is an inexpensive, easy-to-kill companion crop that can protect sugar beet seedlings during their first 2 months while also serving as a soil protectant during drought periods (Clark, 2007). A low-density barley cover crop is easy to stunt or kill a month after planting using the combination of herbicides and crop oil that are normally used in conventional sugar beets for weed control. Alternatively, a single application of an herbicide to control grasses can kill the barley cover crop (Clark, 2007). In H7-1 sugar beets, glyphosate can be used to kill cover crops.

Stachler and Zollinger (Stachler and Zollinger, 2009) provide a summary of living cover crops for North Dakota and Minnesota. Winter rye is more winter hardy than winter wheat, so it is a better choice for fall seeding cover crops in northern areas. Spring-seeded cover crops such as barley and oats are seeded within a few hours to days of the sugar beet crop. Winter rye growing near the sugar beet row needs to be removed (e.g., by band application of glyphosate) to prevent yield losses in sugar beets. However, winter rye growing between the rows can be left until the sugar beet plants are large enough to withstand wind without being damaged. Spring-seeded barley growing near the sugar beet rows should be controlled by the time barley has three leaves. In addition, barley between rows should be removed by the time sugar beets have four leaves and the barley has four or five leaves. Postemergence grass herbicides or cultivation (tillage) can be used to remove winter rye or barley between rows (Stachler and Zollinger, 2009).

In Michigan, red clover frost-seeded into winter wheat suppressed common ragweed growth through wheat harvest and into the summer.

The red clover did not provide complete ragweed control, but there was no adverse effect on wheat yield. A grain crop plus red clover cover crop combination often follows corn, but also can follow sugar beets (Clark, 2007).

Rye, a winter annual grain, is perhaps the most versatile cover crop used in the continental United States. For much of the continental United States, cereal rye is the best choice for catching nutrients after a summer crop (Clark, 2007). Rye is cold tolerant so it continues to grow in late fall or where winters are mild, through the winter months. Rye can put down roots to a depth of 3 feet or more. Conventional management of rye involves removal by disk or broad-spectrum herbicides such as paraquat or glyphosate. Rye can also be killed with a roller, providing an acceptable level of weed control for the subsequent crop. When properly managed under conservation tillage, rye has the ability to reduce soil-borne diseases, nematodes, and weeds. Rye is also not a host for root-knot nematodes or soil-borne diseases. It produces significant biomass that smothers weeds when it is left on the surface and also controls weeds allelopathically through natural weed-suppressing compounds. Fall-planted rye works well in reducing broadleaf weeds in all cash crops that follow. Rye does not control weedy grasses (Clark, 2007). Because sugar beets are a broadleaf crop, weedy grasses are easier to control than broadleaf weeds.

Trap crops are specially bred varieties of radish (*Raphanus sativus*) and mustard (*Sinapsis alba*), which have the potential for controlling the sugar beet cyst nematode (*Heterodera schachtii*). Trap crops, like a true host, stimulate eggs of the sugar beet cyst nematode to hatch, but do not allow them to reproduce. With proper use and management, trap crops can reduce soil populations of the sugar beet cyst nematode and reduce or eliminate nematicide use (Koch et al., 1996).

Cover crops are not typically used in California sugar beet farming (2011).

(3) Weed Management for Conventional Varieties (Non-GE) – Chemical Methods

Herbicides are used by virtually all sugar beet growers. In 2000, approximately 98 percent of planted acres received one or more herbicide applications (Ali, 2004). Prior to adoption of H7-1 sugar beets, growers regularly used multiple chemical herbicides to control weeds (Cole, 2010); (Kniss, 2010a; Wilson, 2010). Herbicides can be applied before the crop emerges from the ground (preemergence) or after (postemergence). Preplant incorporated (PPI) herbicides can be mixed in with the soil before planting. In selecting an herbicide and application method, a grower must consider, among other factors, whether an herbicide may be used on the crop because it has been registered by the EPA, the potential adverse effects on the crop, residual effects that can limit crops that can be grown in rotation, effectiveness on expected weeds, and cost. Herbicide use is not regulated by APHIS but regulated by U.S. Environmental Protection Agency (EPA) under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and its amendments (Schneider and Strittmatter, 2003).

In conventional sugar beet cropping systems, herbicide applications in early season have been reported to reduce sugar beet vigor by 17 to 22 percent and cause a 6- to 8-percent reduction in sugar beet root yield at harvest (Wilson, 2010). Several factors can influence a crop's tolerance to herbicides. Individually each factor might have little effect, but when two or more occur at the same time crops can suffer stress that is more noticeable. Factors that influence herbicide injury to crops include:

- Crop plant stage; sugar beet cotyledon to two-leaf stage is less resistant than the mid-four-leaf stage and later (Stachler and Zollinger, 2009). Herbicide labels include information on plant stage for safe application;
- Use after other herbicides; it is not always possible to predict the interactions that could occur (Bayer CropScience, 2004);
- Nutrient deficiency (e.g., manganese) (Bayer CropScience, 2004);
- Soil acidity/lime deficiency (Bayer CropScience, 2004);
- Substantial day-to-night temperature fluctuations (Bayer CropScience, 2004);
- Sudden change from cool and cloudy to hot and sunny (Stachler and Zollinger, 2009);
- Periods of low temperature or frost (Bayer CropScience, 2004);
- High light intensity (e.g., full sunlight – May to June) (Bayer CropScience, 2004);
- Wind or hail damage including damage from blown soil particles (Bayer CropScience, 2004);
- Recent flooding (Stachler and Zollinger, 2009);
- Insect or fungal attack (Bayer CropScience, 2004);
- Rolling or harrowing carried out within 7 days of application (Bayer CropScience, 2004); and

- Temperature above 21 °C (70 °F) on the day of spraying; applications should be made after 5 p.m. (Bayer CropScience, 2004).

Some examples of herbicide injury symptoms in sugar beets include leaf tip and leaf margin necrosis, necrotic spots (Betamix®), leaf malformation (Eptam®, Ro-Neet™), leaf chlorosis (Pyramin®), leaf petiole elongation and distorted leaf growth (Stinger®), and girdling at the root crown and stunting (Treflan® HFP) (Morishita and Downard, undated). In most cases the injury is not lethal and the sugar beets recover but yield can be reduced.

Table 3–9 summarizes the effectiveness of herbicides on important sugar beet weeds based on observations in three sugar beet growing regions: the Great Lakes (Michigan Sugar, 2009; Sprague and Everman, 2011), the Midwest (Stachler and Zollinger, 2009), and the Northwest (Morishita 2009). Herbicide effectiveness was scored as N=no control, P= poor (40-65% control), F=fair (65-80% control) , G=good (80-90% control), or E=excellent (90-99% control) (North Dakota State University 2011. http://www.ag.ndsu.edu/weeds/weed-control-guides/nd-weed-control-guide-1/wcg-files/17-Ratings.pdf accessed 7.14.11). As the table shows, no single herbicide is effective on all weeds. Applying multiple herbicides, often at the same time in a tank mix, can result in effective control of annual broadleaf and grass weeds. In general, none of the non-glyphosate herbicides gives effective control of perennial weeds. Furthermore, the combination of non-glyphosate herbicides frequently causes severe crop injury which results in yield losses (Sprague and Everman, 2011) in contrast to glyphosate, which manages a wide spectrum of weeds without causing crop injury. In considering the herbicide management program, growers attempt to balance the yield losses from weeds with the yield losses from herbicide injury.

Current practices for weed control in conventional sugar beets include tillage, rotations, cover crops (see section III.B.1.d(2)), preplant incorporation of grass and broadleaf herbicides, and in-crop use of herbicide tank mixtures (Dexter and Luecke, 2003; Dexter and Zollinger, 2003; WSSA, 2007). Each practice has limitations. Tillage preplant incorporation, and in-crop use of herbicides are associated with narrow windows of application, which is based on a specific weed size or crop stage (Baker and Johnson, 1979; Baker et al., 1982; Campbell and Janzen, 1995). Additionally, herbicide effectiveness is influenced heavily by soil pH, target weed size, crop size, air temperature, and irrigation practices. Moreover, many of the currently applied herbicides leave soil residues, the persistence of which can impact crop rotation options in subsequent seasons (Dexter and Zollinger, 2003; WSSA, 2007).

Conventional weed control options are complex due to the need for several applications of multiple tank-mixed herbicides to achieve long-term, broad-spectrum weed control. As an example, a common practice in sugar beet production is to use "micro-rates" (Dexter and Zollinger, 2003) by tank mixing multiple herbicides at reduced rates in combination with an oil additive. The components of the tank mixture can include Betanex® (desmedipham), Betamix® (phenmedipham + desmedipham), Nortron® (ethofumesate), Upbeet® (triflusulfuron-methyl), Stinger® (clopyralid), and also Select® (chlethodim) if grasses are present. A minimum of three applications are recommended, beginning at the cotyledon growth stage and followed by weekly applications. The intent of the micro-rate program is to lower overall herbicide costs and reduce the potential for crop injury.

Table 3- 9. Effectiveness of Herbicides on Major Weeds in Sugar Beets

	Broadleaves											**Grasses**			**Perennials**			**Parasites**
Herbicide	Cocklebur	Kochia	Lambsquarter	Mallow (common)	Nightshade	Pigweed	Ragweed (common)	Smartweed	Velvetleaf	Wild Mustard	Wild Buckwheat	Barnyard-grass	Foxtail	Wild Oats	Canada thistle	Nutsedge	Sow-thistle	Dodder
Preplant incorporated																		
Ro-Neet™																		
GL	P	P	F	-	F	G	F	P	G	P	F	G	G	-	N	G	N	-
MW	P	P	F/G	F/G	F/G	F/G	F	P	-	P	P-F	G	G/E	F/G	N	-	-	-
NW	P	P	E	P	G	E	-	P	-	P	P	G	G	F	P	F	P	P
Preemergence																		
Nortron®																		
GL	F	F	G		G	G	P	G	F	G	G	P	F	-	N	P	N	-
MW	P	F/G	P/F	P	F/G	G/E	P	G	-	P/F	F/G	P	F/G	F/G	N	-	-	-
NW	P	F/G	G/E	P	F/G	G/E	-	F/G	-	G	F/G	G	G	F	P	P	G	P
Pyramin®																		
GL	P	P	E		G	G	G	G	F	G	G	P	P	-	N	N	N	-
NW	P	P	G	P	F/G	G/E	-	G	-	G	P	P	P	P	P	P	P	P
Eptam®																		
MW	P	F	F/G	F/G	F/G	F/G	F	P	-	P	P/F	G/E	G/E	G	N	-	-	-
NW	P	F	G	P	F/P	F/G	-	P	-	P	F	G	G	F/G	P	F	F	P

Table 3-9. (continued)

	Broadleaves											**Grasses**			**Perennials**			**Parasites**
Herbicide	Cocklebur	Kochia	Lambsquarter	Mallow (common)	Nightshade	Pigweed	Ragweed (common)	Smartweed	Velvetleaf	Wild Mustard	Wild Buckwheat	Barnyard-grass	Foxtail	Wild Oats	Canada thistle	Nutsedge	Sow-thistle	Dodder
Postemergence																		
Nortron®																		
GL	P	-	F	-	G	F	P	G	P	G	G	P	F	-	N	N	N	-
Pyramin®																		
GL	P	-	F	-	F	F	F	F	F	F	F	N	N	-	P	N	P	-
Betamix®																		
GL	F	F	E	-	F	G	G	F	P	G	F	P	F	-	N	N	N	-
MW	P/F	F	G	P	F/G	G	F	P	-	G/E	F	P	F	N	N	-	-	-
NW	F	P/F	E	P	F/G	G/E	-	P	-	G	F/G	P/F	F	P	P	P	E	P
Betanex®																		
GL	F	-	F	-	F	E	F	F	P	G	P	P	P	-	N	N	N	-
MW	P	P/F	G	P	F/G	G/E	F	P	-	G/E	P/F	P	P	N	N	-	-	-
Upbeet®																		
GL	F	-	P	-	F	F	F	F	G	E	F	P	P	-	P	N	N	-
MW	N	P/E	P	G	F	F	F	F	-	G/E	F	N	F/G	N	N	-	-	-
NW	F	G	G	F	G	G/E	-	G	-	G	G	P	P	P	P	P	G	P
Stinger®																		
GL	E	N	P	-	F	P	E	F	P	P	F	N	N	-	G	N	G	-
MW	E	N	P/F	P	F/G	P	F	F	-	P	F/G	P	P	N	G/E	-	-	-
NW	E	P	F	P	F/G	P	-	G	-	P	E	P	P	P	E	P	G	P

Table 3-9. (continued)

Herbicide	Broadleaves											Grasses			Perennials			Parasites
	Cocklebur	Kochia	Lambsquarter	Mallow (common)	Nightshade	Pigweed	Ragweed (common)	Smartweed	Velvetleaf	Wild Mustard	Wild Buckwheat	Barnyard-grass	Foxtail	Wild Oats	Canada thistle	Nutsedge	Sow-thistle	Dodder
Progress (a mixture of Betamix® plus Nortron®)																		
GL	F	F	E	-	G	G	G	G	P	G	G	P	F		N	N	N	-
MW	F	F/G	G/E	P	G	G	F/G	F/G	-	G	F/G	P	F/G	N	N	-	-	-
Assure® II/Select® (Assure® II only for U of ID)																		
GL	N	N	N	-	N	N	N	N	N	N	N	G	E	-	N	N	N	-
MW	N	N	N	N	N	N	N	N	-	N	N	E	E	E	N	-	-	-
NW	P	P	P	P	P	P	-	P	-	P	P	E	E	G/E	P	P	P	P
Poast®																		
GL	N	N	N	-	N	N	N	N	N	N	N	E	E	-	N	N	N	-
NW	P	P	P	P	P	P	-	P	-	P	P	E	E	G/E	-	P	P	P
Glyphosate																		
GL	E	G	G	-	G	E	G	G	G	G	E	E	E	-	G	F	G	G
MW	E	F/E	P/E	P/G	P/G	E	G/E	P/E	-	G/E	G/E	E	E	G/E	G/E	-	-	-
Select®																		
NW	P	P	P	P	P	P	-	P	-	P	P	E	E	G–E	P	P	P	P
Treflan® HFP																		
NW	P	F	F/G	P	P	G	-	P/F	-	P	F	G	G	F	P	P	P	P

Sources:

GL: Michigan Sugar Company, 2009, Sprague and Everman, 2011; **MW:** (Stachler and Zollinger, 2009)**; NW:** Morishita, 2009

E=excellent; **G**=good; **F**=fair; **P**=poor; **N**=no effect; **GL**=Great Lakes; **MW**=Midwest; **NW**= Northwest

A member of the Minn-Dak Farmers Cooperative, who farms about 1,100 acres of sugar beets annually, described his conventional weed control system (Mauch, 2010):

> "Prior to planting Roundup Ready® sugar beets, my herbicide regimen for conventional beet seed was very complicated and labor intensive. Preemergence, I used a combination of Eptam® (which is very toxic to the sugar beets) and Ro-Neet™ (which is very expensive). Approximately 2 weeks after the beet plants emerged, I started spraying a mix of BetaMix®, Betanex®, Upbeet®, Nortron® and Stinger® and adjuvants to make the herbicides stick better. This would be sprayed four times (approximately once per week). Even after spraying several times, there were still weeds and I then needed to hire manual labor to hoe and pull out the weeds."

This description of the complexity of conventional weed control is similar to that provided by researchers evaluating weed management in sugar beets (Odero et al., 2008). Odero et al. (2008) evaluated 20 different weed treatment alternatives for conventional sugar beets and found that the following treatment yielded the highest net economic return: PPI treatment with Nortron® (ethofumesate), followed by three postemergence micro-rate treatments of a tank mixture of Betamix® (phenmedipham + desmedipham) and Nortron® (ethofumesate), followed by Outlook® (dimethenamid-P); with hand-hoeing following each herbicide application.

Herbicide application is further complicated because oil adjuvants[4] used in herbicides combined with some fungicides or insecticides can increase crop injury (Stachler and Zollinger, 2009). In addition, broadleaf herbicides antagonize[5] grass herbicidesTherefore, grass herbicides should be applied 24 hours before broadleaf herbicides or 3–5 days after broadleaf herbicide (Stachler and Zollinger, 2009).

A combination of herbicides plus hand hoeing is sometimes required to effectively control weeds in conventional sugar beets (Dexter and Luecke, 2003). In 2000, 25 percent of sugar beet acres in Minnesota and eastern North Dakota were hand weeded (Dexter and Luecke, 2001). Hand-weeding is necessary in many situations but it is cost-prohibitive as a replacement for herbicides. USDA data show that in 2000, conventional sugar beet growers spent an average of USD 94.28 per acre for all chemicals (insecticides, herbicides, fungicides, etc.) (Ali, 2004). Five-

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[4] For pesticide regulation, adjuvants are chemicals added to a pesticide by users to improve the pesticide's efficacy. Agricultural chemical adjuvants are grouped according to their intended purpose in a tank mix (U.S. EPA, 2011c).
Herbicide antagonism is defined as the reduction of control of certain weeds as the result of applying mixtures of two or more herbicides (Ottis et al., 2005).

year studies of the cost of hand-weeding sugar beets at the University of California-Davis, as reported by the California Beet Growers Association, found that the cost of hand weeding was between USD 260 to over USD 650 per acre (California Beet Growers Association, 1999). Using the midyear of 1996 as the base year, this is equivalent to approximately USD 373 to USD 914 per acre in 2010 dollars, or approximately three to seven times what sugar beet growers spent on all chemicals. More recently, scientists in Wyoming have found that net returns for optimal herbicide application combined with hand weeding are more than twice the net returns for hand weeding alone (Odero et al., 2008).

Mapping weed infestations in a field can help farmers make weed management decisions. Perennial weeds like Canada thistle and quackgrass often occur in patches, so can be spot treated with an herbicide or rogued or cultivated (Wilson et al., 2001). Because of the overwintering parts of perennial weeds proper timing is required to control these parts of the plants and thus need careful application timing. Field scouting immediately after the crop begins to emerge helps with early identification of weeds and the selection of an appropriate postemergence herbicide (Wilson et al., 2001).

Herbicide labels include information on rotation restrictions following herbicide applications (table 3–10). As can be seen in table 3–10, glyphosate and Betanex® have the advantage over all the other sugar beet herbicides that no time restrictions are needed for planting any of the listed rotation crops. Crop injury or failure can result if rotation restrictions are not followed. Because Betanex® fails to control most sugar beet weeds, glyphosate is unique in its effectiveness on a wide number of weed species and lack of crop rotation restrictions.

Table 3- 10. Herbicide Crop Rotation Restrictions (in months)[1]

	Soybeans	Field Corn	Seed Corn	Wheat	Oats	Barley	Rye	Alfalfa	Dry Beans	Sugar Beets	Potatoes	Cucumbers	Tomatoes
Assure® II	0	4	4	4	4	4	4	4	0	0	4	4	4
Betamix®	0	4	4	4	4	4	4	0	0	0	0	0	0
Betanex®	0	0	0	0	0	0	0	0	0	0	0	0	0
Eptam®	10	1	10	3	10	10	3	0	0	10	10	10	10
Glyphosate	0	0	0	0	0	0	0	0	0	0	0	0	0
Nortron®[1]	6/12	6/12	6/12	6/12	6/12	6/12	6/12	6/12	6/12	0	6/12	6/12	6/12
Poast®[2]	0	1	1	1	1	1	1	0	0	0	0	0	0
Pyramin®[1]	10	10	10	10	10	10	10	10	10	0	10	10	10
Ro-Neet™	–	–	–	–	–	–	–	–	–	–	–	–	–
Select®	0	1	1	1	1	1	1	0	0	0	0	0	0
Stinger®[2]	10.5	0	0	0	0	0	0	10.5	0	18	18	18	18
Treflan® HFP	0	5	5	5	5	5	5	5	0	12	5	5	5
Upbeet®	0.5	0.75	0.75	0.5	0.5	0.5	0.5	0.5	0.5	0	0.5	0.5	0.5

Source: Michigan State University Extension, 2003.

[1] Crop rotation restrictions may vary from state to state. Due to primacy of the State law, the label can only be more stringent than federal law.

[2] Consult the Remarks and Limitations section on the herbicide label for further information.

Note that – means no information was given on this label.

Herbicide application methods include:

- Spot treatment – the application of herbicide to just specific plants or areas of the field, usually done by hand with a backpack sprayer.

- Ground broadcast – the application of herbicide using a tractor with spray nozzles. The nozzle height and spray width can be adjusted. Broadcast application can cover the crop and in between the rows.

- Band – the application of herbicide that is sprayed over the crop row and later the space between the rows is cultivated (Donald and Nelson, 2004). Zone herbicide application is a banding method where herbicide rates vary. For example a preemergence herbicide can be applied at greater rates between rows (Donald and Nelson, 2004). Lay-by treatments are applied at last cultivation to provide an extended period of weed control (UNL, 2011).

- Irrigation – the application of herbicides by incorporating or metering into an irrigation system (Morishita, 2003). For example, Ro-Neet™ can be applied through sprinkler irrigation systems, such as center pivot, lateral move, end tow, wheel line, traveling big gun, solid set, or hand moved lines.

- Aerial broadcast – the application of herbicide using an airplane. This type of application is commonly used in forestry applications but is more seldom used over cropland (USDA–FS, 2006).

Dexter and Luecke (2001) report that broadcast methods dominate the application of herbicides on conventional sugar beets. Based on acres treated averaged across all herbicides, these authors report that in 2000 approximately 54 percent were ground broadcast, 9 percent were aerial broadcast, and 37 percent were band applied.

On conventional sugar beets, glyphosate can be used in the fall to prepare for the next growing season, in the spring preemergence, postemergence for spot treatment, or by wiper application (Stachler and Zollinger, 2009); (Hirnyck et al., 2005). Wiper application ("Roundup® wick") of glyphosate involves wiping a cotton wick saturated with glyphosate on weeds that protrude above the sugar beet canopy (Hirnyck et al., 2005). Other height-selective application methods include recirculating sprayers, rotating rollers, and pressure pads controlled by electronic sensors (May and Wilson, 2006). Glyphosate can also be used to remove winter wheat or winter rye seeded as a cover crop prior to conventional sugar beet emergence (Stachler and Zollinger, 2009).

Table 3–11 identifies the application method, whether the herbicide is used preemergence (PRE), postemergence (POST), or PPI, and what the general weed targets are for the 13 herbicides with the best documented use in sugar beets (USDA-NASS, 2008).

Table 3–11 also lists the 13 herbicides used in sugar beets that are included in the NASS Agricultural Chemical Use Database. There are an additional 10 herbicides for use in sugar beets that are mentioned in various extension agency guides. This EIS evaluates the impacts for the 13 herbicides listed by NASS. The additional herbicides shown in table 3–12 may also be used in sugar beets, but data on their usage are not available

(4) Weed Management for H7-1 Sugar Beet Varieties – Chemical Methods

H7-1 sugar beets, assigned the Organization for Economic Cooperation and Development (OECD) unique identifier KM-000H71-4, have been genetically modified to tolerate application of glyphosate herbicide formulations (Schneider and Strittmatter, 2003). The following sections provide an introduction to glyphosate and then describe how it is used on H7-1 sugar beets.

Glyphosate. Glyphosate (N-phosphonomethyl-glycine) (CAS Registry Number 1071-83-6), a nonselective herbicide, was first introduced under the trade name of Roundup® by Monsanto in 1974. Glyphosate is a systemic, herbicide used on both agricultural and nonagricultural sites (Cerdeira and Duke, 2006). It may be used premergent, preplant incorporated, or postemergent with Roundup Ready® crops.

Glyphosate is an aminophosphonic analog of the amino acid glycine. The glyphosate molecule has a methylphosphono group bonded to the nitrogen atom of the amino group of glycine, as denoted in figure 3–9 below.

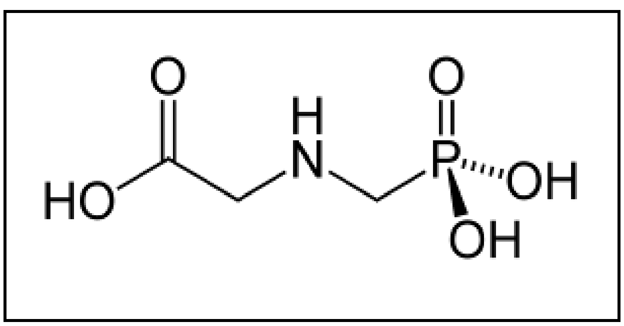

Figure 3- 9. Molecular Structure of Glyphosate

Table 3- 11. Application Methods for 13 Sugar Beet Herbicides

Agricultural Chemical (Herbicide)	Trade Name (Typical)	Application Method	Context (How is it used)	General Target
Clethodim	Select®	7-inch band, broadcast, or micro-rate (with Betamix® or Progress)	POST	Annual grasses
Clopyralid	Stinger®	7-inch band, broadcast, or micro-rate (with Betamix®, Progress, or Poast®)	POST	Cocklebur, sunflower, marshleder, wild buckwheat, ragweed, Canadian thistle
Cycloate	Ro-Neet™	7-inch band or broadcast, lay-by, or sprinkler irrigation (apply at end of irrigation cycle to penetrate 3–4 inches, or mechanically incorporate to depth of 3–4 inches)	PPI or fall when temperature is below 50 °F before freeze or snow	Annual grasses and some broadleaf weeds
Desmedipham	Betanex®	Broadcast or micro-rate	POST	Annual broadleaf weeds
EPTC	Eptam®	7-inch band or broadcast, or lay-by (may be incorporated or metered into sprinkler irrigation lines or injected on each side of beet row)	PPI or fall after Oct 15 before freeze or snow	Annual grasses and some broadleaf weeds; temporary stunting of sugar beets
Ethofumesate	Nortron®	7-inch band or broadcast (requires moisture – sprinkler irrigation or furrow irrigation, no mechanical incorporation)	PPI or PRE (high levels) POST (lower levels) - in combination with Progress, Betanex®, Betamix®, or Roundup® (GT varieties only)	Annual broadleaf weeds
Glyphosate	Several including Roundup®	7-inch band or broadcast	Preplant or any time prior to crop emergence (can work on emerged weeds), POST only in GT varieties	Grasses and broadleaf weeds

Table 3–11 (continued)

Agricultural Chemical (Herbicide)	Trade Name (typical)	Application Method	Context (how is it used)	General Target
Phenmedipham + Desmedipham	Betamix®	7-inch band, broadcast, or micro-rate (do not apply when dew is present, do not apply through irrigation system, do not add wetting agents or spray adjuvants)	POST	Annual broadleaf weeds
Pyrazon	Pyramin®	7-inch band or broadcast (requires moisture – sprinkler irrigation or furrow irrigation)	PRE or POST	Annual broadleaf weeds
Quizalofop-p-ethyl	Assure® II	7-inch band, broadcast, or micro-rate (with Betamix® or Progress[1])	POST	Annual grasses
Sethoxydim	Poast®	7-inch band, broadcast, or micro-rate	POST	Annual grasses
Trifluralin	Treflan® HFP	7-inch band, broadcast, or lay-by (does not need irrigation to activate)	POST	Late emerging annual grasses and some broadleaf weeds
Triflusulfuron-methyl	Upbeet®	7-inch band, broadcast, or micro-rate (with Betamix® or Progress)	POST	Annual broadleaf weeds (kochia, redroot pigweed, common lambsquarters, nightshades, and mustards)

Sources: (Khan, 2011); Morishita and Downard, undated; Morishita, undated; Sprague and Everman, 2011

[1] Progress is phenmedipham, desmedipham, and ethofumesate. It is applied at micro-rates three to five times at 5-day intervals and at low rates two to three times at 7-day intervals.

Table 3- 12. Additional Herbicides that May Be Used in Sugar Beets But Are Not Included in NASS Database

Agricultural Chemical (Herbicide)	Trade Name (Typical)	Context (How is It Used)	General Target
Phenmedipham + Desmedipham + Ethofumesate	Progress (Betamix® + Nortron®)	POST	Annual broadleaf weeds
Flumioxaxin	Valor	PRE	Broadleaf weeds (e.g., preemergence of Amaranthus)
Dimethenamid-P	Outlook	POST	Late emerging annual grasses and some broadleaf weeds
2,4-Dichlorophenoxyacetic acid	2, 4-D	PRE	Broadleaf weeds (e.g., preemergence of Amaranthus)
Alochlor	INTRRO	PRE	Broadleaf weeds (e.g., preemergence of Amaranthus)
Triallate	Far-Go	Spring PPI or fall incorporated after Oct 15 before freeze or snow	Wild oat
S-metolachlor	Dual Magnum	POST	Late emerging annual grasses and some broadleaf weeds
Paraquat	Gramoxone Inteon	Preplant or any time prior to crop emergence (works on emerged weeds)	Nonselective, nonresidual, contact, foliar herbicide
Glufosinate	Ignite 280 (others)	Preplant or any time prior to crop emergence (can work on emerged weeds)	Nonselective, nonresidual, contact, foliar herbicide
Thifensulfuron	Harmony	45 days prior to planting (works on emerged annual broadleaf weeds)	Broadleaf selective, nonresidual, systemic, foliar herbicide

Sources: (Khan, 2011); Morishita, undated; (Zollinger et al., 2011)

Table 3- 13. Glyphosate Use on H7 1 Sugar Beets – Maximum Glyphosate Application Rates

	Acid Equivalent per Acre per Season (lb a.e.)	Active Ingredient per Acre per Season (lb a.i.)	Acid Equivalent per Acre per Application (lb a.e.)	Active Ingredient per Acre per Application (lb a.i.)
Combined Total per Year for All Applications	6	7.32	–	–
Total Preemergence Applications	3.7	4.51	–	–
Total of All Applications Made from Emergence to 8-leaf Stage	2	2.44	1.125	1.37
Total of All Applications Made between 8-leaf Stage and Canopy Closure	1.55	1.89	0.77	0.94

Source: (USDA-APHIS, 2011b).

At normal temperatures, glyphosate is a white crystalline substance that is not volatile (is not likely to vaporize at atmospheric pressure) and is highly soluble in water. Glyphosate salts serve as the source of the a.i. *N*-(phosphonomethyl) glycine. To improve handling, performance, and concentration, the glyphosate acid is formulated as a salt compound. Several salts of glyphosate are currently marketed. The term acid equivalent (a.e.) refers to the weight of the glyphosate acid, which is herbicidally active, while a.i. is the weight of the glyphosate acid plus the salt.

Herbicide formulations in liquid form are generally considered trade secret. One formulation of glyphosate, Honcho®, has a tallow amine surfactant (Monsanto, 2007a). This and other surfactants (surface action agents that are soluble in organic solvents and water), such as polyethoxylated tallowamine (POEA), are added to the herbicide formulations to increase leaf penetration.

As listed on the Roundup® herbicide label, Roundup® Original MAX®, Roundup® WeatherMAX®, and Roundup® Ultra MAX II® products contain 48.8 percent of the potassium salt of glyphosate, equivalent to 4.5 lb of glyphosate a.e. per gallon (540 g glyphosate per L). The product is to be applied over-the-top (e.g., spot treatment, broadcast ground application) for preplant, preemergence, and postemergence weed control.

On sugar beets, according to the Roundup® herbicide label, no more than 6 pounds of glyphosate a.e., or 7.32 pounds a.i. per acre may be legally applied per year (see table 3–13, below). Of those 6 pounds a.e., no more than 3.7 pounds a.e. (4.51 pounds a.i.) per acre can be applied preemergence, no more than 2 pounds a.e. (2.44 pounds a.i.) per acre can be applied from emergence to the 8-leaf stage, and no more than 1.55 pounds a.e. (1.89 pounds a.i.) can be applied between the 8-leaf stage and canopy closure. No glyphosate applications may be made after 30 days prior to harvest. For postemergent applications, up to four sequential applications of glyphosate can be made with 10 days between applications. For each application, no more than 1.125 pounds a.e. (1.37 pounds a.i.) per acre may be applied postemergence prior to the 8-leaf stage and no more than 0.77 pound a.e. (0.94 pound a.i.) per acre may be applied after the 8-leaf stage (table 3–13). According to one report, most H7-1 sugar beet growers typically use two applications of glyphosate per year (Khan, 2010). In the herbicide usage surveys conducted by Stachler et al. (Stachler et al., 2011), the most common herbicide treatment for sugar beet growers (conventional and H7-1) was 0.75 pound a.e. per acre (0.91 pound a.i. per acre). The average total rate of glyphosate applied (the average amount applied per acre) by growers of H7-1 sugar beets was 2.09 lb a.e. per acre (2.53 lb. a.i. per acre).[6] The range of total glyphosate applied per acre by growers of H7-1 sugar beets in 2010 was between 1.51 lb a.e. per acre (1.83 lb a.i. per acre) and 3.0 lb a.e. per acre (3.63 lb a.i. per acre) (Stachler et al., 2011). All of the application rates reported by Stachler et al. (Stachler et al., 2011).and Khan (2010) are within the range of the maximum application rates for glyphosate per application and per season.

Use of Glyphosate with H7 1 Sugar Beets. Glyphosate offers growers several advantages over non-glyphosate herbicides. First, it results in minimal crop injury. Second, it effectively controls most sugar beet weeds including some perennials such as bindweed, Canada thistle, perennial sowthistle, and quackgrass which are not controlled singly or in combination by non-glyphosate herbicides (Sprague and Everman, 2011). Third, it does not necessitate crop rotation restrictions. Fourth., it is more cost effective than using nonglyphosate herbicides (table 3–38, table 3–39). Fifth, it offers growers an herbicide with an additional mechanism of action which as discussed in section 3.C.3.a.(3) is helpful in managing herbicide resistant weeds. Overall, weed management is considerably simplified because fewer herbicides and herbicide applications are needed, the timing of applications are less critical so weather related application delays are less problematic, crop injury from the herbicide application is rarely a problem, and the crop rotation schedule has more flexibility (Kemp, 2009).In field trials, an 18-percent increase in sucrose yield was

[6] The average total rate of glyphosate applied per acre is calculated by multiplying the percentage of acres applied at a particular glyphosate rate by the total acres in Table 1, from Stachler *et. al.* (2011), by that glyphosate rate. Repeat that procedure for each glyphosate rate, add the pounds applied for each rate, and then divide by the total RR sugarbeet acreage in table 4, from Stachler *et.al.* (2011).

observed in H7-1 sugar beets treated with glyphosate when compared with conventional sugar beets treated with a varied mixture of herbicides (Wilson, 2010). This is consistent with other studies showing a 16-percent increase in yield over conventional treatment (Kniss et al., 2004).

With H7-1 sugar beets, growers may replace the previous practice of disking, plowing, packing, and two cultivations with one strip tillage (Wilson, 2010). Because H7-1 sugar beet crops may not require in-crop tillage, H7-1 sugar beet growers can switch to narrow-row production. With narrower rows, H7-1 sugar beets may achieve canopy closure earlier in the growing season, which can deprive weeds of sunlight and therefore impact late-season weed growth (Wilson, 2010). Regardless of row width, initial glyphosate applications should be made before weeds reach 10 cm in height to maximize yield and minimize weed competition with sugar beets (Armstrong and Sprague, 2010).

Glyphosate can be mixed with recommended fungicides, which may reduce application costs (Khan, 2010).

Other herbicides can be used in conjunction with glyphosate to improve control of glyphosate-resistant weeds. For example NDSU recommends adding Stinger® (or generic equivalent) to improve control of volunteer soybean, ragweed, and wild buckwheat; Nortron® to improve control of kochia, lambsquarters, pigweed species, and waterhemp; and Upbeet® + methylated seed oil to improve control of lambsquarters, common mallow, redroot pigweed, and velvetleaf (Zollinger et al., 2011). Preliminary research shows possible antagonism when glyphosate is applied with Betamix®, Betanex®, and Progress (Zollinger et al., 2011). Stachler et al. (2011) reported that the most frequently reported herbicide combinations used by RR sugarbeet growers in 2010 in Minnesota and eastern North Dakota were glyphosate plus Stinger (8.4%) and glyphosate plus Select (2.0%), the latter used primarily to control RR corn volunteers. For discussion of herbicide resistance, see section III.C.3.a.

As mentioned above in section III.B.1.d(3) in 2000, based on acres treated averaged across all herbicides, approximately 54 percent were ground broadcast, 9 percent were aerial broadcast, and 37 percent were band applied Dexter and Luecke (2001). Stachler et al. (Stachler et al., 2011) report that broadcast methods dominate the application of herbicides on H7-1 sugar beets. Based on acres treated averaged across all herbicides, these authors report that in 2010 approximately 93 percent were ground broadcast, 3 percent were aerial broadcast, and 4 percent were band applied.

e. Volunteer Control

Volunteers are plants from a previous crop that are found in subsequent crops. Volunteers are often considered a type of weed, not because the volunteer plants have any other inherent weedy characteristics, but simply because the volunteer plants are growing in an area where they are not wanted and might interfere or compete with other planting activities. For many cropping situations, growers often choose to apply herbicide to fields when rotating from one crop to another to avoid competition from both weeds and volunteer plants. In most crops, volunteers grow from seeds left or carried into the field during harvest.

(1) Sugar Beets as Volunteers

If sugar beet bolters are unmanaged and allowed to go to seed, these mature seeds could shatter and disperse in the crop field. Sugar beet seed may survive and germinate in the following year. These plants are called volunteers and theoretically can act as weeds in the following year's planted crop. However, sugar beet bolters rarely produced seed, volunteers do not compete well with crops used in rotation with sugar beets (CFIA, 2002) and sugar beets are "rarely" observed as weeds in cropland (Beckie and Owen, 2007).

Additionally, groundkeepers are a type of volunteer derived from vegetative tissue (small roots) left in the field after harvest, which can grow in the next season if not controlled. In most parts of the United States where sugar beets are grown, beet roots are not expected to survive the winter, so groundkeepers are of little concern (Panella, 2003, Cattanach, et al. 1991). In the Imperial Valley, groundkeepers could not survive the intense heat from soil solarization of the late summer (2011). Hence volunteers are not a problem from the sugar beet root crop in any regions of the US.

Because sugar beet seed plants release seed in the field during seed harvest, control of volunteers in seed production fields has been an essential component of production practices developed to maximize seed purity. Most seed left in the upper five centimeters of soil would germinate if the conditions are favorable. Seed that is ploughed deeper may remain dormant until the conditions are optimal for germination. It is known that seed may remain dormant for up to 10 years or longer and still retain part of its germination capacity (Monsanto, 2007b). WCBS has detailed requirements in its protocol for postharvest field management. After harvest, the fields are shallow tilled and irrigated to promote sprouting of shattered seeds. Fall plowing is not allowed by WCBS. Any remaining seed that sprouts is destroyed by herbicides or other means. All equipment is cleaned according to WCBS procedures before it can leave the fields. Fields used for growing H7-1 are inspected by WCBS "for a minimum of five years or until no volunteers are noted." Betaseed has similar requirements (Lehner, 2010). After sugar beet seed production, volunteer sugar beets are very rarely observed in other crops, ditches, or on road sides. If volunteer sugar beets were to occur in the following crop, they could be controlled by broadleaf herbicides or by other agricultural practices, such as tillage during seed bed preparation (Monsanto, 2007b).

(2) Volunteers in Sugar Beets

Volunteer crops from previous rotations can sometimes act as weeds in sugar beets. The many crops that can be used in rotation with sugar beets, for example, wheat, barley, potato, and edible beans, that are not cultivated as Roundup Ready®varieties, can be controlled with glyphosate in H7-1 sugar beets (Khan, 2010). However, surveys of sugar beet growers in Minnesota and North Dakota have determined that volunteer Roundup Ready® corn, soybeans, and canola have been identified among the top glyphosate-resistant weeds in glyphosate-tolerant sugar beet fields (Stachler and Luecke, 2009; Stachler et al., 2009b). Volunteer Roundup Ready® corn and soybean in H7-1 sugar beets can be effectively controlled with clethodim and clopyralid, respectively (Khan, 2010); Bloomquist, 2010).

Monsanto Technology Use Guide (TUG) (Monsanto, 2011b) provides specific weed control recommendations for H7-1 sugar beets. The TUG recommends the use of "mechanical weed control/cultivation and/or residual herbicides" with H7-1 sugar beets, where appropriate, and "additional herbicide mechanisms of action/residual herbicides and/or mechanical weed control in other Roundup Ready® crops" rotated with H7-1 (Monsanto, 2011b). See section III.C.3.a for more information on weeds with herbicide resistance.

f. Herbicide Quantity Estimate

This section presents an estimate of herbicide quantities used in conventional and H7-1 sugar beets for 2010. The 2000 data are used as a baseline for comparison because this is the most recent year that national and state-level herbicide application statistics are available for sugar beet root production. The estimate of herbicide use in sugar beet production for 2010 assumes that 95 percent of the total acreage is planted with H7-1 sugar beets and 5 percent is planted with conventional sugar beets based on adoption rates data presented in section III.B.1.

(1) Herbicide Usage for Conventional Sugar Beets, 2000

A regional summary of herbicide usage and acres planted for the five sugar beet root production regions is presented in table 3–14, below.

Table 3- 14. Summary of Herbicide Applications by Sugar Beet Growing Region in 2000

Agricultural Chemical (Herbicide)	Trade Name (Typical)	Midwest Total Applied per Year (lbs ai)	Great Plains Total Applied per Year (lbs ai)	Northwest Total Applied per Year (lbs ai)	Great Lakes Total Applied per Year (lbs ai)	Imperial Valley Total Applied per Year (lbs ai)	Total
Clethodim	Select®	62,000	11,000	3,000	NR[1]	ND[2]	76,000
Clopyralid	Stinger®	68,000	14,000	10,000	10,000	NR	102,000
Cycloate	Ro-Neet™	ND	37,000	79,000	16,000	NR	132,000
Desmedipham	Betanex®	175,000	28,000	35,000	21,000	11,000	270,000
EPTC	Eptam®	NR	15,000	156,000	NR	NR	171,000
Ethofumesate	Nortron®	18,000	27,000	31,000	3,000	3,000	82,000
Glyphosate	(Several)	26,000	17,000	23,000	NR	9,000	75,000
Phenmedipham	Betamix®	80,000	25,000	35,000	19,000	11,000	170,000
Pyrazon	Pyramin®	NR	NR	NR	66,000	NR	66,000
Quizalofop-p-ethyl	Assure® II	4,000	ND	3,000	2,000	NR	9,000
Sethoxydim	Poast®	23,000	ND	7,000	NR	25,000	55,000
Trifluralin	Treflan® HFP	23,000	NR	12,000	NR	7,000	42,000
Triflusulfuron-methyl	Upbeet®	14,000	4,000	8,000	2,000	ND	28,000
Total herbicides applied in 2000 (lbs ai.)		**493,000**	**178,000**	**402,000**	**139,000**	**66,000**	1,278,000
Acres planted in 2000[3,4]		748,000	271,400	256,600	189,000	98,000	
Pounds of herbicide per total acres planted		0.66	0.6	1.55	0.74	0.67	

Pesticide Usage Source: (USDA-NASS, 2008).

[1] NR = None Reported, No use of the herbicide was reported in the region.

[2] ND = No Data were reported for total herbicide applied per year (lb), although the available data indicated that the herbicide was applied in the region; see [tables G1 through G11] in appendix G.

[3] Note that 15,600 acres in western North Dakota are grouped with the Midwest for this table because the herbicide data are grouped in this manner. Note this is why the acres for 2000 are different for the Midwest and Great Plains by 15,600 acres compared to table 3–5.

[4] Data on acres planted are from the USDA 2000 Crop Production Survey (USDA–NASS, 2001). Data on plantings were reported for Ohio (1,200 acres), but no herbicide data were reported in the Agricultural Chemical Use Database for Ohio, so the acreage was omitted from this table.

The sugar beet growing regions, listed in order of most acres planted, are: Midwest (Minnesota and North Dakota), Great Plains (Colorado, Montana, Nebraska, Wyoming), Northwest (Idaho, Oregon, Washington), Imperial Valley (California), and Great Lakes (Michigan). Herbicide usage statistics in table 3–14 are based on 2000 data from the USDA–NASS Agricultural Chemical Use Database (USDA-NASS, 2008), and data for total acreage planted in each region are based on the USDA 2000 Crop Production Survey (USDA–NASS, 2001). Though the USDA Agricultural Chemical Use Database was last updated in 2008, the most recent data for herbicide use are from 2000. Tables containing the usage data for the individual States in each growing region are presented in appendix G (see tables G–1 through G–11), and are based on the same USDA data for 2000 (USDA-NASS, 2008).

Data were reported on sugar beet acres planted in Ohio in 2000, but no herbicide usage statistics were available for Ohio from USDA–NASS (2008a). For this reason, Ohio has not been included in this analysis. The Midwest Region (Minnesota and North Dakota) planted the greatest number of sugar beet acres in 2000, nearly 100,000 acres more than the second largest region, the Northwest Region (Idaho, Oregon, Washington). The Northwest Region had the highest total herbicide application per acre, at a rate nearly double that of the Great Lakes Region, which had the second-highest rate per acre. The high poundage in the Northwest is attributable in part to the use of herbicides such as EPTC and cycloate which are applied at much higher application rates (table 3–15). An estimate of the herbicide use by a.i. for conventional sugar beets, with application rates per application and per acre, in the United States is presented in table 3–15. The application rates and quantities are based on USDA–NASS (2008a) data from 2000, before H7-1 sugar beets were commercially available. These data show the relative application amounts for each of the herbicides used in sugar beets for that year, and give a national-level overview of sugar beet herbicide use before H7-1 sugar beets were available. These data are useful for a comparison of treatment practices before and after the commercial availability of H7-1 sugar beets, which will be discussed further in chapter IV of this document. The most recent year for which sugar beet herbicide usage data are available from USDA–NASS is 2000. It should be noted, there is year-to-year variability that is not captured in this single year snapshot.

(2) Herbicide Usage for H7-1 and Conventional Sugar Beets, 2010

In the 2010 growing season, 95 percent of the sugar beet acreage was planted with H7-1 sugar beets. APHIS assumed glyphosate was used on all of these acres at labeled rates and in agreement with the Monsanto Technology Stewardship Agreement and Monsanto TUG (Monsanto, 2011a). Application rates for glyphosate were consistent with the rates discussed in the final environmental assessment (EA) (USDA-APHIS, 2011b), and with the findings of Stachler and colleagues (2011). In the 2011 TUG (Monsanto, 2011a), Monsanto lists guidelines for H7-1 sugar beet growers that include using “mechanical weed control/cultivation and/or residual herbicides where appropriate.” APHIS assumed that herbicides other than glyphosate were used in H7-1 sugar beets according to the usage profiles described by Stachler, et al. (Stachler et al., 2011) in eastern North Dakota and Minnesota, and according to the application rates from 2000 USDA–NASS data (2008a). The 2010 annual survey used by Stachler et al. (Stachler et al., 2011) asked growers to “list insecticide use, fungicide use, acreage by sugar beet type, acres of hand-weeded sugar beet, herbicide application methods, and cost of hand weeding in sugar beet grown in 2010.” Monsanto does not recommend specific residual herbicides.

To estimate the herbicide usage for 2010, the sugar beet crop was divided into two groups: 5-percent acreage for conventionally grown sugar beets and 95-percent acreage for H7-1 sugar beets. The total acres of sugar beets planted in 2010 were 1,171,400 (USDA-NASS, 2011b). APHIS assumed that 95-percent of those acres (1,112,830 acres) were planted with H7-1 sugar beets and 5-percent (58,570 acres) were planted with conventional sugar beets. As reported by Stachler and colleagues (Stachler et al., 2011), 93 percent of the survey respondents grew H7-1 sugar beets in 2010, which supports the assumption of 95 percent H7-1 acres in 2010 for the analysis.

Table 3–16 shows estimated herbicide usage for the 5 percent of acres that grew conventional sugar beets. The percentage of conventional sugar beet acres treated with each herbicide is based on the USDA–NASS 2000 herbicide acreage percentages (e.g., for Clethodim: 46 percent of 5 percent of the total acres received the 2000 application rate). The depth of the analysis is limited to a national scope because the 2000 data represent national usage amounts. There are herbicide usage data for 2000 that describe production practices in California, which might also serve as a surrogate for conventional production practices.

Table 3- 15. Herbicide Applications to Conventional Sugar Beet Acres1 in the United States, 2000.

Agricultural Chemical (Herbicide)	Trade Name (Typical)	WSSA Mechanism of Action Group No.[2]	Acreage Treated (%)	No. of Applica-tions per Year	Rate per Application (lb/app./acre)	Rate per Acre (lb/acre)	Total Applied per Year (lb)
Clethodim	Select®	1	46	2.5	0.04	0.11	76,000
Clopyralid	Stinger®	4	74	2.8	0.03	0.09	102,000
Cycloate	Ro-Neet™	8	5	1	1.84	1.84	132,000
Desmedipham	Betanex®	5	94	2.8	0.07	0.18	270,000
EPTC	Eptam®	8	6	1	2.61	2.61	171,000
Ethofumesate	Nortron®	8	37	2.1	0.06	0.14	82,000
Glyphosate	(Several)	9	13	1.1	0.39	0.43	75,000
Phenmedipham	Betamix®	5	80	2.6	0.05	0.14	170,000
Pyrazon	Pyramin®	5	6	1	0.82	0.82	66,000
Quizalofop-p-ethyl	Assure® II	1	10	1.6	0.04	0.06	9,000
Sethoxydim	Poast®	1	11	1.7	0.19	0.33	55,000
Trifluralin	Treflan® HFP	3	5	1	0.65	0.66	42,000
Triflusulfuron-methyl	Upbeet®	2	83	2.7	0.008	0.02	28,000
Total							**1,278,000**

Pesticide usage source: (USDA-NASS, 2008).
[1] 1.565 million acres were planted in the United States in 2000. All values are averages.
[2] Source: (WSSA, 2007).

Although up to 50 percent of the conventional sugar beets grown in 2010 were produced in California, data are limited that describe the remaining conventional sugar beet production areas. It is possible that herbicide usage might be different than the national 2000 combined data in California, as well as in other regions where conventional sugar beets are produced, but there are data limitations that prevent further evaluation of this issue. Consequently, we assumed that the 2000 national data would provide a better estimate for 2010 herbicide usage on conventional sugar beets than would the 2000 California data.

Table 3–16 shows the estimated herbicide use on 5 percent of the total sugar beet acreage for 2010 that planted conventional sugar beets (58,570 acres). APHIS assumed that growers of conventional sugar beets would use the same application methods and treatment amounts for herbicides in 2010 as observed in 2000 data for conventional sugar beet production (USDA-NASS, 2008).

Table 3–17 shows the estimated herbicide usage for the 95 percent of the total sugar beet acres that grew H7-1 sugar beets (1,112,830 acres). Data currently available to estimate herbicide usage patterns on H7-1 sugar beets are limited in their geographic scope. APHIS extrapolated the herbicide usage in H7-1 sugar beets reported for eastern North Dakota and Minnesota for 2010 (Stachler et al., 2011) to all U.S. acreage growing H7-1 sugar beets. The survey represents 237 growers and 119,959 acres (Stachler et al., 2011). Of the sugar beet acres reported by Stachler et al. (Stachler et al., 2011), 93 percent were planted with H7-1 sugar beets.

The survey by Stachler et al. (Stachler et al., 2011) represents 21 percent of the total acres planted in the Red River Valley and west central Minnesota; a region where 652,552 acres of sugar beets were planted in 2010. The plantings in this region represent 55.7 percent of the total acreage of sugar beets planted in the United States in 2010 (USDA-NASS, 2011b). The data compiled by Stachler and colleagues (Stachler et al., 2011), are the largest, current, consistently published record of weed control and production practices for sugar beets generally available. Aside from the lack of available data on herbicide usage, this extrapolation has limitations because weed pressures and weather conditions vary across the country, and thus herbicide usage on H7-1 and conventional beets may not be uniform across the growing regions. That being said, this analysis used the most robust data set publicly available and made reasonable assumptions (as detailed below) to provide a quantifiable estimate of herbicide use in conventional and H7-1 sugar beets.

Table 3- 16. Estimated Herbicide Use on Conventional Sugar Beet in the United States Assuming 95-percent H7 1/5% Conventional Sugar Beets, 2010

Agricultural Chemical (Herbicide)	Trade Name (Typical)	WSSA Mechanism of Action Group No.[1]	Acreage Treated (%)	No. of Applications per Year	Rate per Application (lb./appl./acre)[2]	Total Rate per Acre (lb./acre)	Total Acres Treated[3]	Total Estimated Herbicide Applied per Year (in lb)
Clethodim	Select®	1	46	2.5	0.04	0.11	26,942	2,964
Clopyralid	Stinger®	4	74	2.8	0.03	0.09	43,342	3,901
Cycloate	Ro-Neet™	8	5	1	1.84	1.84	2,929	5,388
Desmedipham	Betanex®	5	94	2.8	0.07	0.18	55,056	9,910
EPTC	Eptam®	8	6	1	2.61	2.61	3,514	9,172
Ethofumesate	Nortron®	8	37	2.1	0.06	0.14	21,671	3,034
Glyphosate	(Several)	9	13	1.1	0.39	0.43	7,614	3,274
Phenmedipham	Betamix®	5	80	2.6	0.05	0.14	46,856	6,560
Pyrazon	Pyramin®	5	6	1	0.82	0.82	3,514	2,882
Quizalofop-p-ethyl	Assure® II	1	10	1.6	0.04	0.06	5,857	351
Sethoxydim	Poast®	1	11	1.7	0.19	0.33	6,443	2,126
Trifluralin	Treflan® HFP	3	5	1	0.65	0.66	2,929	1,933
Triflusulfuron-methyl	Upbeet®	2	83	2.7	0.008	0.02	48,613	972
Total								**52,467**

1 Source: (WSSA, 2007).
2 Pesticide application rates are based on data from the USDA National Agricultural Statistics Service Agricultural Chemical Use Database (USDA-NASS, 2008).
3 For the 2010 Conventional estimate, APHIS assumed that 5 percent of acres planted in 2010 (58,570 acres) are treated with same herbicides, in the same proportions, with the same rates as in 2000.

The assumptions made for estimating herbicide usage on H7-1 sugar beets in 2010 (see table 3–17) are:

- The conversion for glyphosate from pounds a.e. to pounds a.i. was based on a ratio of 4.5 pounds a.e. to 5.5 lb. a.i. according to the ratios listed by Hartzler et al. (2006). These values are typical of glyphosate products used on sugar beets as listed in the final EA (USDA-APHIS, 2011b), including Roundup® Original MAX®, Roundup® WeatherMAX®, and Roundup® Ultra MAX II®, which all contain 48.8 percent of the potassium salt of glyphosate.

- The rate of glyphosate applied per application, 0.75 lb. a.e. per acre, is based on the discussion of glyphosate applications in the final EA (USDA-APHIS, 2011b) and the most common application rate in sugar beets observed by Stachler et al. (Stachler et al., 2011).

- To facilitate comparison with data from USDA–NASS (2008a), rates for glyphosate are presented in units of a.i. in the herbicide usage tables, according to the methods described above.

- Glyphosate is applied to H7-1 sugar beets at a rate of 2.29 lb a.i. per acre per year (1.88 lb a.e. per acre per year) based on 0.915 lb. a.i. per acre per application (0.75 lb a.e. per acre per application) with an average of 2.5 applications per year (USDA-APHIS, 2011b); (Stachler et al., 2011).

- Herbicides other than glyphosate included in this estimate are limited to those herbicides for which application data were available from USDA – NASS (2008a). The application rates for these herbicides are based on the USDA – NASS (2008a) 2000 data. Percentage of acres treated and applications per acre per year are based on data from Stachler (Stachler et al., 2011).

- In the case that herbicides other than glyphosate were reported by Stachler (Stachler et al., 2011), but no application data were available to APHIS, those herbicides were omitted from our analysis. This was the case with two tank mix applications applied on a total of 740 (0.6 percent) of the 119,959 acres that the Stachler (Stachler et al., 2011) survey covered. The herbicides omitted were Dual (metolachlor) and Outlook (dimethenamid-p). These applications were assumed to be single herbicide applications for our purposes.

Table 3- 17. Estimated Herbicide Use on H7 1 Sugar Beets in the United States Assuming 95-Percent Acceptance of H7 1 Sugar Beets, 2010

Agricultural Chemical (Herbicide)	Trade Name (Typical)	WSSA Mechanism of Action Group No.[1]	Acreage Treated (%)	No. of Applications per Year	Rate per Application (lb./appl./ac)	Total Rate per Acre (lb./ac)	Total Acres Treated[2]	Total Estimated Herbicide Applied per Year (in lb)
Clethodim	Select®	1	5.700	1.43	0.04	0.06	63,431	3,637
Clopyralid	Stinger®	4	8.400	1.20	0.03	0.04	93,478	3,365
Cycloate	Ro-Neet™	8	1.100	0.20	1.84	2.12	12,241	4,505
Desmedipham	Betanex®	5	1.100	0.20	0.07	0.01	12,241	171
EPTC	Eptam®	8	1.100	0.20	2.61	3.00	12,241	6,390
Ethofumesate	Nortron®	8	0.200	1.00	0.06	0.06	2,226	134
Glyphosate[3]	(Several)	9	95.000	2.50	0.915	2.29	1,112,830	2,544,581
Phenmedipham	Betamix®	5	1.100	0.20	0.05	0.02	12,241	122
Pyrazon	Pyramin®	5	1.100	0.20	0.82	0.25	12,241	2,008
Quizalofop-p-ethyl	Assure® II	1	4.300	1.33	0.04	0.05	47,852	2,546
Sethoxydim	Poast®	1	3.700	0.33	0.19	0.06	41,175	2,608
Trifluralin	Treflan® HFP	3	0.400	1.00	0.65	0.65	4,451	2,893
Triflusulfuron-methyl	Upbeet®	2	1.100	0.20	0.008	0.002	12,241	20
Total								**2,572,979**

[1] Source: (WSSA, 2007)
[2] For 2010 H7-1- Estimate, APHIS assumed that 95 percent of acres planted in 2010 (1,112,830) are treated with the developed treatment scenario based on the findings of Stachler et al. (Stachler et al., 2011) and data from USDA–NASS (2008a).
[3] Glyphosate rate per application is in units of lb. a.i., and rates are presented converted from lb. a.e. application rates.

Additional assumptions were made for herbicide applications based on the findings of Stachler and colleagues (Stachler et al., 2011). Where specific herbicides were named in the report (Stachler et al., 2011), those herbicides were placed in the estimate at the same number of applications and percentage of acres as described in by Stachler et al. (Stachler et al., 2011). The assumptions follow:

- One soil-applied herbicide Ethofumesate (Nortron®) is applied to 0.2 percent of acres for H7-1 sugar beets at 1 application per year.

- A preemergence herbicide, Trifluralin (Treflan® HFP) is applied to

  0.4 percent of acres at 1 application per year for H7-1 sugar beets.

- Postemergence herbicides include:

  – Clethodim (Select®) is applied to 5.7 percent of acres, 1.43 applications per year;

  – Clopyralid (Stinger®) is applied to 8.4 percent of acres, 1.2 applications per year;

  – Sethoxydim (Poast®) is applied to 3.7 percent of acres, 0.33 application per year; and

  – Quizalofop-p-ethyl (Assure® II) is applied to 4.3 percent of acres, 1.33 applications per year.

- "Other combinations" of herbicides are applied to 1.1 percent of acres, 1.2 applications per year.

  – Divide the number of applications for "other combinations" of herbicides among remaining 6 herbicides in table evenly: 1.1 percent of acres, 0.2 application per year for Cycloate (Ro-Neet™), Desmedipham (Betanex®), EPTC (Eptam®), Phenmedipham (Betamix®), Triflusulfuron-methyl (Upbeet®), Pyrazon (Pyramin®), based on the herbicide use in sugar beets described by Morishita (2003).

The purpose of the herbicide usage estimate discussed in this section is to provide an overview of existing data on herbicide use in conventional sugar beets, and to illustrate the change in herbicide production practices with the introduction of H7-1 sugar beets. The changes in herbicide use and the estimated use for 2010 will be used in other sections of this document to evaluate potential impacts of the adoption of H7-1 sugar beets.

Table 3- 18. Estimated Herbicide Usage in 2010 in Sugar Beets

Agricultural Chemical (Herbicide)	Total Estimated Herbicide Applied per Year, Conventional (in lb)	Total Estimated Herbicide Applied, H7-1 (in lb)	Total
Clethodim	2,964	3,637	6,600
Clopyralid	3,901	3,365	7,266
Cycloate	5,388	4,505	9,893
Desmedipham	9,910	171	10,081
EPTC	9,172	6,390	15,562
Ethofumesate	3,034	134	3,167
Glyphosate	3,274	2,544,581	2,547,855
Phenmedipham	6,560	122	6,682
Pyrazon	2,882	2,008	4,889
Quizalofop-p-ethyl	351	2,546	2,897
Sethoxydim	2,126	2,608	4,734
Trifluralin	1,933	2,893	4,826
Triflusulfuron-methyl	972	20	992
Total	**52,467**	**2,572,979**	**2,625,446**

Table 3- 19. Differences in Total Herbicide Use, 2000 vs. 2010 Estimate

Agricultural Chemical (Herbicide)	Total Herbicide Applied, 2000 NASS Data (lb)	Total Estimated Herbicide Applied in 2010 (lb)	Change (lb)
Clethodim	76,000	6,600	-69,400
Clopyralid	102,000	7,266	-94,734
Cycloate	132,000	9,893	-122,107
Desmedipham	270,000	10,081	-259,919
EPTC	171,000	15,562	-155,438
Ethofumesate	82,000	3,167	-78,833
Glyphosate	75,000	2,547,855	2,472,855
Phenmedipham	170,000	6,682	-163,318
Pyrazon	66,000	4,889	-61,111
Quizalofop-p-ethyl	9,000	2,897	-6,103
Sethoxydim	55,000	4,734	-150,266
Trifluralin	42,000	4,826	-37,174
Triflusulfuron-methyl	28,000	992	-27,008
Total	**1,278,000**	**2,625,446**	**1,347,446**

Table 3–18 shows the sum of 2010 estimated herbicide use for conventional sugar beets and H7-1 sugar beets to arrive at a total estimated herbicide usage for 2010.

As expected in the 2010 estimate, glyphosate accounts for the majority of herbicide applied by lb a.i. per acre. All other herbicide quantities decreased significantly following the 95 percent adoption of H7-1 sugar beets. Table 3–19 below compares herbicide usage for 2000 (prior to H7-1 deregulation) to 2010 (following H7-1 deregulation with 95-percent adoption). The analysis shows a doubling in the total amount of herbicide applied, in terms of pounds per acre, with the majority of the herbicide applied represented by glyphosate. An increase in poundage occurs because glyphosate is applied at a higher rate than the other herbicides with the exception of EPTC and cycloate. The analysis also shows that use of all other herbides decreased as did the number of herbicide applications. Herbicides other than glyphosate make up less than three percent of the total herbicide use in 2010. The impacts of these changes in herbicide application behavior will be discussed further in chapter IV of this document.

2. Swiss Chard

As stated above in section III.B.1, Swiss chard (*Beta vulgaris* ssp. *cicla*), sugar beets, table beets, and fodder beets are all the same species meaning that they are all sexually compatible and can interbreed with each other (OECD (Organization for Economic Cooperation and Development)). In the United States, varieties of chard are commonly referred to as Swiss chard, but they are also called silverbeet, perpetual spinach, spinach beet, crab beet, and seakale beet. For simplicity, this crop is referred to as Swiss chard throughout the EIS. Swiss chard is grown both for seed and for food in the United States.

Like all *Beta* crops, Swiss chard is a hardy biennial and requires 2 years to complete its lifecycle. Swiss chard seed is produced by both commercial producers and home gardeners. Similar to sugar beets, the majority of commercial Swiss chard seed production occurs in the Northwest. Seeds can be produced in other parts of the country if roots are dug up before the ground freezes and then replanted in the spring. The steckling method is described above in section III.B.1.b(14). Commercial Swiss chard seed is not usually hybrid and is produced through open, wind pollination. Home gardeners also produce seed though open pollination.

Swiss chard grown for vegetable production occurs throughout the United States by both commercial producers and home gardeners. Swiss chard differs from sugar beet and table beet in that it lacks a fleshy root. It is grown for its foliage, or large leafy greens, in a manner similar to spinach or lettuce (Desai, 2004). The Swiss chard plant grows until it’s growth is stopped by a hard freeze. The plant can be harvested all at once or leaves can be collected over the course of a season.

a. Seed Production
(1) Location

In the United States in 2011, APHIS is aware of commercial Swiss chard seed production occurring on approximately 600[7] acres in Arizona, California, Oregon, and Washington. Table 3–20 lists counties and shows the state acreage of commercial Swiss chard seed production in 2011. Commercial Swiss chard seed acreage was determined through publications from the Washington State Extension Office (McMoran et al., 2010) and personal communications with State Extension Officers in Oregon and Washington and commercial seed producers (Dorsing, 2011) (McReynolds, 2011) (Falconer, 2011; Mcmoran, 2011a). Swiss chard seed acreage reported in the Willamette Valley represents all of the commercial Swiss chard seed being produced by members of the WVSSA in 2011. Any non-members of the WVSSA who are growing Swiss chard seed in Willamette Valley in 2011 are not captured in the above acreage.

Table 3- 20. 2011 Acreage of Swiss Chard Seed Production in the United States.

State	County	Acreage	References
AZ	Yuma	20	(Dorsing, 2011)
CA	Butte, Colusa, and Glenn, Monterey	1–125[1]	(McReynolds, 2011), (Falconer, 2011)
OR	Benton, Clackamas, Jackson, Linn, Marion, Polk, Washington, Yamhill	300[2]	(McReynolds, 2011), (Dorsing, 2011)
WA[3]	Skagit, Snohomish	150	(Mcmoran, 2011a)
Total U.S. Acres		**<605**	

[1] Unknown combination of acreage growing Swiss chard & table beet seed.
[2] Including 8 acres of Certified Organic acres.
[3] Although Swiss chard seed has been historically grown in Whatcom and Lewis Counties, WA, the last available data were for 2007 (McMoran et al., 2010). Swiss chard was not identified as having been grown in those counties in 2011, and therefore, those counties are not represented here.

[7] The information APHIS received on acreage of Swiss chard production in California for Glenn, Colusa, and Butte Counties was aggregate data with combined acreage for both Swiss chard and table beet. Therefore actual acreage of Swiss chard and table beet in each of the individual counties is not known. For the purposes of the EIS, APHIS will assume the highest possible acreage for both of the crops by estimating that the acreage of each is up to 125 acres. (See table 3–21.)

Based on this information, APHIS determined that in 2011, commercial Swiss chard is being grown in the following counties: western Washington (Skagit and Snohomish), Arizona (Yuma), California (Monterey, Glenn, Colusa, and Butte), and Oregon (Marion, Polk, Yamhill, Washington, Benton, Linn, Clackamas and Jackson). The commercial Swiss chard seed production acreage in Benton and Jackson counties in Oregon is being produced following organic standards. The acreage and location of Swiss chard seed being produced by home gardeners is unknown.

Figure 3–10 shows a map of all known commercial Swiss chard seed-producing counties from 2007 to 2011. Figure 3–10 includes all of the counties listed in table 3–20 above and additionally includes Whatcom and Lewis counties in Washington. While Whatcom and Lewis counties were not identified as counties in which commercial Swiss chard seed is being produced in 2011, they are included here as they have historically produced Swiss chard seed (McMoran et al., 2010).

It is entirely possible that not all commercial Swiss chard seed production in 2011 has been captured through the aforementioned research efforts. However, information on Swiss chard acreage and areas of production from previous years indicates that the major areas of U.S. Swiss chard seed production are represented above (Loberg, 2010b; McMoran et al., 2010). The acreage of commercial Swiss chard production in each area varies from year to year due to changes in demand for seed and crop rotation cycles (Loberg, 2010b) (McReynolds, 2011).

Based on the information above, in 2011 approximately half of commercial Swiss chard seed is being produced in Oregon, a quarter of Swiss chard seed is being produced in Washington, slightly less than a quarter is being produced in California, and the remainder is being produced in Arizona.

As mentioned in III.B.1.b(1), Willamette Valley, Oregon is the major commercial vegetable seed producing region in the United States. In addition to other types of vegetable seeds, seed production for sugar beets, Swiss chard, and table beet all occur in Willamette Valley. Approximately 98 percent of known commercial Swiss chard seed production in Oregon, (equaling about half of U.S commercial Swiss chard seed production) in 2011 is being grown in Willamette Valley. Willamette Valley is the only known commercial Swiss chard seed production area where gene flow could occur between Swiss chard and H7-1 sugar beets as both types of *Beta* species are grown for seed production in the same counties. For a map showing the counties where H7-1 sugar beets are grown see figure 3–1. For a map showing the counties where Swiss chard are grown see figure 3–10. Overlap between vegetable beet seed production (Swiss chard and table beet) and sugar beet seed production occurs in six counties in the Willamette Valley of Oregon and one county in Southern Oregon(Marion, Clackamas, Polk, Washington, Benton, Linn, and Jackson counties, shown in brown in figure 3–12). For more information on gene flow and a map of the overlap between sugar beet and Swiss chard seed production see section III.B.5 and figure 3-12.

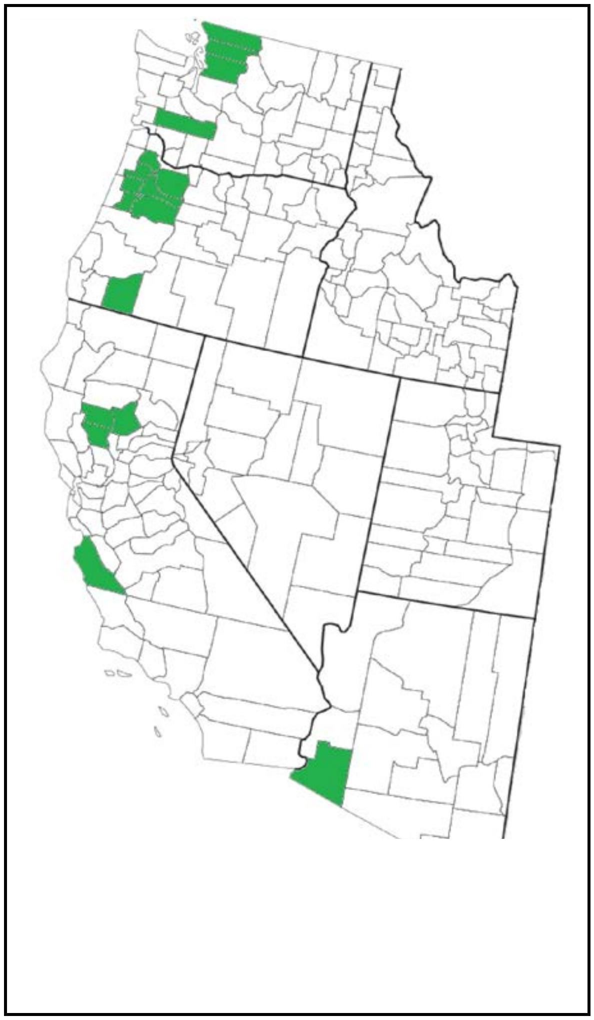

Figure 3- 10. Map of known counties in which commercial Swiss chard seed is, or was historically, produced. Counties shown on the map have been identified as Swiss Chard Seed producing between 2007 and 2011. (Sources: (Dorsing, 2011)

(2) Breeding

Swiss chard has had the least systematic breeding efforts for crop improvement as compared to sugar beets and table beet. Mass selection and collection of seed from open-pollinated plants have been the principle methods for developing new varieties with the desired characteristics (Desai, 2004).

(3) Seed Crop Producers

Swiss chard seed production, much like sugar beet seed production, consists of developing, growing, and processing the seed that Swiss chard growers use to plant their crop. Unlike sugar beet seed production, both commercial growers and home gardeners produce Swiss chard seed.

Commercial Swiss Chard Seed Production. Most commercial Swiss chard seed production is typically conducted under bailment contracts, whereby a seed company (bailor) provides a grower with the seed necessary to produce a crop. The seed company retains ownership of the seed, the growing crop, and the resulting harvested seed. The growers (bailees) produce and harvest the crop and are paid the contract price for the resulting seed. Seed contracts typically specify quality criteria that a grower must meet to be paid for the crop. These criteria include germination percentage and purity. Most seed crops must meet an 85 percent germination rate and must be cleaned to 99 percent purity (du Toit et al., 2007).

Market seed is produced and used for vegetable production, while stock seed is grown specifically for use in planting seed crops. APHIS is aware of 8 acres of organic Swiss chard seed being produced in 2011 (equaling ~ 1 percent of the known commercial seed production for Swiss chard) all of which is occurring in Oregon (McReynolds, 2011). This may be an under-representation of organic commercial Swiss chard seed production acreage, as one of the commercial Swiss chard and table beet growers indicated that on average, 5 to 10 percent of their combined Swiss chard and table beet acreage was organic (Lyons, 2011c). All of the commercial Swiss chard seed grown in the United States, whether grown following organic or conventional methods, is grown for GE-sensitive markets (McReynolds, 2011).

While the size of seed markets vary based on market demand, estimates from seed producers indicate that up to 50 percent of Swiss chard seed grown in the United States is exported annually (McReynolds, 2011) (Lyons, 2011c).

Home Gardener Swiss Chard Seed Production. By definition, home gardeners grow Swiss chard seed for their own personal use and do not grow seed under contract. Home gardeners may or may not use organic methods and may or may not be GE-sensitive.

Non-U.S. Swiss Chard Seed Production. In addition to growing Swiss chard seed domestically, many of the commercial Swiss chard seed producing companies also produce seeds overseas. The main foreign countries where Swiss chard seed is grown are New Zealand, Australia, and China (McReynolds, 2011). There are two main reasons as to why commercial seed companies grow Swiss chard seed overseas:

- **Doubling the growing seasons.** The growing seasons in New Zealand and Australia are opposite of those in the United States. By growing seeds in both areas, seed producers can essentially double the rate of breeding and seed production by doubling the number of growing seasons per year.

- **Increasing the amount of land available**. There is a limited amount of land for seed production, especially in Willamette Valley, Oregon. The isolation distances currently being used between *Beta* species in Willamette Valley limits the number of growers who can produce *Beta* seeds (McReynolds, 2011). For more information on isolation distances in Willamette Valley see section III.B.1.b(10).

(4) Planting and Lifecycle

As stated above, Swiss chard is a biennial plant that requires 2 years to produce seeds. In the second year, after exposure to vernalizing temperatures, the plant produces a tall seed stalk completing the lifecycle.

Seeds are harvested after the base of the flowering stalk has turned brown. At harvest plants are cut, windrowed, and dried in the field for 10-14 days. While the crop is drying, it is hand turned to prevent molding. Seed is taken to a conditioning plant where it is cleaned to 99 percent purity (McMoran et al., 2010).

Weed seeds that cannot be sorted out from the harvested Swiss chard seed can reduce the market value of the seed crop or cause it to be unmarketable (McMoran et al., 2010).

Swiss chard seed can be produced using either the direct-seeded method or the steckling method. Both of these methods can be used by commercial producers and home gardeners and are described in greater detail below.

(5) Direct-Seeded Method

The direct-seeded method, also called the ‘over wintering method’ involves planting the desired variety of Swiss chard seeds in the field in the late summer to early fall and harvesting the seeds the next fall. The direct-seeded method is only suitable for mild climates, such as those found in the Northwest, which is why the majority of commercial Swiss chard seed production occurs in this area.

Commercial Swiss Chard Seed Production. For commercial production in the Northwest, seeds are typically planted in August to September, depending on the variety and the specific location (Desai, 2004);

(McMoran et al., 2010). Slower growing varieties are planted earlier than faster growing varieties. Recommended spacing is 16 inches between plants and 35 inches between rows (Desai, 2004). As the weather becomes colder, the plants become dormant and are vernalized in the ground. Plants begin to bolt to form a flowering stalk in the spring, produce pollen during the late spring-early summer, and seeds in the late-summer. The exact timing for bolting, flowering and seed setting are highly dependent on the specific variety of Swiss chard and the growing conditions.

For an example of timing, the OrCa Seed Production Inc. production schedule from 2010 shows that commercial Swiss chard seeds are direct-seed planted in August, the estimated bloom date is in May–June and the estimated harvest date is August to September (OrCa Seed Production Inc., 2010b). Note that the production schedule does not indicate the location of the Swiss chard seed production. OrCa Seed Production Inc. produces seed in both Oregon and California (OrCa Seed Production Inc., 2010a).

The advantages of the direct seeded method are reduced labor and expenses and that no storage is required compared to the steckling method. The major disadvantages of the direct seeding method are that it can only be used in appropriate climates and it requires more seed,

Home Gardener Swiss Chard Seed Production. Home gardeners producing Swiss chard seed in the Northwest could also use the direct seeded method and would likely follow similar production methods to those of commercial producers. Home gardeners producing Swiss chard seed in other regions with more severe winters would need to use the steckling method described below.

(6) Steckling Method

Stecklings are Swiss chard roots that are grown from seed for less than a full season and are dug up in the spring for replanting after either vernalization in the ground in milder climates or refrigerated storage in colder climates.

Commercial Swiss Chard Seed Production. For commercial production in the Northwest, seeds are typically planted in mid-June to August, depending on the variety and the specific location (Desai, 2004); (McMoran et al., 2010). Slower growing varieties are planted earlier than slower growing varieties. Seeds can be planted either with two rows per bed or as a single row. Row spacing varies from 16 to 35 inches. Depending on method used, 1 acre of stecklings can be used to plant 10 to 20 acres for seed production (Desai, 2004). Plants are rogued for off-types in the fall. In Washington, plants are allowed to overwinter in the field (McMoran et al., 2010).

For an example of timing, in Skagit County, Washington under ideal weather conditions, Alf Christenson Seed Company typically plants Swiss chard stecklings into seed production fields around April 15th, and the estimated bloom date is early June to July (Lyons, 2011a). A harvest time of August is typical for the State of Washington (McMoran et al., 2010).

The major advantage of the steckling method is that it utilizes less seed and provides flexibility in production. For example, young seedlings which are more sensitive to disease can be grown in a disease free region and then transplanted into another where isolation distances can be met. The major disadvantages of the steckling method is that it requires additional labor and expenses and storage is required if roots are not overwintered in the field (Desai, 2004).

Home Gardener Swiss Chard Seed Production. Home gardeners producing Swiss chard seed in the Northwest could also use the steckling method and would likely follow similar production methods to those of commercial producers.

Home gardeners producing Swiss chard seed in other regions would need to modify the production method according to their specific environmental conditions. Swiss chard seeds are planted as early in the season as possible; Swiss chard can be direct seeded mid-spring after danger of frost has passed through mid-summer and into fall in warmer regions (High Mowing Organic Seeds, 2011b). Stecklings are dug up in the fall and any leaves an inch or more above the crown are cut off. In colder climates the stecklings are stored for the winter at temperatures between 32 to 34 °F under conditions of high humidity. In the spring, stecklings are planted outside at a spacing of 6 to 10 inches between plants and 16 to 24 inches between rows. Based on the specific variety and local environmental conditions, plants bolt and flower at varying times during the summer and set seed in the fall.

(7) Isolation Distances

Production of high quality Swiss chard seed requires that the “correct” seed parent be fertilized by the “correct” pollen source. Swiss chard seeds will not meet the quality criteria demanded by purchasers if the percentage of off-type seeds, resulting from unwanted cross-pollination, exceeds contractual thresholds.

Off-type seeds can result from a variety of sources. These sources include gene flow between different Swiss chard varieties, between Swiss chard and table beet and between Swiss chard and sugar beets. Open pollinated varieties usually produce more pollen than do the pollen parents used in hybrid production. Furthermore, in open pollinated fields, every plant produces pollen whereas in hybrid production less than one in four plants produces pollen. As a result, Swiss chard seed production, which most often uses open pollination, generates more than four times as much pollen/acre as hybrid seed production (Westgate, 2010). This means that gene flow from Swiss chard pollen into a hybrid seed crop such as sugar beet seed is more likely than gene flow from sugar beet pollen into Swiss chard. For more on pollen competition see section III.B.5. If detectable levels of gene flow were to occur from H7-1 sugar beets into Swiss chard seed fields, the Swiss chard seed producer may not be able to sell the seed to GE-sensitive purchasers, depending on the level of gene flow and the tolerance level for the presence of a GE trait such as H7-1. For more on gene flow see section III.B.5.

The main process through which Swiss chard seed producers ensure that the desired pollen fertilizes the desired seed donor is to use isolation distances. As described in section III.B.5 below, pollination rates, or gene flow, decreases rapidly as distance from the pollen source increases (Darmency et al., 2009; Eastham et al., 2002). Therefore, just like sugar beet seed producers, Swiss chard seed producers follow strict isolation distances when producing Swiss chard seed, as described below.

APHIS is aware of three major regions in the United States that grow multiple *Beta* species for commercial seed production. See figure 3–9 and table 3–22. These regions are: (1) Willamette Valley, Oregon (Swiss chard, table beet, and sugar beet seed production), (2) Skagit and Snohomish Counties in western Washington (table beet and Swiss chard) and (3) Butte, Colusa, and Glenn Counties in California (table beet and Swiss chard). Commercial *Beta* species producers in each of these regions are known to have either formal or informal isolation distances in place to ensure contractual levels of seed purity.

As mentioned in III.B.1.b(10), all growers of commercial specialty seed in the Willamette Valley, including all commercial companies producing Swiss chard, table beet and sugar beets, are members of the WVSSA. WVSSA has strict (although not mandatory) isolation distances and pinning guidelines for growers to follow. As shown in table 3–3 the isolation distances between *Beta* species range from 1 to 4 miles depending on the specific species, variety and type of pollination used. The minimum isolation distance between Swiss chard and H7-1 sugar beets is 3 miles (WVSSA, 2008). Note that the sugar beet seed producer Betaseed uses a minimum of a 4 mile isolation distance between H7-1 sugar beet seed production and other *Beta* species. For more information see section III.B.1.b(11).

In western Washington, the WSU Northwest Washington Research & Extension Center (NWREC) at Mount Vernon houses a pinning map that covers Skagit, Snohomish, Whatcom, and Island Counties. Isolation distances for *Beta* species (Swiss chard and table beet) used by the WSU NWREC are essentially identical to those used by the WVSSA (McMoran, 2011b). In addition to the WSU NWREC pinning rules, most commercial Swiss chard seed producers maintain an isolation distance of at least 5 miles between *Beta* species (Mcmoran, 2011a). H7-1 sugar beet seed is not produced in this region.

California has the California Seed Growers Isolation Pin Map System. The membership-only, online pinning system is hosted by University of California at Davis. However, the map does not include *Beta* species (CCIA (California Crop Improvement Association), 2011). While APHIS is not aware of any formal pinning schemes being used in this region, *Beta* seed producers work cooperatively on an informal basis and use isolation distances to minimize gene flow (Wahlert, 2011). H7-1 sugar beet seed is not produced in this region.

In many of the counties listed above, increased urbanization and the presence of home gardeners (who do not participate in pinning) have made it more difficult to control pollen flow and ensure that adequate isolation distances are maintained (McMoran et al., 2010) (Wahlert, 2011).

(8) Fertilization

For optimum growth and quality seed production, Swiss chard needs to be fertilized, especially during the bolting and flowering phase. Soil tests should be done to determine the amount of nitrogen in the soil. As a general rule, a ratio of 5:10:5 of nitrogen:phosphorus:potassium fertilizer is recommended (Desai, 2004). Producers growing organic Swiss chard seed can only apply fertilizers that are in compliance with the National Organic Program Standards (NOP) (7 CFR § 205.203). Home growers may or may not apply fertilizers.

(9) Crop Rotation

To prevent buildup of pathogens in the soil, to reduce disease and weed pressure, and to manage volunteers, Swiss chard is generally grown on a 3 to 5 year crop rotation (McMoran et al., 2010).

(10) Swiss Chard Pests and Control Measures

Weeds. In Washington State, vegetable seed crops are not considered to be grown for food or feed, and thus categorized differently in terms of pesticide use. On these sites, pesticide use may include chemicals and amounts of chemicals not permitted on food and or feed crops (McMoran et al., 2010).

Similar to sugar beets, Swiss chard does not compete well with weeds. Seed fields are hoed to control weeds and herbicides are applied to control weeds as needed (McMoran et al., 2010).

The main weeds that compete with Swiss chard seed production in the Northwest include: Shepherds purse, mustards, lambs quarter, pigweeds, smartweed, henbit, groundsel, chickweed, wild turnip, quackgrass, wild oat, Canada thistle, bolt thistle, vetch, nightshades, bed straw, and pineapple weed. Weeds that are related to crops can be difficult to control due to similarities in biology. As a result, lambsquarters, also a member of the Chenopodiaceae family is especially difficult to control in Swiss chard. Spin-Aid, Ro-Neet® and Poast® are commonly used for weed control (McMoran et al., 2010). Producers growing organic Swiss chard seed can only use weed control methods that are in compliance with the National Organic Program (NOP) (7 CFR § 205.206). Home gardeners may or may not use herbicides.

In addition to reducing yield and viability of Swiss chard plants, weeds can also act as host for insects and diseases.

Pest Management. Pest management in the production of Swiss chard seeds focuses on two major types of pests: fungi and insects.

The primary disease problems in Swiss chard seed production are caused by two species of fungus: powdery mildew and downy mildew. Mefenoxam and cymoxanil are used to control downy mildew which can be very severe in some parent lines. Powdery mildew is controlled with a diversity of fungicides including sulfur, azoxystrobin, and pyraclostrobin. Chlorothalonil and mancozeb are used for general disease control and to help prevent resistance to fungicides developing in the pathogen populations (McMoran et al., 2010). Producers growing organic Swiss chard seed can only use fungal control methods that are in compliance with the NOP (7 CFR § 205.206). Home gardeners may or may not use fungicides.

The most critical insect pests are cabbage aphid and turnip aphid. Other insect pests include armyworms, wireworms, cutworms, thrips, and leafminers. Because aphid infestations are spotty and difficult to detect, fields are inspected regularly for aphid outbreaks. Pirimor is used to control aphids. Diazinon is used to control armyworms and cutworms and thrips (McMoran et al., 2010). Producers growing organic Swiss chard seed can only use insect control methods that are in compliance with the NOP (7 CFR § 205.206). Home gardeners may or may not use insecticides.

(11) Testing for Seed Purity and LLP

Similar to sugar beet producers, Swiss chard seed producers have a strong economic incentive to maintain genetically pure seed in both their breeder and commercial seed. Maintaining high levels of seed purity is important because impure seed lots may not have the desired variety attributes, growth rates, and other traits as demanded by customers. As described in III.B.1.b(19), LLP is the presence of undesired seeds or traits in a seed lot. LLP is the result of unintended pollen movement between flowering fields of compatible *Beta* species and/or through admixtures of seeds (accidental mixing of seeds) if equipment is shared or if seeds are not properly isolated from each other during the post harvesting process. As stated above in III.B.2.a., whether grown under conventional or organic methods, the commercial Swiss chard seed produced in the United States is primarily for GE-sensitive markets (McReynolds, 2011). Swiss chard seed producers may test for the presence of the H7-1 trait in their seed if their customers request the test (Loberg, 2011; McReynolds, 2011) (Lyons, 2011c).

The LLP testing described above is done either through molecular means (testing for DNA and proteins) or through grow-outs. Grow-outs (planting of a representative sample of seeds, followed by visual selection) are used to evaluate the frequency of LLP in different seed crops. Morphological traits can be visually identified to detect the presence of table beet or sugar beet LLP, and help identify the potential source(s) of LLP, as well as determine the percent of LLP in the seed lot. For more information on testing methods and grow-outs see section III.B.5.e.

b. Vegetable Production

As stated above, Swiss chard grown for vegetable production occurs throughout the United States. Swiss chard is grown for its foliage, or large leafy greens (Desai, 2004).

(1) Areas of Production

Like other *Beta* crops, Swiss chard is a temperate-cool climate crop that can be grown in much of the United States. Unlike for Swiss chard seed production, producers of the Swiss chard for greens do not want to induce bolting. Therefore, unlike Swiss chard seed production, commercial Swiss chard grown for greens is not highly concentrated in the Northwest. Swiss chard is grown for its greens by both commercial producers and home gardeners.

(2) Planting/Harvesting/Bolting Cycle

Planting dates for Swiss chard are highly dependent on the local environment in which it is planted. Swiss chard seeds are typically planted as early in the season as possible; the earlier the Swiss chard is planted, the earlier it will begin to produce leaves. Swiss chard can be direct seeded mid-spring (after danger of frost has passed) in colder climates, through mid-summer in mid-range climates, and into fall in warmer regions (High Mowing Organic Seeds, 2011b). Transplants can be started indoors and transplanted outdoors after danger of frost has passed (Drost, 2010). Different regions may grow different varieties of Swiss chard that are best suited to their specific environmental conditions.

The optimal germination temperature for Swiss chard is 55 to 75 °F and it generally requires 7 to 14 days for the plant to emerge (Drost, 2010). Once it has emerged, the optimal growing temperatures are 60 to 75 °F during the day and 40 to 45 °F at night, depending on the variety (Masabni and Lillard, 2010b)a).

Swiss chard grows well on well-drained, clay loam. However Swiss chard will tolerate wide range of loamy soils with a pH range of 6.5 to 7.5 (Masabni and Lillard, 2010b)a).

Production practices used to grow Swiss chard vary depending on the desired product (i.e., baby greens or mature greens) and the local environment. In general for commercial production of mature greens, seed are planted 0.25–0.5 inch deep in the soil, in double-planted rows on 38–40 inch beds with 3–6 inch in row spacing (Masabni and Lillard, 2010b)a; (Western Growers Association, 2001). Depending on the local conditions, fields may be pre-irrigated, tilled, and disked (Western Growers Association, 2001). Furrow irrigation may be used to keep plants watered at a low to moderate level. Overhead sprinkler irrigation is not advisable as it increases the incidence of foliar diseases (Masabni and Lillard, 2010b)a). Baby Swiss chard is grown on 80 inch beds with 12 rows per bed (Western Growers Association, 2001).

Swiss chard can be harvested anywhere from 20–60 days after planting, depending on the variety, the local environmental conditions and type of desired product (i.e., baby leaves or mature greens) (Cornell University, 2011b). However, typical harvest dates for commercial production are 50–60 days after planting as Swiss chard leaves have the best flavor during this period (Masabni and Lillard, 2010b; Western Growers Association, 2001).

Swiss chard is harvested by hand and the plant can continue to be harvested as long as the mature leaves are removed and there is not a hard frost. When harvesting for fresh markets, the plants are trimmed, cleaned and tied into bunches in the field. One or two dozen Swiss chard are packed into wax cardboard boxes and shipped to the coolers (Masabni and

Lillard, 2010b) (Western Growers Association, 2001). Baby Swiss chard is shipped in bulk to packing houses and used in packaged salads.

Because of their perishability, Swiss chard greens should be held as close to 32 °F as possible. At this temperature, they can be held for 10 to 14 days. Relative humidity of at least 95 percent is desirable to prevent wilting (OSU Production Guides, 2004; Western Growers Association, 2001).

Swiss chard grown for greens is primarily for fresh market use which presumably is GE sensitive (OSU Production Guides, 2004). According to the most recent National Organic Farmer's (NOF) Survey (2004), in 2001, 13 producers reported growing certified organic Swiss chard on a total of 33 acres nationwide (Walz, 2004). APHIS is not aware of any national production acreage for non-organic Swiss chard. According to the NOF Survey, organic Swiss chard producers reported that 100 percent of their harvest in 2001 was sold in fresh markets (Walz, 2004).

Much like sugar beets, Swiss chard can bolt during the first season. Bolting can be induced by long days (14 plus hours) following cold temperatures (Masabni and Lillarda, 2010a). Bolting is undesirable for growers producing fresh green as bolts deplete the energy going into the leaves and reduce the quality of the greens. Additionally, seed from annual bolters is not desirable for home gardeners who save their own seed because bolter seed is also likely to produce plants that would also bolt during the first season, resulting in poor quality Swiss chard for fresh greens production.

(3) Fertilization

Much like sugar beets, Swiss chard generally requires nitrogen, phosphorus, and potassium for optimum growth. Soil tests are the best way to determine how much fertilizer should be applied (OSU Production Guides, 2004). The generalized rate of fertilizer used for commercial Swiss chard production (in pounds per acre) is 120 nitrogen, 75 phosphorus, and 80 potassium. These amounts may vary depending on the type of soil, the variety grown and production practices used (Masabni and Lillard, 2010b; OSU Production Guides, 2004). In some regions sulfur, boron and magnesium are also applied (OSU Production Guides, 2004). Lime applications may also be applied when the soil pH is 5.8 or below (OSU Production Guides, 2004). Producers growing organic Swiss chard can only use fertilizers that are in compliance with the National Organic Program Standards (7 CFR § 205.203). Home gardeners may or may not use fertilizers.

(4) Crop Rotation

For commercial production, crops are destroyed upon crop termination to reduce the potential build-up of fungi and other pests. A 3- to 5- year rotation is used to reduce fungal levels in the soil (Masabni and Lillard, 2010b).

(5) Swiss Chard Pests and Control Measures

Weeds. As stated above, Swiss chard does not compete well with weeds. The specific weeds that compete with Swiss chard are dependent on the region in which the Swiss chard is grown. Commercial Swiss chard growers use cultural controls such as tillage, rotary hoeing, hand weeding and in-crop cultivation to control weeds in addition to the use of herbicides (Dimson, 2001). Different regions may recommend different herbicide regimens (Zandstra, 2010) (New England Vegetable Management Guide, 2011; Peachey, 2009). Glyphosate is approved for some applications to control weeds in Swiss chard (New England Vegetable Management Guide, 2011); (Nichino America Inc, 2009); (Peachey, 2009; Western Growers Association, 2001). Again, organic growers can only use weed control methods approved by the National Organic Program Standards (7 CFR § 205.206), and home gardeners may or may not follow commercial production weed control methods.

In addition to reducing yield and viability of Swiss chard plants, weeds can also act as host for insects and diseases.

Pest Management. Similar to the production of sugar beet for roots, pest management in the production of Swiss chard for greens focuses on fungi and insects.

The specific fungi that infect Swiss chard depend on the region in which the Swiss chard is grown. Different regions report different fungi as the main cause of disease in growing Swiss chard for greens; therefore, methods to control fungi may vary by region (Dimson, 2001; Kovatch, 2003; Masabni and Lillard, 2010b; New England Vegetable Management Guide, 2011). Organic growers can only use fungal control methods approved by the National Organic Program Standards (7 CFR § 205.206). Home gardeners may or may not use fungicides to control fungi.

The specific insects that attack Swiss chard also depend on the region in which the Swiss chard is grown. However, aphids are a problem when growing Swiss chard for seed in most, if not all, regions. Control measures for insects may vary by region (Pacific Northwest Insect Management Handbook, 2011);(Dimson, 2001; Masabni and Lillard, 2010b). Organic growers can only use insect control methods approved by the National Organic Program Standards (7 CFR § 205.206). Home gardeners may or may not use insecticides to control insects.

3. Table Beet

The table beet (*Beta vulgaris* var. *vulgaris)* has a long history of cultivation. It is a minor crop in North America and Europe, although popularity has increased in the U.S over the past 30 years (Navazio et al., 2010). As stated above in section III.B.1, table beet is the same species as sugar beets, Swiss chard and fodder beets (OECD (Organization for Economic Cooperation and Development)). Therefore, table beets are sexually compatible with other *Beta* crops and represent a potential gene flow source or sink. For more information on gene flow see section III.B.5. Table beet is grown for seed, leafy greens, and roots in the United States. For simplicity, in this EIS the term "table beet" includes red, white, yellow, and striped table beet cultivars.

Like all *Beta* crops, table beet is a hardy biennial and requires 2 years to complete its lifecycle. Table beet seed is produced by both commercial producers and home gardeners. Similar to sugar beets and Swiss chard, the majority of commercial table beet seed production occurs in the Northwest. However, like Swiss chard, table beet seed can be produced almost anywhere in the United States when the steckling method is used. The steckling method is described above in section III.B.2.a(6), and below in section III.B.3a(6). Commercial table beet seed is usually open pollinated, but breeding lines to produce commercial table beet seeds may be inbreds used for hybrid seed production (Goldman and Navazio, 2008). Home gardeners produce seed though open pollination. Beets grown for seed are not used for human or animal consumption as, after bolting, roots become woody and leaves become unpalatable (du Toit et al., 2007).

Table beet grown for its leafy greens and/or roots occurs throughout the United States. Table beet has a large fleshy root, which can vary in size, shape and color depending on the variety (Desai, 2004). It also produces foliage, or leafy greens, which can be eaten in a manner similar to spinach or lettuce (Navazio et al., 2010). The two main markets for table beets are: 1) leaves and roots for fresh markets; and 2) roots for canning. The table beet plant grows until it is harvested or growth is stopped by a hard freeze (Desai, 2004). Table beet is grown by both commercial producers and home gardeners.

a. Seed Production

(1) Location

In the United States in 2011, APHIS is aware of commercial table beet seed production occurring on around 550[8] acres in California, Washington, and Oregon. Table 3–21 shows the acreage of known commercial table beet seed production by county in each of the table beet seed producing states in 2011. Commercial table beet seed acreage was determined though publications from the Washington State Extension Office (du Toit et al., 2007), personal communications with State Extension Officers in Oregon and Washington, and commercial seed producers (McMoran, 2009; Mcmoran, 2011a; McReynolds, 2011). The

Table 3- 21. 2011 Acreage of Commercial Table Beet Seed Production in the United States

State	County	Acreage	References
CA Total	Butte, Colusa, Glenn	<125[1]	(McReynolds, 2011)
OR Total	Polk, Yamhill	27	(McReynolds, 2011)
WA Total	Island, Skagit, Snohomish	405	(McMoran, 2009; Mcmoran, 2011a)
Total U.S. Acres		**557**	

[1] Unknown combination of acreage growing Swiss chard & table beet seed. The combined acreage totals 125.

[2] Acreage in Island County is for stecklings that are relocated to Snohomish and Skagit counties for seed production (i.e., acreage is double-counted, and therefore not included in WA total acreage).

[3] Most recent data available for Skagit County is 2009.

information in Table 3-21 reflects all commercial table beet seed being produced by members of the WVSSA in 2011 and may not capture production by non-members.

Based on this information, APHIS determined that in 2011, commercial table beet is being grown in the following states in the listed counties: western Washington (Island,[9] Skagit, and Snohomish), California (Glenn, Colusa, and Butte), and Oregon (Polk and Yamhill). The acreage and location of table beet seed being produced by home gardeners is unknown.

[8] The information APHIS received on acreage of Swiss chard production in California for Glenn, Colusa, and Butte Counties was aggregate data with combined acreage for Swiss chard and table beet. Therefore actual acreage of Swiss chard and table beet in each of the individual counties is not known. For the purposes of the EIS, APHIS will assume the highest possible acreage for both of the crops by estimating that the acreage of each is up to 125 acres.

[9] While Island County, Washington, is listed as a table beet seed producing county, only stecklings are grown on the island. The stecklings are then re-located to Snohomish and Skagit Counties for seed production.

Figure 3–11 is a map of all known commercial table beet seed producing counties in 2009 and 2011. Figure 3–11 includes all of the counties listed in table 3–21 above.

Based on the information above, in 2011 approximately five percent of commercial table beet seed is being produced in Oregon, 73 percent is being produced in Washington, and 22 percent is being produced in California.

It is entirely possible that not all commercial table beet seed production in 2011 has been captured through the aforementioned research efforts.

However, information on table beet seed acreage and areas of production from previous years indicates that the major areas of U.S. table beet seed production are represented above (du Toit et al., 2007; Loberg, 2011). The acreage of commercial table beet seed production in each area varies from year to year due to changes in demand for seed and crop rotation cycles (Loberg, 2011; McReynolds, 2011). The acreage and location of table beet seed being produced by home gardeners is unknown.

As discussed previously in III.B.1.b(1) and III.B.2.a(1), commercial sugar beets, Swiss chard and table beet seed are all produced in Willamette Valley, Oregon, making Willamette Valley the only known commercial table beet seed production area where gene flow could occur between table beet and H7-1 sugar beets. Overlap between table beet and H7-1 sugar beet in 2011 occurs in a single county of Oregon, Polk County. For a map showing the counties where both table beet and H7-1 sugar beets are grown see figure 4–2. For a map that shows the overlap between vegetable beet seed production (Swiss chard and table beet) and sugar beet seed production see figure 3–12. For more information on gene flow see section III.B.5.

(2) Breeding

Mass selection and collection of seed from open-pollinated plants has traditionally been the principle method for developing new varieties with the desired characteristics (Desai, 2004). However, innovative breeding strategies have been developed for table beets and some table beet breeders are now producing inbred breeding lines (Desai, 2004; Goldman and Navazio, 2008). For example, similar to sugar beet seed breeding, sterile inbred lines and Cytoplasmic Male Sterility (CMS) are used in some table beet breeding programs (Goldman and Navazio, 2008). CMS is described in greater detail in section III.B.1.b(8).

Figure 3- 11. Map of known counties in which commercial table beet seed is produced. Counties in map have been identified as table beet seed producing in 2009 and 2011. Source:(McMoran, 2009; Mcmoran, 2011a)

(3) Seed Crop Producers

Table beet seed production, much like sugar beet production, consists of developing, growing, and processing the seed that table beet growers use to plant their crop. Like Swiss chard seed production, both commercial growers and home gardeners produce table beet seed.

Commercial Table Beet Seed Production. Similar to seed production with Swiss chard, commercial table beet seed production is conducted under bailment contracts. The seed companies provide growers with the stecklings necessary to produce a beet seed crop (du Toit et al., 2007). Stecklings are described above in section III.B.2.a(6) and below in section III.B.3.a(6). It is common practice under bailment contracts for the seed companies to retain ownership of the seed, the growing crop, and the harvested seed (du Toit et al., 2007). Growers are only paid the contracted price if the resulting seed meets quality criteria stated in the bailment contract, typically an 85 percent seed germination rate and 99 percent purity. As weed seed is similar in size and shape to table beet seed, making it difficult to remove during post-harvest processing of seeds, elevated levels of weed seed may cause a seed company to reject a seed crop (du Toit et al., 2007).

Like for other *Beta* species, table beet seed is produced and used for vegetable production, while stock seed is grown specifically for use in planting seed crops (du Toit et al., 2007). APHIS estimates that 5-10 percent of vegetable beet seed production is organic based on an an interview with Alf Christenson Seed Company, one of the major vegetable beet seed producers. (Lyons, 2011c).

While the size of seed markets vary based on market demand, estimates from seed producers indicate that up to 50 percent of table beet seed grown in the United States is exported annually (Lyons, 2011c; McReynolds, 2011).

Home Gardener Table Beet Seed Production. By definition, home gardeners grow table beet seed for their own personal use and do not grow seed under contract.

Non-U.S. Table Beet Seed Production. Just like Swiss chard seed production, table beet seed production also occurs in other countries for the same reasons stated above in III.B.2.a(3). The main foreign countries in which table beet seed is grown are the same as those in which Swiss chard seed is grown: New Zealand, Australia, and China (McReynolds, 2011). For more information on non-U.S. table beet seed production see section III.B.2.a(3) above.

(4) Planting and Lifecycle

During its 2-year seed-producing lifecycle, table beet plants grow a rosette of numerous above ground leaves and develop a fleshy root the first year (Desai, 2004). In the second year, after exposure to vernalizing temperatures, the plant produces a tall seed stalk completing the lifecycle.

In the Northwest, commercial table beet seed producers can produce a seed crop in a 14- to 16-month period by sowing seeds in the late summer to generate young plants that are vernalized over the winter, and produce a seed crop the following summer (Desai, 2004; du Toit et al., 2007; Navazio et al., 2010).

For both the direct-seeded and steckling seeded methods, seeds are harvested after the base of the flowering stalk has turned brown (Desai, 2004). At harvest plants are cut, windrowed, and dried in the field for 10–14 days. While the crop is drying, it is hand-turned to prevent molding. Seed is taken to a conditioning plant where it is cleaned to 99 percent purity (du Toit et al., 2007).

Table beet seed can be produced using either the direct-seeded method or the steckling method, and both of these methods can be used by commercial producers and home gardeners as described below. It should be noted, however, that 100 percent of table beet seeds grown in western Washington are grown using the steckling method. This method is used in this region because it was determined that beets that over-wintered using direct-seeded method were contributing to the spread of the beet mosaic virus which resulted in drastically reduced table beet seed yields (Navazio et al., 2010).

(5) Direct-Seeded Method

The direct-seeded method, also called the "over wintering method" involves planting the desired variety of table beet seeds in the field in the mid-summer and harvesting the seeds the next fall. The direct-seeded method is only suitable for mild climates, such as those found in the Northwest, which is why the majority of commercial table beet seed production occurs in this area.

Commercial Table Beet Seed Production. For commercial production in the Northwest, seeds are typically planted between mid-June to early September, depending on the variety and the specific location (Desai, 2004); Navazio, 2010). Slower growing varieties are planted earlier than later growing varieties. Recommended spacing is 16–22 inches between plants with two rows on top of a 30- to 40-inch seed bed (Navazio et al., 2010). As the weather becomes colder, the plants become dormant and are vernalized in the ground. Plants begin to bolt to form a flowering stalk in the spring, produce pollen during the mid-summer, and seeds in the late-summer. The exact timing for bolting, flowering and seed setting are highly dependent on the specific variety of table beet and the growing conditions (Lyons, 2011b).

For an example of timing, the OrCa Seed Production Inc. production schedule from 2010 shows that when commercial table beet seeds are direct-seed planted in June, the estimated bloom date is the following June to August and the estimated harvest date is September to October (OrCa Seed Production Inc., 2010b). Note that the production schedule does not indicate the location of the table beet seed production. OrCa Seed Production Inc. produces seed in both Oregon and California (OrCa Seed Production Inc., 2010a).

The advantages and disadvantages of using the direct-seed method to produce table beet seeds are identical to those of Swiss chard (Desai, 2004; Navazio et al., 2010). See section III.B.2.a(5) for more information.

Home Gardener Table Beet Seed Production. Home gardeners producing table beet seed in the Northwest could also use the direct-seeded method and would likely follow similar production methods to those of commercial producers. Home gardeners producing table beet seed in other regions with more severe winters would need to use the steckling method.

(6) Steckling Method. Stecklings are table beet roots that are grown from seed for less than a full season and are vernalized either in the ground or are dug up and stored (depending on climate conditions), and will be replanted in the spring for seed production.

Commercial Table Beet Seed Production. For commercial production in the Northwest, seeds are typically planted in mid-June to August, depending on the variety and the specific location (Navazio et al., 2010); (Desai, 2004; du Toit et al., 2007). In Washington, all commercial table beet seeds for steckling production are planted in Island County to avoid damage to the young seedlings from beet mosaic virus (du Toit et al., 2007; Navazio et al., 2010). Slower growing varieties are planted earlier than faster growing varieties. Recommended spacing is the same as for the direct-seeded method: 16–35 inches between plants with 1 to 2 rows on top of a 30- to 40-inch seed bed (Desai, 2004; Navazio et al., 2010). As with Swiss chard, depending on seeding method used, 1 acre of stecklings can be used to plant 10–20 acres for seed production (Desai, 2004).

In October, when the beet roots have reached a size of 3 to 3.75 inches in diameter, their green tops are removed mechanically, they are dug up and placed in windrows (four to six rows of beet roots covered with about one foot of soil to keep roots from freezing in the winter) (du Toit et al., 2007; Goldman and Navazio, 2008; Navazio et al., 2010). Plants are rogued for off-types before being put in windrows.

The next spring, in March or early April, the stecklings are removed from the windrows, graded for shape, prominence of taproot, absence of disease, and trueness-to-type, and brought to Skagit and Snohomish counties for transplanting into production fields (du Toit et al., 2007); (Goldman and Navazio, 2008). Stecklings are mechanically dropped into furrows in an upright position and then covered in soil, approximately 15–25 inches apart in 30- to 36-inch rows (Goldman and Navazio, 2008).

Table beet plants flower in the summer and seeds are collected in the fall. For an example of timing, in Skagit County under ideal weather conditions, Alf Christenson Seed Company typically plants table beet stecklings around April 15 with an estimated bloom date of late June to late July, depending on the variety (Lyons, 2011a). A harvest time of

August to September is typical for the State of Washington (du Toit et al., 2007).

The major advantages and disadvantages of using the steckling method to produce table beet seeds are identical to those of Swiss chard (Desai, 2004; Navazio et al., 2010). See section III.B.2.a(6) for more information.

Home Gardener Table Beet Seed Production. Home gardeners producing table beet seed in the Northwest could also use the steckling method and would likely follow similar production methods to those of commercial producers.

Home gardeners producing table beet seed in other regions would need to modify the production method according to their specific environmental conditions. Table beet seeds can be planted as soon as the soil can be worked and after the threat of a hard frost as passed. Table beet seeds can be direct seeded mid-spring through mid-summer and into the fall in warmer regions. Optimal germination temperature is 55–75 °F, but seeds will germinate in temperatures as low as 45°F (High Mowing Organic Seeds, 2011a). Stecklings are dug up in the fall when roots are 3–3.75 inches in diameter and any leaves an inch or more above the crown are cut off (Navazio et al., 2010). In colder climates the stecklings are stored for the winter at temperatures between 34–37 °F under conditions of high humidity (Navazio et al., 2010). In the spring, stecklings are planted outside at a spacing of 8 to 12 inches between plants and 18 to 36 inches between rows. Based on the specific variety and local environmental conditions, plants bolt and flower at varying times during the summer and set seed in the fall (High Mowing Organic Seeds, 2011a); UW-Madison, 2011).

(7) Isolation Distances

As described above for Swiss chard seed, production of high quality table beet seed requires that the “correct” seed parent be fertilized by the “correct” pollen source. Table beet seed will not meet the quality criteria demanded by purchasers if the percentage of off-type seed exceeds contractual thresholds.

As described for Swiss chard, open-pollination is used for the majority of commercial table beet seed production, and open-pollinated fields generate more than four times the pollen as hybrid seed production. This means that gene flow from table beet pollen into sugar beet seed is more likely than gene flow from sugar beet pollen into table beet seed.

As described in section III.B.2.a(7), isolation distances are used to maintain seed quality. Much like for Swiss chard seed production, increased urbanization and the presence of home gardeners who do not participate in pinning have made it more difficult to control pollen flow and ensure that adequate isolation distances are maintained for table beet seed production (du Toit et al., 2007; Wahlert, 2011).

(8) Fertilization

Fertilization of table beets is similar to that described for Swiss chard in section III.B.2.a(8).

(9) Crop Rotation

For commercial production, table beet plants grown for seed are typically grown in a 4- to 5-year rotation to mitigate disease problems (du Toit et al., 2007) and to manage volunteers.

(10) Table Beet Pests and Control Measures

a. Weeds
Similar to sugar beets, table beet does not compete well with weeds. Weed competition can reduce the yield by up to 75 percent if weeds are not controlled. Therefore, mechanical cultivation, herbicides, and hand-hoeing are all used to help control weeds in table beet seed production fields (du Toit et al., 2007).

The main weeds that compete with table beet seed production in the Northwest include: nightshade, henbit, pigweed, shepherds purse, lambsquarters, mustard, chickweed, wild buckwheat, pale smartweed, common groundsel, curly dock, wild radish, Canada thistle, pineapple-weed, annual grasses (including annual bluegrass, *Poa annua*, and others), volunteer grain (such as barley, *Hordeum vulgare*, and wheat, *Triticum aestivum*), and seedling perennial grasses (such as quackgrass, *Elytrigia repens*, and perennial ryegrass, *Lolium perenne*). Weeds that are related to crops can be difficult to control due to similarities in biology. As a result, lambsquarters, also a member of the Chenopodiaceae family, is especially difficult to control in table beets. Cycloate (Ro-Neet™), phenmedipham + desmedipham (Betamix®), ethofumesate (Nortron® SC), chloridazon (= pyrazon) (Pyramin®), Fluazifop-P-butyl (Fusilade® DX), and clopyralid (Stinger®) are commonly used for weed control in table beet seed production (du Toit et al., 2007). Producers growing organic Swiss chard seed can only use insect control methods that are in compliance with the National Organic Program Standards (7 CFR § 205.206). Home gardeners may or may not follow commercial production practices for weed control. In addition to reducing yield and viability of table beet plants, weeds can also act as host for insects and diseases.

Pest Management. Pest management in the production of table beet seeds focuses on the control of viruses and fungi, as well as insects. The primary fungal disease problems in commercial table beet seed production in the Northwest are damping-off, black root rot, downy mildew, powdery mildew, and black leg. The disease-causing fungi can be controlled through a combination of cultural means and chemicals. Cultural controls include selecting resistant seed varieties, not over-fertilizing, increasing air circulation, avoiding damp soil and pre-treating or cleaning seed before planting (du Toit et al., 2007). Additionally, fungi can be controlled through the use of chemicals. Fludioxonil, Thiram, Azoxystrobin, and Mefenoxam are commonly used to control damping-off and black root rot. Mefenoxam and cymoxanil and copper hydroxide are used to control downy mildew. Powdery mildew is controlled with a diversity of fungicides including sulfur, azoxystrobin, and pyraclostrobin. Black leg is controlled with thiram (du Toit et al., 2007). Producers growing organic Swiss chard seed can only use fungal control methods that are in compliance with the National Organic Program Standards (7 CFR § 205.206). Home gardeners may or may not use fungicides.

Table beets are also susceptible to beet mosaic virus, beet western yellows virus and BCTV. Most of these viruses are controlled through cultural means (planting stecklings in Island County and transplanting vernalized stecklings onto the mainland in the spring) in western Washington and chemical control is not typically used (du Toit et al., 2007).

The significant insect pests of table beets include three types of aphids, armyworms, and cutworms (larvae), and thrips. Aphids can also spread the beet western yellows virus (although the virus is not transmitted to the seed). Aphids are typically controlled by pymetrozine (Fulfill®). Armyworms and cutworms are controlled by methomyl (Lannate®) and diazinon, which can also be used to control thrips (du Toit et al., 2007). Producers growing organic table beet seed can only use insect control methods that are in compliance with the National Organic Program Standards (7 CFR § 205.206).

(11) Testing for Seed Purity and LLP

Similar to sugar beet and Swiss chard seed producers, table seed producers have a strong economic incentive to maintain genetically pure seed in both their breeder and commercial seed. Growers must maintain high levels of seed purity to ensure seeds produce the desired variety attributes, growth rates, and other traits as demanded by customers. Most producers rogue off-types during seed production and perform grow outs to look for off-types. Some table beet seed producers test for the presence of the H7-1 trait in their seed (Loberg, 2010b) (Lyons, 2011c; McReynolds, 2011). These testing methods are described in more detail above in III.B.2.a(11) and below in III.B.5(e).

b. Vegetable Production

As stated above, table beet vegetable production occurs throughout the United States. The table beet plant grows until it is harvested or growth is stopped by a hard freeze.

In addition to being grown for food, table beet roots are a source of betanin (2,6-pyridinedicarboxylic acid), which is used in a variety of industrial food colorants (Harmer, 1980; Grubben and Denton, 2004). Betanin is a red glycosidic food dye, usually extracted from red table beets where the betanin concentration can reach between 300 and 600 mg per kg. Red beet dyes can be used in cosmetics, candy, ice cream, meat products, yogurt, and powdered drink mixes (Goldman and Navazio, 2008).

(1) Areas of Production

Like other *Beta* crops, table beets can be grown in many regions within the United States. The best growing regions for beets have cool, wet spring weather, followed by cool and relatively dry summer weather. Table beets are grown for their roots and greens, for fresh markets or for canning, by both commercial producers and home gardeners. Unlike table beet seed production, producers of table beets for roots and greens do not want to induce bolting as it ruins the quality of both the roots and the greens (du Toit et al., 2007).

The majority of table beets grown in the United States are grown for the canning industry (Nolte, 2010) which is largely not a GE sensitive market. In 2007 (the most recent year for which data are available), Wisconsin grew the most acres (2784 acres harvested) followed by New York (2,173 acres harvested) (NASS, 2010). Total U.S. acreage of beets harvested in 2007 was 8412 acres. In 2002 9,9092 acres were harvested and in 1997, 11,303 acres were harvested. In 1997 the harvest had a total yield of 122,180 tons (average yield = 16.38 tons per acre), and a total value of USD 8,153,000 (NASS, 2010).

In addition, table beets are grown for fresh markets. According to the Fourth National Organic Farmer's Survey, in 2001, 27 producers reported growing table beets on a total of 42 certified organic acres in the United States (Walz, 2004).

The acreage of table beets grown for roots and greens does not normally exceed 10,000 acres annually (Nolte, 2010). In 2009, the United States produced beets for roots and leaves on roughly 7,000 acres, not including production for microgreens which has increased over the past decade (Nolte, 2010).

(2) Planting/Harvesting/Bolting Cycle

Planting dates for table beet are highly dependent on the local environment in which it is planted. Table beet seed is typically planted as early in the season as possible, usually when soil seed zone has reached a temperature greater than 45°F (Masabni and Lillard, 2010a). Table beet can be direct-seeded in mid-spring (after danger of frost has passed) in colder climates, through mid-summer in mid-range climates and into fall in warmer regions (High Mowing Organic Seeds, 2011a). Transplants can be started indoors and transplanted outdoors after danger of frost has passed. The earlier the table beet is planted, the earlier it will begin to produce leaves. Different regions may grow different varieties of table beet that are best suited to their specific environmental conditions.

Optimal germination temperature for table beets is 55 to 75 °F, but beets will germinate in temperatures as low as 45 °F (High Mowing Organic Seeds, 2011a). The optimal growing temperatures for table beets are 60–75 °F during the day and 45–55°F at night. Beets are fairly cold-tolerant, but do not tolerate heat well (Masabni and Lillard, 2010a).

Table beet grows well on well-drained, sandy or silt loams or muck soils with a pH range of 6.5 to 8.0 (Masabni and Lillard, 2010a). Beets may be grown on heavier soil types, but heavier soils make root harvesting more difficult and may impair root growth (Hemphill and Mansour, 2011)

Production practices used to grow table beet vary depending on the desired product (i.e., microgreens or beet roots) and the local environment. In general, for commercial production of beet roots, seed are planted 0.5–0.75 inch deep in the soil, a little over an inch apart in 18 to 24 inch rows (Hemphill and Mansour, 2011; High Mowing Organic Seeds, 2011a). Seeds should be planted at different densities depending on harvest date; for early harvest, 15–20 seeds per foot, for mid-season harvest, 20–25 seeds per foot, and for late-season harvest 15–20 seeds per foot. For fresh market beets, plants should be 2–3 inches apart. For baby beets, 30–35 seeds are planted per foot and rows are reduced to 10–15 inches (Hemphill and Mansour, 2011).

When irrigation is used, table beets should be irrigated uniformly. The critical irrigation stages are during stand establishment and early growth. Beets do not tolerate water-logged or over-irrigated soils, which can turn beet leaves red, can cause plants to stop growing and may increase diseases (Masabni and Lillard, 2010a) (Hemphill and Mansour, 2011).

Beets grown for root are typically harvested at 42–56 days for table beets, 60–70 days for round beets and 70–80 days for cylindrical beets (Hemphill and Mansour, 2011; Schrader and Mayberry, 2006). Harvest dates can depend on specific planting date, the desired size of the beet and the season in which the beet is grown (Hemphill and Mansour, 2011); (Masabni and Lillard, 2010a). Beets for processing may be harvested by machine. Beets for fresh market are normally hand harvested and bunched (Masabni and Lillard, 2010a).

Harvested beet roots should be stored at 32 °F with high levels of humidity. Topped beets can be stored for up to 4 to 6 months under suitable conditions. Beet greens are far more perishable. They can be stored at 32 °F for up to 10–14 days (Hemphill and Mansour, 2011).

Much like sugar beets, table beets can bolt in the first season. However because beets are typically harvested anywhere from 6–12 weeks and vernalization typically takes place for 12 weeks at temperatures of approximately 2–5 °C. (Goldman and Navazio, 2008), the beet root crop is usually harvested before bolting has time to occur.

(3) Fertilization

Table beet generally requires nitrogen, phosphorus and potassium for optimum growth (Schrader and Mayberry, 2006). Soil tests are the best way to determine how much fertilizer should be applied (OSU Production Guides, 2004). The generalized rate of fertilizer used for commercial table beet production (in pounds per acre) is 80 nitrogen, 80 phosphorus, and 90 potassium (Masabni and Lillard, 2010a). These amounts may vary depending on the type of soil, the variety grown and production practices used (Masabni and Lillard, 2010a; Schrader and Mayberry, 2006). In some regions sulfur, boron and magnesium are also applied (Schrader and Mayberry, 2006). Lime applications may also be applied when the soil pH is 5.8 or below (Schrader and Mayberry, 2006). Producers growing organic table beet can only use fertilizers that are in compliance with the National Organic Program Standards (7 CFR § 205.203).

(4) Crop Rotation

Like other *Beta* species, table beets should be rotated with other crops to reduce weed and other pest pressures (Binning et al., 2011).

(5) Table Beet Pests and Control Measures

In the United States, table beet growth and survival is vulnerable to several pests, including insects, diseases, and weeds. Each of these pests is managed by different practices, either through cultural or chemical means.

Weeds. Like all *Beta* species, table beet does not compete well with weeds. The specific weeds that compete with table beet are dependent on the region in which the table beet is grown. Commercial table beet growers use cultural controls such as tillage, rotary hoeing, hand weeding and in-crop cultivation to control weeds in addition to the use of herbicides (Peachey, 2009; Sanders, 2001). Different regions may recommend different herbicide regimens (Binning et al., 2011; New England Vegetable Management Guide, 2011; Peachey, 2009; Zandstra, 2010). Glyphosate is approved for preplant and pre-emergent applications to control weeds in table beet (Zandstra, 2010) (New England Vegetable Management Guide, 2011; Nichino America Inc, 2009); Pacific Northwest Weed Management Handbook, 2011). Home growers may or may not follow commercial production weed control methods. Organic growers can only use weed control methods approved by the National Organic Program Standards (7 CFR § 205.206).

In addition to reducing yield and viability of table beet plants, weeds can also act as host for insects and diseases.

Pest management. The specific fungi that infect table beet are dependent on the region in which the table beet is grown; therefore, control measures for fungi may vary by region. Different regions report different fungi as the main cause of disease in growing table beet for roots and greens (Masabni and Lillard, 2010a; Ocamb and Pscheidt, 2010) (Binning et al., 2011; New England Vegetable Management Guide, 2011). Producers growing organic table beet for roots or greens can only use fungal control methods that are in compliance with the National Organic Program Standards (7 CFR § 205.206). Home growers may or may not use fungicides.

The specific insects that attack table beets also depend on the region in which the table beet is grown, and control measures for insects may vary by region as well. However, aphids appear to be a problem when growing table beet for vegetables in most, if not all, regions (Binning et al., 2011; Masabni and Lillard, 2010a; Pacific Northwest Insect Management Handbook, 2011). Producers growing organic table beet for roots or greens can only use insect control methods that are in compliance with the National Organic Program Standards (7 CFR § 205.206). Home growers may or may not use insecticides.

4. Fodder beets

Fodder beets (*Beta vulgaris* var. *crassa*) are the same species as sugar beets, Swiss chard and table beets and as such they are all sexually compatible with each other (OECD (Organization for Economic Cooperation and Development)). Before the Second World War, fodder beets were commonly grown as a high yielding forage crop (Draycott and Hollies, 2001; Henry, 2008; Roth et al., 2008); (DLF Trifolium, 2010). While no longer as popular, they are still grown for fodder on 150,000 acres in Europe and New Zealand and may be used for ethanol production (Gibbons and Westby, 1988)Fodder beets are rarely grown in the United States.

Like other *Beta* species, fodder beet is a hearty biennial and requires 2 years to complete its lifecycle. Commercial fodder beet seed is grown by a few seed producers in Europe. Fodder beet seed can either be hybrid or open pollinated, self-fertilizing, or self-incompatible. Seed can be produced using the direct-seeded or the steckling method (Henry, 2008). APHIS is not aware of any fodder beet seed production in the United States (Wahlert, 2011).

Fodder beet grown for its greens and roots occurs across Europe and in New Zealand. Like sugar beets, fodder beet produces a fleshy root in the first year. The root color, size, and shape vary by variety. Both the root and the greens may be eaten for animal feed (Henry, 2008). As farmers only use the vegetative phase for fodder, bolting resistant varieties have been developed as bolting greatly reduces the yield and quality of the fodder (Henry, 2008). APHIS is not aware of any commercial fodder beet vegetable production in the United States.

While there is currently no commercial fodder beet seed or vegetable production in the United States, fodder beet may be grown in limited University plots for ethanol research purposes (Gibbons and Westby, 1988). A limited discussion on fodder beet seed production practices is presented in this EIS due to the sexual compatibility of fodder beets, sugar beets, Swiss chard and table beets. The following discussion is based largely on information relevant to European countries where fodder beets are currently being grown for root and seed.

a. Areas of production

(1) Seed Production

The principal fodder beet seed production occurs in the southwest of France near where sugar beet seed is produced (Henry, 2008).

(2) Forage Production

Fodder beet is currently not a major crop for animal feed in terms of production or area cultivated. Based on the most recent global production data available (Henry, 2008), fodder beet production occurs in: France (32,100 acres), the United Kingdom (24,700 acres), Belarus (19,800–24,700 acres), Denmark (19800 acres), Ireland (18,800 acres), New Zealand (17,300 acres), Belgium (9,900 acres), Germany (9,900 acres), and Switzerland (2,500–3,700 acres).

b. Production/Planting/Harvesting

(1) Seed

Most fodder beet seed sold on the market today is monogerm, triploid seed. Hybrid fodder beet seed breeding and production is modeled on hybrid sugar beet seed breeding and production and involves a complex series of maintaining CMS females and pollinators (Henry, 2008). For more on sugar beet breeding and the use of CMS in hybrid seed production see sections III.B.1.b(6) through III.B.1.b(9).

The steckling method is the most common method used to produce hybrid commercial fodder beet seed. Seed is typically planted in nurseries in August after the basic seed is provided by the breeder to the producer. The plants are grown until November when the stecklings are harvested and vernalized at 40–45°F. Stecklings are transplanted into production fields in March in the desired ratio of male to female plants. After stalk elongation in early summer, females may be topped in order to synchronize flowering. Male pollinators are removed in July with harvest following shortly thereafter, depending on varieties used and the environmental conditions. Stalks are dried in the fields for approximately 10 days after which they are harvested and sent to factories for processing and cleaning (Henry, 2008).

Plants are rigorously checked for off-types from other fodder beet crosses and weedy beets as incorrect crosses will lower the quality and potentially the value of the seed produced (Henry, 2008).

According to the OECD Schemes for the varietal certification of fodder beet seed in international trade (OECD (Organization for Economic Cooperation and Development)) all seed crops for basic seed production must be at least 3280 feet (1 km) from other *Beta* species, and all seed crops used to produce certified fodder beet seed must be a minimum of 980 to 3280 feet away from other *Beta* pollen sources depending on the specific *Beta* source and the type of seed being produced (OECD (Organization for Economic Cooperation and Development)). Additionally, certified seed (not including basic seed) must have a minimum of 97 percent analytical purity (excluding any additives) and a minimum germination percentage of 68, depending on the type of seed being produced (OECD (Organization for Economic Cooperation and Development)).

(2) Forage Production

Fodder beet grown for forage production grows best on well-drained soil with a pH of at least 6.5 to limit fungal growth. When grown on sandy soils, irrigation may be required. Fields can be plowed in the autumn or the spring (DLF Trifolium, 2010).

Seed is planted in spring, after soils are warm enough. Planting occurs around the 5–20 of April in Denmark. Seeds are planted at a depth of 0.2 in and then covered with 0.8–1.2 in of soil. An optimal final germination rate is 70,000 to 75,000 plants per hectar. Germination rates are dependent on the variety but are usually 60–65 percent for triploid varieties and 70–75 percent for diploid varieties. As with other *Beta* species, fodder beets require fertilizer. A typical amount of fertilizer used is 397 lb per hectare nitrogen, 88 lb per hectare phosphorus and 441 lb per hectare potassium, depending on the local soil conditions. (DLF Trifolium, 2010)

At harvest, beets are carefully topped to ensure minimal damage to the beets. Tops may be ensiled for animal fodder. Beets are lifted from the soil and stored at 37–41 °C over the winter. (DLF Trifolium, 2010)

Much like other *Beta* species, fodder beets can bolt the first year. Bolting in fodder beet fields can be due to vernalization of fodder beets, or the presence of weed beets. Some of the fodder beet varieties bolt more easily than others. In either case, bolters are removed as fodder beet bolters reduce the quality of the beets, impede topping and harvesting and weed beet bolters that are allowed to seed will result in the spread of weed beets. Fodder beets cannot be grown successfully in areas with high levels of weeds beets. (DLF Trifolium, 2010).

Similar to other *Beta* species, fodder beets are poor competitors with weeds. Weed control management can include machine and hand hoeing in addition to herbicide use. Much like sugar beet, Swiss chard, and table beet, fodder beets are susceptible to pests and diseases. These can be controlled through chemical and other means. (DLF Trifolium, 2010).

5. Gene Flow in Beta Species

a. Overview of Gene Flow

(1) Gene Flow

Gene flow is a natural biological process necessary for the evolution of plant species and the production of fruits and seeds by most crop species. Gene flow describes the process by which genes move from one plant population (source) to another (sink) genetically distinct population. . Gene flow itself does not pose any particular risk (Bartsch et al., 2003;

Ellstrand, 2006); unless it results in the movement of specific genes or traits with undesired effects into cultivated or weedy plant species.

The movement of genes from one plant population to another requires dispersal of the pollen or seed to a new location followed by either sexual or asexual reproduction. Gene flow as a result of sexual reproduction occurs via transfer of pollen or seeds. Pollen-mediated gene flow (often called cross-pollination or outcrossing) is a term used to describe the movement of plant genes from one plant to another genetically distinct plant via successful pollen movement (Mallory-Smith and Zapiola, 2008) to produce hybrid seeds. Seed-mediated gene flow describes the movement of genes via seeds into new populations. In this case, seed from one population disperses to another in a new location and establishes, introducing new gene or genes into the plant population (Mallory-Smith and Zapiola, 2008).

(2) Hybridization

In plant biology, hybridization occurs when plants from two different populations exchange genes and produce seed with the genetic combination of the two parental plants. For natural hybridization to occur between plant populations, the two plant populations need to overlap in flowering time and physical proximity such that pollen can be carried between the male and female parents. Additionally, the pollen must successfully compete with the pollen produced by the sink population, fertilization must occur, and the resulting hybrid seed must be viable. If the hybrid seed is viable, germinates, and grows into a hybrid plant, gene flow and hybridization has successfully occurred (Ellstrand, 2003). Hybridization is most common between the same or closely related species but can sometimes occur when distantly related species are brought into contact in a new environment or when hybrids are deliberately created by crop breeding.

(3) Introgression

A single case of hybridization between plant populations may not result in lasting genetic changes in the sink population. For example, hybrid plants may be less fertile than parental plants or have other altered traits, reducing their fitness. However, if repeated hybridization events occur, either through hybrid plants exchanging genes with neighboring plants, or if source and sink populations continue to exchange genes over time, then introgression has occurred. Repeated hybridization between hybrid plants and parental plants (backcrossing) must occur in order for the genes of the source population to permanently integrate into the sink population. Introgression tends to be rarer than hybridization because hybridization between distantly related species may not produce viable seeds or fertile hybrid plants. For example, in studies done with canola and a weedy relative, backcrossing occurred at one-hundredth to one-thousandth the rate of the original hybridization (Stewart Jr., 2008). Nevertheless, when a species is introduced to a new area, there is the potential that the introduced plants may hybridize with other closely related species. New hybrid plants therefore may be created with new or modified traits. For example, hybridization events may contribute to the rise of invasive weeds, genetic assimilation, or local extinction of sink population as genetic mixing between previously isolated plant populations can produce a wide array of genetic and phenotypic variation. Some of these new hybrid genotypes may exhibit increased invasive properties (USDA-ARS, 2008).

Many plant species are believed to have been derived from gene flow, hybridization, and introgression between closely related species (Grant, 1981; Hegde et al., 2006; Rieseberg, 1997; Soltis and Soltis, 1993). In addition, the occurrence of gene flow in the evolutionary history of crop species is reported to be widespread (Ellstrand, 2003; Rieseberg et al., 1993). Plant breeders frequently make controlled crosses to move desirable traits between cultivars (different versions of the same crop species) or to introduce traits from wild species into domesticated crops to develop new cultivars. Conversely, gene flow from domesticated crops such as rice, sorghum, and sunflower into wild relatives can result in undesired effects, such as potentially contributing to enhanced weediness of the wild relatives (Ellstrand et al., 1999). Gene flow varies greatly between different species of plants and between different populations of plants of the same species (Ellstrand, 2003).

The rate of gene flow between plant populations varies depending on numerous external factors in addition to the mechanism of gene flow (Mallory-Smith and Zapiola, 2008). Persistence of genes from the source population in the sink community through pollen transfer or self seeding is required to maintain detectable levels of gene flow.

- The rate of pollen-mediated gene flow between populations depends on numerous factors:
  - The species and population of plants involved;
  - Pollination method (e.g., wind pollination or insect pollination);
  - Abundance of pollinator (e.g., high winds, numerous insects);
  - Biology and quantity of pollen produced;
  - Pollen cloud density;
  - Flowering phenology and synchrony (the timing of flowering of both source and sink populations);

- Distance between source and sink populations;
- Relative sizes of source and sink populations; and
- Weather conditions, including temperature, wind, and humidity.

- Seed-mediated gene flow (dispersal) also depends on many factors:
  - Natural dispersal from wind, water, or animals
  - Persistence in the seed bank; and
  - Human-mediated dispersal from field harvesting technology, transportation, or storage.

Gene flow can also result from the dispersal and regeneration of vegetative plant propagules (e.g., stem cuttings). Whether a plant can successfully reproduce asexually depends on the specific clonal nature of a plant species. For example, many plants can regenerate new adult plants from fragments of vegetative tissue. If a plant species can reproduce in this fashion, natural- and human-mediated dispersal mechanisms can lead to gene flow.

Another potential mechanism for the movement of genes between species includes the biological process known as horizontal gene transfer (HGT). Briefly, HGT is a process whereby genes move between species that are not sexually compatible (e.g., plant to bacteria). Relative to the rates of natural gene flow between sexually compatible species, HGT is extremely rare. For a more detailed description of HGT see section III.C.5 of this EIS.

b. Mechanisms of Gene Flow for Sugar Beet Cultivars

Sugar beets (*Beta vulgaris* ssp. *vulgaris*) are a member of the genus *Beta* (Chenopodiaceae) and are cultivated worldwide. The species *B. vulgaris* includes many different crop varieties including sugar beets, fodder beets, Swiss chard, and table beets. The potential mechanisms for hybridization in the United States between sugar beets and the following other crop and wild beets are discussed below: (*Beta vulgaris*) fodder beets, table beets, Swiss chard, ruderal or feral beets (beets that have escaped cultivation), and wild beet species (*B. vulgaris ssp. maritima , B. macrocarpa*). The biological and physical mechanisms that contribute to gene flow between sugar beets and any sexually compatible relative are the same regardless of the agronomic production method: conventional, organic, or GE. Thus, the following sections describe how gene flow processes would affect all three types of agronomic production.

The cultivation of sugar beets can be summarized by two general categories: sugar beets cultivated for the production of a root crop, and sugar beets cultivated for the production of sugar beet seed.

Sugar beets are grown primarily as a root crop and are harvested for their belowground structures (root). Sugar beets are a biennial species, producing a sugary tap root in the first year, and a flowering stalk in the second. Selection has been against annual bolting tendency in sugar beets and vegetable beet varieties. As described in section III.B.1.c., sugar beets require a vernalization period (cold period) to induce flowering. This trait in sugar beets is controlled by a single genetic locus (B locus) (Desplanque et al., 2002). Wild beet species typically carry the dominant allele (genetic sequence) for bolting (flowering in the first year), while cultivated sugar beets carry the recessive allele. Thus, hybrids between wild beets and cultivated sugar beets carry the trait for first year bolting (Boudry et al., 1993). Production of the inflorescence (bolting) in the second year of growth consumes the large taproot formed during the first year of growth. Thus, sugar beets grown for sugar production are grown as annual plants, planted in the spring, and harvested in the fall of the first year without producing flowers. If sufficiently cold weather, 4–7 °C (39–44 °F), occurs in the spring and satisfies the vernalization period (Van Dijk et al., 1997), bolting can occur in sugar beet production fields. In this case, some level of flowering can occur in production fields though intense breeding of modern varieties of sugar beets have reduced the frequency of bolting to 0.01 percent, or 4 plants per acre (Darmency et al., 2009; Ingram, 2000; OECD (Organization for Economic Cooperation and Development)). Sugar beet root production in California is different from cultivation in the other States. Because of mild winters, California production involves planting sugar beets in the fall and the growing season can extend for 10-11 months. As a result, cool winter weather can vernalize sugar beets and lead to first-year bolting prior to root harvest (Bartsch et al., 2003)(see section III.B.1.c).

In contrast to sugar beets grown for the root, the production of sugar beet seeds for use in root crop production requires flowering and the production and movement of pollen. The potential mechanisms for gene flow in sugar beet seed production are described below.

(1) Pollen-Mediated Gene Flow

Movement of pollen from one *Beta spp*. seed field into another seed production field is the primary mechanism for outcrossing between different sugar beet cultivars and between sugar beets and other sexually compatible varieties/species. Sugar beets are predominantly wind-pollinated. Sugar beets are a highly self-incompatible species that require the movement of pollen between individual plants for the production of sugar beet seed. Self-incompatibility in sugar beets is controlled by a number of different genetic loci although temperature-induced breakdown of incompatibility can occur. Genetic incompatibility is further reinforced by asynchronous flower maturation as pollen is released from the flowers before the female structures are receptive (Bosemark, 2006). Production areas for sugar beet seed are discussed in section III.B.1.b.

Sugar beets produce extremely high numbers of pollen per plant (almost 1 billion grains per plant) and a 1-hectare (2.47 acres) seed field can produce an estimated 25 trillion pollen grains (OECD (Organization for Economic Cooperation and Development)). Because of the large amount of pollen produced by sugar beets, the pollen is often referred to as a "pollen cloud" (OECD (Organization for Economic Cooperation and Development)). Because of the great numbers of pollen grains produced by a sugar beet field, competition is very high within the cloud for successful pollination of an ovule (female part of the flower). Pollen survivability in the environment is typically limited to 24 hours and is influenced by humidity and other environmental conditions (OECD (Organization for Economic Cooperation and Development)). Sugar beet flowers are not showy or attractive to insect pollinators. Some studies, however, have reported limited insect pollination by bee, fly, and thrips species (Free et al., 1975; OECD (Organization for Economic Cooperation and Development)) (Desplanque et al., 2002).

In seed production areas, sugar beet seed is produced by hybridizing very specific genetic lines of sugar beets. The female plant line is genetically described as being CMS and typically cannot produce viable pollen. The desired cross pollination can be achieved by planting alternating blocks of CMS female plants with the desired male fertile plants. CMS lines are typically diploid (2N) where its ovules (which become the seeds) are haploid and possess one copy of the sugar beet genome (N) (Campbell, 2002). The male plant line or pollen parent can be diploid (2N) or tetraploid (4N) producing haploid or diploid pollen and the resulting F_1 hybrid sugar beet seed will be diploid (2N) or triploid (3N), respectively

(Campbell, 2002). Diploid F_1 hybrids of sugar beets can be fully fertile if the pollen parent carries the proper restorer genes. In contrast, the triploid hybrids are either sterile or have very limited fertility (Desplanque et al., 2002) and therefore would not be an effective pollinator.

An important factor regarding the use of CMS hybrid production methods for the production of H7-1 seed production is the preferential use of CMS plants (male sterile) that carry the H7-1 trait. The best available data for 2011 suggest that ~85 percent of H7-1 seed production fields in the Willamette Valley use CMS plants (male sterile) that carry the H7-1 trait (APHIS proprietary data). The male pollinator plants in these fields produce all non-H7-1 pollen. Thus the only potential source of H7-1 pollen in these fields arises from the extremely low level of spontaneous fertility in female (CMS) plants (approx. 1 in 16,000 plants) (Lehner, 2010). Because seed purity is important to seed producers, every field is walked to identify and destroy these rare events Because of the lack of fertile H7-1 pollen from these sources, the potential for H7-1 pollen movement in the environment is primarily due to the remaining ~15 percent of H7-1 seed production that utilizes male fertile H7-1 pollinator lines. Details regarding the specifics of CMS plant breeding in sugar beets are presented in section III.B.1.b(8).

Because sugar beet seed production requires pollen movement and sugar beet pollen can travel long distances, large isolation distances are standard practice in sugar beet culture to ensure pollination by the desired pollinator and not from neighboring fields (OSCS (Oregon Seed Certification Service), 1993); see section III.B.1.b(10) for discussion on isolation distances in sugar beet seed production. It should be noted that isolation distances do not guarantee 100% seed purity. Undesired cross pollination can always occur due to interacting factors between the environment, biology, and human error. As a result, seed producers have established isolation distances with the aim of reducing the occurrence of gene flow and cross pollination to a minimum. Seed producers are fully aware that the potential for small amounts of unintended gene flow are possible, but that expanding isolation distances beyond those currently used in seed producing regions (e.g., Willamette Valley of Oregon) would be economically or logistically prohibitive (OSA (Organic Seed Alliance), 2010). For very little tangible benefit, it would greatly restrict the number of *Beta* seed growers.

To maximize the recovery of sugar beet seed produced using CMS hybrid production (currently all commercial sugar beet seed is produced using CMS), fields are typically planted with a 3- to 4-fold excess of CMS lines over the pollen parent. Use of the CMS breeding method for the production of sugar beet hybrid seed naturally reduces the number of plants producing pollen in a given field by a factor of 3 or 4. As such, the pollen clouds created by CMS sugar beet production fields are expected to be smaller than a pollen cloud produced by an identical-sized field of open=pollinated sugar beets (or any other *Beta* crop species). Another potential factor influencing the potential risk of pollen-mediated gene flow could arise through the use of tetraploid (4N) male lines in CMS sugar beet seed production. Tetraploid male lines can have delayed pollen release, relative to diploid lines. Additionally, beet pollen derived from tetraploid lines has been found to be less competitive compared to pollen from diploid lines (Campbell, 2002). Thus, female CMS plants are expected to be at greater risk of incoming pollen flow from diploid *Beta* crops or weeds for a short period of time before tetraploid lines release pollen (OECD (Organization for Economic Cooperation and Development)).

As discussed in section III.B.1.b, APHIS issued permits for H7-1 sugar beet seed production in Eastern Washington (Franklin, Adams, Grant, and Yakima counties), Idaho (Canyon, Cassia, Gooding, Jerome, Minidoka, Payette, Twin Falls, and Washington counties), and Oregon (Benton, Clackamas, Crook, Deschutes, Douglas, Jackson, Josephine, Lane, Linn, Malheur, Marion, Polk, Washington, and Yamhill counties) (APHIS proprietary data). Based on planting records supplied to APHIS by May 15, 2011, planting occurred in all these counties with the exceptions of Yakima, WA, Jerome and Minidoka, ID, and Crook and Yamhill, OR. (see section III.B.1.a(2), figure 3–1).

Many factors can affect the distance over which cross pollination can occur including wind direction, wind speed, humidity, and surrounding vegetation. Additionally, pollen travelling from a source population is faced with pollen competition within the pollen cloud produced by the sink population and can act to reduce the likelihood of long-distance pollen successfully pollinating plants within a given field (Hoffman, 2010). As long-distance pollen will naturally be in lower abundance than local pollen, the likelihood of successful long-distance pollination decreases with increasing distance and the size of the receptor field. Because CMS fields produce less total pollen, gene flow out of CMS fields will be lower than from similarly sized non-CMS fields. Conversely, because the pollen cloud is smaller in hybrid production fields, competition is also less than in similarly sized open pollinated fields and hence rates of long-distance gene flow are expected to be higher into hybrid production fields.

Many studies have been conducted to qualitatively and quantitatively measure pollen-mediated gene flow between sugar beets and other *Beta* species. Studies have indicated that sugar beet pollen can travel a substantial distance depending on wind conditions. Wind-borne sugar beet pollen has been measured to travel up to 5.0 miles (Archimowitsch, 1949; OECD (Organization for Economic Cooperation and

Development)), though the viability of the pollen at this distance was not determined.

Many different studies have been conducted to measure the distances over which cross-pollination between *Beta* crop species may occur (Alibert et al., 2005; Archimowitsch, 1949; Bartsch et al., 2003; Darmency et al., 2009; Darmency et al., 2007; Fénart et al., 2007; Saeglitz et al., 2000). Some of the earliest studies of viable pollen and hybridization indicate that most sugar beet pollen is deposited at short distances (<656 feet) from crop fields (Archimowitsch, 1949). Similarly, in studies comparing gene flow from transgenic sugar beets to non-transgenic ruderal beets and CMS beets, gene flow rates were observed to decrease rapidly with distance. In a study where CMS plants (more susceptible to gene flow due to male sterility) were used as bait plants to measure gene flow, gene flow was highest close to pollen donor plants and was as high as 40 percent at 656 feet. In a second study, gene flow rates to ruderal beets occurred at a level of 0.55 percent at 656 feet, while the more receptive (due to male sterility) CMS plants received 1.46-percent gene flow (Alibert et al., 2005). At greater distances (3,280 feet), CMS plants received less gene flow, 0.15 to 0.26 percent. Due to the use of only male sterile plants, gene flow rates would be expected to be higher than rates to fully fertile plants due to lack of competing local pollen (Saeglitz et al., 2000).

Darmency et al. (2009) summarized these studies and noted that comparisons between these experiments are difficult due to the many different parameters unique to each study (table 3–22). However, Darmency et al. (2009) also noted that the dispersal pattern of pollen movement from sugar beet fields is best described by a leptokurtic curve (power-law distribution) with a fat-tail. That is, gene flow decreases rapidly with approximately 40 percent at the source, dropping to 1 percent at around 1,000 feet and < 0.1 percent around 3,280 feet. Using this model, Darmency et al. (2009) predicted that rare instances of gene flow at great distances can occur. The pattern of pollen movement described by Darmency et al. (2009) suggests that while isolation distances reduce gene flow between *Beta* populations, increases in isolation distance beyond 3,280 feet do not greatly alter the likelihood of successful gene flow and offer little additional practical value.

Table 3- 22. Summary of Gene Flow Studies for Beta vulgaris

Study	Maximum Distance[1]	Gene Flow
(Archimowitsch, 1949)	2,000 ft	0.30%
(Alibert et al., 2005)	660 ft / 3,280 ft	2.10% / 0.15–0.26%
Vigouroux et al., 1999	50 ft	1.20%
(Darmency et al., 2007)	920 ft	1.30%
Madsen, 1994	250 ft	0.31%

Brants et al., 1992	250 ft	8%
(Saeglitz et al., 2000)	660 ft	40%
Bateman, 1947	62 ft	0.07%
Dark, 1971	100 ft	0.10%
Stewart and Cambell, 1952	50 ft	10%
(Fénart et al., 2007)	3 miles	Detected
(Arnaud et al., 2003)	1 mile	Inferred seed dispersal

Source: (Darmency et al., 2009).
[1] Measures of greatest distance have been converted from meters to feet or miles.

(2) Seed Dispersal Leading to Gene Flow

Another mechanism for the movement of genes between sugar beet populations includes the natural or human-mediated dispersal of sugar beet seeds outside of cultivation. Sugar beet seed exhibits a shattering phenotype (release and dispersal of seed) and many seeds can remain in the field after harvest and must be managed to control volunteers. Seeds that drop to the ground do not all germinate in the same season due to germination inhibitors within the seed ball and also due to minimal contact with the soil (OECD (Organization for Economic Cooperation and Development)). Seeds that do disperse from mature plants could be buried and sugar beet seed can exhibit substantial seed dormancy leading to the production of a seed bank. Sugar beet seed has been found to be viable in soil seed banks after 4 years (Desplanque et al., 2002). Seeds that do successfully disperse within sugar beet seed production fields and also germinate can also be identifiable due to position within the field. As planting for sugar beets is highly controlled, plants not in the planting pattern can be identified and removed (Desplanque et al., 2002). Additionally, sugar beet seed production practices include rotational crop species that are easily identifiable from sugar beet. Management practices used by sugar beet seed producers specifically address sugar beet volunteers to limit gene flow from seed dispersal. WCBS has detailed requirements in its protocol for post-harvest field management. After harvesting, the fields are shallow tilled and irrigated to promote sprouting of shattered seeds. Fall plowing is not allowed, and any remaining seed s that sprout are destroyed by herbicides or other means. All equipment is cleaned according to WCBS procedures before it can leave the fields. Fields used for growing H7-1 are inspected by WCBS "for a minimum of 5 years or until no volunteers are noted." Betaseed has similar requirements (Lehner, 2010).

Sugar beets are not considered a particularly competitive plant species and are ecologically limited due to susceptibility to plant pathogens and herbivores and are not typically described as weeds outside of agricultural fields (Bartsch et al., 2001). Sugar beet seeds (and other *B. vulgaris* species) are encased in a specialized woody tissue that can float and disperse via water movement (Fievet et al., 2007). As such, flooding of fields following seed production and harvest could result in dispersal of sugar beet seed beyond field boundaries. Following dispersal, sugar beet seed would need to successfully compete with local weed and pathogen pressure. Sugar beet seed could also be a source of food for small animals and insects. If sugar beet seeds are consumed and survive digestion, sugar beet seeds could disperse with animal vectors. However, no studies could be identified that have examined the viability of consumed sugar beet seed. Feral populations of sugar beets have not been identified (Mallory-Smith and Zapiola, 2008) in the seed production regions of the United States, further suggesting that sugar beets are not a particularly successful weed species in the United States. However, feral populations of *B. vulgaris* have been identified in California (discussed further in section III.B.5.d(2)), potentially arising from escaped Swiss chard, indicating that the potential for persistence of *B. vulgaris* in some geographic regions is possible.

Another mechanism that could contribute to the unintended dispersal and movement of sugar beet seed is non adherence to best management practices for seed harvesting and processing. If the same equipment and processing facilities are used for harvesting both sugar beet and vegetable beet seed, if mislabeling and improper storage of seeds occurs, or if crop refuse containing seed or steckling materials are distributed into fields, seed-mediated gene flow could occur. However, the use of established BMP (discussed in section III.B.1.b(11)) designed to limit the potential for seed mixing specifically address each of these issues and can greatly reduce this potential mechanism for seed-mediated gene flow.

(3) Vegetative Reproduction

Sugar beets also have a limited ability to propagate from vegetative tissue but this ability is likely limited in scope to sugar beet production fields or laboratories. If small roots are left behind in sugar beet fields after harvest, these roots could theoretically overwinter and flower in the next growing season. These small plants are called groundkeepers. However, as sugar beets will be destroyed if they or the ground freezes (23 °F), most winter climates where sugar beet root crop is grown will kill groundkeepers. Another reason groundkeepers are unlikely to survive the winter is that sugar beet roots are a very attractive food source for foraging mammals and are likely to be eaten (see section III.C.1.b.). Under laboratory conditions, sugar beets can be propagated from root cuttings, crown cuttings, or leaf cuttings (Miedema, 1982; Miedema et al., 1980). When sugar beets are harvested, the crown is sometimes removed which renders the beet non viable.

c. Gene Flow Between Sugar Beets and Vegetable Beets

Gene flow to or from sugar beets and vegetable beets (table beets and Swiss chard) is driven by the same processes and at the same likelihoods as those discussed above for pollen-mediated gene flow between sugar beet cultivars or seed dispersal. All varieties of *Beta vulgaris* grown for vegetable products are interfertile with sugar beets if they flower. As such, the properties of pollen and seed dispersal between populations are equivalent. Successful pollination between vegetable beet varieties and sugar beets would result in the production of seed that would produce hybrid plants sharing morphological traits intermediate to, or a mix of, the two parental varieties. As such, hybrid plants can easily be identified in sugar beet fields and removed.

Specific studies examining gene flow between sugar beets and vegetable beets demonstrate the same decrease in pollen-mediated gene flow with distance from source fields. Studies examining gene flow from red table beets into sugar beets have demonstrated that gene flow rates decrease with distance to 0.3-percent gene flow at > 656 feet (Archimowitsch, 1949). The potential for gene flow is equivalent between the crop types with the exception of field size. It has been demonstrated that gene flow in other crop species can be greater from large-scale farming compared with small experimental plots or private gardens (Rieger et al., 2002). The cultivation of vegetable beets can be summarized by three broad categories: commercial vegetable beet production, vegetable beet seed production, and home gardens.

Vegetable beet cultivars (e.g., table beet and Swiss chard) are the same species as sugar beets (*B. vulgaris*) and share the biennial characteristics of sugar beets. Thus, commercial fields cultivated for the production of vegetable crops are harvested before flowering, precluding any possibility of gene flow (Bartsch and Ellstrand, 1999). The exception is that some low level of first-year bolters could occur due to vernalization in the spring (Ingram, 2000) and any fields that are abandoned would flower and be receptive in the second year. As the flowering stalk is undesirable to farmers, a standard practice of farmers is to either remove the bolting inflorescence or the entire plant. Gene flow into bolting plants would only present a problem if plants that have gone to seed are not managed. These bolters could then contribute to weed problems by dispersing seed within the field. However, as the presence of bolters would reduce the quality of the crop harvest, they are typically removed. Hand harvesting of Swiss chard or fresh market table beets would allow harvesters to identify, remove, and discard bolting plants as well as low-quality (off-types) plants. The woody roots that result from bolters can damage harvesting and processing equipment (Ellstrand, 2003) utilized in the harvest of table beets for canning. For these reasons, growers remove bolters.

Because bolters are rare and require several weeks to develop flowers, stewardship can be very successful in eliminating any small probability of pollen shed. As such, the potential for pollen-mediated gene flow into or out of vegetable beet fields grown for vegetable production is zero for the vegetable crop, and can only occur as a result of neglect to remove bolters or harvest the crop in areas where the beets could overwinter. If a field of vegetable beets was abandoned and winter conditions were sufficiently mild to allow overwintering, flowering could occur in the second year and represent a significant source of *B. vulgaris* pollen in the environment that could lead to undesirable offtypes in the neighbors fieldsSimilarly, abandoned vegetable beet fields could also represent potential pollen sink populations. However because they are abandoned cross pollination into that field would not be noticed by the owner. As cultivated beets are not particularly competitive, the persistence of an abandoned field of vegetable beets is unlikely.

Similar to the production of sugar beet seed; the production of vegetable beet seed can be influenced by pollen-mediated gene flow due to the requirement for flowering to produce seeds. Usually vegetable beet seeds are produced using open pollination. As a result, large isolation distances are utilized between seed production fields (0.5–4 miles) to reduce the chance of pollen flow from other varieties independent of H7-1 seed production (OSCS (Oregon Seed Certification Service), 1993).

Available data for sugar beet seed production (H7-1 seeds, non-H7-1 seeds, and organic seeds) are discussed in section III.B.1.b and root production is discussed in section III.B.1.c. From these available data, overlap between vegetable beet seed production (Swiss chard and table beet) and sugar beet seed production occurs in six counties in the Willamette Valley of Oregon and one county in Southern Oregon(Marion, Clackamas, Polk, Washington, Benton, Linn, and Jackson counties, shown in brown in figure 3–12). This region represents the area where gene flow between vegetable beets and sugar beets might occur if precautions are not followed.

Small scale farms and home gardens of Swiss chard and table beet represent a special situation in regard to pollen and gene flow into sugar beet fields or as receptors for gene flow from sugar beet seed production. While sugar beets are not often grown in home gardens, vegetable beet varieties are common. Additionally, these small scale and home gardens may not participate in or take note of isolation distances or pinning maps. For example, in western Washington (Skagit Co.), increases in urbanization and home gardeners and farmers who save seed and sell the vegetable crop have made isolation distances difficult to enforce and maintain high-quality hybrid seed production (du Toit et al., 2007). Different households might grow table beets or Swiss chard for personal use and cultivate plants for seed saving. If the goal of private vegetable gardens is to harvest the vegetative parts in the same year as they were planted, gene flow from sugar beets into home gardens cannot occur and is therefore not a concern. However, home gardens could serve as pollen sources or sinks for gene flow especially if the garden is left unmanaged and vegetable beets bolt or survive the winter and flower, or the vegetable beets are purposely carried over between years to produce a personal stock of seeds. den Nijs et al., (2004) inferred that home gardeners and farmers who save seed could play a role in the movement of vegetable beet traits and genes into wild beet populations in Europe.

Home gardens have also been implicated in successful unintended gene flow into sugar beets. As noted by Anfinrud (2010), sugar beet farmers have detected the presence of Swiss chard and table beet off-types in sugar beet seed grow-outs despite extensive isolation from pinned vegetable beet production. As the nearest vegetable production field was in excess of eight miles from the sugar beet fields, it was inferred that local pollen sources, likely from local home gardens, contributed the unintended pollen.

Though home gardens and small farms are likely to be much smaller than seed production fields, they are difficult to identify and coordinate with and can represent a significant source of pollen if near a seed field and can result in off-types being present in the seed sold for sugar beet root crop production. Gene flow of sugar beets into home gardens that have been abandoned or into gardens where the property owner is practicing seed saving could result in hybrid seeds being dispersed or planted in the following year. Whether home gardeners would use the same careful evaluation of plant traits as commercial growers to remove off-types is unknown.

d. Gene Flow Between Sugar Beets and Wild Beet Species

(1) Wild Beets in Europe

Wild beets can be very common in European sugar beets and vegetable beet production. Several studies have documented the movement of crop alleles (genetic sequences) into wild populations as well as from wild populations into crop production (Ellstrand, 2005).

In Europe, crop varieties of beet (*B. vulgaris* ssp. *vulgaris*) include sugar beets, Swiss chard, table beet, and fodder beet. The cultivated beet can also establish outside of cultivation. In addition to escaped feral sugar beets (*B. vulgaris* ssp. *vulgaris*), there are closely related subspecies *B. vulgaris* (ssp *vulgaris*, ssp. *maritima*, and ssp. *adanensis*) and related species *B. macrocarpa* and *B. patuala*. These subspecies and species are

found throughout the coasts of northern and western Europe, the Mediterranean region, and from Asia Minor to Bangladesh (OECD (Organization for Economic Cooperation and Development)).

Figure 3- 12. Representation of the available county level information for the production of A) Swiss chard seed; B) table beet seed; and C) sugar beet seed in 2011. Map D indicates counties where overlap occurs between sugar beet seed production and at least one additional Beta sp., seed production. (McReynolds, 2011) Note: Not shown on map: H7-1 sugarbeet seeds were also planted in one county in Colorado.

Sugar beet and vegetable beet cultivation in Europe like the U.S., has distinct root and vegetable production areas. Root and vegetable production areas include much of Europe. The primary seed production areas in Europe include eastern England, southwestern France, and northern Italy, although smaller regions also produce limited seed (e.g., Denmark). As these seed production areas overlap with the distribution of wild beets in Europe, they are "hotspots" for gene flow between populations (Bartsch et al., 2003). Vegetable crop production areas also overlap with wild beet distributions in Europe.

Studies examining gene flow in Europe between wild beets and sugar or vegetable beets have demonstrated that both pollen-mediated gene flow and seed-dispersal can play a role in the occurrence of wild beets in sugar beet production fields. In Italian seed production areas, studies have documented pollen-mediated gene flow out of sugar/vegetable beet seed fields into local wild *B. vulgaris* ssp. *maritima* populations (Bartsch et al., 2003), although studies in southern France were unable to detect crop-to-wild gene flow (Desplanque et al., 1999). Different methods were used for detecting hybrids but in some cases wild populations were seen to carry a large proportion of crop alleles (gene sequences found in crops), indicating ongoing gene flow. In other studies (Andersen et al., 2005), hybrids were identified as being triploid, implicating pollen-mediated gene flow from tetraploid male lines used in CMS sugar beet seed production. Pollen-mediated gene flow also occurs into seed production fields. As described in the sections above, pollen-mediated gene flow can be observed both as wild off-types in vegetable production regions that have been planted with hybrid seeds or following the successful establishment of wild beets in the seed production fields themselves. Using genetic markers (Random Fragment Length Polymorphisms and microsatellites), other studies have documented gene flow into seed production areas followed by dispersal to vegetable production regions. Once planted, wild- hybrid off-type plants flower in the first year and disperse seeds, creating a weed seed bank. Although these plants are not difficult to control with herbicides in other crops, they are a problematic weed in *Beta* crops because there are not selective herbicides that distinguish the wild species from the conventional domesticated crop. Studies have also been conducted to measure the rate of gene flow between wild beet populations within vegetable crop fields. Fénart et al.(2007) examined the paternity of hybrid seeds produced by wild beets and determined that gene flow between fields can occur at 3 miles between populations with a few hybridization events at a distance of 5 miles.

Seed dispersal has also been identified as playing a role in the presence of wild beets in Europe. Studies using the CMS genetic signature of female plants and chloroplast markers have tracked the movement of seeds out of cultivated fields up to 1,500 meters, indicating that seed dispersal is a potential vector for the establishment of feral beets (Arnaud et al., 2003). Limited pollen-mediated gene flow was also detected. Waterways have been implicated as a major dispersal pathway for both wild beet species and feral beets. The seed ball produced by *Beta* sp. is resistant to waterlogging and can float over great distances, increasing the potential for seed dispersal (Cureton et al., 2006).

To summarize, gene flow has been detected in both directions between crop and wild populations. Both pollen-mediated and seed-mediated gene flow have been implicated in the development of wild beet populations in Europe. This is due in part to extensive overlap between flowering crop populations (seed production areas) and wild beet species.

(2) Wild Beets in the United States

No native species of *Beta* occur in the United States or North America – all forms of beets in the United States are introduced. Beet species that have been introduced into the United States include *B. vulgaris* (ssp. *vulgaris*, ssp. *maritima*), *B. procumbens*, and *B. macrocarpa*. The distribution of wild beet species in the United States is restricted to two States, Pennsylvania, and California. There is no overlap at the county level of sugar beet seed production and wild beet populations however, as discussed below, there is overlap of wild beet populations and sugar beet root production in Imperial Valley California.

The only location where *Beta vulgaris* ssp. *vulgaris* feral beets are recorded is in California. Research by Bartsch and Ellstrand (1999) suggests that some populations of wild beets in California are actually feral varieties of Swiss chard and table beets (Bartsch et al., 2003). This is evidence that seed dispersal and persistence from vegetable beet crops is possible despite ecological limitations. As they are the same species, there are no specific differences in flowering times or barriers to gene flow between feral beets and sugar beets, though asynchrony may occur due to variation in the planting time of the crop.

Some populations of California wild beets may be introductions of the sea beet (*B. vulgaris* ssp. *maritima*). These beets are primarily found in proximity to the California coast (figure 3–13) whereas sugar beet root crop production is further inland. Imperial Valley appears to have an unsuitable climate for wild populations of *B. vulgaris* (Beet Sugar Development Foundation et al., 2011) and hence there does not appear to be any overlap between the distribution of wild *B. vulgaris* populations and sugar beet root production.

Wild beets of the species *Beta vulgaris* and sugar beets have overlapping flowering times and are fully sexually compatible. Hybrid plants derived from cross pollination between sugar beets and wild beets could be expected to flower in the first year without vernalization. Additionally, hybridization would result in a mix of wild traits and crop traits, for example, little or no sugary root (Ellstrand, 2003). Although many studies have documented hybridization between sugar beets and sea beets in Europe, no direct evidence of these hybrids has been found in the United States.

The distribution of *B. macrocarpa* in the United States is similarly restricted to California and *B. macrocarpa* has been identified as a frequent weed in sugar beet fields in the Imperial Valley (figure 3–14) (2011). Based on the use of genetic markers, *B. macrocarpa* is believed to have been introduced to the United States from populations originating from Spain. Some evidence of introgression between sugar beet and *B.*

macrocarpa has been reported in one population of wild beets in the Imperial Valley (Bartsch and Ellstrand, 1999). This evidence, based on isozyme analysis, requires further testing with current and more sensitive molecular DNA markers before a conclusion can be reached. Several observations are inconsistent with introgression of *B. vulgaris* into *B. macrocarpa* or at least indicative that it is not very likely First, greenhouse crosses using sugar beet as the pollen parent were unsuccessful with *B. macrocarpa* female plants. The reciprocal cross using *B. macrocarpa* pollen onto sugar beet was successful, but the progeny were abnormal and showed signs of chromosomal instability (Lewellen et al., 2003). Second, *B. macrocarpa*, unlike *B. vulgaris*, is highly self fertile and much less prone to outcrossing. Third, *B. macrocarpa* begins to flower in January and has largely gone to seed by May. Bolters of the *B. vulgaris* root crop only begin to flower in April so there is little, if any, flowering overlap (Bartsch et al., 2003; Lewellen, 2011). The hybridizations that may have occurred in the past are hypothesized to have occurred due to rare climatic episodes that have synchronized flowering between the species (Bartsch and Ellstrand, 1999).

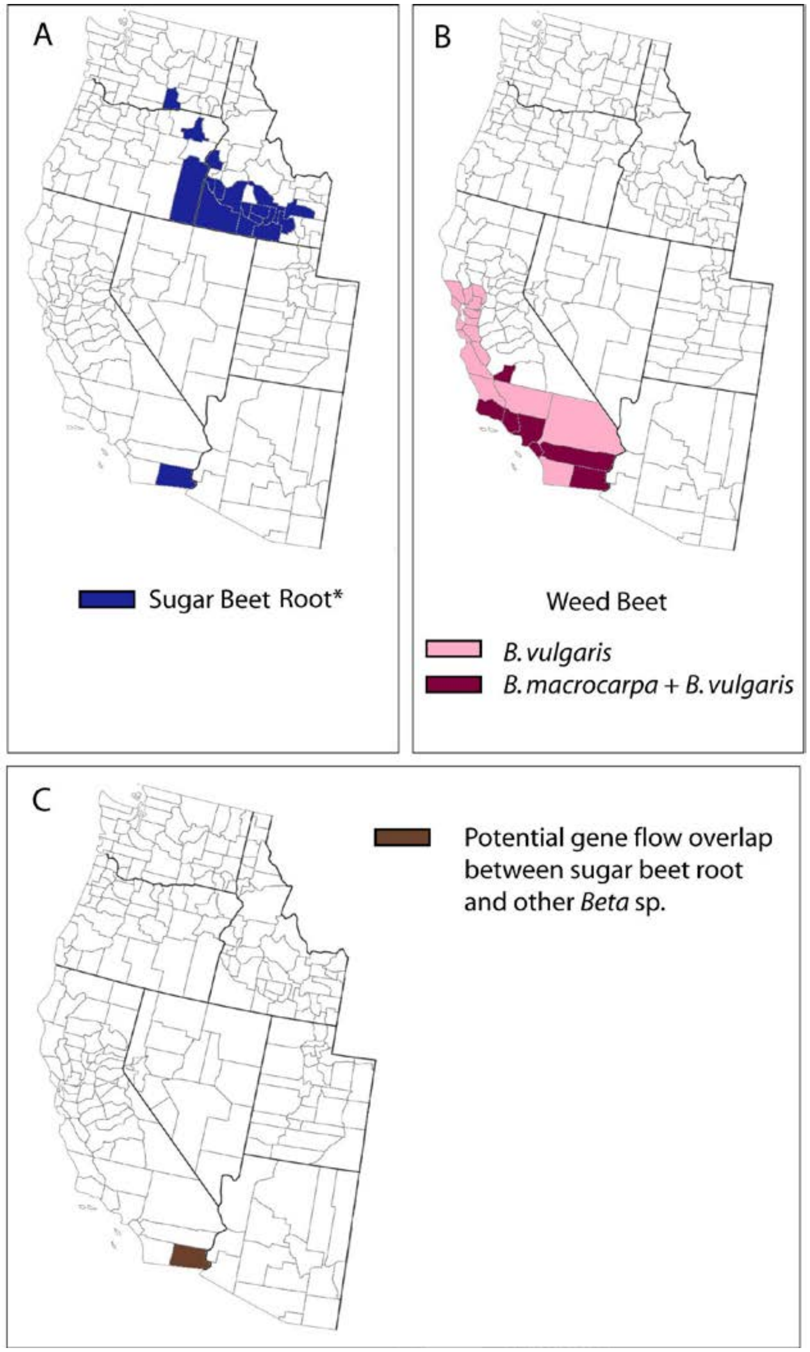

Figure 3- 13. Representation of the available county level information for the production of A) sugar beet root; B) wild beet distributions (B. procumbens not shown); and C) overlap of counties where sugar beet root production and wild beet species occurs. The only county where overlap between sugar beet root production and wild beet occurs is in Imperial Valley. In Imperial Valley the predominant wile species is *B. macrocarpa*. The presence of Wild *B. vulgaris* has been reported but not confirmed in Imperial Valley (sources (Calflora, 2011; USDA-APHIS, 2011b)

Figure 3- 14. Sugar beet fields in Imperial Valley in early May. A. A mostly weed free sugar beet field. B. A sugar beet field containing B. macrocarpa. The brown color represents mature seeds already formed on B. macrocarpa. The sugar beet plants have not yet flowered. C. Mature seeds collected from B. macrocarpa plants shown in B. Photos from Neil Hoffman

Beta procumbens has been identified in Pennsylvania, a state not currently a producer of commercial sugar beets. Although hybrids can be formed between *B. vulgaris* and *B. procumbens*, hybrids have not been observed to occur naturally and seedlings typically do not survive (OECD (Organization for Economic Cooperation and Development)).

To summarize, as there is no overlap between the distribution of wild *Beta* species in the United States and sugar beet seed production areas, the potential for successful gene flow is negligible. Wild beet distribution overlaps with California sugar beet root production in only Imperial county, (figure 3–13). The predominant wild *Beta* species in Imperial Valley is *Beta macrocarpa*, which does not readily cross with sugar beet and flowers prior to the crop.

e. Detecting Outcrossing and Modeling Gene Flow

(1) Detecting Outcrossing

Seed producers are aware of the potential for cross pollination and gene flow to occur between any two compatible crop species. As a result, isolation distances are utilized to separate and thus reduce the overall potential for cross pollination to occur. However, it is very unlikely that cross pollination can be prevented, only mitigated to levels that are very low. As a result, a small percentage of crosses are tolerated and the rate of unintended gene flow can be determined by monitoring seed lots.

If pollen-mediated gene flow occurs into a vegetable seed production field or vice versa, the events could be detected by two types of quality control measures before selling the seed: either by genetic testing of the seed or by a grow-out of the seed and inspection for nonuniformity. Seeds that have formed between sugar beet and vegetable beet cultivars (hybrids) will have a mix of the morphological traits associated with the parent cultivars. These plants are considered “off-types” because the mix of traits is visually identifiable. Though sugar beet seed is not typically certified, part of the seed certification process for other *Beta* seed production is to evaluate the amount of varietal off-types. Seed will not be certified if a particular threshold is exceeded (see section III.B.1.b(19)). Seed producers also respond to customer demand to provide a quality product. Off-types between different groups (such as Swiss chard, table beet, and sugar beet) are less tolerated than between different varieties within a group (for example red and orange table beets). For off-types between table beets of a similar market class, 5 percent is tolerable while off-types between table beets and Swiss chard are much lower, 1 to 2 percent (Navazio, 2010). Evaluating crop purity is not a new step that has resulted due to the initial deregulation of H7-1. However, with H7-1 production, vegetable beet farmers may have to utilize testing methods in order to assure seed purity and some growers are producing for markets that are sensitive to less than one seed in 10,000 (0.01%) if it contains a GE trait. Assuring 100 percent purity is not possible but most seed producers attempt to maintain a level of purity that will satisfy their market. As a result, the isolation distances are greater for sexually compatible varieties between different groups (see section III.B.1.b(10) WVSSA isolation distances).

The purity of breeding and foundation seeds is important in the prevention of adventitious presence of other *Beta* crops in subsequent commercial seed production. Concern regarding the potential for gene flow between

Beta sp. include the potential for these foundation seeds to have adventitious presence of hybrid off-types caused by gene flow of vegetable beets into sugar beets or vice versa. However, while unintended pollen-mediated gene flow between *Beta* sp. can be detected, LLP does not imply that the entire seed lot is off-type and cannot be used in the future. According to Stander (2010), "the removal of unwanted genetic traits from a line is routine in plant breeding programs." If the breeder or foundation seed has LLP, the seed can be cleaned using the "genetic bottleneck" as described by Stander (2010). In case of sugar beets cross pollinated with vegetable beets or vice versa, the seed containing the unwanted trait will be exclusively hybrid seed. The task is to plant a sample of the seed lot and identify the plants that are hybrid plants. These plants are removed and seed is only collected from the non-hybrid plants. The genetic bottleneck means that the breeder only collects seeds which are known to be true to type and in that way the unwanted trait is removed. In the case of cross pollination between sugar beets and vegetable beets, hybrid plants are usually different in leaf coloration, root shape, plant size, or other characteristics. The breeder can usually plant out a sample of seeds, rogue out the hybrid off-types and simply collect seeds from the remainder. In the event that plants do not differ visibly, there are non destructive cost effective tests that can be done on leaf samples from each plant before the plants flower. To increase the efficiency and reduce the costs of testing, groups of plants can be tested as bulk samples where all plants in the group are discarded if it tests positive. Pooling samples is very effective in cases of low level presence, because when the frequency of the GE trait is low, even batches of 50 plants are unlikely to contain the GE trait. As a result, most batches will test negative for the GE trait and these could be selected as a group to regenerate the line of interest. Subsequent breeding from only the plants identified as being free of hybrid traits could restore the breeder or foundation seed to purity in a single generation.

Growers and consumers are also capable of detecting off-types that result from gene flow between sugar beet and vegetable beet varieties. A hybrid plant produced due to gene flow between sugar beets and Swiss chard would have characteristics from each of the parents, depending on the dominant-recessive nature of the traits. As sugar beets and Swiss chard have large differences in the desired product, sugary root versus edible leaves and stem, the hybrid plant would appear to be an off-type to growers of each crop type (figure 3–13). The Swiss chard grower would reject the hybrid off-type because of the mix

Figure 3- 15. Photo of hybrid "off-type" plants in a sugar beet field. Hybrids formed with Swiss chard as the pollen donor and resulting hybrid seed produces a morphologically identifiable plant (larger with increased leaf size) (Stander, 2010)

of undesirable flavor, color, and shape of the leaves and stems. Similarly, sugar beet growers would also reject this hybrid plant because of reduced sugar in the root and other undesirable characteristics. Hybrids between sugar beets and table beets would be rejected by table beet growers due to changes in root color and changes in root morphology (see figure 4-3). If such hybrids were too common, growers would complain to the seed producer and or not purchase the product.

Management practices in the Willamette Valley have been designed to minimize the amount of visible off-types formed between sexually compatible species and varieties and to allow the coexistence of sugar beet, Swiss chard, and table beet seed production in the valley. The seed companies that produce sugar beet seed in the Willamette Valley also monitor their seed harvests for "off-types" by growing out seed subsamples and observing the growing plants for evidence of hybrids (Hovland, 2010; Lehner, 2010). According to Lehner (Lehner), none of Betaseed seed lots had off-types in the preceeding year. Likewise Anfinrud (Anfinrud) indicated that off-types are only observed occasionally and are suspected to be due to unpinned and unmonitored home gardens (Anfinrud, 2010). Root crop producers have also reported screening 1.3 million (Grant, 2010)and 2.4 million (Hofer, 2010) sugar beets in varietal trials since 2007 and "the occurrence of hybrid off-types in sugar beet root production are so low that they are unquantifiable."

In addition to visual inspection for hybrid off-types, gene flow between H7-1 varieties of sugar beets and any other *Beta* spp can be detected by testing for the H7-1 protein with strip tests or the H7-1 DNA by using DNA amplification procedures. Strip tests are relatively inexpensive (less than 10 USD),can detect the presence of transgenic protein from pooled samples and are sensitive to 0.1 percent (1 H7-1 seed in 1,000 seeds) (Anklam et al., 2002; STAVE, 2002) Strip tests do not require specialized equipment, can be used outside of the laboratory and under field conditions, and can be used to test seeds. Several companies produce strip tests to test for the GE protein 5-enolpyruvylshikimate-3-phosate synthase (EPSPS): Quickstix ™ kit for Roundup Ready® bulk sugar beet seed (Envirologix, Portland ME); AgraStrip® RUR Bulk Grain Traitchek (Romer Labs Inc. Union MO); Roundup Ready® ImmunoStrip (CP4 EPSPS) (AgDia, Elkhart IN) (USDA-APHIS, 2010a).

PCR techniques are more expensive (150–1,050 USD) but are more sensitive (1 seed in 10,000) and quantitative (Bullock et al., 2002) (Auer, 2003). Vegetable beet seed producers have voluntarily tested seed crops to determine if H7-1 sugar beet has successfully hybridized with vegetable beet seed production in the Willamette Valley of Oregon. Despite testing over 3 years, no evidence of H7-1 gene flow has been detected (Hoffman, 2010). Detection of H7-1 has been documented in some lots of non-H7-1 sugar beet production. Anfinrud (2010) states that pooled samples (from WCBS) of non H7-1 sugar beets were tested following standard purity testing protocols using PCR techniques in 2007 and the H7-1 trait was detected. Subsequent fine scale testing revealed that the percent of adventitious presence was less than 0.1 percent of seeds. No WCBS pinned fields were in violation of isolation distances of non H7-1 seed field and the source of the adventitious presence was not determined.

(2) Modeling Gene Flow

Modeling gene flow between *Beta* spp. production is a very complex process. Several different environmental and biological factors act to increase and decrease the likelihood of pollen moving between any two populations. To generalize, the potential for pollen-mediated gene flow to occur between fields/populations of *Beta* species is influenced by a number of factors: wind speed and wind direction moving from source to sink fields/populations, insects (to a lesser degree), synchronized flowering time between fields/populations, distance between source and sink populations, topographic barriers (e.g., wind rows, cliffs), pollen viability, pollen survivability,temperature, humidity, relative sizes of source and sink fields (Rognli et al., 2000). As distances increase between populations, the potential for gene flow decreases.

Regarding limitations on pollen-mediated gene flow of the H7-1 trait, 85 percent of H7-1 seed production in the Willamette Valley utilizes female (male sterile) plants that carry the H7-1 trait and non-H7-1 male pollen producing plants. The production of H7-1 pollen from these sources is negligible (Lehner, 2010). The remaining 15 percent of H7-1 seed production produces viable H7-1 pollen. However, the factors of isolation distance and pollen cloud competition act to reduce the likelihood of successful long distance gene flow.

Models have been developed in an attempt to understand the potential for pollen-mediated gene flow out of sugar beet fields. The GENESYS-BEET model is a computational model developed by Sester et al. (2008) and has been used to examine many different components of the cultivated beet and wild beet lifecycles (Sester et al., 2008); (Colbach et al., 2010) (figure 3–16). Results examining the many parameters that contribute to gene flow to wild beets (e.g., pollen-mediated gene flow, seed-dispersal, vernalization, bolting, and reproductive mode) were found to be largely congruent with field-based observations. From this model the authors conclude that the introduction of H7-1 lines of sugar beets are not likely to result in harvest impurities (gene flow between two varieties of sugar beets or between sugar beets and vegetable beets), but might contribute to the rise of herbicide-resistant wild beets in production fields, if sexually compatible species were growing in proximity. However, because wild beets do not grow in the states where sugar beet seed production occurs, as discussed in section III.B.5.d, this possibility is not likely.

Several studies (as reviewed in (Darmency et al., 2009)that have modeled the distribution of gene flow/pollen movement in sugar beets have determined that while pollen movement and gene flow can be as high as 40 percent near source fields, the majority of pollen moves a short distance from its source and decreases to around 1 percent at 1,000 feet and drops to < 0.10 percent at 3,280 feet. Additionally, the measured rate of gene flow (1 percent at 1,000 ft and < 0.10 percent at 3,280 feet) resulted from studies where CMS male sterile plants were the receptor population. The authors concluded that the receptor plants were under pollen limitation indicating that there was little to no local pollen cloud acting as competition for migrating pollen. This conclusion suggests that the real-world rate of gene flow that would result between two actively producing pollen sources would likely be much lower than < 0.10 percent at 3,280 feet. As pollen moves greater distances, gene flow rate continues to decline and tends to follow a specific leptokurtic pattern (power-law distribution) (figure 3–17). Dispersal distance is influenced by the characteristics of the pollen (size, weight, and shape); environmental conditions such as wind speed, direction, and turbulence; topography; pollen source field size; and architectural features of the plant such as height (Aylor, 2003; Jackson and Lyford, 1999).

One particularly important aspect to consider regarding the modeling of gene flow risk is the relative size of the pollen clouds moving from source fields to the pollen clouds produced by sink fields. Quantitative information detailing the strength of adventitious pollen clouds (from source fields) versus local pollen clouds (at sink fields) could be derived from studies of pollen movement (Darmency et al., 2009).

At increasing distances, incoming pollen clouds would continue to be progressively smaller relative to local pollen clouds. At sink fields there is great competition within the pollen cloud for the limited available ovules (only one per flower). As an average sugar beet plant produces 1 billion pollen grains and roughly 10,000 seeds (OECD (Organization for Economic Cooperation and Development)), the pollen to ovule ratio is 100,000:1. In other words there is a huge excess of local pollen available to fertilize each potential seed. To cross pollinate, incoming pollen must compete against this local pollen source. APHIS can estimate how much the incoming pollen cloud is diluted due to dispersal as a function of distance based on the Darmency study. The results of pollen dispersal from Darmency et al., (2009) suggest that the rate of pollen movement that results in gene flow at 3,280 feet to CMS male sterile plants (no pollen production) is < 0.1 percent, or < 1 in 1,000 pollinations. In other words, at 3,280 feet, there is no longer an excess of pollen for each ovule, but only enough pollen to fertilize one out of every 1,000 ovules. It is important to note that this is the rate of outcrossing to CMS plants, without a local competing pollen cloud. Over this distance APHIS can estimate that the pollen cloud was diluted 100 million fold, from a 100,000 fold excess at the source to a limitation of 1 grain for every 1,000 ovules at 3,280 feet. The incoming pollen cloud, which has been significantly diluted over distance, is now further diluted by the local pollen cloud which will be in vast excess over the available ovules. The relative sizes of the pollen clouds are influenced by the size of the fields and the number of plants that produce pollen. Hence a large field produces proportionally more pollen than a smaller field; hybrid fields which have less male fertile plants produce proportionally less pollen than an open pollinated field. A large hybrid seed field might be 100 acres while a small open pollinated field may be 0.1 acre. The hybrid field might have one fourth as many pollinators so the large hybrid field might produce 250 times more pollen than the small open pollinated field. However, because the pollen concentration declines so precipitously with distance, the contribution of field size is a minor factor in the potential for cross pollination at the distances under consideration.

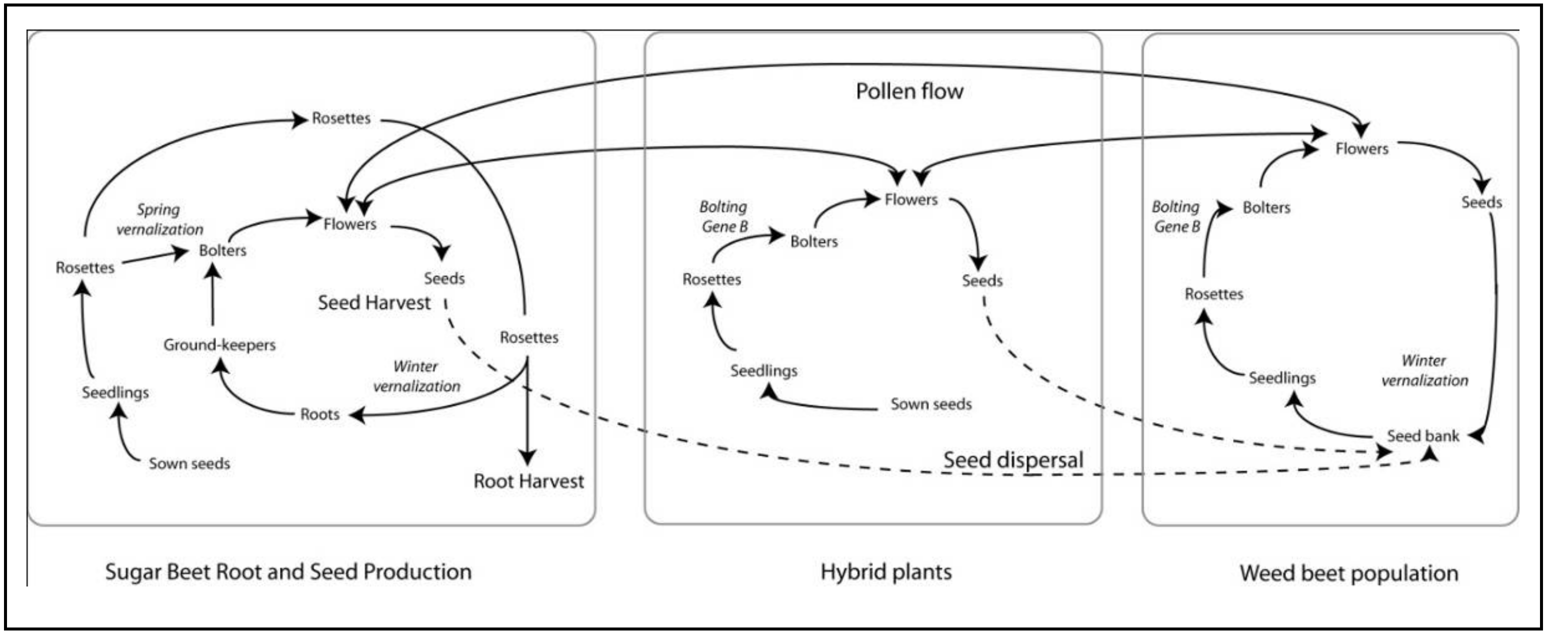

Figure 3- 16. Lifecycles occurring in cultivation areas of sugar beets and modeled in Genesys-Beet (left: biennial crop plants, center: hybrids, right: weeds) with potential pollen flow and seed dispersal showing connections between cycles. (Source: (Sester et al., 2008).) Bolting is Caused Either by Vernalization of Roots (Crop Plants) or Seeds (Weeds) During Winter, Accidental Spring Vernalization of Rosettes (Crop Plants) or by the Bolting Gene B (Hybrids, Weeds)

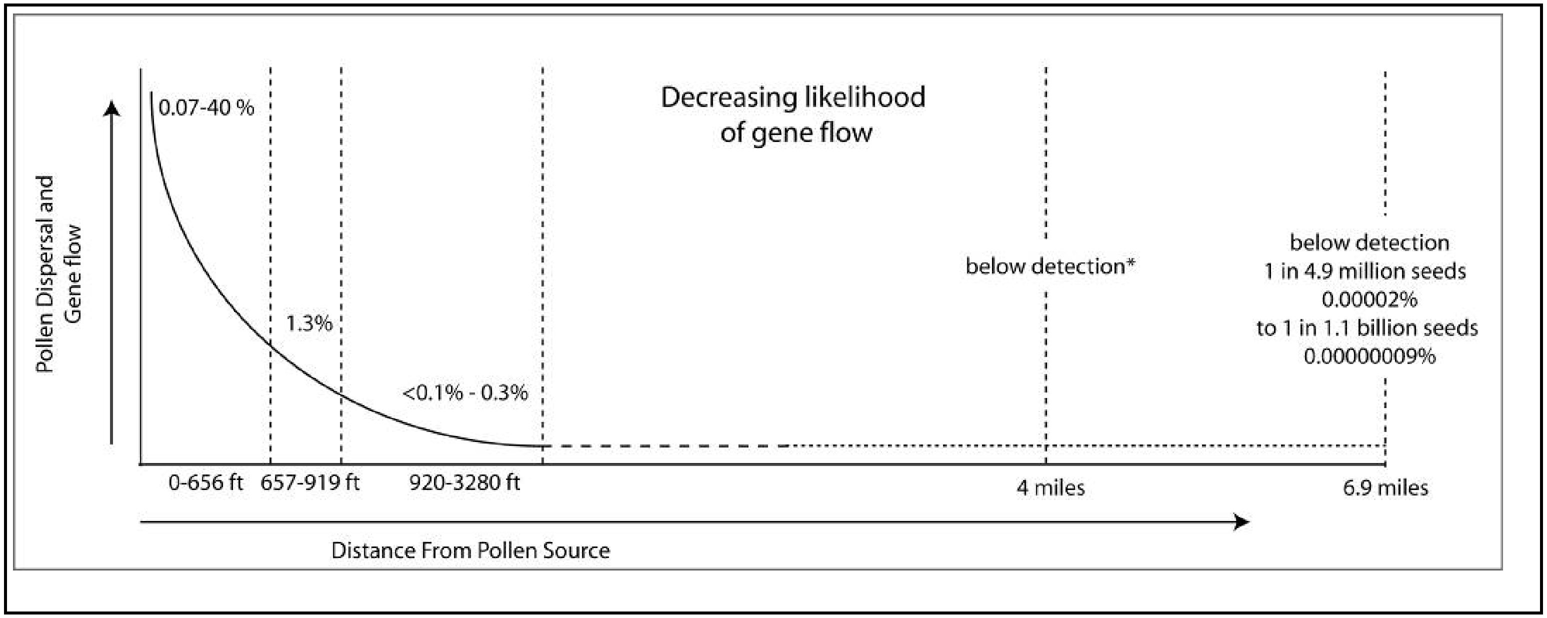

Figure 3- 17. Schematic representation of relationship between gene flow rate and distance. Measures of percent gene flow at short distances range greatly due to differences in research studies but the pattern decreases with increasing distance. Percent values presented in table 3-24. Decreasing likelihood of gene flow occurs as distance increases. (Sources: (Darmency et al., 2009; Westgate, 2010)
Adapted from data presented in Darmency et al. (2009) Asterisk indicates estimate of gene flow at 4 miles is below detection limits. Detection limits are 1 in 10,000 seeds or 0.01 percent. Computer model estimates at 6.9 miles adapted from Westgate (2010).

Based on this analysis, incoming pollen from another source has extremely limited opportunity for successful fertilization. In a large, densely planted population, such as a seed production field, successful pollination and fertilization is much more likely from the pollen originating in the local sink cloud within the field than from pollen migrating from another field (Hoffman, 2010; Westgate, 2010) Most of the pollen migrating from source fields becomes diluted during long-distance pollen dispersal because incoming pollen is vastly overwhelmed by the concentration of local pollen.

Computer-based models using these biological and environmental parameters demonstrate that these assumptions about the rate of pollen dilution and corresponding decrease in gene flow potential continues as distances between fields increase (Darmency et al., 2009; Westgate, 2010). Using biological and environmental information to model long distance pollen flow, Westgate (2010) examined the potential for gene flow from sugar beets into Swiss chard in the Willamette and Rogue Valleys of Oregon. Based on these simulations, the highest likelihood for successful gene flow between vegetable beet and sugar beet fields separated by 6.9 miles ranged from 1 in 4.9 million to 1 in 1.1 billion depending on the modeled date. Given the assumptions of this model, the rapid decrease in pollen movement over distance, and the likely high competition of the pollen cloud and sink populations, the level of gene flow at a 4-mile isolation distance was estimated to be lower than detection limits with current strip (0.1 percent, 1 in 1,000 seeds) or PCR tests (0.01 percent, 1 in 10,000 seeds) (Westgate, 2010). The conclusion of this study was that the chances of detectable gene flow at a 4-mile isolation distance are extremely low and below detection limits by PCR; < 0.01 percent. Given the rapid dissipation of sugar beet pollen in the air and the high competition of local pollen clouds, it is likely that isolation distances much less than 4 miles would still result in non-detectable gene flow. Quantitative studies have not been identified that have tested the likelihood of detecting gene flow at distances greater than 3,280 feet.

Sugar beet root crops that have aberrantly bolted could also act as pollen sinks and sources. However, modern sugar beet cultivars have been selected to have very low bolting rates (0.01 percent of plants). Of these bolting plants, the majority will be removed by management practices to prevent bolting and reductions in the root crop. Bolting root crops outside of California are not at risk of gene flow to or from wild beets. In California, the likelihood of gene flow from bolting sugar beet crop to wild beets (*B. macrocarpa*) is low given the asynchrony in flowering between the two,the high degree of self fertilityin *B. macrocarpa*, and the lack of sexual compatibility between the two species. These properties make gene flow between these populations unlikely (figure 3–18).

The timing of planting, vernalization, bolting, flowering, and harvesting can vary depending on the seed or root crop, as well as for wild beets. The lifecycles of crop and wild beets are described below.

1) Seed production for *Beta* seed crops typically occurs in the Pacific Northwest, where vernalization can occur during the winter months without killing the young plants. Sugar beet seed is planted in late summer–fall in year one (August–September). Swiss chard and table beet seed is also planted in late summer–fall but may be planted earlier than sugar beets (July–August). Plants are vernalized over the winter. Following vernalization, sugar beets (and vegetable beets) bolt in April and flower in early June–July (Westgate, 2010)((Beet Sugar Development Foundation et al., 2011). Seed set for harvest in the mid-late summer of year two (August) (Anfinrud, 2010; Hoffman, 2010)

2) Sugar beet root production in the majority of the United States occurs in geographies with weather conditions that are too severe for sugar beets to survive over winter. Seed is planted in early spring of each year and vegetative roots are harvested in the fall of each year (September to November). Spontaneous bolting can occur (0.01 percent) and would tend to occur in summer with pollen release in August-September. It is standard practice for bolters to be removed or "topped" by farmers. It should be noted that if the sugar beet root crop flowers, pollen release is expected to occur approximately two to three months after a sugar beet seed crop and the plants would not be expected to cross pollinate even if they were in proximity.

3) Sugar beet root production in the Imperial Valley of California is different from the rest of the United States. Winter conditions are temperate and seed for root production is planted in September to October. Plants grow throughout the winter and are harvested in April through July.. Spontaneous bolting in California sugar beets is more likely than in the northern regions. Bolters can start to appear in April.

4) The flowering period of wild beet populations in Imperial Valley typically occurs in February and March prior to the flowering of sugar beet bolters. Wild beets generally have produced seeds at or before pollen release from sugar beet bolters. It is possible that flowering overlap could occur based on rare climate conditions (Bartsch and Ellstrand, 1999).

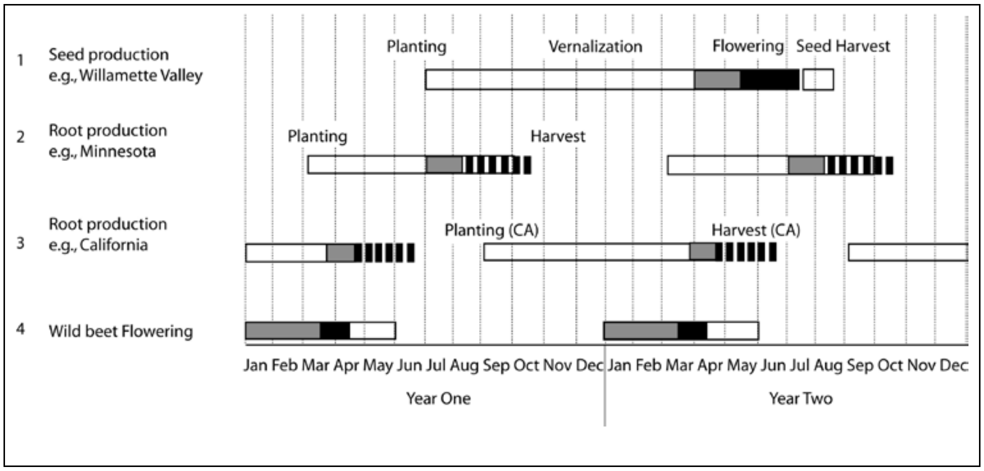

Figure 3- 18. Schematic displaying differences in growing seasons and sugar beet production. Hollow bars indicate the approximate lifecycle of each crop type or wild beet. Grey boxes indicate the approximate range of time associated with bolting. Black boxes indicate the approximate range of the time associated with flowering, or the time of anthesis (when pollen is shed). Anthesis is expected to occur several weeks after bolting and can last 3-4 weeks. Broken boxes indicate rogueing of bolters in root crop production , which can occur beyond expected harvest time as harvest can be delayed by weather.

C. Biological Resources

The affected environment for biological resources consists of the animals and plants that occur in sugar beet fields and the areas within the vicinity of sugar beet fields (e.g., nearby surface waters, ditches, hedge rows, fence rows, wind breaks, yards, etc.) that might be affected by herbicide use and other crop management practices. Additionally, livestock that are fed sugar beet tops or co-products (sugar beet pulp and molasses) from sugar beet processing are included in the affected environment.

The landscape surrounding a sugar beet field varies depending on the specific location of where the sugar beets are grown. Biological resources in the surrounding area and within the sugar beet fields themselves might differ under the action alternatives depending on the different management practices associated with the presence or absence of the H7-1 gene in sugar beets. These practices largely reflect different patterns of herbicide use and tillage and their respective impacts on food resources, reproduction habitat, and protection from predators that may impact the non-target species in the sugar beet field and the non-target area adjacent to the sugar beet field.

1. Animals

Wildlife abundance and composition in and surrounding sugar beet fields depend on geographic location, surrounding habitat conditions, sugar beet field size, and proximity to other sugar beet fields. For example, large patches of wildlife habitat generally support more species than smaller patches of similar habitat (Turner et al., 2001). Also, those species that are specific to sugar beet fields (e.g., the sugar beet root maggot) likely are greater in abundance in areas where several sugar beet fields are in close proximity to each other compared to isolated fields. Animals that could be affected by the alternatives evaluated in this EIS include livestock and wildlife including mammals, birds, reptiles, amphibians, fish, and terrestrial and aquatic invertebrates. .

a. Livestock

As mentioned in section III.B.1.a(1), sugar beet processing generates two valuable agricultural co-products: sugar beet pulp and sugar beet molasses. The sugar beet pulp, which is high-quality feed due to its high energy and high fiber content (Harland et al., 2006), is fed to cattle and sheep. In contrast to molasses derived from sugar cane, which has some food uses, sugar beet molasses is used mainly for livestock feed, partly as a source of energy. Molasses from sugar beets also is sprayed onto low-quality feeds, such as straw and hay, and onto dried sugar beet pulp shreds or pellets to enhance palatability (CFIA, 2002; Harland et al., 2006). Sugar beet tops, which are sources of protein, vitamin A, and carbohydrates, also can be used for livestock feed or as silage (Cattanach et al., 1991). During fiscal year (FY) 2010, 10,453 tons of sugar beets were used as livestock feed in the United States, which was less than 0.01 percent of total livestock feed grain (not including forage crops; USDA–ERS, 2010d). Sugar beet-derived feed generally is consumed by ruminant livestock, such as cattle, sheep, and goats, but can also be fed to pigs (Harland et al., 2006). The recommended commercial feed content of sugar beet byproducts for mammalian livestock ranges from 5 to 40 percent, depending on the animal and their intended purpose (i.e., breeding, dairy producing, fattening for meat) (Harland et al., 2006). Poultry consumption of sugar beet-derived feed is uncommon, and is recommended by Harland et al. (2006) at rates less than 5 percent. Despite its suitability as feedstuff for a variety of animals, sugar beet-derived feed makes up only a small percentage of total animal feed used in the United States.

b. Mammals

Small mammals, such as rabbits, mice, voles, and other rodents, use sugar beet fields for foraging, cover, and shelter, some burrowing into the soil for seed storage, reproduction, and shelter from weather. Rodents can be problematic to sugar beet farmers because they can cause mild damage to the fields in the summer, especially when the soil is dry. Field mice (*Apodemus sylvaticus*) can excavate and destroy sugar beet seeds, and rabbits (*Oryctolagus cuniculus*) and hares (*Lepus capensis*) graze on the vegetation, contributing to plant loss (Dewar and Cooke, 2006). The Southern Great Plains subregion includes sugar beet growing areas in western Nebraska, southeastern Wyoming, and northeastern Colorado, primarily in the valley of the Platte River and its tributaries. All Great Plains sugar beet production requires irrigation (Mikkelson and Petrof, 1999); Thomas et al., 2000; (McDonald et al., 2003). Furrow irrigation appears to deter rodents (Virchow and Hygnstrom, 1991). In other agricultural areas that do not rely on irrigation to deter rodents, commercially available rodenticides or rodent deterrents are used to combat any rodent problem (Witmer and Eisemann, 2007).

Larger mammals, such as deer, use sugar beet fields for foraging. Deer can often be a problem after planting stecklings, because deer prefer the delicate growing leaves of the plant. As part of harvesting the sugar beet root for sugar production, the leafy sugar beet "tops" are usually left in the field, but they occasionally are fed to ruminant livestock as silage (U.S. FDA, 2004). These leafy "tops" may be eaten by foraging wildlife.

As discussed in sections III.B.1.d(3) and III.B.1.d(4), herbicides are applied to sugar beet fields to control weeds and to maximize crop yield. Some typical end-use products (TEP) are more toxic than the technical grade acid equivalent (TGAE) or active ingredient (TGAI), respectively. The adjuvants included in the formulated products to improve the efficacy of the herbicide also increase its toxicity to mammals. On the other hand, some chemical's TGAI could be more toxic than the TEP, owing to the lower concentration of the a.i. in the TEP than in the TGAI. Toxicity of the herbicides to mammals is discussed in more detail in the chapter on environmental consequences, in section IV.C.1.b.(1).

In recent years, some scientists have proposed that chemicals might inadvertently be disrupting the endocrine system of humans and wildlife. Endocrine systems, also referred to as hormone systems, are found in all mammals, birds, fish, and many other types of living organisms. They are made up of:

- glands located throughout the body,
- hormones that are made by the glands and released into the bloodstream or the fluid surrounding cells, and
- receptors in various organs and tissues that recognize and respond to the hormones.

A variety of chemicals have been found to disrupt the endocrine systems of animals in laboratory studies, and there is strong evidence that chemical exposure has been associated with adverse developmental and reproductive effects on fish and wildlife in particular locations(U.S. EPA 2011e). Colborn and Carroll (2007), review human epidemiological studies that link a number of herbicides with reproductive and developmental effects. Included on the list are many of the herbicides used in sugar beet production including synthetic auxins, fatty acid synthase inhibitors (thiocarbamates), ALS inhibitors (imidizolanones and sulfonylureas), and glyphosate (Colborn and Carroll, 2007). Given the widespread use of glyphosate, it has been the subject of laboratory studies and possible endocrine disruptive effects from this herbicide have been reported (Paganelli et al., 2010; Richard et al., 2005; Walsh et al., 2000; Williams et al., 2000).

Disruption of the endocrine system can occur in various ways. Some chemicals mimic a natural hormone, fooling the body into over-responding to the stimulus (e.g., a growth hormone that results in increased muscle mass), or responding at inappropriate times (e.g., producing insulin when it is not needed) (U.S. EPA 2011b). Other endocrine disrupting chemicals block the effects of a hormone from certain receptors (e.g., growth hormones required for normal development) (U.S. EPA 2011b). Still others directly stimulate or inhibit the endocrine system and cause overproduction or underproduction of hormones (e.g., an over or underactive thyroid) (U.S. EPA 2011b).

The Endocrine Disruptor Screening Program (EDSP) focuses on the estrogen, androgen, and thyroid hormones (U.S. EPA 2011b). Estrogens are the group of hormones responsible for female sexual development. Androgens are responsible for male sex characteristics. The thyroid gland secretes two main hormones, thyroxine and triiodothyronine, into the bloodstream. These thyroid hormones stimulate all the cells in the body and control biological processes such as growth, reproduction, development, and metabolism.

The EPA Endocrine Disruptor Screening Program (http://www.epa.gov/endo/) was created as a response to a mandate of the 1996 Food Quality Protection Act (FQPA) and the 1996 Amendments to the Safe Drinking Water Act (SDWA) which require EPA to:

"Develop a screening program, using appropriate validated test systems and other scientifically relevant information, to determine whether certain substances may have an effect in humans that is similar to an effect produced by a naturally occurring estrogen"

The two acts call for the "testing of all pesticide chemicals" and "any other substance that may be found in sources of drinking water" (U.S. EPA 2011b).

The screening has been expanded to include effects on fish and wildlife in addition to humans.

These laws require EPA to develop a screening program that uses appropriate validated test systems and other scientifically relevant information and determine if the effect that certain substances have in humans is similar to the effect produced by a naturally occurring hormone (U.S. EPA 2011b). The science related to measuring and demonstrating endocrine disruption is in its' infancy, so validated methods of testing that indicate specific effects of an endocrine disruptor are still being developed (U.S. EPA 2011b). While EPA has some data on endocrine-disrupting pesticides, currently insufficient scientific data are available on most of the estimated 87,000 chemicals produced today to allow for an evaluation of endocrine associated risks (U.S. EPA 2011b).

To address this issue, EPA is developing a two-tiered screening and testing process (U.S. EPA 2011b). In Tier 1, EPA hopes to identify chemicals that have the potential to interact with the endocrine system (U.S. EPA 2011b). In Tier 2, EPA will determine the specific effect caused by each endocrine disruptor and establish the dose at which the effect occurs (U.S. EPA 2011b). While this approach is expected to enable EPA to gather the information needed to identify endocrine disruptors and take appropriate regulatory action, as mandated by Congress, at this time a determination has not been made for any of the herbicides used on sugar beets.

c. Birds and Reptiles

Because sugar beet fields provide shelter for small rodents, the fields can be important foraging areas for raptors, such as hawks and owls, and for snakes (Kaffka, 1996). Over-wintered sugar beet fields are excellent cover and provide food sources (insects) for nesting pheasants (Kaffka, 1996). Also, several bird species feed on sugar beet leaves and seedlings (e.g., skylarks and house sparrows) (Dewar and Cooke, 2006). Turtles might conceivably move between habitats through sugar beet fields and some might browse on the plants. Lizards would not be present in the colder climates, but might forage on ground insects in sugar beet fields in the more temperate climates. However, the presence of large numbers of reptiles in sugar beet fields is not expected because agricultural fields are not ideal habitat for reptiles due to relatively constant disturbances associated with agriculture (e.g., tilling and pesticide application). Some farmers apply insecticides to their agricultural fields to minimize insect damage. In so doing, farmers reduce the food source (insects) for carnivorous reptiles (e.g., lizards), forcing the species to forage in other areas.

d. Amphibians and Fish

Several species of amphibians (e.g., frogs, toads, salamanders) and fish might be located in water bodies adjacent to or downstream from H7-1 sugar beet fields. Amphibians use a wide range of aquatic habitats for their breeding sites. The presence of large numbers of adult-stage amphibians in sugar beet fields is not expected because agricultural fields are not ideal habitat for amphibians due to relatively constant disturbances associated with agriculture (e.g., tilling and pesticide application). Asmentioned above, some farmers apply insecticides to their agricultural fields to minimize insect damage. In so doing, farmers reduce the food source (insects) for terrestrial-phase amphibians, forcing the species to forage in other areas. Likewise, fish are not expected in agricultural fields, although they may exist in nearby surface waters that receive runoff from the sugar beet fields during storm events or from spray drift that enters water bodies directly from ground or aerial applications.

As shown in table 3–23 below, the potential for bioconcentration of the herbicides in fish is generally low, with a couple (ethofumesate and phenmedipham) being moderate. Ethofumesate bioconcentration in viscera (internal organs) is moderate, but only of concern for wildlife consuming fish. The bioconcentration factors (BCFs) for ethofumesate for the fillet of the fish or the whole fish is low. A notable exception to the low BCF values is trifluralin, which can bioconcentrate to a level more than 5,000 times the concentration of trifluralin in water. Additional information on tissues tested, however, was not provided by the source cited. Other aspects of toxicity of the herbicides to amphibians and fish are discussed in more detail in the chapter on environmental consequences, in section IV.C.1.d.(1).

Table 3- 23. Bioconcentration Factors (BCFs) for Herbicides Used on Sugar Beets.

Herbicide	BCF (kg/L)	Descriptor	Source
Clethodim	0.7–2.1 fillet; 2.3–3.6 whole fish	Low	(U.S. EPA 2007c)
Clopyralid	13	Low	WDOT, 2006; (NLM (National Library of Medicine), 2003)
Cycloate	190	Low	(NLM (National Library of Medicine), 2009)
Desmedipham	20 filet; 98 whole fish; 159 viscera	Low	(U.S. EPA 1996b)
EPTC	37 edible fish; 60 whole fish; 110 non-edible	Low	(U.S. EPA 2010d)
Ethofumesate	595 viscera; 17 fillet; 67 whole fish	moderate	(U.S. EPA Undated-b)
Glyphosate	0.5	Low	University of Hertfordshire, 2011a
Phenmedipham	165	moderate	University of Hertfordshire, 2011b
Pyrazon	2–23	Low	(NLM (National Library of Medicine), 2007)
Quizalofop-p-ethyl	1–4	Low	(U.S. EPA 2007b)
Sethoxydim	7 edible; 25 non-edible; 21 whole fish	Low	(U.S. EPA 2005b)
Trifluralin	5,674	High	University of Hertfordshire, 2011c
Triflusulfuron-methyl	1.3	Low	University of Hertfordshire. 2011d

e. Terrestrial Invertebrates

Terrestrial invertebrates that live in and around sugar beet fields include many beneficial species of insects that prey upon pest species (e.g., aphids) and can effectively reduce pest populations (Dewar and Cooke, 2006). Additionally, many insect species serve as pollinators of crop flowers (e.g., honey bees). Examples of beneficial predatory insects include the larval and adult stages of several ladybird species (e.g., *Adalia bipunctata*, *A. decempunctata*, *Coccinella septempunctata*, and *Propylea quatuordecimpunctata*), adult and larval stages of lacewings (particularly in Chrysopidae and Hemerobiidae), the larvae of several hover fly species (particularly in the genera *Platycheirus*, *Scaeva*, *Sphaerophoria*, and *Syrphus*), ground beetles (Carabidae), rove beetles (Staphylinidae), and mites (Dewar and Cooke, 2006). Non-insect beneficial invertebrates of note in agricultural systems are earthworms that help to aerate soils, redistribute soil nutrients, and improve soil texture.

Other terrestrial invertebrates, particularly insects, are pest species to certain crops, and can cause significant destruction if not controlled. For example, the sugar beet root maggot is the most destructive insect pest of sugar beets in many states. Many other above- and below-ground arthropods generally are present, with those considered to be pests to sugar beets including various species of symphylids and millipedes, wireworms (beetle larvae), cutworms and other caterpillars, lygus bugs, and aphids (Dewar and Cooke, 2006); see section III.B.1.c(5)). Insecticides are used to control insect pests and can be applied at planting and at intervals after planting, depending on label use restrictions (USDA-APHIS, 2011b). Toxicity of the herbicides to terrestrial invertebrates is discussed in the chapter on environmental consequences, in section IV.C.1.e.(1).

f. Aquatic Invertebrates

Aquatic invertebrates that could be present in surface waters adjacent to sugar beet fields include insect larvae and small crustaceans (e.g., water fleas, amphipods, crayfish). Some graze on algae on rocks and other surfaces; others consume detritus in bottom sediments; still others have feeding apparati that allow them to catch micro-organisms and detritus flowing downstream. Toxicity of the herbicides to aquatic invertebrates is discussed in the chapter on environmental consequences, in section IV.C.1.f.(1).

2. Micro-organisms

Beneficial and pathogenic micro-organisms are associated with sugar beets. Beneficial soil micro-organisms include many species of bacteria and fungi that are important in nutrient cycling and recycling in soils. They biodegrade organic matter (e.g., crop residues) and release nutrients contained in the organic matter in the inorganic form, so plants can take up the nutrients (Bot and Benites, 2005).

Pathogenic micro-organisms are those that are detrimental to the crop (e.g., disease-causing) and can vary from region to region. For example, sugar beets in California that are over-wintered in the field have problems with BCTV, which is spread by the beet leaf hopper (*Circulifer tenellus*). Likewise, one of the most important root diseases in sugar beet production is *Aphanomyces* root rot, caused by the soil borne oomycete (*Aphanomyces cochlioides*) (Harveson, 2007). This fungus occurs infrequently in the Imperial Valley, but can be a problem in other regions, such as southern Minnesota and the Red River Valley of North Dakota and Minnesota. Over the past decade, this pathogen has become an important part of a root disease complex (including *Rhizoctonia* root rot and *Rhizomania* or crazy root) and has been demonstrated to be widely distributed throughout western Nebraska and other areas of the Central

High Plains. Chemical control is possible only as a seed treatment (dressing) with hymexazol (Harveson, 2007). Additional root pathogens include *Erwinia carotovera* and *Fusarium oxyporum* (Christenson and Draycott, 2006). The most common sugar beet seedling pathogens are soil-borne fungi. Of particular concern are *Aphanomyces cochlioides and Rhizoctonia solani*, as well as several *Pythium and other* species (Asher and Hanson, 2006). These, like many varieties of fungi, survive for long periods of time in the soil.

Sugar beet pests also include nematodes (parasitic, microscopic worms), such as false root knot nematode (*Nacobbus aberrans*) and beet cyst nematode (*Heterodera schachtii*) (Dewar and Cooke, 2006). Beet cyst nematode is found in almost all beet-growing areas, and false root knot nematode is a serious sugar beet pest in some parts of the western United States (Dewar and Cooke, 2006).

Several aspects of sugar beet production can affect the population density and species composition of soil micro-organisms, fungi, and bacteria in particular. These include herbicide applications, tillage practices, and crop rotation. Some types of soil micro-organisms share metabolic pathways with plants, and might be affected by herbicides. Tillage disrupts multicellular relationships among micro-organisms, and crop rotation changes soil conditions in ways that favor different microbial communities.

3. Plants

Plant composition in and surrounding sugar beet fields depends on, among other characteristics, geographic location, surrounding habitat conditions, and sugar beet field size. For purposes of discussion, plants are divided into target weed species and non-target plant species. Target weed species are those weeds located within sugar beet fields that compete with the crop for available resources (e.g., sunlight, water, nutrients). Nontarget plant species include other nearby crops and non-agricultural plants.

a. Developing Herbicide Resistance and Weed Shifts

This section starts with an overview of herbicide resistance and weed shifts along with the mechanisms by which they occur. It then discusses herbicide mechanisms of action, measures to mitigate the evolution of herbicide-resistant weeds, the herbicide resistance of weeds in general, and major sugar beet weeds in particular.

(1) Overview of Herbicide Resistance, Weed Shifts, and Associated Mechanisms

The Weed Science Society of America (WSSA) official definitions for resistance and tolerance are as follows (WSSA, 2008):

- Herbicide resistance: "Herbicide resistance is the inherited ability of a plant to survive and reproduce following exposure to a dose of herbicide normally lethal to the wild type. In a plant, resistance might be naturally occurring or induced by such techniques as genetic engineering or selection of variants produced by tissue culture or mutagenesis."

- Herbicide tolerance: "Herbicide tolerance is the inherent ability of a species to survive and reproduce after herbicide treatment. This implies that there was no selection or genetic manipulation to make the plant tolerant; it is naturally tolerant."

The Penn State Agronomy guide[10] provides the following definition of a weed shift:

> "A weed shift is the change in the composition or relative frequencies of weeds in a weed population (all individuals of a single species in a defined area) or community (all plant populations in a defined area) in response to natural or human-made environmental changes in an agricultural system. Weed shifts occur when weed management practices do not control an entire weed community or population."

Natural differences between species, such as differences in tolerance to herbicides or greater ability to survive cultural and/or mechanical control, can contribute to shifts in the dominant weed species within crop fields.

Weed shifts occur when the local population of weeds changes due to the changing pressures of differing management strategies. Weed shifts could occur due to natural differences in herbicide tolerance in some weed species. For example, while the herbicide Betamix® is very good at controlling pigweed species, cocklebur is naturally tolerant. In crop production where Betamix® is used as a postemergence herbicide, one might expect a progressive shift in the presence of the weed community/population to fields dominated by cocklebur (see section III.B.1.d). However, it should be noted that weed shifts are not a unique phenomenon associated with the use of herbicides. Weed communities can change over time in response to whatever form of control is utilized, including changes in tillage, manual weed control, and herbicide application (Johnson et al., 2009). Because weed shifts can occur regardless of the mechanism for weed control, a natural shift to weeds

[10] http://extension.psu.edu/agronomy-guide/pm/sec1/sec14a

species that are inherently more tolerant to herbicides is not a unique property associated with any one herbicide.

Plants of a given species are not all identical, but are made up of “biotypes” with various genetic traits. Biotypes possess certain traits or characteristics not common to the entire population. When a selection is applied through an herbicide application or management technique, a biotype that confers a selective advantage becomes more prevalent. Herbicide resistance arises when a rare individual in a population has a mutation or rare combination of alleles that confers a fitness advantage in the presence of the herbicide. The herbicide does not cause the mutation but selects for the survival of this rare individual. The evolution of weed herbicide resistance can be the result of continued application of an herbicide that uses the same mechanism of action without rotation to other methods of control thereby favoring a weed shift to the resistant “biotype” (Johnson et al., 2009; Neve, 2007; Orloff et al., 2009). Crops with engineered herbicide resistance do not exert selection pressure on weeds directly. Rather the agricultural practices associated with weed control during cultivation of the plant exert selection pressures on weeds (Boerboom and Owen, 2007; Owen, 2008). In other words, herbicide resistance is primarily a result of management practices utilized in crop fields independent of the crop. It is important to note that even if crop management practices, such as repeated use of the same herbicide, contribute to the development of herbicide-resistant weeds, the herbicide can continue to be an effective means of control of other weeds in the same crop. For example, while 69 different weed species have developed resistance to the herbicide atrazine, this herbicide is still an effective method of weed control. When used in herbicide product or tank mixes, continued selection for resistance to only one herbicide is avoided. In this way, atrazine resistant weeds are manageable for corn farmers in the U.S. cornbelt (Nandula, 2010).

Shifts in weed species composition from highly susceptible toward more naturally tolerant species will happen more rapidly than selection for resistance (Orloff et al., 2009; Shaner, 2000).

The herbicide resistant trait can spread into other population of sexually compatible plants by cross pollination. In this way, traits can be introduced into wild relatives from crop plants. The potential for hybridization between H7-1 sugar beets and sexually compatible species is discussed in section III.B.5.

Different mechanisms can allow herbicide-resistant weed populations to persist from year to year. For example, resistant weeds that mature and release seeds into crop fields or field margins can lead to the formation of a weed seed bank that may be buried for several years. Differences in soil management (tillage) for future crop species may ultimately result in these resistant seeds resurfacing where they can germinate and grow in subsequent years in rotation crops (Sosnoskie et al., 2009).

Resistant weeds are not restricted to the location in which they arose. Resistant weed seeds may move between infested and clean fields through mechanisms of seed dispersal. For example, the weed species *Kochia scoparia* and *Conyza canadensis* are very efficient at long distance pollen and seed dispersal and can move from field to field. As such, the selection for resistant biotypes in a nearby field may lead to increased potential for herbicide resistant biotypes in neighboring fields, both due to dispersal of seeds and through pollen movement and hybridization between populations. Through seed dispersal herbicide resistant weeds can move from crops to non-agricultural lands and vice versa. Additionally, connectivity between separated fields could result if farmers own or lease discontinuous field plots and use the same equipment between fields without proper cleaning. Computer simulations modeling the dispersal of glyphosate-resistant *C. canadensis* indicated that adding conventional crop rotations (alfalfa) to Roundup Ready® soybean cultivation would not limit spread of the herbicide resistant weeds in the short term but could have long term benefits by reducing the ease at which resistant weeds spread. In contrast, inclusion of an additional Roundup Ready® crop rotation (Roundup Ready® corn) increased the potential spread rate of glyphosate-resistant weeds to neighboring fields because additional herbicide selection would be applied (Dauer et al., 2009).

An example of these processes has recently been observed in Michigan. *Conyza canadensis* biotypes resistant to glyphosate in Michigan first appeared in a Christmas tree farm in 2007. In 2011, resistant biotypes were identified in a no-till soybean field and a stale seed-bed sugar beet field in two Michigan counties (Sprague and Everman, 2011).

Weeds, including herbicide resistant biotypes, can also spread between croplands and non-agricultural settings and vice versa. About half of all glyphosate resistant weed species have developed from the use of glyphosate in non-agricultural settings or in agricultural settings such as orchards that do not involve the use or RoundupReady® crops. Some of these settings are listed in table 3–24.

(2) Herbicide Mechanisms of Action and Resistant Weeds

Herbicides are classified according to their mechanism of action, which is the overall manner by which the herbicide affects a plant at the tissue or cellular level. Most herbicides bind to, and thereby block the action of, a specific enzyme. WSSA (Undated) has classified herbicides by group number, based on their mechanism of action. Currently, there are 13 main herbicides used in sugar beet cultivation (see table 3-16 and 3–17) and they fall into Groups 1, 2, 3, 4, 5, 8, and 9 (Dexter et al., 1994; Tranel and

Trucco, 2009). These herbicides represent the following mechanims of action: acetyCoA carboxylase inhibition (ACCase) (clethodim, pyrazon, quizalofop-p-ethyl, sethoxydim); acetolactate synthase (ALS) inhibition (triflusulfuron-methyl); mimic of the plant growth regulator, auxin (clopyralid); fatty acid synthesis inhibition (cycloate, EPTC, ethofumesate); Photosystem II inhibition (desmedipham, phenmedipham+desmedipham); Microtuble (mitosis) inhibition (trifluralin); and 5-enolpyruvylshikimate-3-phosphate (EPSP) synthase inhibition (glyphosate) (HRAC (Herbicide Resistance Action Committee), 2011).

Currently, five different modes of herbicide resistance have been identified in weed species: (1) altered target site due to a mutation at the site of herbicide action which results in the complete or partial lack of inhibition; (2) metabolic deactivation, where the active chemical of the herbicide is broken down or transformed into non-toxic components; (3) reduced absorption into the plant or reduced translocation (movement) within the plant; (4) sequestration or compartmentalization of the herbicide such as in storage vacuoles or the cell wall; and (5) gene amplification or overexpression of the target site in excess of herbicide dose (Nandula, 2010). Mechanisms for herbicide resistance for each of the classes of herbicides used in sugar beet cultivation are detailed below (as referenced in (Tharayil-Santhakuma, 2003). The number of resistant species for each herbicide group is presented at the end of each group description (Heap, 2011).

ACCase (Group 1): Group 1 herbicides function by inhibiting the action of the enzyme ACCase which is needed for lipid biosynthesis. Group 1 herbicides used in sugar beet production includes clethodim, quizalofop-p-ethyl, and sethoxydim. Group 1 herbicides are used to control grasses. Forty weed species have ACCase resistance.

ALS (Group 2): Group 2 herbicides function by inhibiting the action of the enzyme ALS which is needed for amino acid synthesis. The group 2 herbicide used on sugar beets is triflusulfuron-methyl. It is used to control broadleaf weeds such as bedstraw, kochia, redroot pigweed, shepardspurse, smartweed, velvetleaf, wild mustard, and wild radish. One hundred and nine weed species have ALS resistance.

Microtubule (Mitosis) Inhibitors (Group 3): Group 3 herbicides function by inhibiting cell division. Trifluralin is the group 3 herbicide used on sugar beets. It controls annual grasses and some broadleaf weeds. Ten weed species have resistance to microtubule inhibitors.

Synthetic Auxin Mimics (Group 4): Group 4 herbicides function by mimicking the plant growth hormone auxin and causing uncontrolled cell growth. Clopyralid is the group 4 herbicide used on sugar beet. It is used to control broadleaf weeds such as Canada thistle, wild buckwheat, cocklebur, jimsonweed, ragweed, marshelder, and wild sunflower. Twenty-eight weed species have resistance to synthetic auxins.

Photosystem II Inhibitors (PSII) (Group 5): Group 5 herbicides function by inhibiting photosynthesis. For use on sugar beets, they include desmedipham, phenmedipham, and pyrazon. They are used to control broadleaf weeds such as annual sowthistle, black nightshade, lambsquarters, common ragweed, and redroot pigweed, sheperd's-purse, annual smartweed, and purslane. Sixty-nine weed species have resistance to PSII inhibitors.

Fatty acid Synthesis (Group 8): Group 8 herbicides function by inhibiting the synthesis of fatty acids and lipids. Herbicides used in this group on sugar beets include cycloate, EPTC, and ethofumesate. These herbicides control grasses such as barnyardgrass, crabgrass, foxtail, wild oats, and broadleafs such as lambsquarters, purslane, redroot pigweed, black nightshade, common chickweed, kochia, Russian thistle, wild buckwheat,. Specific mechanisms for resistance to fatty acid synthesis inhibitors have not been identified. Eight weed species have resistance to fatty acid synthesis herbicides.

Inhibition of 5-enolpyruvylshikimate-3-phosphate (**EPSP**) synthase which is needed for amino acid synthesis. **(Group 9):** Group 9 herbicides function by inhibiting the action of the enzyme EPSPS, interfering with the shikimate pathway[11], an essential metabolic process in plants. Because this enzyme is present in nearly all plants but absent in most if not all animals, and glyphosate binds to this enzyme and does not appear to bind to other targets, it is highly specific (Cole, 2010). The group 9 herbicide used in sugar beets is glyphosate which is used to control grasses and broadleaf weeds. Twenty-one weed species have confirmed resistance to glycine herbicides.

Glyphosate resistance in plants has been engineered into crop plants by transforming plants with a resistant *epsps* gene. The most common trait, CP4, is a naturally occurring resistant *epsps* gene isolated from the soil bacteria, *Agrobacterium*. Another route used to create a glyphosate resistance gene has been to convert a sensitive plant *epsps* gene into a resistant version by site directed mutagenesis. A third route has been to introduce into plants an enzyme that inactivates glyphosate through N-acetylation (Castle et al., 2004). In this case an N-acetylase gene was found in *Bacillus licheniformis* that had weak activity torwards glyphosate. The efficiency of this enzyme was increased by directed evolution in the lab (Castle et al., 2004).

[11] The shikimate pathway links the metabolism of carbohydrates to biosynthesis of aromatic compounds.

Different mechanisms have been identified that confer glyphosate resistance in weeds. (Cerdeira and Duke, 2006; Nandula et al., 2005; Stoltenberg and Jeschke, 2003) (Funke et al., 2006; Gaines et al., 2010; Yuan et al., 2010) (Baerson et al., 2002; Service, 2007; Yuan et al., 2006) (Jasieniuk et al., 2008; Wakelin and Preston, 2006) (Powles, 2010).

- *Resistant EPSPS* – Variants of EPSPS with decreased binding to glyphosate have evolved in the weed species goosegrass (*Eleucine indica*), Wimmera ryegrass (*Lolium rigidum*), and Italian ryegrass (*Lolium multiflorum*) (Gaines et al., 2010).

- *Increased copy number of epsps gene* – Glyphosate-resistant populations of *Amaranthus palmeri* found in Georgia were found to have 5- to 160-fold more copies of the *epsps* gene in their genomes compared to glyphosate-sensitive populations. Furthermore, the extra copies were found to be distributed among all the chromosomes, suggesting a transposon-mediated amplification. The resulting overexpression of *epsps* likely confers resistance to glyphosate (Gaines et al., 2010) (Powles, 2010).

- *Altered translocation of glyphosate* – Some limited evidence indicates that, in some glyphosate-resistant ryegrass, glyphosate accumulates in mature leaf tissue rather than in the growing parts. In addition, although the mechanism of resistance in horseweed is unknown, translocation experiments suggest that resistant biotypes do not translocate glyphosate to the growing parts of the plant (e.g., roots, young leaves, and crown).

- *Subcellular sequestration* – Glyphosate-resistant horseweed has been shown to exhibit vacuolar sequestration. By compartmentalizing glyphosate away from the cytoplasm, plant cells can keep glyphosate from coming in contact with EPSPS (Ge et al., 2010).

Even though glyphosate has been used extensively as a preplant burndown for more than three decades and on GE crops for the past 15 years, fewer cases of developed resistance have been reported compared to many other herbicides (see section III.C.3.a.(4), Figure 3-19). Furthermore, even though 21 species have selected for herbicide resistance, glyphosate is still highly effective in controlling more than 250 weeds (USDA-APHIS, 2011b).

In 2009, approximately 135 million of the 173 million acres of corn, soybeans, and cotton in the United States were planted with an herbicide-resistant variety, with the most common resistant trait being glyphosate resistance (USDA-NASS, 2009b). An estimated 6 percent of the total planted corn, soybean, and cotton acres in the United States have some level of weeds that are resistant to glyphosate (WSSA, 2010).

Selection of glyphosate-resistant weeds has occurred most commonly when glyphosate is used in consecutive years such as in vineyards, orchards, or roadways, or where glyphosate-resistant corn and soybean are planted without rotation. Two species of weeds have been selected for glyphosate resistance in a two-crop rotation where glyphosate-resistant corn was rotated with glyphosate-resistant soybean (Kniss, 2010b). To date, there are no known cases where a glyphosate-resistant weed was selected in a three-crop rotation (Kniss, 2010b).

Sugar beets are a crop susceptible to many diseases, nematodes, and insects. In some areas, by contractual agreement with sugar beet cooperatives, sugar beet growers are prohibited from planting a sugar beet root crop in the same field more frequently than once every 3 years. In other areas such as California, back-to-back planting of sugar beets is allowed as long as sugar beets are planted no more than 4 years out of every 10 years. (2011). In some sugar beet-growing States (including Oregon, Washington, and Idaho), sugar beets may be the only glyphosate-resistant crop grown in the rotation. In other States (Colorado, Montana, Wyoming, Nebraska, Northern North Dakota, and Northern Minnesota), at least one non-glyphosate-resistant crop is included in the rotation. Southern Minnesota and Michigan farmers may grow glyphosate-resistant crops in all three rotations (USDA–APHIS, 2010a). In Wyoming and California, sugar beet growers may grow sugar beets in consecutive years before rotating to another crop. The role of crop rotations in delaying the development of resistance is discussed further in the sections below.

(3) Measures to Mitigate Selection of Herbicide-resistant Weeds

Overview of Mitigation Measures. Strategies to minimize herbicide-resistant weed development include (Stachler and Zollinger, 2009).

- Rotate herbicides with different mechanisms of action in consecutive years. By changing herbicides with different mechanisms of action between years, an individual that arises with a new mutation conferring herbicide resistance to the first herbicide is unlikely to survive due to control of that individual with the second herbicide. As a result, the emergence of herbicide resistant populations will be delayed. Because herbicide resistance is a heritable trait, multiple growing seasons of herbicide use are required before herbicide-tolerant weeds emerge and become the predominant biotype in a specific area (Cole, 2010). Researchers have concluded that even if growers completely relied on only one herbicide, at least 5 years are likely required for a herbicide-resistant weed population to develop (Beckie, 2006; Kniss, 2010b; Neve, 2008; Werth et al., 2008). Crop monitoring, follow up, subsequent testing and reporting by academic and industry weed scientists in cases of suspected resistance are important parts of all herbicide-resistance stewardship programs.

- Apply herbicides in tank-mix, prepackage, or sequential mixtures that include multiple mechanisms of action. Two or more herbicides in the tank-mix must have substantial activity against potentially resistant weeds. Most commercial premixes do not contain herbicides that target the same weed species. Antagonism among tank-mix partners should be avoided. Use of herbicides with different mechanisms of action, either concurrently or sequentially, is an important defense against weed herbicide resistance (WSSA, 2010). According to WSSA, "Use of a single product or mode of action for weed management is not sustainable. Some of the best and most sustainable approaches to prevent resistance include diversified weed management practices, rotation of mechanisms of action and especially the use of multiple product ingredients with differing mechanisms of action" (WSSA, 2010).

  A common practice of conventional sugar beet growers is to use herbicides applied at several times but at low levels. This "micro-rate" application method utilizes mixes of herbicides designed to reduce weeds while limiting damage to the sugar beet crop. Dale et al. (2006)examined the efficacy of micro-rate herbicide applications. The mixture of herbicides in the micro-rate technique may act to lower the likelihood of selection of resistant weeds by utilizing multiple modes-of-action. However, Dale et al. (2006) also noted that not all weeds were eliminated as a result of micro-rate applications. While the micro-rate method of weed control has been widely adopted in conventional sugar beet production and has lead to reduced amounts of herbicide used in sugar beet fields (Dale et al., 2006), it may also represent a potential mechanism for rapid resistance evolution. Research by Neve and Powles (2005) examined the effect of low doses of herbicides on the weed *Lolium rigidum* and observed rapid changes in herbicide resistance after exposure. Additionally, low-dose exposure to some herbicides not only leads to increased resistance in the tested populations it also resulted in cross-resistance between several different ACCase and ALS herbicides (Neve and Powles, 2005). Low levels of herbicides increase the likelihood that resistant weed biotypes survive, hybridize with other biotypes, and create new biotypes that have resistance to higher doses of the herbicide (Stachler and Zollinger, 2009). No studies could be identified that link micro-rate applications to new herbicide-resistant weed biotypes.

- Rotate crops, particularly those with different lifecycles, e.g., winter annual crops (winter wheat), perennial crops (alfalfa), and summer annual crops (spring wheat, corn, or beans). Do not use herbicides with the same mechanism of action in the different crops unless other effective control practices are also included such as the use of an herbicide with a different mechanism of action or a different tillage or cultural practice. Two options for resistance management are: (1) use the desired herbicide until resistance occurs and then change to an alternative; and (2) rotate control methods to delay the on-set of resistance.

Crop rotation is an additional effective strategy for managing herbicide-resistant weeds because it provides more control opportunities and disrupts life cycles of weeds that are crop mimics ((Derksen et al., 2002)and references therein). Because cropping systems create different environments, weed communities become more diverse in diverse cropping systems and the predominance of any one weed is minimized (Derksen et al., 2002; Liebman and Dyck, 1993). Crop rotation independent of herbicides is thought to be important in altering weed communities. (Liebman and Dyck, 1993). Several mechanisms could be responsible for this effect, including allelopathy, microbial community changes, and differential resource partitioning, which could influence seed production or survival of seeds in the seedbank (Sosnoskie et al., 2009). Differences in crop height, density, and canopy architecture can also favor some weed species over others (Sonoskie et al., 2009). Additionally, more diverse crop rotations allow growers to vary the timing and mechanisms of action of herbicides, thus delaying the selection of herbicide-resistant biotypes (Derksen et al., 2002). For example in a corn soybean rotation, broadleaf weeds can be controlled more effectively in corn, a warm season grass, than in soybean, a warm season broadleaf crop, using herbicides that target broadleaf weeds while grasses can be controlled more effectively in soybean than in corn using herbicides that target grasses. Thus the different cultural conditions of the crop rotation such as planting date, harvest date, tillage practices, irrigation practices, fertilization practices, available herbicide chemistries, and herbicide timing (preseeding, in crop, preharvest, or postharvest) vary the selection pressures on the crop. The more diverse the crop rotation, the more varied the selection pressure, and the less likely weeds will be selected to a given selection pressure such as herbicide (Derksen et al., 2002) (Nazarko et al., 2004).

Sugar beet crops are rotated with other crops in all of the five root production regions of the United States (see section III.B.1). For a full discussion of crop rotations in the different regions see sections III.B.1.b(16) and III.B.1.c(4).

- Scout fields regularly and identify weeds that escape herbicide treatment. Monitor changes in weed populations early (a few plants in the field) and restrict spread of potentially resistant weeds that match the field history and herbicide pattern. If there are dead plants, unaffected plants, and/or plants showing intermediate responses, then resistance should be strongly considered. Use full rates of all products and use the most effective adjuvants when tank-mixing with glyphosate.

- Use high labeled rates of postemergence herbicides. Reduced rates may allow hybridization among plants resistant to low levels of herbicide to produce plants resistant to high levels of herbicide.

Additional best management practices (BMPs) that can help delay the occurrence of herbicide resistance are discussed below.

WSSA reports higher levels of awareness among growers regarding the need to minimize the potential for development of glyphosate resistance: "In a market research study that surveyed 350 growers in 2005 and again in 2009, in response to the question, 'are you doing anything to proactively minimize the potential for resistance to glyphosate to develop,' 67 percent said yes in 2005 and 87 percent said yes in 2009" (WSSA, 2010). "In a 2007 survey of 400 corn, soybean, and cotton growers, resistance management programs were often or always used by 70% or more of all three grower groups" (WSSA, 2010). The 2007 survey included respondents from 22 States, and although the survey was not targeted at sugar beet growers, the survey did include respondents from three States that together plant more than 57 percent of the sugar beet root crop: Minnesota, North Dakota, and Nebraska (table 3-5). Corn and/or soybeans are major rotation crops for sugar beets in these States (see table 3–6). These surveys examined the use of 10 different BMPs of corn, cotton, and soybean farmers and indicated that seven BMPs were readily adopted by farmers (>75 percent) while three were less likely to be followed. The seven BMPs were: use of the labeled rate of herbicides; scouting for weeds before application; scouting for resistant weeds after herbicide applications; starting with clean fields; use of new seed; control of weeds early; and controlling weed escapes. The three BMPs less likely to be followed by farmers of all three crops were: cleaning of equipment; use of multiple herbicides with different mechanisms of action; and supplemental tillage (Frisvold et al., 2009).

Information is widely available from universities and other sources regarding glyphosate resistance. Public universities (e.g., North Dakota State University, University of Minnesota), herbicide manufacturers (e.g., www.weedresistancemanagement.com, www.resistancefighter.com), and crop commodity groups (e.g., National Corn Growers Association, American Soybean Association) have Internet Web sites with information on prevention and management of herbicide resistance. An example of information provided by public universities is that from Dr. Don Morishita, a weed scientist at the University of Idaho, who advises sugar beet growers on weed herbicide resistance management strategies (Dumas, 2008). The Sugar Industry Biotech Council provides weed herbicide resistance resources on its Web site (http://www.sugarindustrybiotechcouncil.org/sugar-industry/weed-resistance-management/).

Monsanto/KWS SAAT AG includes information on weed herbicide resistance management practices in its TUG that is mailed annually to all licensed growers. The sugar beet industry associations also hold annual meetings where weed herbicide resistance management practices and other stewardship measures are included as part of the proceedings.

Sugar beet growers in particular have strong financial and practical interests in managing weeds effectively to reduce the development of herbicide resistance and to maximize yield potential. Sugar beets are a high-value crop, and competition from weeds for moisture and light can negatively impact yields and the overall value of the crop. The development of glyphosate-resistant weeds harms the economic return per acre for the individual farmer and the entire sugar beet industry (Cole, 2010). In response to the incidence of glyphosate resistant weeds and to preserve the use of glyphosate as a broad-spectrum herbicide, incentive programs for farmers to include residual herbicides as mixes with the use of glyphosate have been implemented to encourage use of combined mechanisms of action in herbicide applications in glyphosate-resistant corn, soybean, and cotton crops (e.g., Roundup® plus) (Monsanto, 2011a).

As such, strategies and recommendations to delay the development of glyphosate-resistant weeds have been developed for H7-1 sugar beets (Monsanto, 2011a). Specifically, the TUG recommends the use of "mechanical weed control/cultivation and/or residual herbicides" with H7-1 sugar beets, where appropriate, and "additional herbicide mechanisms of action/residual herbicides and/or mechanical weed control in other Roundup Ready® crops" that are rotated with H7-1 (Monsanto, 2011a). Adding a conventional crop in the rotation would promote the use of other non-glyphosate herbicides and provide diversity of the herbicide mechanism of action, which will reduce the selection pressure for glyphosate resistance.

When a grower encounters a biotype that is resistant to an herbicide he or she is using, the grower should remove the resistant biotype using management practices such as those routinely used by sugar beet growers, including herbicide mixtures, herbicide rotation, crop rotation, and increased cultivation.

Rotation Crops as Sources for Resistant Weeds. As mentioned above, crop rotations are an important mechanism that can delay the development of resistance in weed populations. These rotation crops can also be sources of weeds for sugar beets. As discussed in section III.B.1.c(1), there are five different regions that produce sugar beet root crops. Crop rotations are used in all five regions and while there are several common crops used in sugar beet rotations (e.g., corn), differences do exist. (See sections III.B.1.b(16) and III.B.1.c(4) for a discussion on crop rotations.)

Table 3–24 lists the estimated number of acres in sugar beet producing states that are confirmed to have weeds resistant to groups of herbicides used in sugar beet production. While many of these crops are not rotated with sugar beet, it provides an indication of how widespread herbicide-resistant weeds are found. For example, while sugar beets were planted on 1.4 million acres in 2002, 3.1 million acres of the sugar beet producing states reported problems with herbicide-resistant weeds. These estimates may not be very accurate because they may underestimate acreage due to a lag in reporting and they may overestimate acreage when resistant weeds overlap on the same acreage. At this time, the vast majority of herbicide resistant weeds that pose problems for sugar beet growers are resistant to non glyphosate herbicides.

In some states, one or more Roundup Ready® crops are rotated with sugar beets (see table 3–6). Table 3–6 also estimates that about 50 percent of the sugar beet acreage could be followed with a Roundup Ready® crop.

The most widespread herbicide-resistant weeds likely to impact sugar beet root production include kochia resistant to ALS-inhibitors and wild oat with resistance to ACCase inhibitors.

Table 3- 24. Estimation of Herbicide Resistant Weed Infestation in Sugar Beet Root Production States

Region	State	Crops Infested	Maximum Acres Infested
Northwest	Idaho	Cereals, lentils, peas, potato, roadsides, wheat	238,000
	Oregon	Alfalfa, cropland, grass seed, bluegrass, mint, orchards wheat	127,800
	Washington	Cereals, lentils, mint, nurseries, roadsides, wheat	17,100
Midwest	North Dakota	Cereals, corn, cropland, soybean, sunflower, wheat	1,513,900
	Minnesota	Corn, cropland, soybean, sugar beet, wheat	128,200
Great Lakes	Michigan	Asparagus, blueberry, carrot, corn, cropland, nurseries, roadsides, soybean, sugar beet, vegetables	169,000
Great Plains	Colorado	Barley, corn, roadsides, wheat	66,300
	Wyoming	Corn and wheat	6,300
	Nebraska	Corn and soybeans	5,500
	Montana	Barley, cereals, cropland, railways, sugar beet, and wheat	617,900
Imperial Valley	California	Almonds, asparagus, barley, corn, onion, orchards, railways, rice roadsides, vineyards, and wheat	205,400

Source: (Heap, 2011)

This is based on the estimated large acreage of cropland infested with these resistant biotypes that includes sugar beets and its rotation crops as analyzed above. In addition, these two species have biotypes that are resistant to multiple mechanisms of action. Kochia resistant to both a PSII inhibitor and an ALS inhibitor was identified in Illinois (Heap, 2011). A wild oat resistant to four mechanisms of action (ACCase inhibitor, ALS inhibitor, thiocarbamates, and arylaminopropionic acids) was identified in Canada (Heap, 2011). Fortunately, wild oat has not yet developed resistance to glyphosate so this herbicide can bring about effective control where many other herbicides cannot.

(4) Herbicide Resistance of Major Sugar Beet Weeds

Weeds and Herbicide Resistance in General. As of December 12, 2010, 348 herbicide-resistant weed biotypes have been reported to be resistant to 19 different herbicide mechanisms of action worldwide (Heap, 2011). Glyphosate-resistant weeds account for roughly 6 percent of the herbicide-resistant biotypes, while weeds resistant to herbicides that inhibit ALS account for 31 percent of the herbicide-resistant biotypes (Heap, 2011).

Figure 3–19 shows the increase in herbicide-resistant biotypes with time. Among the herbicides commonly used in conventional sugar beet farming, Assure® II, Poast®, and Select® are ACCase inhibitors – Group 1; Upbeet® is an ALS inhibitor – Group 2; Treflan® HFP is a dinitroaniline that affects microtubule assembly – Group 3; Stinger® is a synthetic auxin – Group 4; and glyphosate is a glycine EPSPS inhibitor – Group 9. Figure 3–19 shows only the number of confirmed resistant biotypes. The total extent and distribution of resistant biotype varies widely.

The relative risk of weed herbicide selection for resistant biotypes is highly correlated to the herbicide mechanism of action (Sammons et al., 2007). Herbicide families have been classified according to their risk of resistant weed development. Beckie (2006) lists ALS- and ACCase-inhibiting herbicides as “High” risk for selection of resistant biotypes, while glyphosate is considered a “Low” risk herbicide for the selection of herbicide-resistant biotypes. ALS- and ACCase-inhibiting herbicides are commonly used in conventional sugar beet production, and weeds resistant to these two herbicide groups are widely distributed across sugar beet growing regions of the United States (Kniss, 2010b).

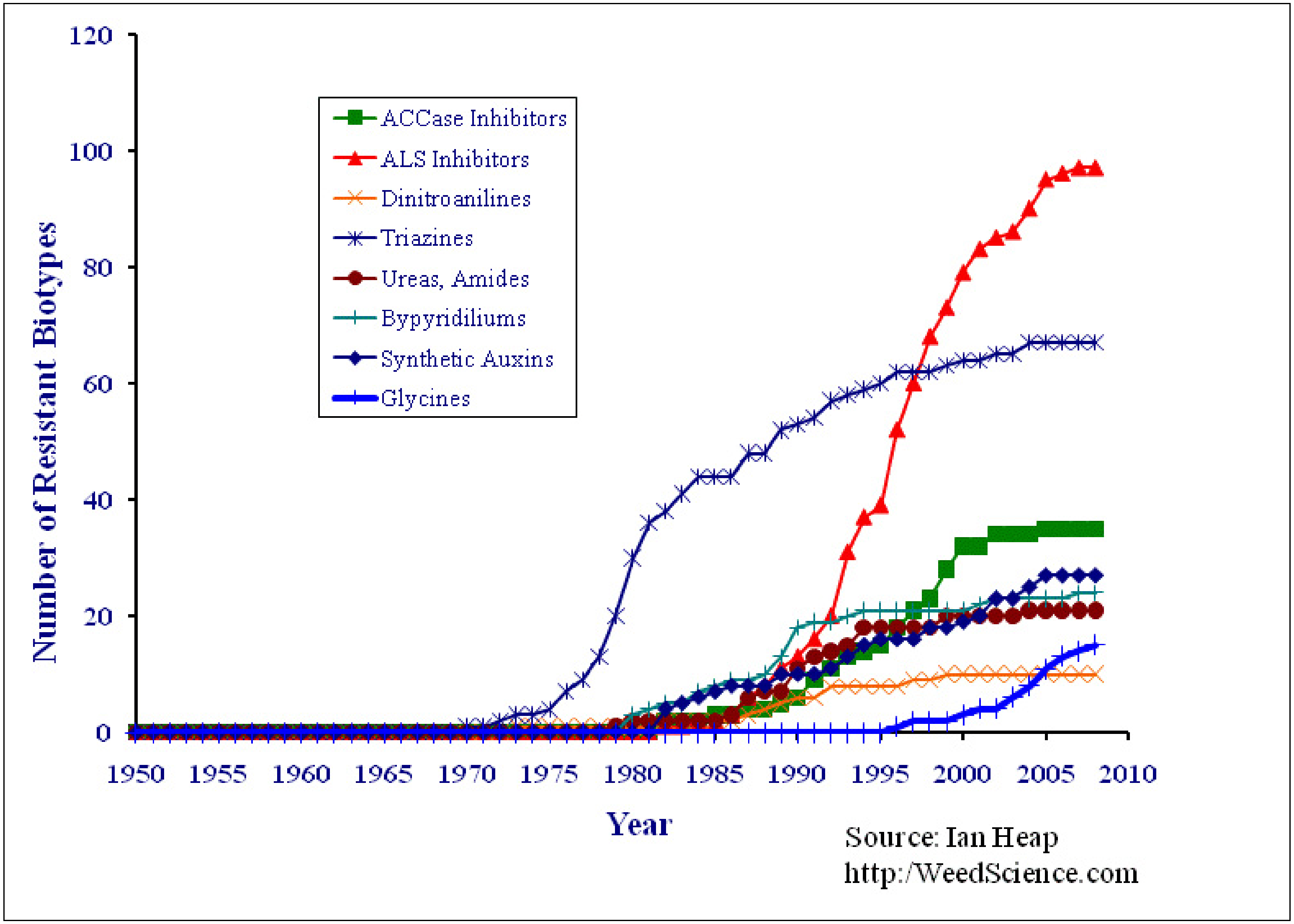

Figure 3- 19. Increase in herbicide resistance through present.

Because glyphosate is a low-risk herbicide, Kniss has suggested that H7-1 sugar beets can help delay resistance to these high-risk herbicides in additional weeds species (Kniss, 2010b):

> "In fact, glyphosate resistant sugar beet adds to the diversity of herbicide modes of action in many sugar beet crop rotations because it introduces a new mode of action (glyphosate) into the rotation with non-glyphosate-resistant crops that tend to rely heavily upon acetolactate synthase ("ALS") inhibitors. ALS inhibiting herbicides pose a far greater risk of developing weed resistance than does glyphosate. By adding glyphosate to their crop rotations, growers of glyphosate resistant sugar beet actually decrease the likelihood of developing resistance to ALS inhibitors, just as the use of other crops and alternative modes of action in rotation with GR sugar beet reduce the likelihood of glyphosate resistant weeds."

Table 3–25 summarizes the weeds that have developed resistance to herbicide groups used in sugar beets for states where sugar beets are grown commercially. A weed is listed for a state when herbicide resistance has been confirmed. To be listed as an herbicide-resistant weed by the WSSA, weed biotypes must meet all of the following criteria: (1) fulfill the WSSA definition of resistance, (2) confirmation of resistance using acceptable scientific protocols, (3) resistance must be heritable, (4) the weed must demonstrate practical field impact, and (5) the weed must be identified as a problem weed at the species level, not the result of deliberate or artificial selection (WSSA, 2005). The table does not show the extent of the weeds with the noted resistance.

Major Weeds of Sugar Beet Production and Herbicide Resistance.

Currently, there are many weeds that are noted as problematic weeds for sugar beet growers. For a list of common sugar beet weeds, see section III.B.1.d. Sugar beets (roots) are produced in five regions: Great Lakes, Great Plains, Midwest, Northwest, and Imperial Valley (see figure 3–6). Sugar beet weed species may be found in all five regions or be unique to only a subset. Many of these weeds have developed resistance to conventional herbicides and in some cases, glyphosate-resistant biotypes have also been identified.

Based on information in the ISHRW (Heap, 2011) several herbicide-resistant weeds occur in sugar beets or in crops that are grown in rotation with sugar beets (see tables 3–26 and 3–27). Table 3–9 summarizes the effectiveness of herbicides on major weeds in sugar beets as provided by three sources.

Table 3- 25. Weeds with Resistance to Herbicides in Sugar Beet States
(Heap, 2011)

Species	Common Name	Year	Herbicide Mechanisms of Action
California			
1. *Senecio vulgaris*	Common groundsel	1981	Photosystem II inhibitors
2. *Lolium perenne*	Perennial ryegrass	1989	ALS inhibitors
3. *Cyperus difformis*	Smallflower umbrella sedge	1993	ALS inhibitors
4. *Sagittaria montevidensis*	California arrowhead	1993	ALS inhibitors
5. *Salsola iberica*	Russian thistle	1994	ALS inhibitors
6. *Avena fatua*	Wild oat	1996	Unknown
7. *Ammania auriculata*	Redstem	1997	ALS inhibitors
8. *Scirpus mucronatus*	Ricefield bulrush	1997	ALS inhibitors
9. *Echinochloa phyllopogon*	Late watergrass	1998	ACCase inhibitors
10. *Echinochloa phyllopogon*	Late watergrass	1998	Thiocarbamates and others
11. *Lolium rigidum*	Rigid ryegrass	1998	EPSPS inhibitors
12. *Ammania coccinea*	Long-leaved loosestrife	2000	ALS inhibitors
13. *Echinochloa crus-galli*	Barnyardgrass	2000	ACCase inhibitors
14. *Echinochloa crus-galli*	Barnyardgrass	2000	Thiocarbamates and others
15. *Echinochloa oryzoides*	Early watergrass	2000	Thiocarbamates and others
16. *Echinochloa phyllopogon*	Early watergrass	2000	ACCase inhibitors
17. *Echinochloa phyllopogon*	Late watergrass	2000	Thiocarbamates and others
18. *Phalaris minor*	Late watergrass	2001	ACCase inhibitors
19. *Digitaria ischaemum*	Little seed canary grass	2002	Synthetic Auxins
20. *Conyza Canadensis*	Smooth crabgrass	2005	EPSPS inhibitors
21. *Conyza bonariensis*	Hairy fleabane	2007	EPSPS inhibitors
22. *Conyza bonariensis*	Hairy fleabane	2009	Bipyridiliums
23. *Conyza bonariensis*	Hairy fleabane	2009	EPSPS inhibitors
Colorado			
1. *Aramanthus retroflexus*	Redroot pigweed	1982	Photosystem II inhibitors
2. *Kochia scoparia*	Kochia	1982	Photosystem II inhibitors

3. *Kochia scoparia*	Kochia	1989	ALS inhibitors
4. *Avena fatua*	Wild oat	1997	ACCase inhibitors
Idaho			
1. *Lactuca serriola*	Prickly lettuce	1987	ALS inhibitors
2. *Kochia scoparia*	Kochia	1989	ALS inhibitors
3. *Salsola iberica*	Russian thistle	1990	ALS inhibitors
4. *Lolium multiflorum*	Italian ryegrass	1991	ACCase inhibitors
5. *Avena fatua*	Wild oat	1992	ACCase inhibitors
6. *Avena fatua*	Wild oat	1993	Thiocarbamates and others
7. *Avena fatua*	Wild oat	1993	Unknown
8. *Anthemis cotula*	Mayweed chamomile	1997	ALS inhibitors
9. *Kochia scoparia*	Kochia	1997	Synthetic Auxins
10. *Amaranthus retroflexus*	Redroot pigweed	2005	Photosystem II inhibitors
11. *Lolium multiflorum*	Italian ryegrass	2005	ACCase inhibitors
12. *Lolium multiflorum*	Italian ryegrass	2005	ALS inhibitors
13. *Lolium multiflorum*	Italian ryegrass	2005	Chloroacetamides and others
Michigan			
1. *Chenopodium album*	Lambsquarters	1975	Photosystem II inhibitors
2. *Ambrosia artemisiifolia*	Common ragweed	1990	Photosystem II inhibitors
3. *Senecio vulgaris*	Common groundsel	1990	Photosystem II inhibitors
4. *Portulaca oleracea*	Common purslane	1991	Photosystem II inhibitors
5. *Portulaca oleracea*	Common purslane	1991	Ureas and amides
6. *Daucus carota*	Wild carrot	1993	Synthetic Auxins
7. *Ambrosia artemisiifolia*	Common ragweed	1998	ALS inhibitors
8. *Amaranthus tuberculatus (syn. rudis)*	Common waterhemp	2000	ALS inhibitors
9. *Amaranthus powellii*	Powell amaranth	2001	Photosystem II inhibitors
10. *Amaranthus powellii*	Powell amaranth	2001	Ureas and amides
11. *Amaranthus retroflexus*	Redroot pigweed	2001	Photosystem II inhibitors
12. *Amaranthus retroflexus*	Redroot pigweed	2001	Ureas and amides
13. *Chenopodium album*	Lambsquarters	2001	ALS inhibitors
14. *Polygonum persicaria*	Ladysthumb	2001	Photosystem II inhibitors
15. *Amaranthus*	Smooth pigweed	2002	ALS inhibitors

hybridus			
16. *Conyza canadensis*	Horseweed	2002	ALS inhibitors
17. *Conyza canadensis*	Horseweed	2002	Photosystem II inhibitors
18. *Conyza canadensis*	Horseweed	2002	Ureas and amides
19. *Atriplex patula*	Spreading orach	2003	Photosystem II inhibitors
20. *Abutilon theophrasti*	Velvetleaf	2004	Photosystem II inhibitors
21. *Chenopodium strictum var. glaucophyllum*	Late flowering goosefoot	2004	Photosystem II inhibitors
22. *Solanum ptycanthum*	Eastern black nightshade	2004	Photosystem II inhibitors
23. *Kochia scoparia*	Kochia	2005	ALS inhibitors
24. *Setaria faberi*	Giant foxtail	2006	ALS inhibitors
25. *Conyza canadensis*	Horseweed	2007	EPSPS inhibitors
Minnesota			
1. *Chenopodium album*	Lambsquarters	1982	Photosystem II inhibitors
2. *Abutilon theophrasti*	Velvetleaf	1991	Photosystem II inhibitors
3. *Amaranthus retroflexus*	Redroot pigweed	1991	Photosystem II inhibitors
4. *Avena fatua*	Wild oat	1991	ACCase inhibitors
5. *Kochia scoparia*	Kochia	1994	ALS inhibitors
6. *Xanthium strumarium*	Common cocklebur	1994	ALS inhibitors
7. *Setaria faberi*	Giant foxtail	1996	ALS inhibitors
8. *Setaria viridis var. robusta-alba Schreiber*	Robust white foxtail	1996	ALS inhibitors
9. *Setaria lutescens*	Yellow foxtail (Lutescens)	1997	ALS inhibitors
10. *Ambrosia artemisiifolia*	Common ragweed	1998	ALS inhibitors
11. *Setaria viridis var. robusta-alba Schreiber*	Robust white foxtail	1999	ACCase inhibitors
12. *Setaria viridis var. robusta-purpurea*	Purple robust foxtail	1999	ACCase inhibitors
13. *Ambrosia trifida*	Giant ragweed	2006	EPSPS inhibitors
14. *Amaranthus tuburculatus (syn. rudis)*	Common waterhemp	2007	EPSPS inhibitors
15. *Ambrosia artemisiifolia*	Common ragweed	2008	EPSPS inhibitors
16. *Ambrosia trifida*	Giant ragweed	2008	ALS inhibitors

17. *Ambrosia trifida*	Giant ragweed	2008	EPSPS inhibitors
Montana			
1. *Kochia scoparia*	Kochia	1984	Photosystems II inhibitors
2. *Salsola iberica*	Russian thistle	1987	ALS inhibitors
3. *Kochia scoparia*	Kochia	1989	ALS inhibitors
4. *Avena fatua*	Wild oat	1990	Fatty acid synthesis inhibitor
5. *Avena fatua*	Wild oat	1990	Unknown
6. *Avena fatua*	Wild oat	1990	ACCase inhibitors
7. *Kochia scoparia*	Kochia	1995	Synthetic Auxins
8. *Avena fatua*	Wild oat	1996	ALS inhibitors
9. *Avena fatua*	Wild oat	2002	ACCase inhibitors
Nebraska			
1. *Sorghum bicolor*	Shattercane	1994	ALS inhibitors
2. *Amaranthus tuberculatus*	Tall waterhemp	1996	Photosystem II inhibitors
3. *Conyza canadensis*	Horseweed	2006	EPSPS inhibitors
North Dakota			
1. *Kochia scoparia*	Kochia	1987	ALS inhibitors
2. *Setaria viridis*	Green foxtail	1989	Dintroanilines and others
3. *Avena fatua*	Wild oat	1991	ACCase inhibitors
4. *Kochia scoparia*	Kochia	1995	Synthetic Auxins
5. *Avena fatua*	Wild oat	1996	ALS inhibitors
6. *Kochia scoparia*	Kochia	1998	Photosystem II inhibitors
7. *Amaranthus retroflexus*	Redroot pigweed	1999	ALS inhibitors
8. *Sinapis arvensis*	Wild mustard	1999	ALS inhibitors
9. *Solanum ptycanthum*	Eastern black nightshade	1999	ALS inhibitors
10. *Iva xanthifolia*	Marshelder	2003	ALS inhibitors
11. *Ambrosia artemisiifolia*	Common ragweed	2007	EPSPS inhibitors
12. *Kochia scoparia*	Kochia	2010	EPSPS inhibitors [1]
Oregon			
1. *Lolium multiflorum*	Italian ryegrass	1987	ACCase inhibitors
2. *Avena fatua*	Wild oat	1990	ACCase inhibitors
3. *Avena fatua*	Wild oat	1990	Dintroanilines and others
4. *Kochia scoparia*	Kochia	1993	ALS inhibitors
5. *Lactuca serriola*	Prickly lettuce	1993	ALS inhibitors
6. *Salsola iberica*	Russian thistle	1993	ALS inhibitors

7. *Amaranthus retroflexus*	Redroot pigweed	1994	Photosystem II inhibitors
8. *Poa annua*	Annual bluegrass	1994	Thiocarbamates and others
9. *Poa annua*	Annual bluegrass	1994	Ureas and amides
10. *Poa annua*	Annual bluegrass	1994	Photosystem II inhibitors
11. *Senecio vulgaris*	Common groundsel	1995	Nitriles and others
12. *Bromus tectorum*	Downy brome	1997	ALS inhibitors
13. *Camelina microcarpa*	Smallseed falseflax	1999	ALS inhibitors
14. *Lolium multiflorum*	Italian ryegrass	2004	EPSPS inhibitors
15. *Bromus tectorum*	Downy brome	2005	ACCase inhibitors
16. *Capsella bursa-pastoris*	Shepherd's-purse	2007	Photosystem II inhibitors
Washington			
1. *Senecio vulgaris*	Common groundsel	1970	Photosystem II inhibitors
2. *Salsola iberica*	Russian thistle	1987	ALS inhibitors
3. *Centaurea solstitialis*	Yellow starthistle	1988	Synthetic Auxins
4. *Kochia scoparia*	Kochia	1989	ALS inhibitors
5. *Avena fatua*	Wild oat	1991	ACCase inhibitors
6. *Amaranthus powellis*	Powell amaranth	1992	Photosystem II inhibitors
7. *Lactuca serriola*	Prickly lettuce	1993	ALS inhibitors
8. *Sonchus asper*	Spiny sowthistle	2000	ALS inhibitors
9. *Lactuca serriola*	Prickly lettuce	2007	Synthetic Auxins
Wyoming			
1. *Kochia scoparia*	Kochia	1984	Photosystem II inhibitors
2. *Kochia scoparia*	Kochia	1996	ALS inhibitors

Sources: (Heap, 2011) (Stachler et al., 2010).
[1] Unconfirmed reports of glyphosate-resistant Kochia in North Dakota (Stachler et al., 2010).

Table 3–26 also includes an analysis of information from table 3–9 as to whether glyphosate and/or an alternative herbicide with a mechanism of action different from the reported resistance is rated as providing fair to excellent control of the resistant weed species in either a preplant incorporated, preemergent, or postemergent application.

Table 3–26 illustrates that herbicide resistant biotypes have been selected in 18 major sugar beet weeds to herbicides representing all the mechanisms of action used on sugar beets: ACCase inhibitors, ALS inhibitors, mitosis inhibitors, synthetic auxin mimics, PS II inhibitors, fatty acid synthesis inhibitors, and EPSPS inhibitors. Because most of the weeds are resistant to non glyphosate herbicides, H7-1 sugar beet provides the opportunity to add another tool, glyphosate, to control resistant weeds.

Glyphosate-Resistant Weeds That May Impact Sugar Beets. Since 1996, 21 weed species with glyphosate resistant biotypes have been found globally(Heap, 2011). Thirteen of these glyphosate-resistant biotypes have been found in the United States. Seven of the glyphosate-resistant weeds known globally are also known to be weeds in sugar beets (see section III.B.1.d for a list of weeds in sugar beets). At least 21 weeds that have natural tolerance to glyphosate exist (table 3–27). Eight of these glyphosate-tolerant weeds are also listed as weeds in sugar beets in the U.S. Table 3–27 lists the weeds known to be glyphosate-resistant or –tolerant and which are weeds in sugar beet.

The 15 weed species considered weeds of sugar beets that are either naturally tolerant to glyphosate or for which resistant biotypes have been reported (table 3-27) potentially pose the greatest likelihood to become more prevalent and difficult to control in glyphosate resistant sugarbeet cropping systems if recommended rates of glyphosate are ineffective and/or other herbicides or control practices are either not available or not used to control them. To date, no glyphosate-resistant weeds have been reported to have been first identified in sugar beet fields in the United States as of 2010 (Kniss, 2010b).

Table 3- 26. Major Sugar Beet Weeds with Resistance to Herbicide Groups (USDA–APHIS, 2010a)

Weed Common Name	Herbicide Mechanism of Action for Resistant Biotype	States Reported and Year Reported or Confirmed	Crops Infested, Estimated Number of Sites and Acres (A). (+ indicates that either the # of sites or acres is increasing)	Effective Control Option with Glyphosate and/or Alternative Herbicide
Barnyardgrass	ACCase Inhibitor & Fatty acid synthesis inhibitor	CA 2000	Rice-11–50 sites, 101–500 A+	Glyphosate/Post-E
Kochia	PSII inhibitor	CO 1982, WY, MT 1984, ND 1998	CO-Corn, 501–1,000 sites, 1,001–10,000 A+; WY-Corn, 11–50 sites, 1,001–10,000 A stable; MT-railways, 6–10 sites, 501–1,000 A+, ND-Corn,1 site, 11–50 A.	Glyphosate/Pre-E, Post-E
	ALS inhibitor	ND 1987, WA, MT, CO, ID 1989, OR 1993, MN 1994, WY 1996, MI 2005	ND-Cropland & wheat, 501–1,000 sites, 1–2 million A+; WA-Cereals & wheat, 501–1,000 sites, 1,001–10,000 A+; MT- Cropland & wheat, 1,001–10,000 sites, 0.10–1.0 million A+; CO-Roadsides & wheat, 501–1,000 sites, 10,001–100,000 A+; ID- Roadsides & wheat, 501–1,000 sites, 10,001–100,000 A+; OR-Wheat, 51–100 sites, 1,001–10,000 A+; MN-Cropland & wheat, 11–50 sites, 1,001–10,000 A +; WY-Wheat, 2–5 sites, 501–1,000 A+; MI-Sugar beet, 2–5 sites, 101–500 A+	Glyphosate/Pre-E, Post-E

Weed Common Name	Herbicide Mechanism of Action for Resistant Biotype	States Reported and Year Reported or Confirmed	Crops Infested, Estimated Number of Sites and Acres (A). (+ indicates that either the # of sites or acres is increasing)	Effective Control Option with Glyphosate and/or Alternative Herbicide
	Synthetic auxin	ND, MT 1995, ID 1997	ND-Wheat, 6–10 sites, 101–500 A+; MT-Cropland & wheat, 101–500 sites, 1,001–10,000 A+; ID-Roadsides, 1 site, 1–5 A+.	Glyphosate/Pre-E, Post-E
	EPSPS inhibitor[1]	ND, 2010		
Wild oat	ACCase inhibitor	MT 1990 & 2002; OR 1990; WA, MN, ND 1991; ID 1992; CO 1997	MT-Cropland, sugar beet and wheat. 51-–100 sites, 1,001–10,000 A+ OR-Wheat, 101–500 sites, 1,001–10,000 A+; WA- Wheat, 51–100 sites, 10,000 A+; MN- Sugar beet & wheat. 51–100 sites, 1,001–10,000 A+.; ND-Cereals & wheat. 101-500 sites, 1,001–10,000A+ ID - Cereals & wheat. 11–50 sites, 1,001–10,000A+ CO- Barley & wheat. 6–10 sites, 101–500 A+	Glyphosate/PPI, Pre-E, Post-E
	Fatty acid synthesis inhibitor	MT 1990, ID 1993	MT-Barley. 501–1,000 sites, 10,001–100,000A+; ID-Cereals. 51–100 sites, 10,001–100,000A+	Glyphosate/Post-E
	ALS inhibitor	MT & ND1996	MT-Cereals,. 2–5 sites, 11–50 A+; ND-Wheat. 2–5 sites, 501–1,000 A+.	Glyphosate/PPI, Pre-E, Post-E
Wild oat (cont'd)	Mitosis inhibitor	OR 1990	Cropland. 1 site, 11–50 A stable.	Glyphosate/PPI, Pre-E, Post-E
Lambsquarter	PSII inhibitor	MI 1975, MN 1982	MI -Corn, nurseries, soybean. 100,000 A. MN – Corn. 101–500 sites, 501–1,000 A. stable.	Glyphosate/PPI, Pre-E, Post-E
	ALS inhibitor	MI 2001	Soybean. 2–5 sites, 101–500 A+.	Glyphosate/PPI, Pre-E, Post-E
Redroot pigweed	PSII inhibitor	CO 1982, MN 1991, OR 1994, ID 2005	CO - Corn, 501–1,000 sites, 10,000 A +; MN – Corn, 1 site, 11–50 A stabilized; OR-Mint, 6–10 sites, 101–500 A+. ID-Potato, 2–5 sites, 501–1,000 A.	Glyphosate/PPI, Pre-E, Post-E

	PSII inhibitor (incl. Ureas and Amides)	MI 2001	Asparagus. 6–10 sites, 51–100 A+	Glyphosate/PPI, Pre-E, Post-E
	ALS inhibitor	ND 1999	Soybean. 1 site. 1–5 A. stable.	Glyphosate/PPI, Pre-E, Post-E
Tall water hemp	ALS inhibitor	MI 2000	Soybean. 6–10 sites, 101–500 A.	Glyphosate/PPI, Pre-E, Post-E
	EPSPS inhibitor	MN 2007	Soybean. 2–5 sites, 51–100 A +.	PPI, Pre-E, Post-E
	PSII inhibitor	NE 1996	Corn – NA	Glyphosate/PPI, Pre-E, Post-E
Powell Amaranth	PSII inhibitor	WA 1992	Mint – NA	Glyphosate/PPI, Pre-E, Post-E
	PSII inhibitor, Urea and amides	MI 2001	Asparagus & nurseries. 11–50 sites, 101–500 A +.	Glyphosate/PPI, Pre-E, Post-E
Smooth pigweed	ALS inhibitor	MI 2002	Soybean. 2–5 sites, 101–500 A.	Glyphosate/PPI, Pre-E, Post-E
Velvetleaf	PSII inhibitor	MI 2004	Corn, nurseries, soybean. 2–5 sites, 101–500 A +.	Not rated
	PSII inhibitor	MN 1991	Corn. 1 site, 11–50 A. Stabilized	Not rated but not a weed in SB rotation crops in MN.
Eastern Black nightshade	PSII inhibitor	MI 2004	Blueberry. 2–5 sites, 101–500 A.	Glyphosate/PPI, Pre-E, Post-E
	ALS inhibitor	ND 1999	Soybean. 2–5 sites, 501–1,000 A +	Glyphosate/PPI, Pre-E, Post-E
Giant Foxtail	ALS inhibitor	MN 1996; MI 2006	Corn & soybean. MN -1 site, 11–50 A. + MI -1 site, 101–500 A.	Glyphosate/PPI, Pre-E, Post-E
Robust White Foxtail	ALS inhibitor	MN 1996	Corn & soybean. 1 site, 11–50 A, +.	Glyphosate/PPI, Pre-E, Post-E
	ACCase inhibitor	MN 1999	Soybean. 6–10 sites, 11–50 A, stabilized.	Glyphosate/PPI, Pre-E, Post-E
Purple Robust Foxtail	ACCase inhibitor	MN 1999	Soybean. 1 site, 11–50 A, stabilized.	Glyphosate/PPI, Pre-E, Post-E
Yellow Foxtail	ALS inhibitor	MN 1997	Soybean. 1 site,1–5 A, increasing.	Glyphosate/PPI, Pre-E, Post-E

Green Foxtail	Mitosis inhibitor	ND 1989	Sunflower and wheat. 501–1,000 sites, 1,001–10,000 A, increasing.	Glyphosate/PPI, Pre-E, Post-E

Table 3-26. (continued)

Weed Common Name	**Herbicide Mechanism of Action for Resistant Biotype**	**States Reported and Year Reported or Confirmed**	**Crops Infested, Estimated Number of Sites and Acres (A). (+ indicates that either the # of sites or acres is increasing)**	**Effective Control Option with Glyphosate and/or Alternative Herbicide**
Giant Ragweed	EPSPS inhibitor	MN 2006	Soybeans. 2–5 sites, 101–500 A, increasing.	Post-E
Common Cocklebur	ALS Inhibitor	MN 1994	Soybeans. 2–5 sites, 11–50 A, increasing.	Glyphosate/Marginal Pre-E; Post-E
Spiny Sowthistle	ALS Inhibitor	WA 2000	Lentils and wheat. 6–10 sites and acres.	Pre-E; Post-E

[1]Glyphosate-resistant Kochia has been reported but not confirmed in ND (Stachler et al., 2010).

Table 3- 27. Glyphosate-Resistant and -Tolerant Weeds

Scientific Name	Common Name	Resistant Biotype (RB) Tolerant (NT) reported worldwide	Resistant Biotype Reported in U.S.	Sugar Beet Weed	Listed on Roundup® Label (Monsanto, 2007)	Source
Abutilon theophrasti	Velvet leaf[2]	NT	NA	Yes	Yes (mixture also recommended)	(Nandula et al., 2005); (Cerdeira and Duke, 2006)
Amaranthus palmeri	Palmer amaranth	RB	Yes	No.	Yes (with resistant biotype note)	(Heap, 2011)
Amaranthus tuberculatus (syn. rudis)	Tall waterhemp	RB	Yes	Yes	Yes (with resistant biotype note)	(Nandula et al., 2005); Heap, 2011
Ambrosia artemisiifolia	Common ragweed[2]	RB	Yes	Yes	Yes (with resistant biotype note)	(Heap, 2011)
Ambrosia trifida	Giant ragweed	RB	Yes	Yes	Yes (with resistant biotype note)	(Heap, 2011)
Chamaesyce hirta	Pillpod sandmat	NT	NA	No	No	(Cerdeira and Duke, 2006)
Chenopodium album	Common lambsquarters	NT	NA	Yes	Yes (mixture also recommended)	(Nandula et al., 2005)
Chloris truncate	Australian gingergrass	RB	NA	No	No	(Heap, 2011)
Commelina benghalensis	Tropical spiderwort[2]	NT	NA	No	No	(Nandula et al., 2005)
Commelina communis	Asiatic dayflower	NT	NA	No	No	(Nandula et al., 2005)
Convolvulus arvensis	Field bindweed[2]	NT	NA	No	No (mixture recommended)	(Nandula et al., 2005)
Conyza bonariensis	Hairy fleabane	RB	Yes	No	Yes	(Heap, 2011) (Nandula et al., 2005)
Conyza canadensis	Horseweed[3]	RB	Yes	Yes	Yes (with resistant biotype note)	(Nandula et al., 2005); (Heap, 2011) (Sprague and Everman, 2011)

Table 3–27. (continued)

Scientific Name	Common Name	Resistant Biotype (RB) or Naturally Tolerant (NT)	Resistant Biotype Reported in U.S.	Sugar Beet Weed	Listed on Roundup® Label (Monsanto, 2007)	Source
Conyza sumatrensis	Sumatran fleabane	RB	No	No	No	(Heap, 2011)
Cynodon dactylon	Bermudagrass[2]	NT	No	No	Yes (partial control notes)	(Cerdeira and Duke, 2006)
Cyperus spp.	Nutsedge[2]	NT	No	Yes	Yes	(Cerdeira and Duke, 2006)
Dicliptera chinensis	Chinese foldwig	NT	No	No	No	(Nandula et al., 2005)
Digitaria insularis	Sourgrass	RB	No	No	No	(Heap, 2011)
Digitaria sanguinalis	Large crabgrass	NT	No	Yes	Yes (mixture also recommended)	(Cerdeira and Duke, 2006)
Echinochloa colona	Junglerice	RB	No	Yes	Yes (mixture also recommended)	(Heap, 2011)
Eleusine indica	Goosegrass	RB	Yes	No	Yes	(Nandula et al., 2005); Heap, 2011
Erodium spp.	Filaree	NT	No	Yes	Yes (mixture also recommended)	(Van Deynze et al., 2004)
Euphorbia heterophylla	Wild poinsettia[2]	RB	No	No	No	(Heap, 2011)
Ipomoea purpurea	Morning glory[2]	NT	No	No	Yes (mixture also recommended)	Hilgenfeld et al., 2004; (Cerdeira and Duke, 2006)
Kochia scoparia	Kochia[2]	RB	Yes	Yes	Yes	(Heap, 2011)
Lolium multiflorum	Italian ryegrass	RB	Yes	No.	Yes (with resistant biotype note)	(Nandula et al., 2005); (Heap, 2011)
Lolium perenne	Perennial ryegrass	RB	No	No	Yes (with resistant biotype note)	(Heap, 2011)
Lolium rigidum	Rigid ryegrass	RB	Yes	No.	Yes (with resistant biotype note) glyphosate, paraquat, and ACCase multiple resistance	(Nandula et al., 2005); Yu et al., 2007; (Heap, 2011)

Table 3–27. (continued)

Scientific Name	Common Name	Resistant Biotype (RB) or Naturally Tolerant (NT)	Resistant Biotype Reported in U.S.	Sugar Beet Weed	Listed on Roundup® Label (Monsanto, 2007)	Source
Lotus corniculatus	Birdsfoot trefoil	NT	No	No	No	(Nandula et al., 2005)
Malva parviflora	Cheeseweed	NT	No	Yes	No (mixture recommended)	(Van Deynze et al., 2004)
Parietara debilis	Florida pellitory	NT	No	No	No	(Cerdeira and Duke, 2006)
Parthenium hysterophorus	Ragweed parthenium	RB	No	No	Yes (with resistant biotype note)	(Heap, 2011)
Plantago lanceolata	Buckhorn plantain[1,2]	RB	No	No	No	(Heap, 2011)
Poa annua	Annual bluegrass	RB	Yes	No	Yes	(Heap, 2011)
Portulaca oleracea	Purslane[2]	NT	No	Yes	Yes (mixture also recommended)	(Van Deynze et al., 2004)
Richardia brasiliensis	Tropical Mexican clover	NT	No	No	No	(Cerdeira and Duke, 2006)
Sesbania exalta	Hemp sesbania[2]	NT	No	No	Yes	(Cerdeira and Duke, 2006)
Sorghum halepense	Johnsongrass[2]	RB	Yes	Yes	Yes (mixture also recommended)	(Heap, 2011)
Spermacoce latifolia	Oval-leaf false buttonweed	NT	No	No	No	(Cerdeira and Duke, 2006)
Urochloa panicoides	Liverseedgrass[2]	RB	No	No	No	(Heap, 2011)
Urtica uren	Burning nettle	NT	No	Yes	No (mixture recommended)	(Van Deynze et al., 2004); Canevari et al., 2004

[1] These 3 weeds are not fully controlled by any of the 16 herbicides listed in the University of California Pest Management Guidelines (Rogan and Fitzpatrick, 2004).
[2] These weeds are on at least one State's noxious weed list (USDA-NRCS, 2010).
[3] While previously not considered a weed of sugar beet, *Conyza canadensis* in Michigan has now been identified in sugar beet fields in two counties (Sprague and Everman, 2011).
Abbreviations: NA = Not available

Glyphosate-resistant weeds that occur in sugar beet producing States that may become problematic include:

Horseweed (Conyza canadensis). A glyphosate resistant horesweed in Michigan has recently been observed in fields for soybeans and sugar beets (Sprague and Everman, 2011). Horseweed is a winter annual and doesn't survive where fall/spring tillage is used. (Kniss, 2011), personal communication). It could become a problem in areas where strip till and no till are practiced such as parts of the Northwest and Great Plains.

Common waterhemp ((*Amaranthus tuberculatus*) is a problem weed in sugar beets in Michigan, Minnesota, and North Dakota (Robert Wilson, personal communication). A glyphosate resistant biotype was observed in soybean in Minnesota in 2007. NDSU recommends adding Nortron® to improve control of waterhemp (Zollinger et al., 2011).

Common ragweed (*Ambrosia artemisiifolia).* Glyphosate-resistant biotypes were reported in Minnesota and North Dakota in 2008. According to Stachler and colleagues (Stachler et al., 2009c), common ragweed may become more challenging to control in sugar beet. Stachler and colleagues (Stachler et al., 2009c), recommend a mix of glyphosate and clopyralid to provide control.

Giant ragweed (*Ambrosia trifida*). A glyphosate resistant giant ragweed was observed in soybean in Minnesota in 2006. Glyphosate resistant giant ragweed could become a problem in sugar beet. ND weed research 2010 recommends a mixture of glyphosate and stinger for control.

Kochia (*Kochia scoparia*) is a problematic sugar beet weed in the Northwest, Great Plains, and Midwest. A glyphosate resistant kochia was confirmed in Kansas. While no sugar beets are grown in Kansas, it is possible that this biotype may disperse into nearby sugar beet production areas in the Great Plains. In 2010 there were unconfirmed reports of glyphosate-resistant kochia in Sargent and McIntosh counties of North Dakota (Hildebrant, 2011). If confirmed, the resistant biotype could disperse into nearby sugar beet counties in the Midwest. Kochia may be particularly problematic as biotypes resistant to both ALS and PSII inhibitors already exist.

Junglerice (*Echinochloa colona*) is a problematic weed in sugar beets in the Imperial Valley. In 2008, a glyphosate resistant biotype was discovered in California in corn, orchards, and roadsides (Heap, 2011). It is possible that the resistant biotype may disperse into the sugar beet production area where it would need to be controlled with grass herbicides. Currently, there are no U.S. biotypes of junglerice resistant to other herbicides though it has evolved resistance to PS II inhibitors, ACC inhibitors, ureas and amides, synthetic auxins, and ALS inhibitors in Australia and South America (Heap, 2011).

Johnsongrass (*Sorghum halepense)* can be a problem weed in sugar beet in the Imperial Valley. Glyphosate resistant biotypes have been observed in Arkansas and Louisiana. If a glyphosate resistant biotype evolved in California, it could be controlled by grass herbicides.

Because there already is a difficulty in controlling herbicide-resistant weeds with conventional herbicides, H7-1 sugar beet offers a new mechanism of action and hence a greater level of control than is currently possible especially when glyphosate is used in conjunction with other herbicides

b. Herbicide Drift to Nontarget Plants

As a result of spraying herbicides onto crops, the potential exists for spray drift, inadvertent direct overspray, or transport (via wind or water flow from rainfall) of soil particles loaded with adsorbed herbicides to contact non-target terrestrial and aquatic plants (including nontarget crops and non-agricultural plants) in the vicinity of sugar beet fields. As discussed in section III.B.1.d(3) (and presented in table 3–11), the main methods of application of the herbicides used on sugar beets is either in bands, broadcast, or microrate. Glyphosate is nearly always broadcast-applied with a ground sprayer to sugar beets (Stachler et al., 2009a; Stachler et al., 2009b). Growers producing sugar beets for the American Crystal Sugar Company, the Minn-Dak Farmers Cooperative, and the Southern Minnesota Beet Sugar Cooperative were surveyed about their weed control practices in Minnesota and eastern North Dakota and indicated that herbicides were broadcast-applied by air to only 1 percent of the sugar beet acreage in 1998, 9 percent in 2000, and 14 percent in 2002 (Stachler et al., 2009b). Herbicide application via ground-based methods to sugar beets results in less herbicide drift than aerial application.

c. Sugar Beet Weediness Potential in Non-agricultural Settings

Could problem weeds be the "unintended crop descendents from transgenic crops?" Ellstrand (2006) states, "The possibility of unintended reproduction by transgenic crops has raised questions about whether their descendents might cause problems. These problems have fallen into two broad categories: first, the direct feral descendents of the crops may prove to be new weeds or invasive plants, and second, that unintended hybrids between transgenic crops and other plants could lead to certain problems." This section discusses the weediness properties of H7-1 sugar beets, and addresses the concern of direct descendents of the crop that "may prove to be new weeds or invasive plants." Gene flow from sugar beet to wild relatives is discussed in section III.B.5.

In permitted trials, summarized below in III.C.3.d(2), no differences were observed between H7-1 lines and conventional lines with respect to the plants' ability to persist or compete as a weed (Schneider and Strittmatter, 2003); USDA–APHIS, 2005). In these evaluations, APHIS considered data on plant vigor, bolting, seedling emergence, seed germination, seed dormancy, and other characteristics (USDA–APHIS, 2005).

In a separate evaluation, the CFIA, whose responsibilities include regulating the introduction of animal food and plants (including crops) to Canada, reached the same conclusion about the weediness potential of H7-1 sugar beets compared with conventional sugar beets. In 2005, the CFIA authorized the "unconfined release into the environment and livestock feed use of the sugar beet H7-1" (CFIA, 2005). In its evaluation of H7-1 sugar beets, CFIA "determined that germination, flowering, root yield, susceptibility to plant pests and diseases typical to sugar beets and bolting percentage were within the normal range of expression of these traits currently displayed by commercial sugar beet hybrids" (CFIA, 2005). The CFIA reached the following conclusions (CFIA, 2005):

> "No competitive advantage was conferred to these plants, other than that conferred by tolerance to glyphosate herbicide. Resistance to Roundup® agricultural herbicides will not, in itself, render sugar beets weedy or invasive of natural habitats since none of the reproductive or growth characteristics were modified."

The above considerations, together with the fact that the novel traits have no intended effects on weediness or invasiveness, led the CFIA to conclude that the H7-1 sugar beet transformation event has no altered weed or invasiveness potential compared to currently commercialized sugar beets.

The USDA is not aware of any feral populations of sugar beet in the U.S. No *Beta* species are listed as weeds on any of the 12 weed lists from the USDA PLANTS database (USDA-NRCS, 2010). Below are these 12 weed lists:

- Plant Protection and Quarantine. 2006. *Federal noxious weed list* (24 May 2006). USDA Animal and Plant Health Inspection Service. Washington, DC. 2pp. (104 entries)

- Assorted authors. S*tate noxious weed lists for 46 States.* State agriculture or natural resource departments. (661 entries)

- California Invasive Plant Council. 2006. *California Invasive Plant Inventory*. Cal-IPC Publication 2006-02 (February 2007). California Invasive Plant Council. Berkeley, California. (107 entries)

- Florida Exotic Pest Plant Council. 1999. *Invasive plant list* (19 October 1999). Florida Exotic Pest Plant Council. Florida. (134 entries)

- USDOI (United States Department of the Interior), Geological Survey. 1999. *Information index for selected alien plants in Hawaii* (20 October 2003). Hawaiian Ecosystems at Risk Project, Biological Resources Division, Haleakala Field Station. Makawao, Hawaii. (197 entries)

- Haragan, P.D. 1991. *Weeds of Kentucky and adjacent States: a field guide.* The University Press of Kentucky. Lexington, Kentucky. 278pp. (141 entries)

- Uva, R.H., J.C. Neal, and J.M. DiTomaso. 1997. *Weeds of the Northeast*. Cornell University Press. Ithaca, New York. 397pp. (237 entries)

- Stubbendieck, J., G.Y. Friisoe, and M.R. Bolick. 1994. *Weeds of Nebraska and the Great Plains.* Nebraska Department of Agriculture, Bureau of Plant Industry. Lincoln, Nebraska. 589pp. (287 entries)

- Southeast Exotic Pest Plant Council. 1996. *Invasive exotic pest plants in Tennessee* (19 October 1999). Research Committee of the Tennessee Exotic Pest Plant Council. Tennessee. (140 entries)

- Southern Weed Science Society. 1998. *Weeds of the United States and Canada*. CD-ROM. Southern Weed Science Society. Champaign, Illinois. (411 entries)

- Hoffman, R., and K. Kearns (eds.). 1997. *Wisconsin manual of control recommendations for ecologically invasive plants*. Wisconsin Dept. Natural Resources. Madison, Wisconsin. 102pp. (75 entries)

- Whitson, T.D. (ed.) et al. 1996. *Weeds of the West*. Western Society of Weed Science in cooperation with Cooperative Extension Services, University of Wyoming. Laramie, Wyoming. 630pp. (344 entries)

d. Agronomic Characteristics of H7-1 Sugar Beets

Information on the agronomic evaluation of H7-1 sugar beets can be found in the *Petition for determination of nonregulated status for Roundup Ready® sugar beet H7-1* (Schneider and Strittmatter, 2003). This reference includes information on H7-1 sugar beets and its disease and pest susceptibilities evaluated through nursery and field trials, agronomic characteristics, performance, phenotype, composition, and nutrient quality. Sections III.C.3.d(1) through III.C.3.d(4) are summaries of information in (Schneider and Strittmatter, 2003).

(1) Disease and Pest Susceptibilities of H7-1 Sugar Beets

During nursery trials, H7-1 sugar beet plots were observed for their susceptibility, as compared to conventional sugar beet varieties, to *Cercospora* leaf spots, *Aphanomyces* root rot, and curly top and *Rhizoctonia* root rot. The tables presented in Schneider and Strittmatter (2003) on this information include comparative analyses of observed disease ratings. H7-1 sugar beets were also tested in field trials established for the purpose of developing sugar beet varietals according to U.S. industry standards (i.e., proprietary performance trials, official yield performance and disease nursery trials, agronomic trials, growout field trials, steckling production trials, and seed multiplication trials), and again compared to conventional varieties. Schneider and Strittmatter (2003)reports H7-1 sugar beet response to the following diseases that impact sugar beet production: fungal seedling diseases (e.g., *Pythium ultimum, P. aphanidermatum*), beet necrotic yellow vein virus (*Rhizomania*), and powdery mildew (*Erysiphe betae*), in addition to the diseases mentioned earlier. Schneider and Strittmatter (2003) also reports observations of damage to H7-1 sugar beets after exposure to the following insects and nematodes that are also economically relevant to sugar beet production: sugar beet root aphid (*Pemphigus populivenae*), sugar beet root maggot (*Tetanops myopaeformis*), sugar beet cyst nematode (*Heterodera schachtii*), and root knot nematode (various *Meloidogyne spp.*).

Information on H7-1 sugar beet damage or injury from diseases and pests relevant to Europe, as observed in European field trials conducted in France and Germany, can also be found in Schneider and Strittmatter (2003). These include diseases and pests examined in the U.S. trials (i.e., powdery mildew, *Cercospora* leaf spot, *Rhizoctonia* root rot, fungal seedling diseases, *Rhizomania*, and cyst nematode) as well as additional diseases and pests relevant for both Europe and the United States (i.e., downy mildew (*Peronospora farinose*), *Ramularia* leaf spot, *Alternaria* leaf spot, sugar beet rust (*Uromyces betae*), and *Phoma* fungal seedling diseases).

The nursery and field trials showed that H7-1 sugar beets are comparable to conventional varieties with respect to disease and pest susceptibility, and the H7-1 trait does not affect plant-disease or plant-pest interactions (Schneider and Strittmatter, 2003).

(2) Agronomic Characteristics, Performance, and Phenotype of H7-1 Sugar Beets

All new sugar beet varietals must meet industry standards before they are approved for distribution on the market. Schneider and Strittmatter (2003)reports results from coded trials performed according to these industry standards to evaluate agronomic characteristics of H7-1 sugar beets, including vigor, percent of bolting plants, plant emergence average, yield tons per acre, recoverable sugar pounds per ton of sugar beets, and recoverable sugar pounds per acre, as compared to conventional varieties.

Plant phenotype characteristics of H7-1 sugar beets were compared to conventional varieties of sugar beets as well. Information on the hypocotyl color, leaf color, leaf chlorosis, and leaf size of H7-1 sugar beets is reported in Schneider and Strittmatter (Schneider and Strittmatter, 2003). Inflorescence and flowering traits examined and reported include ramification type, thousand kernel weight in grams, percent seed germination rate, seed dormancy, time for vernalization, bolting date, onset of flowering, seed harvest date, and the classification of plant development on a scale of 1 to 6.

Based on these evaluations and observations, H7-1 shows no meaningful differences in agronomic characteristics, performance, and phenotype when compared to conventional varieties, and the H7-1 trait does not alter weediness potential of the H7-1 variety (Schneider and Strittmatter, 2003).

(3) Compositional and Quality Component Analyses of H7-1 Sugar Beets

Tissue samples from H7-1 sugar beet roots and tops were collected from European field sites to evaluate compositional equivalence of H7-1 sugar beets to conventional varieties. Analyses reported in Schneider and Strittmatter (2003) include the amounts of polarization, potassium, sodium, invert sugar, and amino-N in root tissue, as well as percentages of dry matter, crude protein, crude fiber, crude ash, crude fat, and carbohydrates; the amount of saponin; and the percent of each amino acid found in both the top and root tissues.

In all of the analyses, the ranges reported for H7-1 sugar beets significantly overlapped or fell completely within the ranges reported for conventional varieties of sugar beets, indicating that H7-1 sugar beets are compositionally equivalent to conventional varieties with respect to key nutrients and components (Schneider and Strittmatter, 2003).

(4) Disease Susceptibility from Herbicide Stress

Environmental factors that contribute to severity of herbicide injury are discussed in section III.B.1.d(3).

The issue of increased disease susceptibility due to glyphosate treatment has been raised for both conventional and glyphosate-resistant plants in a number of different crop plants (Duke and Cerdeira, 2007; Johal and Huber, 2009). Research conducted in greenhouse studies suggested the possibility that Roundup Ready® sugar beets treated with glyphosate may have more sensitivity to *Rhizoctonia solani*, and *Fusarium oxysporum*, both serious diseases of sugar beets (Larson et al., 2006). The Larson 2006 experiments obtained statistically significant results that were both cultivar- and isolate-specific. The study looked at two glyphosate-resistant cultivars and four fungal isolates. Of the eight possible combinations of cultivar and isolate, they observed the glyphosate effect three times. This means that only some of the plants studied showed a response to glyphosate resulting in increased disease and only when challenged by certain types of the pathogens. In other words, there was not a uniform response of glyphosate-resistant sugar beets to have an increase in disease as a result of glyphosate application. The dataset was too limited to determine why the inconsistency existed (Larson, 2010). In addition the experiments were conducted on event GTSB77 sugar beets, not event H7-1 sugar beets (Larson, 2010). Larson (2010) attempted to replicate the greenhouse studies under natural field conditions, but failed to show significant differences in disease severity between glyphosate-resistant and conventional sugar beets. The small increases in disease severity following glyphosate application that were initially observed in some instances in the greenhouse were likely a result of stress to the plant induced by the application of an herbicide. In the greenhouse study, a benign surfactant was applied to the control plants prior to inoculation, which did not cause the plants the same stress that an application of an herbicide would cause. In the field tests, conventional herbicides were applied to the control plants, which were compared to the plants treated with glyphosate. Conventional herbicides are equally, if not more stress-inducing, to sugar beets than glyphosate. The results of field studies strongly indicate that stress, not glyphosate, was the cause of the increased disease severity observed in the initial greenhouse study (Larson, 2010). In industry conducted field trials, only six out of 98 trial sites over four growing seasons indicated a difference in disease susceptibility with no trend associated with event H7-1. In three of the six trial sites with observed differences in disease susceptibility, event H7-1 had increased resistance to powdery mildew compared to conventional varieties, which is in contrast to the increased susceptibility observed at the other three trials sites. These observations supports the conclusion that H7-1 sugar beets are not more susceptible to diseases than conventional sugar beets (Carson, 2010).

Differences between greenhouse studies and field studies have also been observed in soybean. For example, glyphosate-resistant soybean showed increased disease severity following glyphosate application in the greenhouse (Sanogo et al., 2000), but no increase was seen in the field even with three years of testing (Sanogo et al., 2001).

As noted in section III.B.1.b(4), all sugar cooperatives evaluate the disease resistance traits of sugar beet hybrids which are significant to their regional environments before their member-growers are permitted to purchase hybrid seed. Cooperatives evaluate hybrids through "Official Variety Trials," which take place over a two or three year period, for the overall disease tolerance of each hybrid to a wide array of pathogens. In these trials, referred to as disease nurseries, hybrids are either subjected to natural infection or artificial inoculation. Pathogens tested include *Rhizoctonia* (evaluated by American Crystal, Minn-Dak, Southern Minnesota, Western Sugar, and Michigan Sugar) and *Fusarium* (evaluated by American Crystal, Sidney Sugars, and Western Sugar) among others, and there are many commercially-available H7-1 hybrid varieties that have high levels of tolerance to these and other diseases (Larson, 2010). Hybrids classified as resistant in these disease nurseries have repeatedly shown tolerance in the field under commercial production. Sugar beet growers will not purchase hybrid seed that does not have the proven disease-resistance traits they need for their particular growing area (Meier, 2010).

4. Horizontal Gene Transfer

Horizontal gene transfer (HGT) is the movement of genetic material between non-sexually compatible, unrelated organisms. HGT has been studied intensively since the 1940s, gaining renewed attention after the commercial release of transgenic plants in the mid 1990s (Dröge et al., 1998). HGT has contributed to major transitions in evolution and occurs frequently between bacterial species, particularly in marine environments (McDaniel et al., 2010). One reason that HGT is thought to occur easily between bacteria or other single celled organisms is due to the relatively easy contact between nuclear genomes when single celled organisms fuse or consume other single celled organisms. It is thought that HGT into multicellular organisms, such as higher plants, with a defined germline is much less likely. HGT would have to occur between the two different species and specifically to germline cells in order for the HGT to permanently be incorporated into the receptor species (Richardson and Palmer, 2007). While there is no evidence of HGT occurring between plant chloroplasts, HGT can occur in plant mitochondria. In all of the cases of HGT between plants, the inferred result of the transfer is the movement of mitochondrial genes to other mitochondria, not between nuclear genomes (Richardson and Palmer, 2007). All known transfers between plants have occurred on an evolutionary time scale ranging from 60 million to 480 million years ago (Richardson and Palmer, 2007). Of the transfers, a common pattern is the observation that mitochondrial HGT in plants frequently involve transfers between flowering plants and parasitic plants. Most of the transferred genes are non-functional, though a few events of HGT have resulted in new gene sequence combinations that may result in functional genes (Keeling and Palmer, 2008).

Plants growing in nature have numerous opportunities to interact directly with other organisms such as fungi, bacteria, and parasitic plants. Despite this frequent interaction, there are no reports to date of significant HGT between sexually incompatible or evolutionarily distant organisms (as reviewed in (Keese, 2008). Accumulated evidence shows universal gene-transfer barriers exist, regardless of whether transfer occurs among closely or distantly related organisms (Koonin et al., 2001; Wood et al., 2001) (Brown, 2003; Kaneko et al., 2000; Kaneko et al., 2002) Sorek et al., 2007). Many genomes (or parts thereof) have been sequenced from bacteria that are closely associated with plants, including *Agrobacterium* and *Rhizobium* (Kaneko et al., 2000; Kaneko et al., 2002; Wood et al., 2001). There is no evidence that these organisms contain genes derived from plants as would be expected if HGT occurred frequently. Regarding transgenic plants, a study of the interaction between transgenic corn (cultivated for 10 consecutive years and expressing an antibiotic resistance gene for ampicillin) and soil bacteria demonstrated that the growth of the transgenic corn did not affect the frequency of antibiotic resistance detected in the soil bacteria (Demanèche et al., 2008). These data indicate that HGT between GE corn and soil bacteria did not occur at detectable rates.

Studies examining the mechanisms of HGT between plants and bacteria have demonstrated that HGT can occur under optimized laboratory conditions at a low frequency (Pontiroli et al., 2007). Very few studies have demonstrated the presence of eukaryotic (e.g., plant or animal) genes in bacterial genomes (Keeling and Palmer, 2008), and some evolutionary analyses of the genetic changes in these presumably HGT genes indicate that the potential HGT occurred before the species divergence of the bacteria (millions of years before present) (Jenkins et al., 2002; Schlieper et al., 2005).

Where data indicate HGT might have taken place, these events are believed to have occurred on an evolutionary time scale on the order of millions of years (Koonin et al., 2001) (Brown, 2003). Combined, the above studies indicate that inter-kingdom HGT (e.g., between plants and bacteria) is an extremely rare event in nature, and most of those rare events have occurred over millions of years of evolution. In addition, there has been no evidence of HGT occurring as a result of transgenes in crop species (Pontiroli et al., 2007). Keese (2008) concluded that “in most cases the occurrence of HGT from GM crops to other organisms is expected to be lower than background rates. Therefore, HGT from GM plants poses negligible risks to human health or the environment.”

D. Socioeconomics

The socioeconomic resources described in this section are those potentially affected by the alternatives analyzed in chapter 4. The first is the production of sugar beets and its contribution to the U.S. sugar market. This involves the producers of sugar beet seed, producers of sugar beet roots, sugar processors, consumers, and traders. Sections III.D.1 and III.D.2 describe the production of sugar beets and its role in the U.S. sugar market detailing supply and demand from seed to consumer. The second resource is the organic and conventional markets for sugar beets and sugar. Although a segment of the general sugar beet and sugar markets, these markets are described separately in section III.D.3, given their relevance to the discussion in chapter 4. The third resource is the vegetable beet market, described in section III.D.4 to aid the analysis of impacts from potential cross-fertilization of sugar beets with vegetable beets. Section III.D.5 identifies minority and low-income populations in the affected environment for analysis of potential environmental justice impacts in chapter 4.

1. Sugar Beet Root Crop

a. The U.S. Sugar Market

Table 3–28 shows that demand for sugar in the United States (deliveries for domestic use) increased at an average annual rate of approximately 0.9 percent per year since 1997, similar to the growth rate in the U.S. population.[12] Exports typically absorbed an additional 1–4 percent of production. Between 40 and 50 percent of the U.S. sugar market is supplied by sugar from sugar beets in any given year, depending primarily on the share of the market supplied by imports (USDA-ERS, 2010b). Refined sugar from sugar cane or from sugar beets is typically 99.95 percent sucrose. Sucrose is identical irrespective of its sugar cane or sugar beet origin (The Sugar Association, undated).

A small fraction of domestic sugar demand is for nonhuman use such as for livestock feed (typically in the form of molasses) and polyhydric alcohol production and for the sugar-containing products re-export

[12] Average annual growth rate of the U.S. population was 0.9 percent between 2000 and 2009 (U.S. Census Bureau, 2009)).

program in which U.S. companies produce sugar containing products that they then export. The remainder of domestic sugar demand is used in foods and food products for human consumption within the United States.

Table 3- 28. The U.S. Sugar Market, Historic Data, Fiscal Years 1997–2011 (1,000 tons, raw value[1])

	FY97	FY98	FY99	FY00	FY01	FY02	FY03	FY04	FY05	FY06	FY07	FY08	FY09	FY10	FY11
Total Production[2]	7,204	8,021	8,366	9,050	8,769	7,900	8,426	8,649	7,876	7,399	8,445	8,152	7,531	7,968	8,230
Total Imports	2,774	2,163	1,823	1,636	1,590	1,535	1,730	1,750	2,100	3,443	2,080	2,620	3,082	3,320	2,744
Total Exports	211	179	230	124	141	137	142	288	259	203	422	203	136	211	150
Change in Stocks[3]	4	-191	40	-577	36	652	-142	-227	566	-366	-101	135	130	34	236
Miscellaneous[4]	30	-1	-67	-126	123	-24	161	23	94	-67	-132	0	0	-22	0
Deliveries for Domestic Use	9,742	9,815	10,066	10,111	10,132	9,974	9,711	9,862	10,188	10,340	10,135	10,704	10,607	11,133	11,060
Total Use	9,983	9,992	10,238	10,090	10,396	10,087	10,014	10,172	10,542	10,476	10,424	10,907	10,743	11,321	11,210

Source: (USDA-ERS, 2010b), Table 24a.

1 Raw value: equivalent in weight of raw sugar with an average content of sucrose of 96 degrees, as determined by polarimetric testing.

2 Production reflects processors' estimates compiled by the Farm Service Agency.

3 Includes stock held privately and by the Commodity Credit Corporation (CCC).

4 Mostly a statistical adjustment calculated as a residual and largely consisting of change in invisible stocks.

In FY 2010, almost 98 percent of domestic sugar demand was for human use (USDA FSA (Farm Services Agency), 2010). In that same FY, about 26 percent of sugar deliveries for human use or re-export went to wholesale grocers, jobbers, and dealers, while 25 percent went to bakeries and producers of cereal and related products. Beet sugar deliveries were especially concentrated among bakeries and producers of cereal and related products, which accounted for 34 percent of beet sugar deliveries for human use or re-export (table 3–29).

Table 3–30 shows U.S. exports of sugar to selected destinations. United States exported sugar to over 120 countries since 1997. However, Mexico is the main importer of U.S. sugar, importing more than half of the total value of U.S. raw and refined sugar exports since 1997, with Canada a distant second at under 10 percent.

The domestic sugar market is closely managed by USDA's sugar program and therefore not governed solely by supply and demand. USDA is required by section 156 of the Federal Agriculture Improvement and Reform Act of 1996, as amended by the Food Conservation, and Energy Act of 2008 (the 2008 Farm Act) and the Harmonized Tariff Schedule of the United States (HTS) to establish a range of acceptable market conditions – maintain a price floor in potentially oversupplied situations by removing surplus supply and maintain "adequate supply" in potentially undersupplied market situations. To maintain a price floor, USDA provides loans to processors of sugar from sugar beets and sugar cane with processed sugar provided as collateral at established rates. USDA must accept sugar at those rates, if processors choose to forfeit their loan collateral at loan maturity (Colacicco, 2010a). The current loan rates for refined sugar from sugar beets are:

- 22.9 cents per pound in FY2009,
- 23.5 cents per pound in FY2010,
- 23.8 cents per pound in FY2011, and
- 24.1 cents per pound in FY2012–13 (USDA-ERS, 2009b).

To the maximum extent possible, the price support loans program must work at no cost to the Federal government. For this reason, the Federal government manages other policy instruments to control supply in order to keep domestic sugar prices high enough to avoid having to take title of forfeited sugar. The main instruments in place with this aim are marketing allotments and import tariff-rate quotas (TRQs).

Table 3- 29. Sugar Deliveries for Human Consumption and Product Re-Exports by Type of User, Fiscal Year 2010[1]

Product or Business of Buyer	Beet Sugar (tons)[2]	Percent of Beet Sugar Deliveries (%)	Cane Sugar (tons)[2]	Percent of Cane Sugar Deliveries (%)	All Sugar (tons)[2]	Percent of All Sugar Deliveries (%)
Bakery, Cereal, and Related Products	1,420,264	33.8	974,387	18.0	2,394,650	24.9
Confectionery and Related Products	393,988	9.4	669,856	12.4	1,063,844	11.0
Ice Cream and Dairy Products	232,417	5.5	367,041	6.8	599,458	6.2
Beverages	224,588	5.3	188,529	3.5	413,117	4.3
Canned, Bottled and Frozen Foods	254,232	6.0	141,125	2.6	395,357	4.1
Multiple and All Other Food Uses	324,395	7.7	270,512	5.0	594,906	6.2
Nonfood Uses	27,483	0.7	78,805	1.5	106,288	1.1
Hotels, Restaurants, Institutions	61,337	1.5	64,500	1.2	125,837	1.3
Wholesale Grocers, Jobbers, Dealers	708,094	16.8	1,748,976	32.3	2,457,070	25.5
Retail Grocers, Chain Stores	423,233	10.1	836,375	15.4	1,259,608	13.1
Government Agencies	2,846	0.1	28,455	0.5	31,301	0.3
All Other Deliveries	133,514	3.2	54,368	1.0	187,883	2.0
Total Deliveries	**4,206,392**		**5,422,929**		**9,629,321**	

Source: Farm Service Agency. Database can be accessed at http://www.fsa.usda.gov/FSA/webapp?area=home&subject=ecpa&topic=dsa. FY 2010: Yearly Sweetener Market Report, Table 9

[1] Excludes from domestic deliveries those for nonhuman consumption and those from nonreporters.

[2] Actual weight.

Table 3- 30. U.S. Raw and Refined Sugar Exports, 1997–2009 (USD 1,000)

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Raw and Refined Sugar[1]	61,524	53,561	50,270	39,849	51,967	52,045	41,007	69,171	90,402	157,133	194,184	139,557	104,725
Share of Total U.S. Exports of Raw and Refined Sugar (%)													
Mexico	17.3	18.0	16.6	23.1	23.5	28.3	51.1	70.8	54.9	63.4	65.1	66.8	70.8
Canada	5.1	14.2	12.3	20.4	14.2	10.6	11.6	8.6	16.0	10.7	10.6	12.0	8.5
Netherlands Antilles	2.3	3.1	2.4	2.7	2.3	2.4	5.5	2.9	3.4	1.9	1.4	1.3	2.2
Netherlands	1.4	1.8	2.7	3.4	2.1	3.0	3.2	1.7	1.3	1.2	0.7	2.0	2.2
Germany	0.5	0.8	1.0	0.5	2.7	0.6	1.7	1.2	1.0	1.0	1.0	1.7	2.2
Bahamas	3.0	3.3	3.9	4.5	4.8	5.4	5.7	2.6	3.0	1.6	1.1	0.8	1.4
Japan	1.0	1.3	0.9	1.6	1.6	1.5	1.6	0.9	0.8	0.3	0.4	1.1	0.7
Haiti	6.3	5.7	4.8	0.0	3.8	0.0	0.0	0.0	0.1	0.1	0.1	0.2	0.3
Jamaica	25.7	21.1	22.6	29.3	17.6	7.4	1.4	0.2	1.5	0.4	0.1	0.1	0.1
Peru	11.7	11.6	3.5	0.0	9.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source: U.S. Census. Database can be accessed at http://www.fas.usda.gov/gats/default.aspx.
1 U.S. exports in U.S. Harmonized Tariff Schedule (HTS) codes 170111, 170112, 170191 and 170199. Includes exports and re-exports.
[1] Harmonized System code 170111, 170112, 170191 and 170199. Includes exports and re-exports.

Marketing allotments establish maximum amounts of sugar allowed to be sold domestically by refined beet sugar processors (54.35 percent of the Overall Allotment Quantity [OAQ]) and raw cane sugar processors (45.65 percent of the OAQ) (USDA-ERS, 2009b). The initial FY2011 OAQ was 9,235,250 short tons, raw value (STRV), the allotment for beet sugar is 5,019,358 STRV (75 FR 60715). The OAQ was increased to 9.4 million on June 21, 2011. Allotments are further broken down for individual processors. The 2008 Farm Act allows reallocation of allotments under various circumstances but has no provision for reallocation of allotments between the beet and cane sugar sectors (USDA-ERS, 2009b).

Import TRQs are used to limit the amount of imported sugar entering the U.S. market. A minimum of 1.256 million STRV of sugar must be allowed to enter each year, per commitments made within the World Trade Organization (WTO), but the USDA may set a higher quota (Jurenas, 2007) (USDA-ERS, 2009b). Within this quota, foreign sugar pays a low or no import tariff, depending on established trade agreements, and allocations are made by the U.S. Trade Representative to approximately 40 countries (USDA-ERS, 2009b). Above this quota, foreign sugar may be imported in any amount as long as a typically prohibitive over-quota tariff is paid, currently 16.3 cents per pound for refined sugar (USITC (United States International Trade Commission), 2010). Within the quota, smaller quotas exist for refined sugar – 24,251 STRV – and specialty sugar (including organic sugar)[13] – 86,825 STRV for FY2011 (Jurenas, 2007) (USDA-ERS, 2009b); USDA–FAS, 2010b). In addition to the TRQs established by the WTO, the United States has separate TRQs in place; for various countries under the Dominican Republic-Central American Free Trade Agreement (DR-CAFTA); and for Peru, Columbia, and Panama under separate trade agreements. Imports from these countries count toward the WTO TRQ but continue to receive low or no tariffs until their respective TRQs have been reached, even if the WTO TRQ has been exceeded (Jurenas, 2007; USDA-ERS, 2009b). Under the North American Free Trade Agreement (NAFTA), Mexico has unlimited access to the U.S. sugar market.

U.S. sugar policies also allow for imported raw sugar to replace sugar that has been exported as refined sugar or in sugar-containing products, not subject to the TRQ (Re-Export Programs and Feedstock Flexibility Program, a program to allow excess sugar production to be reallocated to ethanol production) (USDA-ERS, 2009b).

Total U.S. production of sugar has fluctuated between 7.2 million STRV and 9.1 million STRV since FY1997 due to various conditions, mostly

[13] Specialty sugar includes organic sugar, brown slab sugar, pearl sugar, vanilla sugar, rock candy, fondant, caster sugar, golden syrup, golden granulated sugar, cake decorations, and sugar cubes (USDA–FAS, 2008).

weather-related (table 3–28). Imports have added another 1.5–3.4 million STRV to domestic sugar supplies during that same period , responding to whatever quantity was necessary to fill demand requirements (table 3–28). Most imported sugar consists of raw sugar from sugar cane and originates in a diverse set of countries, with the largest volume coming from Mexico. About 80 percent of the refined sugar imported in 2009 originated in Mexico (USDA-FAS, 2010b). The main suppliers of the total raw and refined sugar imported in 2009 were (in United States Dollar (USD) value) Mexico (42.5 percent), Brazil (7.2 percent), Dominican Republic (6.3 percent), and the Philippines (6.2 percent) (table 3–31). Seven sugar beet processors and eight sugar cane processors received sugar allotments in FY2010 and FY2011 (75 FR 60715).

b. Demand for Sugar Beet Roots

Because the primary use of sugar beets is for production of sugar from its root, the demand for sugar beets is derived from the demand for sugar. In any FY, the demand for sugar from sugar beets will typically correspond to 54.35 percent of the OAQ established for domestic sales by the U.S. sugar policy. As shown in the previous section, exports are typically not an important component of U.S. sugar demand. Exports are even less important for U.S. sugar beets: in 2009, beet sugar exports totaled approximately USD 19 thousand (USDA-FAS, 2010b).

Sugar beet production, more than most field crops, requires close coordination between the grower and the processor. The crop is of little value without a processor to extract the sugar, and a sugar processing facility cannot stay in business without a reliable supply of sugar beets (Kaffka and Hills, 1994). Because sugar beets are 75 percent water (Michigan Sugar Company, 2010b) and highly perishable (USDA-ERS, 2009b), sugar beets are typically grown within 60 miles of a processing facility. However, sugar beets can be grown up to 100 miles away (Western Sugar Cooperative, 2006). Therefore, for any given producer, the demand for sugar beets typically originates from one nearby processor.

As of 2010, there are 22 processing plants for sugar beets, belonging to

7 processors,[14] and located in 5 regions: the Great Lakes, Red River Valley (Midwest), Great Plains, Northwest, and Imperial Valley (California). As of 2000, about 93 percent of sugar beet farms in the Red River Valley (located in Minnesota and North Dakota) and the Northwest were part of grower-owned cooperatives.

[14] Two additional processors are sometimes counted separately: Sidney Sugars Inc., operated by American Crystal Sugar Company; and Spreckels Sugar Company, a subsidiary of Southern Minnesota Beet Sugar Cooperative.

Table 3- 31. U.S. Raw and Refined Sugar Imports, 1997–2009 (USD 1,000)

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Raw Sugar[1]	956,417	715,264	556,663	461,485	480,420	494,605	534,052	516,316	705,675	862,187	675,720	614,677	776,202
Refined Sugar[2]	38,042	40,645	51,873	41,116	33,599	63,496	40,201	51,801	158,492	487,164	150,270	483,217	416,468
Total	**994,459**	**755,909**	**608,536**	**502,601**	**514,019**	**558,101**	**574,253**	**568,117**	**864,167**	**1,349,351**	**825,990**	**1,097,894**	**1,192,670**
Mexico	1.5%	3.1%	5.8%	4.8%	10.1%	14.2%	2.2%	3.6%	14.8%	28.4%	12.4%	37.2%	42.5%
Brazil	11.9%	12.7%	11.9%	11.6%	14.7%	9.1%	11.3%	10.8%	15.7%	9.4%	13.2%	8.7%	7.2%
Dominican Republic	19.0%	15.0%	10.8%	15.5%	12.7%	12.5%	13.5%	13.0%	9.0%	8.3%	12.3%	6.1%	6.3%
Philippines	10.2%	10.9%	10.7%	7.0%	7.2%	5.6%	10.5%	9.6%	6.6%	6.8%	8.6%	5.8%	6.2%

Source: U.S. Census. Database can be accessed at http://www.fas.usda.gov/gats/default.aspx
[1] U.S. Imports in Harmonized System codes 170111 and 170112.
[2] U.S. Imports in Harmonized System codes 170191 and 170199.

Sugar beet farms in the Great Lakes and Great Plains regions typically were not organized in cooperatives as of 2000 (Ali, 2004). However, those regions have since transitioned to the use of cooperatives, and all sugar beet processors in the United States are now structured as cooperatives, with the exception of Wyoming Sugar Beet Company, LLC, who is, nonetheless, owned mostly by sugar beet producers as well and Spreckles Sugar in the Imperial Valley. The cooperatives own the processing facilities, and the sugar beet farmers are members of the cooperatives. The members own shares of stock that require them to grow a specified acreage of sugar beets in proportion to their stock ownership in the cooperative and guarantee processing for their sugar beets. Cooperatives are owned by growers who are principally family farmers.

The Michigan Sugar Company has over 1,000 members and has become the third-largest sugar beet processor in the United States, processing all the sugar beets in the Great Lakes region, as well as sugar beets from Ontario, Canada. The cooperative has over 1,000 grower-shareholders who grow sugar beets on 150,000 acres each year. The sugar beets are processed into sugar at four factories in Bay City, Sebewaing, Caro, and Croswell. The cooperative employs 450 year-round and 1,200 seasonal employees, generates nearly USD 400 million in direct economic activity annually in the local communities in which it operates, and annually produces nearly one billion pounds of sugar(Michigan Sugar Company, 2010a).

Three cooperatives operate in the Upper Midwest: American Crystal Sugar, Minn-Dak Farmer’s Cooperative, and Southern Minnesota Beet Sugar Cooperative. American Crystal Sugar Company, the largest beet sugar producer in the United States, is owned by approximately 3,000 shareholders who raise 500,000 acres of sugar beets in the Red River Valley of Minnesota and North Dakota. The company operates five sugar processing facilities in the Red River Valley: three in Minnesota (Crookston, East Grand Forks, and Moorhead) and two in North Dakota (Drayton and Hillsboro). American Crystal also operates a sugar beet processing facility in eastern Montana at Sidney, under the name Sidney Sugars Incorporated. American Crystal’s FY2009 Red River Valley crop averaged 25.4 tons per acre with 17.6 percent sugar content. In 2009, the company produced approximately 3 billion tons of sugar and 681,000 tons of agriproducts (molasses and pulp) (American Crystal Sugar Company, 2009). Minn-Dak Farmers Cooperative, with 450 shareholders, operates a processing facility in Wahpeton, in the far southeastern corner of North Dakota. Minn-Dak also operates a yeast factory that uses the molasses from sugar beet processing (Minn-Dak Farmers Cooperative, undated). The Southern Minnesota Beet Sugar Cooperative has approximately 600 shareholders who farm 120,000 acres and operates a processing facility near Renville, Minnesota (Cooperative, 2011)

The Western Sugar Cooperative, with 135,000 acres and 5 factories, processes most of the Great Plains sugar beets. Processing facilities are in Fort Morgan, Colorado; Billings, Montana; Scottsbluff, Nebraska; and Lovell and Torrington, Wyoming. Wyoming Sugar Beet Company, LLC is not a cooperative but is owned mostly by local producers and landlords and works through the Washakie Farmers Cooperative to acquire sugar beets for its plant in Worland, Wyoming (Boland, 2003).

The Amalgamated Sugar Company LLC processes all of the sugar beets produced in Idaho, Oregon, and Washington. Amalgamated is owned by Snake River Sugar Company, a grower-owned cooperative, and is headquartered in Boise, Idaho with processing plants in Paul, Twin Falls, and Nampa, Idaho (Snake River Sugar Company, 2009).

Spreckels Sugar Company, a subsidiary of Southern Minnesota Beet Sugar Cooperative, operates a sugar beet processing facility in Brawley, California, in the Imperial Valley. Yields in the Imperial Valley are higher than anywhere else in the United States, averaging approximately 40 tons per acre (Spreckels Sugar, 2009).

Although existing facilities have been upgraded, no new currently operating processing facilities have been built in the United States since 1975. An estimated cost for an average-sized new facility in 1991 was USD 100 million (Cattanach et al., 1991). Accounting for inflation, a USD 100 million plant in 1991 would cost approximately USD 160 million in 2010.[15] There is actually a recent history of closures. Since 1996, 13 sugar beet processing plants have shut down. There have also been sugar cane mill and refinery closures (table 3–32). The closures were part of a consolidation process in the industry, with gains in efficiency: production of sugar did not decline thanks to increased production by the remaining facilities. Sugar production from sugar beets also yields pulp and molasses as co-products. Sugar beet pulp is dried sugar beet fiber residue left over from sugar extraction. Sugar beet pulp is used in plain dried, molasses dried (containing 25 percent molasses), and pelleted forms (SMBSC, undated). Drying sugar beet pulp can require significant fossil fuel inputs. To reduce fuel consumption, the pulp can be pressed and ensiled (stored in a silo) rather than dried (Sporndly, 2008).

[15] Cost adjusted to 2010 dollars using the Bureau of Labor Statistics Consumer Price Index.

Table 3- 32. Sugar Mill and Refinery Closures Since 1996

Beet Mill Closures	Cane Mill Closures		Cane Refinery Closures
Spreckels Sugar Manteca, California—1996	Ka'u Agribusiness Hawaii, 1996	Caldwell Sugar Cooperative Louisiana, 2001	Aiea, C & H Hawaii, 1996
Holly Sugar Hamilton City, California—1996	Waialua Sugar Hawaii, 1996	Glenwood Sugar Cooperative Louisiana, 2003	Everglades, Imperial Florida, 1999
Western Sugar Mitchell, Nebraska—1996	McBryde Sugar Hawaii, 1996	New Iberia Sugar Cooperative Louisiana, 2005	Sugarland, Imperial Texas, 2003
Great Lakes Sugar Fremont, Ohio—1996	Breaux Bridge Sugar Louisiana, 1998	Jeanerette Sugar Company Louisiana, 2005	Brooklyn, Domino New York, 2004
Holly Sugar, Hereford, Texas—1998	Pioneer Mill Company Hawaii, 1999	U.S. Sugar, Bryant Florida, 2005	
Holly Sugar Tracy, California—2000	Talisman Sugar Company Florida, 1999	Cinclare Central Facility Louisiana, 2005	
Holly Sugar Woodland, California—2000	Amfac Sugar, Kekaha Hawaii, 2000	Atlantic Sugar, Belle Glade Florida, 2005	
Western Sugar Bayard, Nebraska—2002	Amfac Sugar, Lihue Hawaii, 2000	South Louisiana Sugar Cooperative Louisiana, 2007	
Pacific Northwest Moses Lake, Washington—2003	Hawaiian Commercial & Sugar, Paia Hawaii, 2000	Gay & Robinson, Kaumakani, Hawaii, 2009	
Western Sugar Greeley, Colorado—2003	Evan Hall Sugar Cooperative Louisiana, 2001		
Amalgamated Sugar Nyssa, Oregon—2005			
Michigan Sugar Carrollton, Michigan—2005			
Spreckels Sugar Mendota, California—2008			

Source: ASA, 2011.

Sugar beet pulp is used as a feed primarily for dairy cows but also for cattle and sheep intended for meat production (Southern Minnesota Sugar Cooperative, undated). Sugar beet pulp has comparable feeding value to and acts as substitute for corn silage (Park et al., 2001). A dairy cow's diet can include up to 25 kg of sugar beet pulp per day, while beef cattle can consume 35 kg per head per day. Sheep and pigs consume about 3 kg per head per day (KW Alternative Feeds, 2008). Data on domestic consumption of sugar beet pulp are not available.

The United States is an exporter of sugar beet pulp and exported approximately 500,000 tons of sugar beet pulp each year from 2006 to 2009. The level of sugar beet pulp exports was higher in the first half of the decade, peaking at about 700,000 tons in 2001. More than half of U.S. sugar beet pulp exports go to Japan, and considerable amounts also are exported to Morocco and Spain (USDA-ERS, 2010b).

Sugar beet molasses contains about 50 percent sugar and is used for yeast, chemical, and pharmaceutical production. Sugar beet molasses is also used in mixed cattle feeds. (Southern Minnesota Sugar Cooperative, undated). Sugar beets currently are not used for ethanol production in the United States, but they could be used for that purpose in the future, especially if the introduction of GE plants increases sugar beet yields (McKee and Boland, 2007). Sugar beet molasses could also be used to produce high fructose corn syrup (Atiyeh and Duvnjak, 2002). Data on consumption of sugar beet molasses are not available.

c. Production of Sugar Beet Roots

Annual production of sugar beets has oscillated around 30 million tons since 1997, with no clear tendency of growth or decrease. The number of harvested acres has been below the recent average of 1.3 million acres since 2007. However, since 2006, production has benefited from higher yields,[16] averaging over 26 tons per acre between 2006 and 2010, compared to 22 tons per acre for the preceding 5-year period (table 3–33).

Over half of the U.S. production of sugar beets occurs in the Midwest, with almost 40 percent in Minnesota alone. The remainder is mostly distributed among the Northwest, the Great Plains, and the Great Lakes with a small share of production in California (3.1 percent), although California obtains the highest average yield (table 3–34). Imports of sugar beets are typically negligible, not counting sugar beets produced in Canada and processed in Michigan, and there were no imports in 2009 (USDA-FAS, 2010a).

[16] According to Haley and Dohlman (2009) the rise in yields was due mainly to the use of *Rhizomania*-resistant seed varieties and the use of Poncho Beta to control for Curly Top.

Table 3- 33. Sugar Beet Crop Production, 1997–2009

Year	Acreage (1,000)		Yield per Harvested Acre (tons)	Production (1,000 tons)	Price per Ton (USD)	Value of Production (USD 1,000)
	Plante d	Harveste d				
1997	1,459	1,428	20.9	29,886	38.80	1,160,029
1998	1,498	1,451	22.4	32,499	36.40	1,181,494
1999	1,561	1,527	21.9	33,420	37.20	1,242,895
2000	1,564	1,373	23.7	32,541	34.20	1,113,030
2001	1,365	1,241	20.7	25,708	39.80	1,023,054
2002	1,427	1,361	20.4	27,707	39.60	1,097,329
2003	1,365	1,348	22.8	30,710	41.40	1,270,026
2004	1,346	1,307	23.0	30,021	36.90	1,109,272
2005	1,300	1,243	22.1	27,433	43.50	1,193,151
2006	1,366	1,304	26.1	34,064	44.20	1,506,985
2007	1,269	1,247	25.5	31,834	42.00	1,337,173
2008	1,091	1,005	26.8	26,881	48.10	1,292,976
2009	1,186	1,149	25.9	29,783	50.40	1,499,676
2010	1,171	1,156	27.6	31,901	61.70	1,968,292

Source: (USDA-NASS, 2011a); ERS/USDA data, Table 17 http://ers.usda.gov/Briefing/Sugar/data.htm (yearbook)

After a demonstration planting in Idaho in 2006, commercial production of H7-1 sugar beet varieties started in 2007 (ASSBT (American Society of Sugar Beets Technologists), 2007) and grew quickly in subsequent years. Colacicco (2010b) reports that 95 percent of the 2009 crop was of H7-1 sugar beet varieties and estimates a similar share in 2010 (most of the production outside California).

Table 3- 34 Sugar Beet Production by Region

Region	State	Harvested Acreage (1,000 acres)	Yield (tons/acre)	Production (1,000 tons)	Share of Total (%)	
					Harvested Acres	Production
Imperial Valley	California	25.0	40.0	1,000	2.2	3.1
Northwest	Idaho	170.0	30.3	5,151	14.7	16.1
	Oregon	10.3	35.1	362	0.9	1.1
Midwest	Minnesota	442.0	27.0	11,934	38.3	37.4
	North Dakota[1]	211.0	26.5	5,592	18.3	17.5
Great Lakes	Michigan	147.0	26.5	3,896	12.7	12.2
Great Plains	Montana	42.6	29.5	1,257	3.7	3.9
	Nebraska	47.5	22.6	1,074	4.1	3.4
	Colorado	27.8	29.5	820	2.4	2.6
	Wyoming	30.3	28.0	848	2.6	2.7
United States		1,153.5	27.7	31,934	100.0	100.0

Source(USDA-NASS, 2010c), forecasted.
[1] Western counties of North Dakota belong to the Great Plains region but are included in the Midwest region here for lack of county level data.

As in the case of sugar beet processing plants, sugar beet farms have also decreased in number in the last two decades. Table 3–35 shows how the number of farms growing sugar beets decreased between 1992 and 2007 from 8,810 to 4,022. Production was maintained by increases in the average acreage planted in the remaining farms and to some increase in yields (table 3–34).

Table 3-35 Number of Farms Growing Sugar Beets, 1992–2007

	1992	1997	2002	2007
Great Lakes	1,745	1,198	1,010	737
Midwest	2,350	2,437	2,063	1,800
Great Plains	2,076	1,678	960	747
Northwest	1,554	1,099	766	583
Imperial Valley	723	456	228	155
Other[1]	362	0	0	0
Total	**8,810**	**6,868**	**5,027**	**4,022**

Source: (USDA-NASS, 1999, 2004, 2009c)
[1] Texas, except for 5 farms whose location the 1992 census does not identify.

d. Production Costs and Returns for Sugar Beet Roots

The average total economic costs (which include operating costs, ownership costs, opportunity costs, and overhead) of sugar beet production in 2000, as reported to the 2000 Agricultural Resources Management Survey (ARMS), was USD 835.58 per planted acre. These costs varied considerably by region; as shown in table 3–36 the highest total economic cost was in the Northwest (Washington and Oregon) where sugar beet production cost was USD 1,166.44 per acre, while the lowest total economic cost was in the Red River Valley (Midwest: Minnesota and Eastern North Dakota) where production cost was USD 670.14. Operating costs, which include all inputs that are consumed in one production period (e.g., seed, fertilizer, chemicals, hired labor), accounted for 45–51 percent of the total economic costs in all four production regions as shown in table 3–36. Chemicals, including herbicides and insecticides, accounted for a significant share of costs in all regions, ranging from 15 to 32 percent of operating costs by region, as shown in table 3–37.

Table 3- 35. Sugar Beet Production Operating Costs By Region, 2000 (USD/acre)

	Great Lakes	Midwest[2]	Great Plains	Northwest	All ARMS[3]
Seed	38.93	44.89	48.13	41.44	44.21
Fertilizer	66.5	28.74	53.73	71.87	46.86
Chemicals	74.17	109.03	77.68	88.64	94.28
Custom Operations	28.52	23.49	35.86	50.46	36.04
Fuel, Lube and Electricity	50.19	24.86	54.26	109.89	50.9
Hired Labor	29.1	51.76	52.4	95.36	58.7
Other Operating Costs[1]	81.24	57.54	84.52	126.04	80.47
Total Operating Costs	**368.65**	**340.31**	**406.58**	**583.7**	**411.46**
Total Economic Cost	**799.16**	**670.14**	**889.38**	**1166.44**	**835.58**

Source: (Ali, 2004).
[1] Other operating costs include: repairs, purchased irrigation water, freight, and dirt hauling, hauling allowance, interest on operating capital, and other miscellaneous costs.
[2] Appears in source as "Red River."
[3] Data exclude Imperial Valley region (California) due to insufficient data for disclosure.

Table 3- 36. Sugar Beet Production Costs as a Share of Total Operating Costs, 2000

	Great Lakes (%)	Midwest[2] (%)	Great Plains (%)	Northwest (%)	All ARMS[3] (%)
Seed	10.6	13.2	11.8	7.1	10.7
Fertilizer	18.0	8.4	13.2	12.3	11.4
Chemicals	20.1	32.0	19.1	15.2	22.9
Custom Operations	7.7	6.9	8.8	8.6	8.8
Fuel, Lube and Electricity	13.6	7.3	13.3	18.8	12.4
Hired Labor	7.9	15.2	12.9	16.3	14.3
Other Operating Costs[1]	**22.0**	**16.9**	**20.8**	**21.6**	**19.6**
Total Operating Costs	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Source: (Ali, 2004).
[1] Other operating costs include: repairs, purchased irrigation water, freight, and dirt hauling, hauling allowance, interest on operating capital, and other miscellaneous costs.
[2] Appears in sources as "Red River."
[3] Data excludes Imperial Valley region (California) due to insufficient data for disclosure.

Chemical costs varied substantially by region and were actually highest in the Red River Valley (Midwest), where total costs were the lowest. Hired labor, fertilizer, and fuel, lubricant and electricity costs also varied significantly and were highest in the Northwest. Seed costs were relatively consistent across regions (Ali, 2004).

Other studies have found differing production costs for sugar beets. A study conducted by the University of California Cooperative Extension (at UC Davis) found the total economic costs of sugar beet production in Imperial County, California in 2004 to be USD 1,428.79 USD per acre. For comparison with the ARMS data, this total economic cost is equivalent to USD 1,302 in 2000.[17]

The UC Davis study assumes that all mechanical operations are hired out (i.e., as custom operations) (Meister, 2004b), while the ARMS study shows less reliance on custom operations and accounts for capital costs of machine ownership (Ali, 2004). Because of this difference, operating costs as a share of total economic costs were 78 percent according to the UC Davis study but only 49 percent according to the ARMS study. Discounting custom operations, the relative share of operating costs

[17] Price adjusted to 2000 dollars using the Bureau of Labor Statistics Consumer Price Index.

accounted for by seed, fertilizer, and labor are approximately consistent between the studies. The UC Davis study shows a chemical cost of USD 185 per acre (equivalent to USD 169 in 2000), 36 percent of operating costs discounting custom operations, and significantly higher than the chemical costs reported in the ARMS study. Herbicide alone cost USD 75 per acre (equivalent to USD 68 in 2000) in the UC Davis study (Meister, 2004b).

Another study conducted by WSU found the total economic cost of sugar beet production in the Columbia Basin, Washington, in 1996 to be between USD 925.19 and USD 1,015.05 per acre (equivalent to between USD 1,015 and USD 1,114 in 2000). This total economic cost depends on the method of irrigation (Hinman and Kulp, 1996). These totals are slightly lower than those found in the ARMS survey for the Northwest. The WSU report includes expenditures of USD 143.75 per acre (equivalent to USD 158 in 2000) for custom operations (Hinman and Kulp, 1996), higher than the amount reported in the ARMS study but lower than that reported in the UC Davis study. Unlike the UC Davis study, the WSU report does include capital costs for machinery and does not assume that all mechanized operations were hired out. The seed, fertilizer, and labor costs reported in the WSU study are approximately consistent with the costs reported in the other studies. The reported chemical costs of USD 138.20 per acre (equivalent to USD 152 in 2000) (Hinman and Kulp, 1996) are comparable to those reported in the UC Davis study and are substantially higher than those reported in ARMS study.

The above studies all deal with the production of conventional sugar beets. The production costs for sugar beets from H7-1 sugar beet seed might differ from the costs estimated in those studies. An annual survey of sugar beet weed control and production practices has been conducted for over 40 years in North Dakota and Minnesota (for a detailed review, see section III.B.1.d). This survey indicates that the adoption of H7-1 sugar beets has been accompanied by a reduction in hand weeding and row crop cultivation, reducing labor costs and sugar beet injury (Stachler et al., 2011; Stachler et al., 2009b). Similar results were found for Montana and western North Dakota in the Great Plains region (Stachler et al., 2009a). As discussed in section III.B.1.d, there is also some evidence that the use of H7-1 sugar beet seeds has encouraged the use of strip tillage, as opposed to conventional tillage. Use of strip tillage might reduce fuel inputs to tillage operations, fertilizer applications, labor costs (Overstreet et al., 2007) and water costs (Norberg, 2010; Washington State University, 2010).

Herbicide costs have decreased with the adoption of H7-1 sugar beets and the switch to glyphosate from other herbicides. Table 3–38 shows the price of glyphosate relative to that of the commonly used herbicides in conventional sugar beet production in Minnesota in 2008, as well as average use rates and resulting dollars per application per acre. The average cost per application per acre of glyphosate is comparable to that of each of the other herbicides shown in the table. However, H7-1 sugar beet farmers often use only glyphosate per application, while conventional sugar beet farmers often apply several herbicides in combination during a single application (Stachler et al., 2008). As shown in table 3–39, costs of herbicides on H7-1 sugar beets range from about \$7–\$22/acre whereas cost of herbicides on conventional sugar beets range from \$45–\$55/ acre. The table illustrates that the use of glyphosate on H7-1 sugar beets can reduce herbicide costs under common herbicide practices in some regions.

Table 3- 37. Costs per Application per Acre of Herbicides Commonly Used in Conventional and H7 1 Sugar Beet Production

	Glyphosate	Progress	Betamix®	Betanex®	Stinger®	Upbeet®	Select®
Average Herbicide Price (USD/lb)[1]	4.85–9.95	54.30	66.60	66.60	152.20	1509.65	123.40
Average lb/applic./acre, When Used – Conventional[2]	0.39	0.06[3]	0.05	0.07	0.03	0.008	0.04
Average Herbicide Cost USD/applic./acre), When Used – Conventional	1.89–3.88	3.26	3.33	4.66	4.57	12.08	4.94
Average lb/applic./acre, When Used – H7-1[2]	0.75–1.12[3]	0.06[4]	0.05	0.07	0.03	0.008	0.04

Table 3- 38. Costs per Acre of Herbicide Mixtures Commonly Used in Conventional and H7 1 Sugar Beet Production

	Common Herbicide Mixtures Used On Conventional Sugar Beets, 2008[1]			Common Herbicides Used On H7-1 Sugar Beets, 2008[1]		
	Progress + Stinger® + Upbeet® + Select®	Betamix® + Stinger® + Upbeet® + Select®	Betanex® + Stinger® + Upbeet® + Select®	Glyphosate 0.75 lb/applic./acre	Glyphosate 1.0 lb/applic./acre	Glyphosate 1.12 lb/applic./acre
Average Number of Applications[1]	1.90	2.20	1.70	2.00	2.20	1.60
Average Herbicide Cost (USD/application/acre)[2]	24.84	24.91	26.24	3.64–7.46	4.85–9.95	5.43–11.14
Average Herbicide Cost (USD/acre)	47.19	54.80	44.61	7.28–14.93	10.67–21.89	8.69–17.83

[1] (Stachler et al., 2008).
[2] Sum of the cost per application per acre (see table 3–43) for each included herbicide. Costs for conventional sugar beet herbicides exclude the cost of oil adjuvants.

Average Herbicide Cost (USD/applic./acre), When Used – H7-1	3.64–11.14	3.26	3.33	4.66	4.57	12.08	4.94

[1] University of Minnesota, 2009. Price of glyphosate varies by brand.
[2] (USDA-NASS, 2008) (except for glyphosate applied to H7-1).
[3] (Stachler et al., 2008).
[4] The application rate for Progress was assumed to be similar to those of Betamix® and Betanex.®

A recent study comparing costs and returns for H7-1 sugar beet production and conventional sugar beet production in Wyoming produced comparable results, concluding that the average cost of herbicide in H7-1 production was lower than in conventional production: USD 20 per acre in H7-1 sugar beet production (ranging from USD 16 per acre to USD 28 per acre) compared to USD 62 per acre in conventional sugar beet production (ranging from (USD 23 per acre to USD 159 per acre) (Kniss, 2010b). However, actual costs may vary considerably from region to region and from farmer to farmer. Because in the ARMS study, the Great Plains region had the highest absolute and relative chemical costs, it is possible that other regions have not seen the same benefits in herbicide cost reduction.

Although production cost savings might be associated with H7-1 sugar beet varieties, farmers adopting H7-1 sugar beet seed must pay the technology fee charged for the H7-1 sugar beet seed. This technology fee is currently USD 106 per 100,000 seeds. At approximately 123,500 seeds per ha, this amounts to USD 131 per ha (Kniss, 2010b).

In addition to potential production cost effects, the H7-1 trait could also affect the yields and sugar content of sugar beets and impact net returns to farmers. Kniss (2010b)compared 22 sugar beet fields (11 H7-1 and 11 conventional) in Wyoming in 2007. These were commercial fields and were paired so that the fields would resemble each other as much as possible, with the only difference being the choice of conventional or H7-1 seed. The study reports that yields of H7-1 sugar beets were 15 percent higher than those of conventional varieties, while the sugar content was similar. When cost savings related to labor and herbicides were added, the net economic benefit to farmers of H7-1 sugar beet adoption was USD 576 per ha (USD 233 per acre) after considering the technology fee. Sexton (2010a) conducted a survey in early 2010 with 123 sugar beet growers from nine States, gathered at the American Sugarbeet Growers Association meeting. Growers were asked to report expected gross profits per acre for their sugar beet production when adopting conventional or H7-1 sugar beet seed. Average expected gross profits for growing H7-1 sugar beets were USD 276 per acre more than the average expected gross profits for conventional sugar beet seed. In a follow-up survey with processors, Sexton (2010b)estimated that the total reduction in grower profits from planting conventional as opposed to H7-1 sugar beets amounted to approximately USD 144 million. If this number is divided by the total sugar beet acreage in 2010 (almost 1.2 million acres), the decreased gross profit would be about USD 120 per acre. The differences in estimates might reflect, at least in part, regional differences. Because the USD 120 per acre is the result of a processor survey, weighted by the acreage planted in each region, and because it is lower than the previous estimates, grower profit per acre is likely lower in the largest production region (Midwest) than in other parts of the country.[18] Given the over 95 percent rate of adoption of H7-1 sugar beets by root growers, however, returns should be positive in all major regions of production.

2. Sugar Beet Seed Crop

a. Demand for Sugar Beet Seeds

Demand for sugar beet seed is derived from the demand for sugar beets, which in turn is derived from the demand for sugar from sugar beets, which is an allotted share of the U.S. sugar market under U.S. sugar policies. Farmers may plant anywhere from 1 to 10 pounds of seed per acre depending on row width, distance between seeds and type of seed (http://www.beetseed.com/agronomy/growing1.php). An estimate for the domestic demand for sugar beet seed in weight could, therefore, be anywhere between 1 and 12 million pounds a year (see table 3–34 for sugar beet acreage data). In 2010, U.S. farmers planted approximately 1.15 million acres of sugar beets (USDA-NASS, 2010c) suggesting that sugar beet farmers consumed between 1.15 million and 11.5 million pounds of sugar beet seed in 2010 (575 tons to 5,750 tons). Demand for sugar beet seed from exports is also important and was above 700 tons (1.4 million pounds) a year during 2005–2009, having increased from the previous 5-year period mostly due to increased exports to Canada and Mexico (table 3–40).

The production of sugar from sugar beets and the resulting demand for sugar beet seed, however, occurs in a multi-year cycle requiring several years of planning and involving sugar beet processors, sugar beet producers, and seed suppliers. Figure 3–20 below illustrates this multi-year cycle starting in 2006, the first year of widespread planting of the H7-1 sugar beets for seed. Sugar beet seed suppliers plant the commercial sugar beet seed crop in the fall of Year 1, which produces the commercial seeds harvested in the fall of Year 2. The commercial seed is processed over the winter and sold to sugar beet growers who plant it in the spring. Sugar beet growers harvest the sugar beet root in the fall of Year 3 and deliver them to sugar beet processing facilities owned by the sugar beet processors. Beet sugar is extracted by sugar beet processors beginning in the fall of Year 3 and throughout Year 4. The sugar produced from these sugar beets is purchased by food manufacturers and consumers (Colacicco, 2010b). Therefore, there is almost a 2-year lag between the planting of seed for commercial hybrid seed production by seed suppliers to the purchase and planting of seed by sugar beet producers. There is at

[18] Results for specific regions are not reported for business confidentiality reasons.

least another 0.5 to 1 year before sugar produced from these sugar beets reaches the market.

Sugar beet processors have seed committees that develop the policies and procedures for the conduct of the official trials as well as the rules for determining which varieties achieve approval. The seed varieties that sugar beet growers may choose are limited to varieties on the company's approved variety list. While the number of approved varieties varies from year to year, the average sugar beet grower has the ability to choose from among 10–20 different approved varieties.

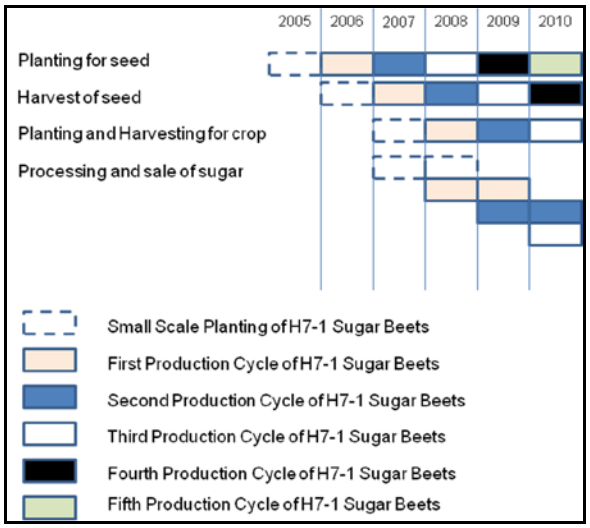

Figure 3- 20. Production cycle of sugar from H7 1 sugar beets. (Source: (Colacicco, 2010b).)

Sugar beet farms require a diversity of hybrid varieties depending on their specific climates, pests, and disease risks. The varieties can be tailored to the specific customer (http://www.beetseed.com/agronomy/growing1.php). The approved varieties have undergone extensive multi-year planting trials to determine how well each variety tolerates exposure to particular diseases and pests known to infest the growing region, particular growing conditions such as exposure to particular weather conditions, and the variety's ability to deliver acceptable yields per ton and sugar content (Manning, 2010). Sugar beet varieties that do not make the approved variety lists cannot be delivered to the processor for sugar production because they do not meet the standards set forth by the processor (Manning, 2010).

The demand for sugar beet seed is satisfied by domestic production and imported seed. Table 3–41 shows sugar beet seed imports between 1997 and 2009. Although imports have fluctuated considerably, the domestic use of imported seed is usually challenged by the compatibility of existing varieties to local conditions and the potential presence of weed beet seeds.

Table 3- 39. Sugar Beet Seed Exports, 1997–2009 (tons)

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total	480	529	567	422	630	735	683	544	1,003	706	798	718	797
Share of Total U.S. Sugar Beet Seed Exports (%)													
Canada	67.3	77.9	79.7	77.1	80.7	66.1	63.7	72.1	64.5	67.2	82.1	70.8	84.3
Mexico	2.0	1.4	1.8	0.9	0.3	3.6	0.0	1.3	4.0	2.7	3.4	15.3	4.8
Hong Kong	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	20.3	11.0	0.0	4.2	0.5
Netherlands	2.5	0.3	0.0	6.0	3.6	0.5	1.1	0.0	0.0	3.1	1.0	2.5	1.9
Malaysia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.7	2.5
Sweden	0.2	0.1	0.2	0.0	0.0	0.5	1.0	4.3	1.3	1.2	0.5	0.2	0.8
UK	0.0	0.5	0.9	1.6	0.4	0.0	0.3	0.9	0.0	0.0	0.0	0.0	1.3
Australia	0.0	0.0	0.1	1.7	0.5	0.7	0.6	0.7	0.2	0.5	0.0	0.0	1.2

Source: (USDA-FAS, 2010b), Harmonized System code 120911 (1997–2001) and 120910 (2002–2009).

Table 3- 40. Sugar Beet Seed Imports, 1997–2009 (tons)

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Total	1,190	1,126	3,952	8,417	14,097	3,265	2,290	2,862	3,429	12,422	9,057	121	31
Share of Total U.S. Sugar Beet Seed Imports (%)													
France	0.0	1.1	10.3	0.0	1.3	0.1	21.5	0.0	0.1	30.3	12.5	0.0	47.0
Italy	50.1	0.0	55.0	17.3	6.5	11.7	10.3	36.5	3.9	1.1	6.0	71.9	0.0
Belgium	3.7	2.2	34.4	79.2	86.4	87.9	36.3	0.0	22.3	67.5	78.5	26.7	9.3
Germany	0.4	60.7	0.1	1.7	5.5	0.1	0.1	0.1	48.3	0.0	0.0	0.9	10.0
Netherlands	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	3.9
Canada	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0	29.2
Chile	0.0	0.0	0.0	0.0	0.0	0.0	23.0	63.3	16.5	0.0	2.4	0.0	0.0

Source: (USDA-FAS, 2010b), converted from Metric tons. Harmonized System code 120911 (1997–2001) and 120910 (2002–2009).

b. Production of Sugar Beet Seeds

Complete data on sugar beet seed production are not readily available. In 2010, the U.S. Department of Agriculture's Farm Service Agency (FSA) registered at least 4,776 acres in 7 States; 74 percent in Oregon; and the remaining in Michigan, Washington, Nebraska, Minnesota, Idaho, and California. About 95 percent of the Oregon production occurred in the Willamette Valley (Stankiewicz Gabel, 2010). Data provided by the USDA Farm Service Agency provide information on acreage and location of sugar beet seed production that was reported to FSA by farmers for access to a variety of support programs managed by the agency. Because participation in these programs is voluntary, the data available are likely incomplete. In 2011, seed planting permits show H7-1 sugar beet seed is produced almost exclusively in the States of Oregon and Washington, with a few acres in Idaho and Colorado (see section III.B.1.b (1)). Additional acreage might exist for conventional seed, but the information is not publicly available. Miller (2010) suggests sugar beets planted for seed production occupy less than 0.5 percent of the total sugar beet acreage. This would mean a maximum annual acreage of 5,500 to 7,200 since 1997 (see table 3–34). Data from the Agricultural Census indicate that in 2007, harvested acreage of sugar beet seed totaled 3,199 down from 4,335 in 2002. This corresponded to a production of 7,000,504 pounds in 2007 and 9,542,593 pounds in 2002, with 93 farms producing sugar beet seed in 2007 and 130 in 2002 (USDA-NASS, 2009c).

Most U.S. sugar beet seed is produced, processed, and marketed by five private entities (Manning, 2010):

(1) Crystal Beet Seed, a division of American Crystal Sugar Company;

(2) Betaseed, Inc., a subsidiary KWS SAAT AG;

(3) Syngenta Seeds, Inc.;

(4) SES VanderHave Sugarbeet Seed; and

(5) Holly Hybrids, owned by Spreckels Sugar Inc., shares an alliance with SES VanderHave.

American Crystal Sugar, Syngenta, SES VanderHave, and Holly Hybrids are members of the West Coast Beet Seed (WCBS) cooperative. The American Crystal Sugar Company produces seed that is marketed to its grower owners in the Red River Valley. Betaseed, Syngenta, SES VanderHave and Holly Hybrids develop products to serve all U.S. beet seed markets. Betaseed, Syngenta, and SES VanderHave are owned by larger seed companies who together encompass most of the global beet seed business. Sugar beet seed is generally not certified.

When H7-1 sugar beet seed was deregulated in 2005, the industry began full production of H7-1 sugar beets (Manning, 2010). According to Manning (2010), seed producers have not engaged in conventional seed development since 2006–2007, and most seed production from those years onward has been of H7-1 sugar beet varieties. This may or may not still be the case: given the current regulatory uncertainty regarding the future availability of H7-1 sugar beet seed, it is possible that sugar beet seed companies are once again developing and producing conventional varieties. For business confidentiality reasons, this information is not currently available to APHIS.

3. Organic and Non-Genetically Engineered Sugar Beet and Sugar Markets

a. Organic and Non-Genetically Engineered Sugar and Sugar Beet Root Markets

The organic sector is rapidly growing both in the United States and the EU. Together, consumer purchases in these two regions made up 95 percent of estimated world retail sales of organic food products in 2003 (Dimitri and Oberholtzer, 2005). In 2006, world retail sales of organic food products were estimated to be on the order of USD 40 billion (Organic Monitor, 2006). In reporting the results of their annual manufacturer survey, the Organic Trade Association (2010b) reports that U.S. organic food sales were estimated to be USD 24.8 billion in 2009. Although the economic recession is likely responsible for a much slower growth rate of the organic foods sector in 2009 than in previous years, growth of organic food sales in 2009 was still considerably higher than growth in overall U.S. food sales: 5.1 percent compared to 1.6 percent (Organic Trade Association, 2010b). In 2010, organic food sales increased another 15 percent.

The demand for organic sugar in the United States was projected to be over 110,000 tons (approximately 100,000 MT) in 2008, having increased steadily since 2001 (Willerton, 2008). This would amount to roughly 1 percent of the domestic sugar market estimated at about 10 million tons (table 3–28). The vast majority of the organic sugar sold in the United States is cane sugar imported under the specialty sugar quota,[19] the leading suppliers being Paraguay, Brazil, and Argentina (Willerton, 2008). The

[19] In addition to organic sugar, the specialty sugar quota includes: brown slab sugar (also known as slab sugar candy), pearl sugar (also known as perl sugar, perle sugar, and nibs sugar), vanilla sugar, rock candy, demerara sugar, dragees for cooking and baking, fondant (a creamy blend of sugar and glucose), ti light sugar (99.2% sugar with the residual comprised of the artificial sweeteners. aspartame and acesulfame K), caster sugar, golden syrup, ferdiana granella grossa, golden granulated sugar, muscovado, molasses sugar, sugar decorations and sugar cubes (15 CFR 2011 subpart B).

Organic Trade Association is predicting an organic sugar shortage for FY2011 based on very strong demand growth and an insufficient replenishment due to weather related issues in the key producing countries. USDA increased the FY2010 Specialty Sugar quota by 13 percent over the prior year but the organic industry is still predicting an organic sugar shortage (Association, 2011a).

Because refined sugar from sugar cane is 99.95 percent identical to refined sugar from sugar beets (The Sugar Association, Undated), any domestic demand for organic sugar can be met with sugar produced from organic sugar beets or from organic sugar cane. Organic cane sugar is primarily available though imports though at least one U.S. company, Florida Crystal[20]. Florida Crystal produces organic cane sugar grown and harvested in the U.S. Traditionally, the demand for sugar beets comes from 9 sugar beet processors operating 22 plants. Existing processors have not shown an interest in producing organic beet sugar and it is currently not considered to be economically viable (Association, 2011b). APHIS is aware of attempts to produce organic sugar beets in California and Minnesota (Beet Sugar Development Foundation et al., 2011). Both failed after 1-year due to difficulty with weed control. Another challenge for a fledgling organic sugar beet industry would be securing access to a processing plant. Dedicated processing plants have a very high upfront cost estimated at 160 million USD (see section III.D.1.b) and need enough throughput to make them economical. As 13 plants have shut down since 1996 (see section III.D.1.b), it might be possible to aquire and restart one of the closed plants for less. Alternatively, it might be possible for operational plants to be used prior to processing conventional sugar beets. However, shared plants might require substantial process alterations to be compatible with organic production. Lastly, organic beet sugar would need to compete with organic cane sugar which is already being produced in the U.S. and abroad. Because the growth of the organic market demand for sugar is outrunning the TRQ, the growth of organic demand may eventually provide economy of scale for viable domestic organic sugar production and refining. It is possible that the increased demand for organic sugar will make organic beet sugar production economically feasible in the future.

Less than 5 percent of the 2009 sugar beet crop was estimated to be of conventional sugar beet varieties (Colacicco, 2010b). Private certification standards and labeling for conventional beet sugar also exist through the Non-Genetically Modified Project Working Standard, although no such beet sugar seems to be currently available (Non-GMO Project, 2010). The conventional sugar beet root crop is typically not identity preserved after

[20] http://www.floridacrystals.com/Products.aspx?id=1 (accessed June 15, 2011).

harvest. The demand for conventional sugar beet seed is derived mainly from the California plant, because varieties with the H7-1 trait have not yet been made available for this region. APHIS expects varieties of H7-1 to be available for California in the near future (2011). Some demand from export destinations such as Mexico may also be for conventional varieties.

In general, demand for GE foods or for foods free of GE content is difficult to estimate. and no estimate of consumer demand for GE-free food products appears to be available (Noussair et al., 2004). A summary of 25 valuation studies relating to GE food suggests some preference for non-GE foods in the United States, although possibly less than in Europe, based on various estimates of willingness to pay for GE-free foods (Lusk and Rozan, 2005).

A report by Hallman (2003) found that support for GE foods is slipping where 59% of Americans said they thought GE foods would make their lives better in 2001 but only 39% had a similar response in 2003 and 35% felt it would make their life worse. The same report found that 45% of respondents believe it is safe to consume GE foods while 18% say they don't know. The Hallman (2003) report found that 94% of respondents were in favor of labeling. Several studies have argued that even with the negative opinions Americans express about biotechnology in surveys, there has been little apparent effect on sales of food items that contain or are raised on GE ingredients or feeds.

Fernandez-Cornejo and Caswell (2006), for example, argue that many products in the United States contain GE ingredients, and the demand for these products apparently has been unaffected by negative opinions about biotechnology expressed in surveys. In most of these studies), consumers indicated that they were willing to pay more on average for GE-free foods or to avoid foods containing GE ingredients. However, in many of the studies, at least some consumers did not require a discount to buy foods containing GE ingredients, while some expressed that they would not be willing to buy foods containing GE ingredients at all. "Putnam (2005) makes this same point, arguing that GE crops, such as corn and soybeans, have been used as animal feed for years with no perceptible impact on the marketing of beef.

Kalaitzandonakes (2005)found that a majority of consumers in the Netherlands did not shift away from the purchase of processed foods containing GE ingredients in the presence of alternatives in stark contrast to findings based on opinion surveys. His study used national level, syndicated point of purchase grocery store scanner data over a 5-year period from 1997–2002. Over that period mandatory labeling of processed foods was instituted and he compared population purchase behavior before labeling, after labeling, and after GE foods were voluntarily removed from the marketplace in 2000. Over the time period of the analysis, Dutch consumers expressed a decreasing willingness to purchase GE food where 32% of Dutch consumers indicated they would buy GE food in 1996, 30% were willing in 1999, and 15% were willing in 2001 ((Kalaitzandonakes et al., 2005) and references therein). Despite the trend in the stated preferences of the population to avoid GE foods, consumers continued to purchase these foods at the same rate before labeling was instituted or after GE ingredients were no longer used. This data further supports the idea that the link between the elicited attitudes expressed in surveys and product demand is weak.

Some suggest that the demand for food free of GE content can be found in the growth of the organic market. A unique attribute of organic foods, and one possible reason consumer demand for organic foods is increasing, is the intended absence of GE ingredients in the process of producing them (Anderson et al., 2006; Dhar and Foltz, 2005; Larue et al., 2004). Because the organic standard is process and not product based, organic food may contain LLP. Manufacturers have been active in creating a market for GE-free foods. From 2000 to 2004, manufacturers introduced over 3,500 products that had explicit non-GE labeling (The First Decade of Genetically Engineered Crops in the United States /EIB-11, Economic Research Service, 2006). Recently, an initiative, the Non-GMO Project, evolved out of consumer demand for products that lack GE ingredients. It was started by the North American organic and natural product industry to focus specifically on whether food contains GE content. It’s goal is to create an industry-wide standard for “non-GMO” and to provide labeling, “Non-GMO Project Verified”, for products that meet the non-GMO standard. Like the Organic standard, the non-GMO project is also a process based standard. However it differs in that its focus is on avoidance of ingredients from GMOs while the organic standard is much broader, prohibiting the use of certain substances and practices commonly used in conventional agriculture. While both standards include traceability and segregation practices, the non-GMO project also includes testing of ingredients at certain points in the process.Ingredients must test below a threshold of 0.9% to be used in a non-GMO project verified product. Thus, such products also may contain LLP. Several hundred products are now non—GMO project verified. Many of these products are not organic (http://www.nongmoproject.org accessed July 6, 2011) indicating the market for organic and non-GMO are not completely overlapping.

The organic standard is broader than the absence of GE content, involving the prohibition of many substances commonly used in conventional agriculture and specific processes and procedures. From a survey conducted by the organic industry ranking the most important reasons consumers buy organic products, the most important reasons were, in order of importance, to avoid pesticides, to avoid artificial hormones, to avoid antibiotics, to avoid GMOs, and to avoid artificial colors and flavors (Organic Trade Association, 2010a) The maximum allowable prohibited pesticide residue for organic food is 5% of the tolerance standard set by EPA. (AMS, 2011). A threshold does not exist however for GE ingredients. As described in the regulation, the inadvertent presence of GE material in an organic crop does not constitute a violation of the organic rule. The regulation from the National Organic Program Final Rule at 7 CFR Part 205

> "prohibits the use of excluded methods in organic operations. The presence of a detectable residue of a product of excluded methods alone does not necessarily constitute a violation of this regulation. As long as an organic operation has not used excluded methods and takes reasonable steps to avoid contact with the products of excluded methods as detailed in their approved organic system plan, the unintentional presence of the products of excluded methods should not affect the status of an organic product or operation."

The main export markets for U.S. sugar and sugar beet seed are Canada and Mexico. Both have approved H7-1 sugar beets for food and feed (USDA-FAS, 2010a, 2010d). Canada has approved H7-1 for planting. Mexico has not yet approved GE seed for commercial planting, and Mexico's legislation requires GE seed for planting to be labeled as such (USDA-FAS, 2010d). Japan is the main export destination for sugar beet pulp and has also approved the use of H7-1 sugar beet varieties (USDA-FAS, 2010c).

b. Organic and Non-Genetically Engineered Sugar Beet Seed Markets

Demand for organic sugar beet seed derives from the demand for organic sugar beets, as the NOP requires the use of organic seeds to produce organic sugar beets (7 CFR § 205.204).[21] APHIS is not aware of a current demand for organic beet sugar. Although there are no data on exports of organic sugar beet seed, demand for organic sugar beet seed from abroad is likely limited by an organic sugar market that is currently supplied by sugar from sugar cane. APHIS is not aware of any organic sugar beet seed production in 2011. APHIS was informed that 200 pounds of organic sugar beet seed were produced as part of a pilot in 2009 by Seeds of Change (Reiten, 2010). In 2011, APHIS made several unsuccessful attempts to follow-up with the commenter as to the fate of this pilot.

4. Vegetable Beet Markets

a. Vegetable Beet Root Markets

In the USDA database, "beets" include table beets, Swiss chard, and spinach beets (grown for the leaves). In this document, these nonsugar beet crops are referred to collectively as vegetable beets. The demand and supply of vegetable beets are described in this section to aid the analysis of socioeconomic impacts from potential cross-fertilization of sugar beets with vegetable beets.

Table 3–42 shows trade in vegetable beets and other edible roots since 1997. Data for U.S. consumption of vegetable beets are not readily available. Production estimates based on acreage and yields suggest a decline of U.S. vegetable beet production (table 3–43, table 3-44). Because trade in vegetable beets is relatively small, consumption has likely declined as well. Although imports have increased, more detailed data for imports (not available for exports) suggest much of this increase has been in imports of radishes and total trade volumes remain small relative to estimated domestic production declines.

Demand for U.S. vegetable beets from foreign countries is small and more than 85 percent of U.S. exports of beets, radishes, and other edible vegetable roots are destined to Canada (USDA-FAS, 2010b).

Data on U.S. vegetable beet production are also not readily available. However, until 2001, USDA–NASS estimated production of vegetable beets for processing. Table 3–43 shows these data for the period 1997–2001. Production fluctuated somewhat with a tendency toward reduction. More recent data for production of vegetable beets for processing in the

[21] An exception is made to the requirement of using organic seeds in cases where these are not available. In these cases, untreated conventional seeds or seeds treated with substances included in the National List of synthetic substances allowed for use in organic crop production are typically allowed. The exception is not permanent and may change.

State of New York[22] suggest this tendency toward reduction in processing might have continued after 2001 (USDA-NASS, Various Years).

At an average yield of 7 tons per acre for fresh market vegetable beets (Schrader and Mayberry, 2003),[23] production of fresh market vegetable beets would have been 30,065 tons in 1997. Total production of vegetable beets in that year would equal just over 152,000 tons. If there were no changes in yield between 1997 and 2007, production in 2002 and 2007 would have fallen proportionally to the reduction in acreage and would equal approximately 122,000 and 113,000 tons, respectively (table 3–44). Because acreage harvested for processing ranges between 61 percent and 63 percent of total vegetable beet acreage harvested between 2002 and 2007 (table 3–45), total production of vegetable beets was likely considerably higher than that reflected in table 3–43.

[22] As of 2007, New York and Wisconsin had more than 90 percent of the harvested acreage of vegetable beets for processing (USDA-NASS, 2009b)
[23] Schrader and Mayberry (2003) report average yields for processed beets to be much higher and close to 18 tons/acre.

Table 3- 41 Trade in Vegetable Beets and Other Edible Roots, 1997–2009 (tons)[1]

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Exports	17,031	14,654	16,122	15,628	15,760	16,944	18,227	16,243	15,125	14,703	16,095	14,818	15,898
Imports	17,024	22,188	19,080	21,995	18,326	20,726	21,548	25,078	25,587	29,092	30,886	31,102	28,491

Source: (USDA-FAS, 2010b).

[1] Harmonized System Code 706900. Includes beets, radish, horseradish and other edible roots, fresh or chilled (carrots and turnips not included). Converted from metric tons.

Table 3- 42 Vegetable Beet Production for Processing, 1997–2001

	1997	1998	1999	2000	2001
Production (tons)	122,000	103,530	117,200	113,160	111,180
Value (USD 1,000)	8,153	6,361	6,976	6,965	7,317

Source: (USDA-NASS, Various Years).

. Table 3- 43 Total Vegetable Beet Production Estimates, 1997–2007 (tons)[1]

	1997	2002	2007
Production	152,000	122,000	113,000

[1] Estimates explained in preceding paragraph.

Assuming 62 percent (average of 61 percent and 63 percent) of acreage was harvested for processing in 1997 (7,008 acres), 4,295 acres were processed for the fresh market (table 3–45: 11,303 − 7,008).

Acreage data are available from the Agricultural Censuses, as shown below in table 3–45. In 2007, the most recent year for which published data are available, 8,413 acres of vegetable beets were harvested in the United States, on 2,768 farms, for an average of 3 acres per farm (USDA-NASS, 2009b).

Table 3- 44. Vegetable Beet Acreage, Farms and Acres Harvested, 1997–2007

	1997	2002	2007
Acres Harvested	11,303	9,092	8,413
For Processing	NA	5,510	5,275
For Fresh Market	NA	3,582	3,138
Farms	2,333	2,123	2,768
Acres/Farm	4.8	4.3	3.0

Source: (USDA-NASS, 2004, 2009b).
Abbreviations: NA = Not available

b. Vegetable Beet Seed Markets

Demand for vegetable beet seed is derived from the demand for vegetable beets. As discussed above, U.S. demand for vegetable beet likely declined after 1997. As of 2001, the last year for which vegetable beet seed export data are available, there was no sign that foreign demand would increase to compensate for such decline in U.S. demand (table 3–46).

Table 3- 45. Trade in Vegetable Beet Seed, 1997–2001 (tons)

	1997	1998	1999	2000	2001
Exports	900.9	779.7	865.7	770.8	725.9
Imports	2.5	6.8	18.9	4.5	17.2

Source: (USDA-FAS, 2010b).
[1] Harmonized System Code 120919: Other Beet Seed (other than sugar beet). Converted from metric tons. Not reported after 2001.

USDA does not systematically collect data on vegetable beet seed production. Based on publications from the Washington State Extension Office and personal communications with State Extension Officers in Oregon and Washington and commercial seed producers, APHIS estimates that approximately 550 acres of table beet seed were planted in 2011, mostly in the state of Washington, but also in California and Oregon (see section III.B.3.a(1)). Swiss chard seed was grown on approximately

600 acres, in the states of Oregon, Washington, California (and 1 county in Arizona) (see section III.B.2.a(1)).

5. Environmental Justice

Executive Order (EO) 12898 (*Federal Actions To Address Environmental Justice in Minority Populations and Low-Income Populations*, February 11, 1994) directs Federal agencies to identify and address "disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations." In implementing EO 12898 in the context of The National Environmental Policy Act and subsequent amendments (NEPA), a lead agency must determine whether a proposed action would have any disproportionally high or adverse human health or environmental effects on low-income or minority populations as compared to impacts on the general population.

Council on Environmental Quality (CEQ) guidance for implementation of EO 12898 in the context of NEPA (*Environmental Justice. Guidance under the National Environmental Policy Act*, December 10, 1997) identifies a minority population as an affected area where more than 50 percent of the population belongs to a minority group or where the percentage presence of minority groups is meaningfully greater than in the general population. Geographically dispersed groups with common conditions of environmental exposure may also be considered as a community subject to analysis for percentage presence of minority groups (e.g., agricultural workers).

Table 3–47 shows the minority presence as a share of total population in the United States and in sugar beet root and seed producing states and counties. Sugar beet root states and counties included are those for the 2007 Agricultural Census (130 counties in 11 States). Sugar beet seed states and counties included correspond to those indicated in H7-1 sugar beet seed production permit requests in 2011. Because conventional seed is produced by the same companies that produce H7-1 seed, it is assumed that these counties are also the main conventional seed producers (see section III.B.1.b (1)). Seed companies applied for H7-1 sugar beet seed production permits in twenty six counties in Washington, Oregon, and California. Although not all counties later reported actually planting for seed, all 26 were included for the purposes of our analysis, under the assumption that all these twenty six could produce in the future.[24]

Minority presence was typically lower or slightly higher in sugar beet producing States and counties than in the United States as a whole, with the exception of California, where the presence of Hispanics in nine sugar

[24] One additional county (in Colorado) reported planting less than 1 acre and was not included.

Table 3- 47. Minority Presence in the United States, 2009

Geography	Total Population	Percent of Total Population							
		White (%)	Black or African American (%)	Alaska Native or American Indian (%)	Asian (%)	Native Hawaiian and Other Pacific Islander (%)	Two or More Races (%)	Hispanic or Latino[1] (%)	Total Minority Population[1] (%)
United States	*307,006,550*	*79.57*	*12.91*	*1.03*	*4.56*	*0.19*	*1.73*	*15.77*	*34.90*
Root Grower States	73,220,728	81.39	6.55	1.33	8.11	0.31	2.31	23.04	40.08
Root Grower Counties	9,381,741	87.94	4.41	1.73	3.85	0.17	1.90	25.81	36.23
Seed Grower States	12,035,653	87.07	2.93	1.67	5.19	0.39	2.75	10.64	22.52
Seed Grower Counties	3,360,340	91.62	1.26	1.58	3.06	0.25	2.24	16.50	23.72
California	36,961,664	62.65	6.08	0.80	12.50	0.37	3.81	37.02	58.54
California Counties	3,736,200	82.39	5.63	1.84	7.45	0.29	2.39	48.43	63.07
Root Grower States w/o California	36,259,064	86.45	6.47	1.45	3.45	0.18	2.01	8.79	21.51
Root Grower Counties w/o California	5,645,541	91.60	3.61	1.65	1.46	0.10	1.58	10.84	18.47

Source: (U.S. Census Bureau, 2009).

[1] Individuals who identify themselves as Hispanic, Latino, or Spanish might be of any race; the sum of the other percentages under the “Percent of Total Population” columns plus the “Hispanic or Latino” column therefore does not equal 100 percent.

[2] The total minority population, for the purposes of this analysis, is the total population minus the non-Latino/Spanish/Hispanic white population.

beet producing counties was three times higher than the average presence in the country as a whole and approximately 11 percentage points above the presence of Hispanics in the state. Total minority presence in California sugar beet producing counties was also higher than in the rest of the State and approximately twice that of the country as a whole. American Indians, Asians, and Pacific Islanders were also more present in California sugar beet producing counties than in the rest of the country.

Because California is responsible for roughly half of the population of root grower states and about a third of the population for root grower counties, APHIS also included in table 3–47 information on minority presence in grower States and counties, after excluding California. Table 3–47 shows that minority presence in root grower States and counties is considerably minority presence in the rest of the country, when California is not included. For the purpose of this EIS, APHIS has determined that only the minority presence in California root growing counties may be considered meaningfully greater than in the country as a whole.

Table 3–48 shows the presence of minorities among farm operators (those who run the farm: owners or other) in the sugar beet root and seed grower counties compared to sugar beet root and seed grower states and to the country as a whole. The total minority share (total population minus non-Hispanic whites) is not available at the county level. Among farm operators, minority presence was typically lower or slightly higher in sugar beet producing states and counties than in the Unites States as a whole, with the exception of Asian and Hispanic farm operators in sugar beet growing counties. The same table shows, however, that if California is excluded from the sugar beet growing states and counties, the share of farm operators belonging to a minority group is less than the share of minorities in the total populations in the remaining sugar beet growing areas.

A large percentage of agricultural workers in the United States are foreign-born. According to the 2002 National Agricultural Workers Survey, 75 percent of crop workers were born in Mexico (U.S. DOL, 2005). A relatively small share – 14 percent – of all crop workers had a field crop (such as sugar beets) as their primary crop in FY2002, and most agricultural workers were employed in fruit, vegetable, and horticultural crops (such as vegetable beets) (U.S. DOL, 2005). Still, because the percentage presence of Hispanics among agricultural workers is much higher than in other segments of the population, APHIS has determined that agricultural workers meet the criteria for a minority population for the purpose of this analysis.

CEQ guidance for implementation of EO 12898 in the context of NEPA (*Environmental Justice. Guidance Under the National Environmental*

Table 3- 48. Minority Farm Operators, 2007[1]

	Total Operators	Share of Total Operators							
		White (%)	Black or African American (%)	American Indian or Alaska Native (%)	Asian (%)	Native Hawaiian or Other Pacific Islander (%)	Multi-Race (%)	Spanish, Hispanic or Latino Origin[2] (%)	Total Minority Operators[3] (%)
United States	3,281,534	95.71	1.21	1.70	0.56	0.07	0.75	2.51	6.62
Root Grower States	732,445	96.85	0.14	1.16	1.06	0.09	0.69	3.30	6.19
Root Grower Counties	195,551	96.51	0.13	1.17	1.47	0.09	0.63	3.89	NA
Seed Grower States	165,007	96.86	0.09	1.28	0.76	0.12	0.90	2.95	5.92
Seed Grower Counties	65,669	97.20	0.09	0.95	0.73	0.13	0.90	3.91	NA
California	127,127	92.56	0.34	1.45	4.55	0.24	0.86	11.17	17.67
California Counties	37,116	90.29	0.43	1.52	6.74	0.23	0.79	13.83	NA
Root Grower States w/o CA	605,318	97.76	0.10	1.10	0.33	0.06	0.66	1.64	3.78
Root Grower Counties w/o CA	158,435	97.96	0.06	1.09	0.24	0.05	0.60	1.56	NA

Source: (USDA-NASS, 2009c).

[1] Because the race and ethnicity characteristics of farm operators were collected from only up to three farm operators per farm, the total number of operators used in this table is the total for which race and ethnicity information is available, and corresponds to about 98% of the total number of farm operators reported in the Agricultural Census.

[2] Individuals who identify themselves as Hispanic, Latino, or Spanish might be of any race; the sum of the other percentages under the “Share of Total Operators” columns plus the “Spanish, Hispanic, or Latino” column therefore does not equal 100 percent.

[3] The total minority operators, for the purposes of this analysis, equals the total operators minus the non-Latino/Spanish/Hispanic white operators.

Abbreviations: NA = Not available

Policy Act, December 10, 1997) suggests using U.S. Census Bureau Current Population Reports, Series P-60 on Income and Poverty for identification of low-income populations. These data are based on the American Community Survey completed annually through a representative household sample. Table 3–49 below shows the share of population in poverty in sugar beet root and seed grower counties compared to sugar beet root and seed grower states and to the country as a whole.

Table 3- 49. Average Low-Income Presence, 2005–2009

Region	Total Population	Population Below Poverty Level	Percent of Population Below Poverty Level (%)
United States	293,507,923	39,537,240	13.5
Root Grower States	70,348,499	9,086,269	12.9
Root Grower Counties	8,906,152	1,418,962	15.9
Seed Grower States	11,439,350	1,441,674	12.6
Seed Grower Counties	3,194,467	447,273	14.0

Source: U.S. Census Bureau 2009c.

The share of the population in poverty in root and seed grower counties is slightly higher than but comparable to the shares in the rest of the root and seed grower States and in the rest of the country.

With respect to farm households, in 2003, 11 percent of the U.S. population was below the U.S. Census Bureau poverty line, while 14 percent of farm households were poor. Offutt and Gundersen (2005) argue that the U.S. Census Bureau poverty line might not adequately capture poverty in farm households, given that it does not capture the volatility of farm income and the greater asset holdings of farm households. Under the USDA alternative concept of Limited Resource Farmer, 11 percent of farm households would fall under that category in 2003, while under the USDA Low Income/Low Wealth concept, only 5 percent of farm households would be classified as such in that same year.

According to the 2002 National Agricultural Workers Survey, 30 percent of farm workers had family incomes below the poverty line[25] (U.S. DOL, 2005), roughly twice the national poverty rate indicated in table 3–49. APHIS has determined that agricultural workers meet the criteria for a low-income population for the purpose of this analysis.

E. Physical Environment

[25] Based on poverty guidelines from the U.S. Department of Health and Human Services.

Four physical environment resources are described in this section: land, soil, air, and water. The land discussion describes land use: where sugar beets are currently grown and how much land is currently used for this crop. The soil discussion describes the preferable soil traits for growing sugar beets and crop management methods that affect soil, including tillage and chemical treatments. The third discussion concerns air quality and climate change: how the production of sugar beets generates air emissions. The fourth discussion concerns surface water and groundwater quality: how much water is required in the production of sugar beets, and runoff from cropland.

1. Land Use

Although GE crops have become available in recent years, crop data provide no indication that the introduction and widespread planting of GE crops has resulted in any substantial change to the total U.S. acreage devoted to agricultural production. The acreage in the United States that is planted in principal crops, which include corn, sorghum, oats, barley, winter wheat, rye, durum, spring wheat, rice, soybean, peanuts, sunflower, cotton, dry edible beans, potatoes, canola, proso millet, and sugar beets, has remained relatively constant over the past 25 years (USDA-NASS, 2010b). From 1983 to 1995, the average yearly acreage of principal crops was 328 million (USDA-NASS, 2010b). Biotechnology-derived crops, including several principal crops such as soybeans, corn, and cotton, were introduced in 1996. In 2009, 319 million acres of principal crops were planted, of which about half were GE(USDA-ERS, 2010a). Overall the amount of cropland planted has declined less than 3-percent since 1996 (USDA-NASS, 2010b)

Sugar Beet Production: Acreage and Location

According to USDA–NASS (2010e), the acreage planted in sugar beets in the United States has changed little over the past 50 years. In 1961, total planted acreage was approximately 1.13 million acres and in the 2009–2010 production year, the planted acreage was approximately 1.18 million acres (a 5 percent increase) (USDA-NASS, 2010b). Figure 3–21 shows the national planted acreage of sugar beets from 1913 to 2010. For more detailed discussion about the land used for sugar beet production see sections III.1.b.(1) and III.1.c.(1).

2. Soil Quality

This section discusses influences on soil quality by sugar beet production. Sugar beets are well adapted to a wide range of soil types (Draycott, 2006). In the United States, sugar beets are produced on coarse textured sandy soils to high organic matter, high clay content, silty clay, or silty clay loam soils (see table 3–50 for definitions for a variety of soil types and textures). Soil with high water holding capacities is desired (Cattanach et al., 1991).

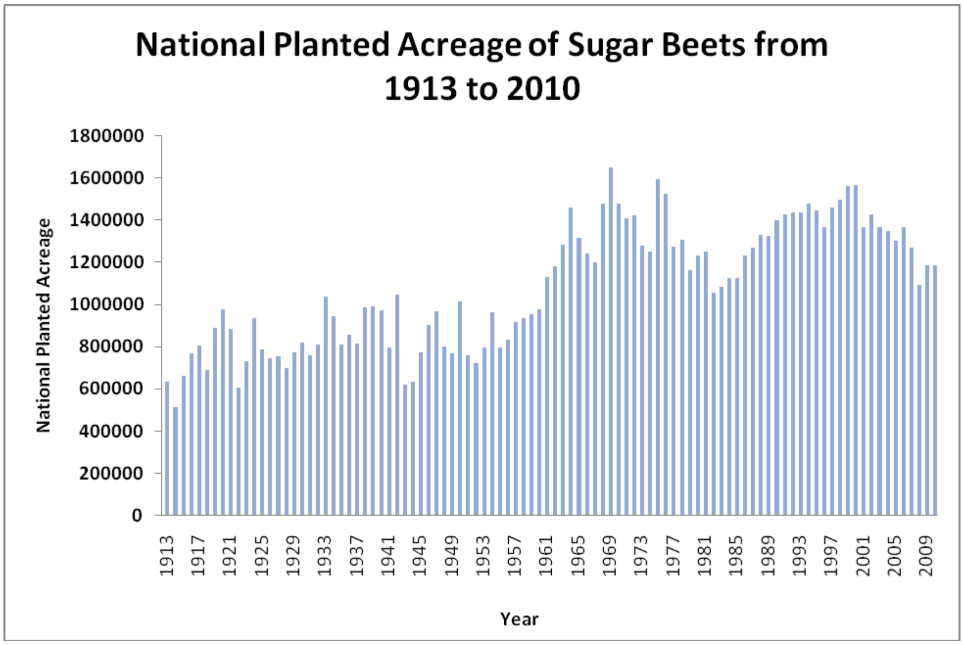

Figure 3- 21. National planted acreage of sugar beets from 1913 to 2010. (Source: (USDA-NASS, 2010b))

The soil environment in and around agricultural fields contains numerous micro-organisms (Bot and Benites, 2005). Typically, bacteria, followed by fungi, are the most abundant micro-organisms found in soil. As discussed in section III.C.2, sugar beet soils contain both beneficial and pathogenic micro-organisms. These micro-organisms play several important roles in soil ecology, including decomposition of plant litter, which maintains soil structure and releases nutrients (that are required for plant growth) back into the soils. Certain micro-organisms can also contribute to the protection of the root system against soil pathogens (Morillo-Velarde and Ober, 2006).

A soil that is free, or nearly free, of stones is particularly desirable as stones cause problems for planting, thinning, harvesting, and processing equipment (Cattanach et al., 1991). The sugar beet plant has a taproot system that uses water and soil nutrients to depths of 5–8 feet (Cattanach et al., 1991). Sugar beets are very sensitive to low pH and will only produce full yields in soil near the neutral point, 7, of the pH scale (Christenson and Draycott, 2006). Observations in the United Kingdom and the United States indicate that sugar beets grow best on soils of pH between 6.5 and 8.0 (Christenson and Draycott, 2006).

Table 3- 50. Soil Types and Textures–Definitions and Particle Sizes

Name	Definition	Particle Size
Soil Types		
Sandy	Soil material that contains 85% or more of sand; percentage of silt, plus 1.5 times the percentage of clay, shall not exceed 15.	Sand: 0.2 to 0.02 mm Clay: <0.002 mm Silt: 0.05 to 0.002 mm
Clay	Soil material that contains 40% or more clay, <45% sand, and <40% silt.	Sand: 0.2 to 0.02 mm Clay: <0.002 mm Silt: 0.05 to 0.002 mm
Loam	Family particle-size class for soils with textures finer than very fine sandy loam (soil material that contains 50% or more very fine sand) but <35% clay and <35% rock fragments in upper subsoil horizons.	Very Fine Sandy Loam Consists of: Coarse Sand – 2.0 to 0.2 mm Medium Sand – 0.5 to 0.25 mm Fine Sand – 0.2 to 0.02 mm Clay: <0.002 mm Rock Fragments: 2.0 mm to 12.5 mm
Peat	An organic soil in which the plant residues are recognizable. The sum of the thicknesses of the organic layers are usually greater than the sum of the thicknesses of the mineral layers. See also peat, muck, muck soil, and Histosol.	N/A
Light Sand	Soil material that contains 50% or more fine sand (or) <25% very coarse, coarse, and medium sand and <50% very fine sand.	Coarse Sand: 2.0 to 0.2 mm Medium Sand: 0.5 to 0.25 mm Fine Sand: 0.2 to 0.02 mm Very Fine Sand: 0.10 to 0.05 mm
Soil Textures		
Coarse	Texture group consisting of sand and loamy (silt, clay, and sand) sand textures.	Sand: 0.2 to 0.02 mm Loam Consists of: Silt – 0.05 to 0.002 mm Clay – <0.002 mm Sand – 0.2 to 0.02 mm
Light	A coarse-textured soil; a soil with a low drawbar pull and hence easy to cultivate.	N/A
Fine	A broad group of textures consisting of or containing large quantities of the fine fractions, particularly of silt and clay. (Includes all sandy clay, silty clay, and clay textural classes).	Silt: 0.05 to 0.002 mm Clay: <0.002 mm
Homogeneous	Of uniform structure or composition throughout (Merriam-Webster)	N/A

Source: (Soil Science Society of America, 2011).

Sugar beets are almost always grown in rotation with other crops to reduce the risk from a wide variety of weeds, diseases and other pests (Dewar and

Cooke, 2006). Rotations can be particularly effective against relatively immobile pests with narrow host ranges (e.g., beet cyst nematode) or insect pests with at least one stage that is restricted to the soil (e.g., pygmy beetle and wireworm) (Dewar and Cooke, 2006).

Agronomic and nutritional needs of sugar beet crops depend on specific soil conditions, the preceding crop, and regional conditions (Kockelmann and Meyer, 2006). Thus, the types and amounts of fertilizers, soil amendments, and pesticides (fungicides, herbicides, and insecticides) applied to produce a healthy crop each year can vary by region and crop rotation.

As discussed in section III.B, sugar beets are biennial plants, meaning it takes 2 years of field growth to complete the plant lifecycle (from a seed to the production of new seed). Sugar beets that are grown for root production are harvested after 1 year of growth.

Sugar beets that are grown for seed production need to complete the 2 year growth cycle. Two methods are used for seed production: the direct "field" method where seeds are planted where they will flower and the indirect "steckling" method where seedlings are grown in a nursery and then transplanted to the flowering location. The best soils for both direct "field" and indirect "steckling" are loamy, with 40–70 percent of silt and 20–50 percent of clay, with neutral to slightly alkaline pH (6.5–8.0, typically) (Kockelmann and Meyer, 2006). Alkaline soils can be treated by adding lime or lime slurries, and spent lime can be used on acidic soils to help adjust the pH level to an optimal level for sugar beet production (Sims et al., 2005). Further, fertilizer is important to soil quality because it helps balance the nutrients needed during seed development and germination which can affect seed quality (Chastain, 2010). Nitrogen levels in particular are important to keep in balance as too little nitrogen in the soil can lead to low crop yield and too much nitrogen can reduce the sugar content of the crop (Lamb et al., 2008). Thus, to attain a suitable nutrient balance in soils, including nitrogen, phosphorous, and potassium, fertilizers could be applied based on the results of a soil analysis for a particular area (Kockelmann and Meyer, 2006). Sugar beet seed crops require 125–150 percent of the fertilizer nutrients that sugar beet root crops require (Desai, 2004).

Most sugar beet seed production in the United States uses the steckling method. The steckling seed production method involves harvesting the plants (which have produced small beets called stecklings) at the end of the first growing year and then replanting them the second year for flowering. The steckling method involves more passes through the production fields to accommodate the harvesting and replanting between seasons and, therefore, has a larger effect on soil than the direct seed method. Soil preparation and quality of transplanting are key factors for high seed yield and seed quality in the steckling method. Cultivation of soil must ensure a structure that enables plants to settle their roots easily in the soil and preserve soil moisture (Kockelmann and Meyer, 2006).

a. Sugar Beet Tillage Methods
(1) Purposes for Tillage

Sugar beet crops usually require a fine, homogeneous (see table 3–50 for definition of soil types) seedbed (Häkansson et al., 2006). Thus, some form of tillage, either conventional, conservation, or reduced tillage is used prior to planting almost every acre of sugar beets (conventional or H7-1 sugar beet) in the United States.

The intensity of tillage, the number of operations, the types of implements used, the timing of operation, and the purposes for tillage encompass a wide range. The tillage system and the individual field operations within this system should have specific purposes that contribute to the harvest size and quality of the crop (Smith, 2008). These purposes commonly include:

- controlling weeds prior to planting,
- incorporating crop residue, manure, nutrients or herbicides into the soil,
- reducing soil compaction,
- facilitating a cover crop or manipulating the soil surface to minimize soil erosion,
- enabling the grower to provide consistent seed depth and spacing,
- conserving soil moisture,
- enabling soil moisture below the seed to move up to the seed as the soil surface loses moisture, and
- minimizing soil clods at seed depth for maximum seed-soil contact while providing some clods on the surface to minimize soil erosion and soil crusting.

The right type of tillage conducted at the right time with the right implement is a necessary and important part of sugar beet production (Smith, 2008). Most soil problems, including clods, compaction, soil crusting, and lack of good tilth (soil structure suitable for seeding), are caused by or at least aggravated by tillage and machinery traffic (Smith, 2008).

When sugar beet crops are grown with tillage methods, the soil surface remains unprotected from wind for a prolonged period after sowing. Particularly on poorly structured soils, such as light sands and peats, wind erosion during this period can be a serious problem (Häkansson et al., 2006). The seedbed, and even the seed, can be blown away or re-deposited. After emergence, abrasion by wind-blown soil particles can damage seedlings, which may also become covered by soil. In severe cases, re-sowing might be necessary (Häkansson et al., 2006). Figure 3–22 shows where excessive erosion from wind and water is occurring on croplands across the United States. It can be seen that there are regions of excessive erosion in all the sugar beet root crop growing areas.

In many sugar beet production areas, the most relevant method to protect soil from wind erosion is a cultural practice that leaves an adequate amount of crop residues on the soil surface (Fornstrom and Miller, 1998), which usually means some form of reduced or conservation tillage (see following subsections for a detailed discussion). On light soils, reduced/conservation tillage is desirable because it decreases the risk of erosion. It also reduces the risk of surface-layer hardening, which is of interest particularly for soils with high silt content (Häkansson et al., 2006). On fine-textured soils with a more stable structure, reduced/conservation tillage can be profitable because it saves time and energy. Sandy soils, on the other hand, are easily compacted, and relatively deep annual tillage could be a prerequisite for normal root development. As a result of a large series of trials on various soils in Sweden, Håkannson (2006) citing Rydberg, 1987) reported mainly negative effects of reduced/conservation tillage on various crops on sandy soils and positive effects on silty soils. On clay soils, the results varied but were often positive (Häkansson et al., 2006). In the United States, soils are sandy or fine textured/silty within the northern Great Plains along the Yellowstone River and its tributaries which are major sugar beet growing area (Mikkelson and Petrof, 1999); in the Northwest most sugar beet production is focused around the sandy loam soil of the Snake River Valley in Idaho (Traveller and Gallian, 2000); within the Great Lakes region sugar beets are commonly grown on medium- and fine-textured soils (Häkansson et al., 2006); in the Midwest within Red River Valley production area the soil is characterized as a clay to silty-clay composition (Schwert, 2003); and in the Imperial Valley sugar beet production region the crop acreage primarily consists of heavy clay and clay loam soils (California Beet Growers Association, 1999).

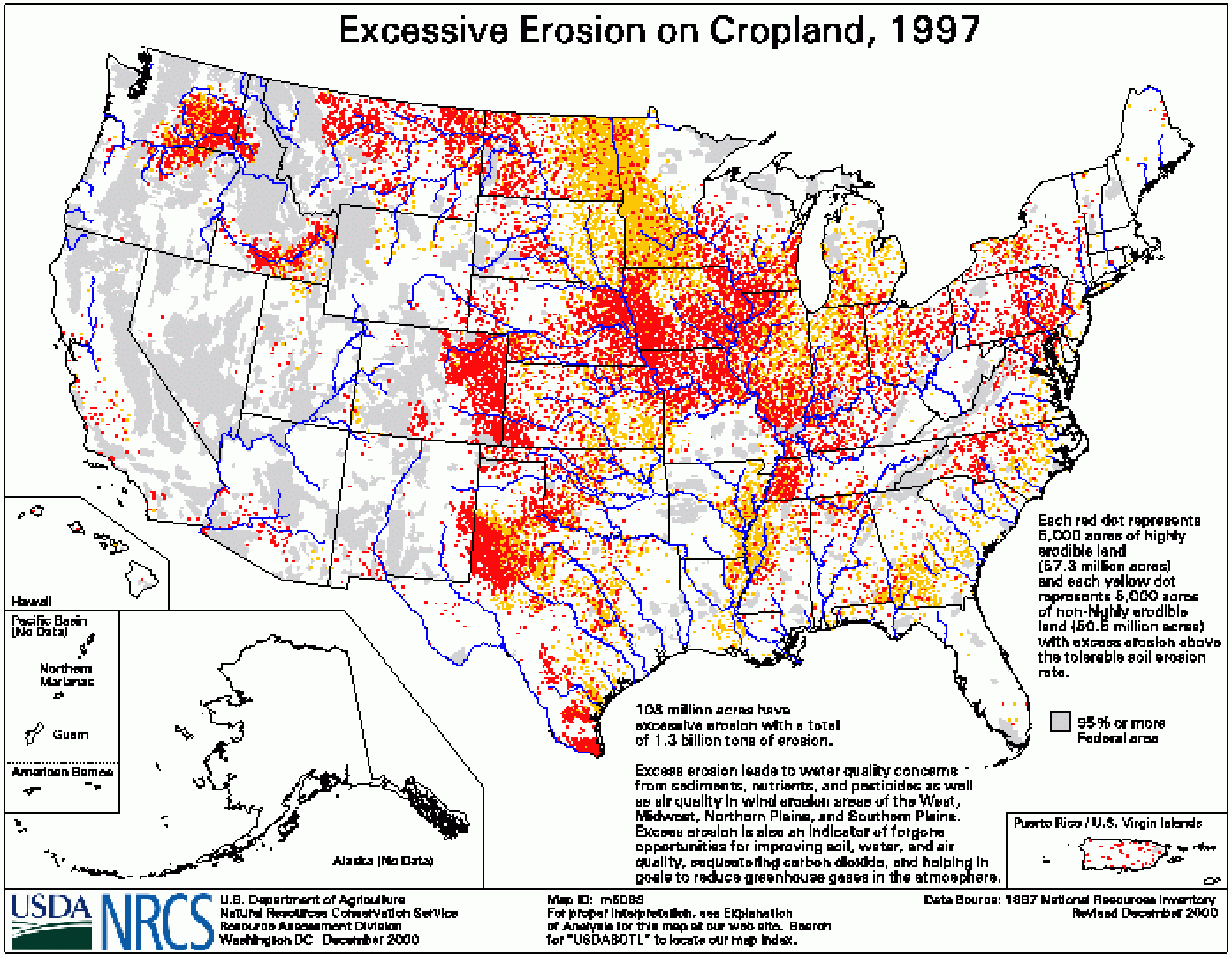

Figure 3- 22. Excessive wind erosion on U.S. cropland, 1997. (USDA-NRCS, 2011a)

(2) Tillage Methods

Tillage methods for sugar beet production were introduced in section III.B.1. Additional details regarding tillage methods, their influence on soil quality, and regional variations are discussed in this section.

Tillage helps in seedbed preparation by assisting in crop residue management, improvement of soil structure, elimination of early weeds, and reduction in erosion risks presented by compacted soils. However, tillage which can be done in the fall and spring, can also by itself exacerbate erosion problems, release more carbon into the atmosphere, and can also result in increased moisture loss from the soil as compared to no tillage or strip tillage (Cheesman, 2004; Nowatzki et al., 2008).

The following sections discuss conventional or traditional tillage, conservation tillage, reduced tillage, and strip tillage methods used in sugar beet production across the United States. Conventional tillage using moldboard plowing has traditionally been the most common primary tillage method in sugar beet production. However, other methods of tillage, such as conservation tillage and reduced tillage are included under Crop Residue Management (CRM) have been used increasingly for sugar beet crops (Häkansson et al., 2006). CRM includes preserving residue from the previous crop and reducing the number of times equipment passes over a field and is designed to protect soil and water resources and to provide additional environmental benefits (Anderson and Magleby, 1997). A cover of crop residue helps cut soil losses from wind and water erosion.

Conventional Tillage. The USDA–ERS defines conventional tillage as a full-width tillage that is performed prior to and/or during planting, and generally involves plowing with a moldboard plow and/or other intensive tillage equipment. Conventional tillage leaves less than 15 percent residue cover on the soil surface after planting and weed control is accomplished with crop protection products and/or cultivation (Anderson and Magleby, 1997). It results in 100 percent soil disturbance (USDA-NRCS, 2008) and is primary tillage followed by one or more secondary tillage(s), planting, and row cultivation operations that bury virtually all previous crop residue (see section III.B.1.c for further detail).

In the United States, the trend among northern Great Plains farmers is toward using less tillage to produce field crops with more residue left on the soil surface (Nowatzki et al., 2008). Since the widespread adoption of H7-1 sugar beets in 2008, the use of conventional tillage has decreased in sugar beets, which is thought to be largely due to improved weed control through the use of glyphosate applications (Duke and Cerdeira, 2007; NRC (National Research Council), 2010; Wilson Jr, 2009).

Conservation Tillage. As discussed in section III.B.1.c(2), conservation tillage as defined by the USDA–ERS is a cultural operation that maintains at least 30-percent cover of the soil surface by plant residue at the time of planting (Anderson and Magleby, 1997). The crop residue protects the soil from both wind and water erosion (Häkansson et al., 2006). Conservation tillage systems require more planning, and better management than conventional tillage (Cattanach et al., 1991).[26]

According to USDA–ERS, the three types of conservation tillage are no till, ridge-till, and mulch-till.

No till as defined by USDA–ERS (Anderson and Magleby, 1997) is a method that leaves previous crop residue undisturbed from harvest to planting except for nutrient injection or narrow strips, and planting or drilling is accomplished in a narrow seedbed or slot. Weed control is primarily accomplished with herbicides and cultivation may be used for emergency weed control.

Under ridge-till, residue from the previous crop is left undisturbed from harvest to planting except for nutrient injection. Planting is completed in a seedbed prepared on 4 to 6 inch high ridges that are formed and rebuilt during row cultivation for weed control and residue is left on the surface between ridges.

Mulch-till is a full-width tillage system that usually involves one to three tillage passes over the field performed prior to and/or during planting, and after planting leaves at least 30 percent of the soil surface covered with residue. Weed control under ridge-till and mulch-till is accomplished with herbicides and/or cultivation (USDA-ERS, 2006).

Conservation tillage has been increasingly used for sugar beets in the United States, although it has been more commonly used for other U.S. crops, such as soybean, corn, sorghum, and small grains (Sandretto, 2005). The percentage of conservation tillage-managed land in the United States increased from 26 percent in 1990 to 41 percent in 2004 (Sandretto and Payne, 2006) and, among sugar beet growing regions, conservation tillage with reduced or mulch tillage has been found to be most common in the Red River Valley, followed by the Great Lakes region (Ali, 2004). As described by Sandretto (2001) in the USDA–ERS Agricultural Outlook,

[26] The USDA–ERS defines conservation tillage and reduced tillage as distinct tillage systems with conservation tillage leaving at least 30 percent soil cover and reduced tillage leaving between 15–30 percent soil cover. However, some authors do not always make a distinction between conservation tillage and reduced tillage, and appear to use the terms interchangeably. Others use the term 'reduced' tillage to mean 'less intensive' tillage and not the USDA–ERS definition of reduced tillage of 15–30 percent soil cover. Draycott (2006) uses reduced tillage to mean conservation tillage and it is assumed so do many contributing authors to the book edited by Draycott *World Agricultural Series. Sugar Beet* (Draycott, 2006). In such instances it is assumed reduced tillage can also mean conservation tillage and they are referred to as reduced/conservation tillage.

benefits of conservation tillage include improved soil quality by reducing soil erosion, building soil organic matter, improving soil tilth (to aid root penetration), increasing soil moisture (through reduced water runoff, enhanced water infiltration, and suppressed evaporation), and minimizing soil compaction. For a discussion of tillage impacts on air quality and water quality, see sections III.E.3.a(1) and III.E.4.c, respectively.

Reduced Tillage. Reduced tillage as defined by the USDA–ERS is a full-width tillage that usually involves one or more tillage passes over the field prior to and/or during planting, and leaves 15–30 percent residue cover after planting (USDA–ERS, 2006).

Strip Tillage. Strip till is a field tillage system that combines no till and full tillage to produce row crops. The seed and fertilizer are placed in narrow strips, 6–12 inches wide, which are tilled in crop stubble, with the area between the rows left undisturbed (Nowatzki et al., 2008). The spacing between the rows varies with crops, but research indicates that strip tillage works well with crops grown with 30-inch row spacing; however, narrower row spacings also work (Nowatzki et al., 2008). Often, fertilizer is injected into the tilled area during the strip tilling operation, and seeds are planted directly into the tilled strips. Strip tilling normally is done in the fall after harvest, but also can be done in the spring before planting (Nowatzki et al., 2008). Section III.B.1.c(2) discusses the advantages of a strip till system.

NDSU research with sugar beets grown with 22-inch row spacing was conducted during 2005–2007 at several Red River Valley locations (Overstreet et al., 2007). Sugar beet yields were similar among tillage systems in 2 of the 3 years (table 3–51). Strip till yields were approximately the same as conventionally tilled plots (Nowatzki et al., 2008).

(3) Regional Variations in Sugar Beet Tillage Methods

With the introduction of H7-1 sugar beets in 2005 and the adoption of the crop, differences in tillage methods have been observed across the sugar beet growing regions. Since H7-1 sugar beets have not been cultivated in the Imperial Valley region and that region is unlikely to adopt conservation tillage due to widespread use of furrow irrigation, that region is not discussed here. As stated in section III.B.1.c(2) due to a lack of sufficient data for all regions, not all differences are described for all regions.

Section III.B.1.c(2), describes a national survey conducted in 2000 (in 2000, the Great Lakes sugar beet growing region included Michigan and Ohio; sugar beets were last produced in Ohio in 2004), that found that 73 percent of sugarbeet farms in the Great Lakes used conventional tillage (with and without moldboard plow) (Ali, 2004) and 28 percent of the sugar beet farms used reduced or mulch tillage. In subsequent years, Michigan sugar beet farms have shown an increase in the percentage of fields that have been planted into stale seedbeds (where fields are tilled in the fall and then left untouched the following spring when planting begins), with 25 percent of Michigan's sugarbeet fields being planted into stale seedbeds, up from less than 5 percent in 2006–2007 (Lilleboe, 2011).

Table 3- 51 Sugar Beet Yields (Tons/Acre) with Various Tillage Systems

Tillage System[1]	Fargo, ND 2005	Fargo, ND 2006	Fargo, ND 2007	Prosper and Moorhead, MN 2007	3-Site Average (Fargo)	5-Site Average (Fargo, Prosper and Moorhead)
Conventional	12.9	24.0	22.1	30.0	19.7	22.3
No Till	16.6	23.4	22.1	–	20.7	–
Strip Till	15.0	23.9	22.7	29.6	20.5	22.8
Least Significant Difference (0.05)	3.2	Not significant	Not significant	Not significant	–	–

Source: (Nowatzki et al., 2008)
[1] Previous crops: Fargo- soybeans; Prosper and Moorhead- wheat.

Since 2008, when H7-1 sugar beet varieties became widely adopted, sugar beet growers in some areas, such as western North Dakota and eastern Montana, have converted to nearly 100 percent H7-1 sugar beet varieties (Stachler et al., 2009a). According to the 2000 national survey, with only conventional sugarbeet growing in the Midwest, 64 percent of sugar beet farms in the Midwest used conventional tillage, while 36 percent of the farms used reduced tillage or mulch tillage (Ali, 2004). As discussed in section III.B.1.c(2) recent studies at NDSU have found strip tillage is a viable option for sugar beet production that reduces fuel and fertilizer costs and susceptibility to wind erosion (Overstreet et al., 2009). Ridge tillage has only been used on a limited number of acres (less than 1000) in the region, and strip tillage and no tillage are rarely used (Overstreet, 2011). However, reportedly there have been changes in the amount of postemergence tillage required for H7-1 sugar beets. For example, a member of the Minn-Dak Farmers Cooperative, who farms about 1,100 acres of sugar beets annually, has found that instead of three postemergence tillage trips across the fields, with H7-1 he now needs "little to no tillage postemergence" (Mauch, 2010).

Ninety-four percent of sugar beet farms in the Great Plains used conventional tillage according to the 2000 national survey, and 0.1 to less than 5 percent of farms used reduced or mulch tillage for sugarbeet production (Ali, 2004). A 2007 study in Warland, Wyoming, comparing H7-1 sugar beet production to similar, nearby fields of conventional sugar beet production found that in crop tillage was reduced by 50 percent in the H7-1 sugar beet fields as compared to the conventional sugar beet fields (Kniss, 2010b).

Similar to the Great Plains region, according to the 2000 national survey, 96 percent of farms in the Northwest used conventional tillage for sugar beet production and 0.1 to less than 5 percent of farms used reduced or mulch tillage for sugarbeet production (Ali, 2004) (the Imperial Valley was not included in the survey as data were insufficient). Further, researchers in Idaho found that while conventional tillage was necessary for weed control with conventional beets, the practice has little to no benefit with H7 1 sugar beets (Miller and Miller, 2008).

b. Soil Compaction

Soil compaction is a form of soil degradation typically caused by heavy machinery and livestock trampling. Soils with low organic matter are particularly vulnerable. Compaction can make tillage costly, impede emergence of seedlings, and decrease water infiltration, causing higher runoff of rainwater and increasing water erosion (WRI, 1992).

Seedbed preparation and sowing operations normally lead to a considerable decrease in the depth of the plow layer.[27] The central and deeper parts of the plow layer are compacted by the wheels of the tractors, and only the shallow seedbed remains loose. In sugar beet cultivation, the number of vehicle passes used in field preparation increase compaction risk and are particular sources of concern (Cheesman, 2004). For sugar beet crops, growers employ a combination of tillage, hand labor and chemical weed control, requiring multiple passes through the field with equipment. Additional passes across the field could be required after seedbed preparation, and throughout the growing season, to apply herbicides, fungicides, insecticides, etc., or to conduct mechanical weeding, which could further compound compaction. In some instances, as indicated in section III.B, ranchers and farmers have been known to allow livestock to graze beet tops, which could lead to localized areas of compaction. Soil compaction results in increased bulk density and soil strength ((Cheesman, 2004) citing Martin 1979 and Soane et al., 1982) and decreased porosity, permeability and water infiltration rates ((Cheesman, 2004) citing Hansen 1982). Compaction can also lead to surface sealing, which reduces infiltration rates and increases runoff and can thus exacerbate erosion problems (Cheesman 2004 citing Morgan 1986, Schwertmann 1986, and Hartemink 2003).

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[27] The plow layer means soil ordinarily moved in tillage, or its equivalent in uncultivated soil, ranging in depth from about 4 to 10 inches (10 to 25 centimeters). Also designated as the 'surface layer'. (USDA NRCS, 2011c)

c. Crop Rotation
Crop rotations have been shown to have a positive impact on soil quality. Benefits include an increase in soil organic matter, higher crop yields, and soil salinity control (USDA–NRCS, 1996). Crop rotations can help minimize the impacts of certain soil-borne diseases, nematodes (parasitic, microscopic worms) and weeds (Mikkelson and Petrof, 1999); (Hirnyck et al., 2005; USDA-ERS, 2009b). Depending on the type of crop rotation and tillage operation used benefits could include a decrease in soil erosion and there could be a reduction in the amount of pesticide buildup (USDA–NRCS, 1996).

Sugar beet root crops are usually grown with other crops in 3- to 5-year rotations to improve the soil and reduce the presence of weeds, diseases, and pests (Dewar and Cooke, 2006). The length of the rotation and the type of crops that are rotated with sugar beets vary by region, and may include other glyphosate-tolerant crops, such as corn or soybeans. However, in no regions are sugar beets rotated to other beet crops such as Swiss chard or table beet. Sugar beet seed production and steckling production is carried out on a 5- to 8-year rotation with other crops (American Crystal Sugar Company, 2010). Suitable crops include cereals such as wheat, vegetable crops, and grasses (Kockelmann and Meyer, 2006; USDA-APHIS, 2011b).

d. Herbicides and Soil
Herbicide influence on soil quality and persistence in soil depend on various site-specific facts as well as the characteristics of the specific herbicide being used. In general, soil factors affecting herbicide persistence include the composition of the soil, micro-organism activity in the soil, and soil chemistry. Soil composition is a physical factor determined by the relative amounts of sand, silt, and clay in the soil, as well as by the organic-matter content. An important chemical property of soil that can influence herbicide persistence is pH. The microbial aspects of the soil environment include the types and abundance of soil micro-organisms present in the soil (Curran, 1998). Some of the more important elements of soil composition in relation to sugar beet production is discussed in the following three sections.

e. Micro-organism Contribution to Soil Quality
Soil biota play a critical role in several ecosystem processes that are essential for crop production, soil resource quality, and environmental health (Gupta and Roget, 2010). The interactions between micro-organisms and organic matter in the soil largely determine the fertility and overall quality of the soil. Some functions of soil micro-organisms in agricultural systems include (Kennedy et al., 2004):

- release plant nutrients from insoluble inorganic forms,

- decompose organic residues and release nutrients,
- produce plant growth-promoting compounds,
- transform atmospheric nitrogen into plant-available nitrogen,
- improve soil aggregation, aeration, and water infiltration, and
- help in pesticide degradation.

Management practices used in crop production affect soil micro-organisms either through direct effects on populations and activity or indirectly through the modification of the soil environment. Both can be either beneficial or detrimental to the soil biota. Agricultural practices that favor build-up of soil organic matter can lead to higher micro-organism diversity, whereas practices that involve high disturbance and reliance on chemical additives can result in limited microbial diversity or elimination of some biological groups (Kennedy et al., 2004). Management practices that can influence microbial populations and their activities include (Gupta and Roget, 2010; Kennedy et al., 2004):

- tillage practices,
- irrigation practices,
- crop rotations (both crop and variety types),
- application of fertilizers and pesticides,
- residue cover,
- cover cropping, and
- soil compaction.

Severe disturbances, such as those caused by heavy tillage, can reduce plant diversity and growth, which leads to decreased microbial growth and functioning (Kennedy et al., 2004).

Differences in farm machinery use and labor have been observed since the introduction of H7-1 sugar beets. On Minnesota and North Dakota farms growing H7-1 sugar beets, the rotary hoe or harrow was used on 15 percent of acres in 2008 compared to 25 percent in 2007, 41 percent in 2006, 56 percent in 2005, and 64 percent in 2004. This equates to a reduction of 49 percent between 2004 and 2008. However, although there was a trending decrease in use of rotary hoe or harrow leading up to use of large scale H7-1 (2008), it is difficult to conclude that there was a reduction in rotary hoe or harrow solely because of H7-1 sugar beets.

Hand weeding also has decreased with the increased use of H7-1 sugar beet varieties (Stachler et al., 2009b). (See section III.B for more details on the results of the NDSU annual survey.)

Crop rotation can improve conditions for diversity in soil micro-organisms because of variability in type and amount of organic inputs (Kennedy et al., 2004). Crop rotation enhances beneficial micro-organisms and increases microbial diversity (Kennedy et al., 2004). Studies have long shown the positive effects of crop rotation on crop growth, attributing these to changes in composition of microbial community (Kennedy et al., 2004) citing Shipton 1977, Cook 1981, and Johnson et al., 1992). In general, yields and quality are highest when sugar beets follow barley or wheat in a crop rotation. Yields are also high when sugar beets follow corn, potatoes, or summer fallow in rotation; however high levels of residual nitrogen in the soil can reduce sugar beet quality (Cattanach et al., 1991). As discussed in section III.B the pattern of wheat, barley, or corn crops preceding the sugar beet crop is relevant for both conventional sugar beets and H7-1 sugar beet plantings.

Herbicide use is a key component of modern agriculture, particularly under reduced till systems which are prone to weediness (Cattanach et al., 1991). With increased implementation of stubble retention and reduced till practices and the introduction of new herbicides, herbicide use would remain an essential practice in the near future (Gupta and Roget, 2010). Nontarget effects of herbicides on soil biological activities can cause undesirable effects on essential transformation processes (e.g., reduced nitrification and nitrogen mineralization)(Gupta and Roget, 2010).

f. Manganese in Soil

Manganese enters into the structure of at least two enzymes in sugar beets and is required by a large number of enzymes as an activator (Christenson and Draycott, 2006). Under conditions of low supply, sugar beets are most responsive to manganese, as well as boron and iron (Christenson and Draycott, 2006). Soil conditions promoting manganese deficiency are high pH and low soil moisture. In many soils, high pH is an inherent characteristic of the soil, and not a result of over-liming, so it is not always managed by adjusting the soil pH. Higher organic matter content is also associated with increased manganese deficiency. Rainfall can alter the severity of manganese deficiency within and between growing seasons; the wetter the soil, the greater the manganese availability. Therefore, manganese deficiency symptoms will often disappear during periods of high rainfall and get more severe with drought (Camberato et al., 2010).

Soil-applied manganese fertilizer is relatively ineffective at correcting manganese deficiency because it becomes unavailable soon after application. Foliar-applied manganese is the more effective method for correcting manganese deficiency. Tank mixing manganese with glyphosate is not recommended as it interacts with glyphosate in a tank mix, resulting in reduced herbicide efficacy and lower manganese availability. Another option to remedy manganese deficiency is to apply foliar manganese in a separate application 7–10 days after the glyphosate application. When sprayed alone (without glyphosate), most manganese fertilizers are equally effective. The delay in manganese application can result in yield loss (due to manganese deficiency), however, negating some of the benefit of separate manganese fertilizer and glyphosate applications (Camberato et al., 2010).

Shortly after the introduction of glyphosate-resistant soybean, questions arose whether these varieties or glyphosate applications to them alter manganese relations compared to conventional soybean varieties. It is well documented that certain cations,[28] including manganese, can reduce the performance of glyphosate when the cations are present in water used as a carrier. The complexes formed between glyphosate and metal cations are not absorbed as efficiently as free glyphosate, resulting in reduced weed control (Hartzler, 2010).

g. Nitrogen Availability in Soil

The three main nutrients typically applied to sugar beets are nitrogen, phosphate and potassium (Christenson and Draycott, 2006). However, nitrogen is the most limiting nutrient in sugar beet production, and proper nitrogen management is critical (Davis and Westfall, 2009). Several factors including, genotype, soil fertility, the availability of water, nitrogen supply, and plant population density, have been shown to influence the cell size of the sugar beet root ((Milford, 2006) citing Milford and Watson 1971). Crops that are well supplied with nitrogen tend to product larger yields of beet containing a lower concentration of sugar than crops grown with less nitrogen ((Draycott, 2006) citing Draycott and Christenson 2003). Sugar beets absorb nitrogen in a mineralized form, mainly as nitrate and partly as ammonium. This “mineral” nitrogen stems from three major sources: unstable organic matter in soil, organic manure (e.g., slurry from animal breeding or non-agricultural sources), and unused nitrogen fertilizers left from previous crops. The availability of mineral nitrogen in soil depends directly on microbial processes (Cariolle and Duval, 2006). These processes determine mineralization, which results in ammonium nitrogen production from organic matter, and ensure nitrification (transformation of ammonium nitrogen into nitrate). Micro-organisms also consume mineral nitrogen for their own use. These processes are simultaneous and balanced, depending on climate factors

[28] A “cation” is a positively charged ion. The cations used in largest amounts by plants are calcium (Ca^{++}), potassium (K^{+}), and magnesium (Mg^{++}). The ionic forms of Ca and Mg have two positive electrical charges while K has one (Rehm, 2009).

(e.g., temperature and moisture) and trophic factors (e.g., availability of carbon and nitrogen in soil (Cariolle and Duval, 2006).

Nitrogen requirements for sugar beets (both conventional and H7-1 sugar beet varieties) depend on the microbial balance responsible for mineralization and nitrification, the previous crop and fertilizer residue, and the organic supply naturally occurring in the soil. Therefore, soil characteristics alone are not sufficient to predict the nitrogen available in the soil before and after growing a sugar beet crop (Cariolle and Duval, 2006). Although most of the nitrogen taken up by sugar beets was long considered to come from fertilizer, these observations indicate that mineral fertilization provides only part of the supply, complementing that supplied by the soil (Milford, 2006). Soil amendments in the form of nitrogen fertilizer, livestock manure, and wastewater treatment plant sewage sludge are typical options for replenishment of nitrogen stores in soil. The difficulty remains to estimate the optimal soil amendment dosage: not too low risking a reduction in sugar yield, and not too high risking a decrease in sugar content and juice purity (Cariolle and Duval, 2006).

Cariolle and Duval (2006) suggest that the H7-1 sugar beet varieties are capable of both substantially higher yields and more efficient recovery and utilization of available nitrogen. To date, no conclusive studies demonstrate a significant difference between conventional sugar beets and H7-1 sugar beets in nitrogen recovery and utilization.

3. Air Quality and Climate Change

Air quality and climate change can affect public health and welfare and the natural environment. The Clean Air Act (CAA) (42 USC §7401–7671g) is the primary Federal legislation that addresses air quality. Under the authority of the CAA and its amendments, the EPA has established National Ambient Air Quality Standards (NAAQS) for six "criteria pollutants" (40 CFR part 50).[29] The criteria pollutants are carbon monoxide, nitrogen dioxide (one of several oxides of nitrogen), ozone, sulfur dioxide, particulate matter with an aerodynamic diameter equal to or less than 10 microns, and 2.5 microns (fine particles), and lead. Ozone is not emitted directly by plants or farm equipment, but is formed in the atmosphere by chemical reactions of precursor pollutants in the presence of the ultraviolet component of sunlight (U.S. EPA 2010b). Thus, potential effects of ozone are evaluated based on emissions of the precursor pollutants nitrogen oxides and volatile organic compounds (VOCs). Gases that trap heat in the atmosphere, and cause climate

[29] "Criteria pollutants" is a term used by EPA, other regulatory agencies, industry, and the public to collectively describe the six common air pollutants for which the CAA requires the EPA to set NAAQS. The EPA calls these pollutants "criteria" air pollutants because it regulates them by developing human-health based or environmentally-based criteria (science-based guidelines) for setting permissible levels (Section 108 of the CAA, 42 USC §7408).

change, are often called greenhouse gases (GHGs). The GHGs relevant to the proposed action are carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) (U.S. EPA 2010b).

Agriculture in general, including sugar beet farming, involves activities that produce emissions that can affect air quality and climate in a variety of ways. Emissions associated with sugar beet farming may have changed over time as cultivation of H7-1 sugar beets became more widespread. In order to provide perspective on these changes that may have occurred in the affected environment over time, and to support the air quality and climate impact analysis in section IV.E.3, this section discusses the emission sources associated with sugar beet farming.

Emissions associated with sugar beet farming can include criteria pollutants, VOCs, GHGs, pesticides, odors, and airborne allergens. One source of emissions is the use of tractors and other farm equipment during typical tillage, harvesting, and pesticide application. This equipment use results in fuel combustion emissions, dust, and soil compaction (Fawcett and Towery, 2002). Other potential impacts on air quality and climate can arise from traffic and harvest emissions, pesticide drift from spraying, smoke from agricultural burning, and nitrous oxide emissions from the use of nitrogen fertilizer (Fawcett and Towery, 2002), as well as odors and allergens. Agricultural practices for both conventional and GE crops have the potential to directly and indirectly affect air quality and climate change. Odors and agricultural burning would not differ between conventional and H7-1 sugar beet farming and are not assessed in this EIS. Allergens are discussed in section III.F. The remainder of this section discusses criteria pollutants, pesticide drift, and GHGs.

a. Air Quality

(1) Tillage and Particulates

Tilling and other agricultural activities (e.g., seedbed preparation, planting, and harvesting) can introduce soil particulates into the air (Holmen et al., 2006). For example, peak levels of particulate concentrations are known to coincide with the peak agricultural harvest season in California's Central Valley (Giles and Downey, 2006). Tillage contributes to the release of GHGs because carbon is lost as carbon dioxide to the atmosphere, and because soil organic matter is exposed and subsequently is oxidized (Baker et al., 2005). Emissions released from agricultural equipment used for tillage and other activities (e.g., irrigation pumps and tractors) include carbon monoxide, nitrogen oxides, particulate matter less than 2.5 micrometers in diameter and less than 10 micrometers in diameter, sulfur oxides, volatile organic compounds, and GHGs (U.S. EPA 2010b).

Conservation tillage can reduce particulates arising from soil by 85 percent (Madden et al., 2008). Dust production can be reduced by both limiting the number of passes through a field and by changing key soil properties. These changes include increasing water-holding capacity and aggregate stability, both improved by accumulation of soil organic matter typical of no-till production. Additionally, reduced tillage can potentially limit the loss of carbon dioxide to the atmosphere by preventing exposure and oxidation of soil organic matter (West and Wilfred, 2002).

As mentioned in section III.E.2, the USDA–ERS defines conservation tillage as cultural operations that maintain at least 30-percent cover of the soil surface by plant residue at the time of planting (Anderson and Magleby, 1997). Conservation tillage can encompass a range of management practices, from no till (defined by USDA–ERS as maintaining at least 67 percent cover) to ridge- and strip till cultivation to minimum tillage systems that restrict equipment traffic to dedicated zones. Special tillage field equipment can often perform the equivalent functions of several standard implements, reducing the necessity for multiple passes through the field. Implementing conservation tillage practices can lead to both economic and production quality benefits, as well as having positive environmental impacts. For further information on tillage practices for conventional and H7-1 sugar beets see section III.E.2. For additional discussion of regional variations in tillage practices see section III.E.2.a.

The amount of machinery exhaust emissions, as well as soil particulate emissions, would vary with the type of equipment used and the number of passes made across the field. The number of passes differs among tillage practices, with conservation or reduced tillage systems generally requiring fewer passes than conventional tillage systems, as discussed above.

(2) Pesticide Applications

Agricultural pesticides enter the atmosphere through volatilization from soil and plant surfaces, through drift (the movement of herbicide through the air to unintended sites), and through wind erosion. Pesticides consist of insecticides, fungicides, and herbicides. Overall, as discussed in section III.B.1, insecticide and fungicide options and applications vary regionally according to pest and disease pressure and needs, but do not appear to vary between conventional sugar beets and H7-1 sugar beets. Herbicide usage, however, does vary between conventional sugar beets and H7-1 sugar beets and accordingly the remainder of this section focuses on herbicides.

Airborne pesticides can partition between gas and particle phase, be transported through wind, and then be deposited again by rainfall or particulate settling (Vogel et al., 2008). The concentrations of pesticides in the atmosphere are highest within the treatment area and the immediate vicinity (Vogel et al., 2008). The distance traveled by airborne pesticides and their ultimate fate depends on their chemical and physical nature, method of application, and the atmospheric conditions at time of treatment.

Though volatilization of pesticide from a soil or plant surface is affected by many factors, such as surface characteristics and local meteorology, its vapor pressure provides an indicator of its propensity to enter the atmosphere (Spencer et al., 1988). Table 3–52 provides a comparison of the vapor pressures of several common pesticides. Although the herbicide glyphosate is essentially nonvolatile (Monsanto/KWS, 2010) and was not thought to be an atmospheric contaminant (Cerdeira and Duke, 2006)it has recently been reported as a contaminant of air (<0.01 to 9.1 ng/m3) and rain (from <0.1 to 2.5mg/L) (Chang et al., 2011). Section IV.E.3 contains further discussion of pesticide volatilization and air quality.

H7-1 sugar beets have been engineered to tolerate exposure to glyphosate, which is “more environmentally benign than the herbicides that it has displaced, product toxicity not withstanding” (Fernandez-Cornejo and McBride, 2002; NRC (National Research Council), 2010). As shown in table 3–19, as glyphosate usage has increased, the use has decreased of most other herbicides including clethodim, clopyralid, cycloate, desmedipham, EPTC, pyrazon, sethoxydim, trifluralin, and triflusulfuron-methyl, which are more volatile than is glyphosate. These herbicides are more volatile than is glyphosate, are applied more frequently, and are more likely to be applied with aerial applications (see section III.B.1.d). All these factors are associated with higher air contaminants both from the pesticides themselves and indirectly from the machinery exhaust resulting from more frequent application.

b. Climate Change

There is robust scientific evidence that human-induced climate change is occurring. The Intergovernmental Panel on Climate Change (IPCC)

Fourth Assessment Report states with “very high confidence” that human activities have altered the global climate (IPCC (Intergovernmental Panel on Climate Change), 2007).

Climate change affects average temperatures and temperature extremes; timing and geographical patterns of precipitation; snowmelt, runoff, evaporation, and soil moisture; the frequency of disturbances, such as drought, insect and disease outbreaks, severe storms, and forest fires; atmospheric composition and air quality; and patterns of human settlement and land use change (Backlund, 2008).

Table 3- 52 Volatility Data for Herbicides

Active Ingredient	Vapor Pressure (mm Hg at 25 ºC unless otherwise noted)	Reference
Clethodim	$<3.5 \times 10^{-7}$ at 20 ºC	(U.S. EPA 2007c)
Clopyralid	3.99×10^{-7}	(U.S. EPA 2009a)
Cycloate	6.2×10^{-3}	(U.S. EPA 2004)
Desmedipham	$>10^{-5}$	(U.S. EPA 1996b)
EPTC (S-Ethyl dipropylthiocarbamate)	2.4×10^{-2}	(U.S. EPA 1999)
Ethofumesate	5.9×10^{-8}	(U.S. EPA 2005f)
Glyphosate	9.8×10^{-8}	(NLM, 2011)
Phenmedipham	9.75×10^{-12}	(U.S. EPA 2005g)
Pyrazon	4.5×10^{-7} at 20 ºC	(NLM, 2011)
Quizalofop-p-ethyl	6.49×10^{-9} at 20 ºC	(NLM, 2011)
Sethoxydim	1.6×10^{-7}	(U.S. EPA 2005d)
Trifluralin	$>1.0 \times 10^{-5}$	(U.S. EPA 1996c)
Triflusulfuron-methyl	$<1 \times 10^{-7}$	(U.S. EPA 2002a)

(1) Agricultural Sources of GHGs

Methane (CH_4) and nitrous oxide (N_2O) are the primary GHGs emitted by agricultural activities in the United States (U.S. EPA 2010b). Agricultural activities contribute directly to emissions of GHGs through a variety of processes, including enteric fermentation in domestic livestock (CH_4), livestock manure management (CH_4), rice cultivation (CH_4), agricultural soil management such as fertilizer application (N_2O) and other cropping practices (N_2O and CO_2), and field burning of agricultural residues (CO_2) (U.S. EPA 2010b). Fossil-fuel use during farm production contributes GHG emissions (primarily CO_2) (U.S. EPA 2010b). Land use changes, either to or from agricultural lands, also affect agricultural GHG emissions (U.S. EPA 2010b). Of these potential GHG sources, fertilization, tillage practices, and fossil-fuel use (machinery exhaust) are relevant to sugar beet farming.

Fertilizer application is expected to be the largest source of N_2O emissions associated with H7-1 sugar beet farming. More than half (69–94 percent) of nitrous oxide emissions occur during two periods – immediately after application of nitrogen fertilizers and during the winter when soil water-filled pore space exceeds 90 percent (Engel et al., 2006). Nitrous oxide is produced in soils through the microbial processes of nitrification and denitrification. Several agricultural activities increase mineral nitrogen availability in soils, thereby increasing the amount available for nitrification and denitrification, and ultimately the amount of nitrous oxide emitted (U.S. EPA 2010b). These activities include fertilization, application of livestock manure and sewage sludge, production of nitrogen-fixing crops, retention of crop residues, irrigation, drainage, tillage practices, and fallowing of land (U.S. EPA 2010b). Weather and soil properties also influence nitrous oxide emissions from croplands.

(2) Climate Trends in the United States

In the United States during the 20th century, the country warmed and became wetter overall, with changes varying by region. For example, southern regions have cooled, while northern regions have warmed. Much of the eastern and southern United States now receive more precipitation than 100 years ago, while other areas, especially in the southwest United States, receive less. Heat waves have increased in frequency and duration, and there is some evidence of increased frequency of heavy rain falls (Backlund, 2008).

These trends would likely continue, with predicted temperature increases of 1 ºC (1.8 ºF) to more than 4 ºC (7.2 ºF) by 2100 (Backlund, 2008). The western and southwestern United States are likely to become drier, while the eastern United States is likely to experience increased rainfall. Heat waves are likely to be hotter, longer, and more frequent, and heavy rainfall is likely to become more frequent. Even under the most optimistic climate change scenarios, changes in regional and super-regional temperatures and precipitation patterns could have profound effects, especially on agriculture (Backlund, 2008). Impacts could include changes in crop yields, need for modification of irrigation methods, and changes in the latitudes and altitudes at which prime farmland occurs.

(3) Climate Change and Regional Sugar Beet Yield

Given the complex interactions between global climate change, increased weather variability, regional effects, and local climates, accurately predicting how sugar beet production might change as a result of climate change in a given region is difficult. The discussion below provides a general indication of how the affected environment may evolve as a result of climate change.

Thomson (2005) simulated dryland agriculture of five crops (corn, soybeans, winter wheat, alfalfa, and clover hay) in the United States under different climate change scenarios to assess potential future agricultural production. This model was considered relevant to sugar beet production because, while it doesn't include sugar beets per se, the model includes crops that are major rotation crops of sugar beet. In general, study results showed that higher temperatures reduced production and higher carbon dioxide concentrations increased production. Overall, national production of the five crops changed by ±5 percent from current levels, depending on the climate model used. Impacts were more notable regionally, with crop production varying by more than ±50 percent from baseline levels.

Analysis indicated that the regions most likely to be affected by climate change are those on the margins of the areas in which the five crops investigated in the study are currently grown (Thomson et al., 2005). Crop yield variability was found to be primarily influenced by local weather and geographic features rather than by large-scale changes in climate patterns and atmospheric composition (Thomson et al., 2005).

c. Air Quality and Climate Change Before and After Introduction of H7-1 Sugar Beets

The difference in the air quality-affected environment between the pre-H7-1 sugar beet period and the period after H7-1 sugar beet introduction is uncertain. As discussed above, some reports suggest that H7-1 sugar beets can be grown with conservation tillageor reduced tillageand with consequent savings in fuel and labor, because weeds can be effectively controlled with glyphosate applications. Use of postemergence herbicides helps to promote an increase in the practice of no-till farming, which can lead to a decrease in tractor use and to subsequent benefits in terms of reduced fuel use and emissions (Fawcett and Towery, 2002). In a study of conventional compared to H7-1 sugar beets in Idaho, H7-1 sugar beets required fewer cultivation passes, fewer herbicide applications, and less fuel, with an estimated 5.8–23.7 pounds less of carbon dioxide released per acre (Hirnyck, 2007). Emissions related to climate change, ozone depletion, summer smog, and carcinogenicity, among others, are typically lower as a result of reduced tillage (Bennett et al., 2004; Derpsch et al., 2010; Mortenson et al., 2004). Such emission reductions, if achievable, would be realized only to the extent that sugar beet growers implement and properly manage reduced tillage practices.

Scientists, however, have found little or no significant difference between soil carbon (a key factor in climate change potential) in no-till soils and conventional-till soils, depending on the soil, climate, and other factors (Angers et al., 2009; Bergstrom et al., 2001). Studies have shown that no-till soils result in elevated N_2O emissions for a variety of reasons including elevated moisture levels and soil characteristics (Linn and Doran, 1984) (Linn and Doran, 1984; MacKenzie et al., 1998; Mkhabela et al., 2008).

4. Surface and Groundwater Quality

a. Water Use and Irrigation

This section discusses effects on water resources by sugar beet production and processing. According to a USDA survey (Ali, 2004) about 40 percent of U.S. sugar beet acres are irrigated. The Great Lakes region sugar beet producers do not irrigate, and the Red River Valley sugar beet producers irrigate less than 5 percent of their crops (Ali, 2004). The Great Plains and Northwest region producers irrigate nearly 100 percent of their crops (Ali, 2004). In three States, Michigan (Great Lakes region), North Dakota (Midwest Region), and Colorado (Great Plains Region), water is derived fairly equally from surface water and groundwater (USDA-NASS, 2007). In Minnesota (Midwest Region) and Nebraska (Great Plains Region), irrigation water comes predominantly from groundwater sources (USDA-ERS, 2003). In Idaho (Northwest Region), Montana (Great Plains Region), Oregon (Northwest Region), Washington (Northwest Region), and Wyoming (Great Plains Region), irrigation water is derived predominantly from surface water sources (USDA-ERS, 2003). In the Imperial Valley region (California), approximately one-third of the irrigation water comes from groundwater and two-thirds from surface water (USDA-ERS, 2003).

Sugar beet turns out to be a very efficient user of water compared to many other crops when comparing the amount of water required to produce the digestible portion of sugar beets to other crops (Kaffka and Hills, 1994). Kaffka and Hill noted “because beets are efficient at accumulating photosynthate in a useful form, they are also efficient convertors of agricultural inputs such as water and nitrogen” (Kaffka and Hills, 1994). Morillo-Velarde and Ober (2006) found that sugar beet plants can use from 350 mm of water in temperate areas to more than 1,000 mm in arid areas, and that sugar beets consume no more or less than other common crops. Kaffka and Hills (1994) found that irrigation water requirements range from 450 mm of water per hectare per season in a cool climate where the soil is filled with plentiful winter rain, to as much as 1,400 mm per hectare in a hot, dry climate with limited winter rain; their study found that barley’s water use efficiency was about half of sugar beets. Seed production water needs are generally less than root production water needs, but this varies greatly depending on other factors such as climate and soil moisture (Morillo-Velarde and Ober, 2006). It is likely that H7-1 sugar beets have the same water requirements and efficiency levels as conventional sugar beets because the genetic alteration does not affect the water needs and efficiency of the plant.

b. Water Quality

Agriculture contributes to the presence of several types of chemicals or pollutants in water resources. These include nitrogen, phosphorus, sediment, and various pesticides that can move with surface runoff and lead to eutrophication of surface waters and other deleterious consequences. Areas of concern are groundwater and aquifers where nitrogen levels are either approaching or have exceeded the maximum contaminant level (10 mg per L) (Klocke et al., 1999) defined under the Federal Safe Drinking Water Act of 1974. In areas, such as Nebraska, where soybean and corn are grown in rotation and where groundwater is a principal source of water for human consumption, this can be a critical issue. In other areas, surface water movement of contaminants is of concern, and agricultural tile drainage systems have been shown to be a source of nitrate entering streams and rivers (Randall and Mulla, 2001). In areas where water retention in fields is high, periodically impeding crop production, such subsurface drainage systems are commonly used (Hoeft et al., 2000a; Hoeft et al., 2000b). Because sugar beets are often grown as part of a crop rotation plan, identifying water quality impacts directly related to sugar beet production is difficult (Cheesman, 2004).

Rain and irrigation water percolate down through the soil into groundwater, and in turn, the groundwater level can affect soil moisture and thus sugar beet growth and health. Herbicides used on sugar beets have varying chemical fates, with glyphosate and its primary degradation product aminomethyl phosphonic acid (AMPA) generally being less persistent and characterized by lower mobility in soils. Herbicides can enter surface waters through two routes during sugar beet application – directly from spray drift and indirectly from surface runoff. Due to the strong adsorptive characteristics of glyphosate and AMPA, leaching of these chemicals is more limited compared to other herbicides, and they are much less likely to leach to groundwater from the soil (Cerdeira and Duke, 2006). (For more information on herbicides and water infiltration and runoff, see section III.E.4.d below.)

Adequate soil fertility is one of the requirements for profitable sugar beet production (Davis and Westfall, 2009). Selection of fertilizer type and application is done according to soil analysis, taking into account the preceding crop and regional experiences in production (Cariolle and Duval, 2006). Sugar beet seed crops require 125–150 percent of the fertilizer nutrients that root crops require (Desai, 2004). Generally, two applications of fertilizer are made during production of sugar beet seed crops to maximize net sucrose. Sugar beet growers are encouraged to have sufficient soil nitrogen to attain maximal sugar content, with premiums paid for crops with higher than average sugar content (Michigan Sugar Company, 2010a, 2010b). However, as presented in section III.E.2., excessive nitrogen can injure beets, reduce sugar content, and juice purity. Previous crops can also affect the total amount of nitrogen that should be applied to the new beet crop (Michigan Sugar Company, 2010a, 2010b). Methods of reducing pollution from fertilizer applications during sugar beet production include cultivation of intermediate crops and reducing amounts of fertilizer applications (Cariolle and Duval, 2006). Intermediate crops act as nitrogen traps by absorbing mineral nitrogen present in soil and locking it up in the vegetation produced; therefore, providing a long term sustainable reduction of nitrogen fertilizers (Cariolle and Duval, 2006).

Sugar beet processing facilities produce wastewater that is used for irrigation or discharged to land or surface waters (Cheesman, 2004). Effluent from the sugar beet processing facilities tends to be largely organic and consist of soils and sugar beet solid waste (Cheesman, 2004), which is removed in settling ponds prior to discharge. Sugar beet processing facilities consume fresh water to rinse the excess dirt from sugar beets but this water is often recycled and used for other purposes (such as cooling towers and spray ponds), reducing the overall amount of effluent wastewater (Cheesman, 2004). Any processing facility wastewater discharged to a surface water would be required to meet the Clean Water Act water quality standards outlined in the facility's National Pollutant Discharge Elimination System (NPDES) permit. There is no difference in the processing methods for conventional sugar beets and H7-1 sugar beets.

c. Tillage and Water Infiltration and Runoff

The amount and type of tillage necessary for successful sugar beet seed and root production vary greatly and highly depend on several factors, including previous crops present in the rotation, soil type, climate, and amount of weed infestation present (Häkansson et al., 2006). See section III.E.2.a above for more information on tillage practices for sugar beets. Use of conservation tillage compared to use of conventional tillage in many soils could allow 10 to 40 percent greater water infiltration into soils (Hoeft et al., 2000a; Hoeft et al., 2000b). Crop residues established by conservation tillage on soil surfaces slow water runoff, increase porosity by increasing numbers of wormholes and by means of remnants of crop residue, and reduce evaporation through the insulating ability of surface mulches. Conservation and strip till techniques also reduce soil erosion by 90 percent on highly erodible lands (Zhou et al., 2009), and no till can reduce runoff volume 35-fold compared to conventional tillage (Gregory et al., 2005).

d. Herbicides and Water Infiltration and Runoff

Three herbicide characteristics are important in determining the potential for an herbicide to leach into groundwater or move with surface runoff after application. These characteristics include: (1) solubility in water (water solubility), (2) tendency to adsorb to the soil (soil adsorption), and (3) herbicide persistence in the environment (half-life). Water solubility is a measure of how easily a chemical dissolves in water. The lower a chemical's solubility, the less likely the chemical would move with water through the soil. Soil adsorption is the tendency for an herbicide to attach to soil particles, and is measured by the adsorption coefficient (K_{oc}). High K_{oc} values indicate a very strong tendency for an herbicide to attach to soil and, therefore, is less likely to move unless soil erosion occurs. An herbicide's half-life is a measure of persistence; it is the time (in days) it takes for an herbicide to degrade in soils to 50 percent of its original amount. In general, the higher the half-life of an herbicide, the higher potential for movement in the environment.

Several factors can influence the fate and transport of an herbicide, such as the characteristics of the soil that the herbicide is sprayed on, the slope of the land, rain, and irrigation volumes. Steeper sloped land would increase the potential for transporting herbicides, and increased rain or over-irrigation can increase the movement of herbicides.

No one factor—adsorption, water solubility, or persistence—can be used to predict herbicide behavior, and it is the interaction of these factors and their interaction with the particular soil type and environmental conditions that determines herbicide behavior in the field (Wright et al., 1996). Because sugar beets are grown in five different regions in the United States over vast areas, the characteristics of soil may vary greatly from field to field. However, an herbicide's adsorption, water solubility, and persistence characteristics provide relative risk estimates, and allow for some general comparisons between various herbicide products. The USDA–NRCS has developed a pesticide environmental risk screening tool (WIN-PST) to evaluate the potential of pesticides to move with water and eroded soil/organic matter, and potential to affect non-targeted organisms. Part of the database that NRCS has compiled for WIN-PST includes creating algorithms that provide a rating of potential risks from herbicide leaching, herbicide surface runoff potential, and herbicide adsorbed runoff potential, which is summarized in table 3–53 for the 13 common sugar beet herbicides. The algorithms use each herbicide's half-life, solubility, and K_{oc} values to determine a rating for each herbicide.

. **Table 3- 53 USDA–NRCS WIN–PST Data and Results for Common Sugar Beet Applied Herbicides**

Herbicide	Solubility in Water (ppm)	Half Life (Days)	K_{oc} (mL/g)	Herbicide Leaching Potential[1,4]	Herbicide Solution Runoff Potential[2]	Herbicide Adsorbed Runoff Potential[3]
Clethodim	5,400	3	10	Low	Intermediate	Low
Clopyralid	1,000	30	2	High	Intermediate	Low
Cycloate	95	30	430	Intermediate	High	Low
Desmedipham	8	30	1,500	Low	Intermediate	Intermediate
EPTC	344	6	200	Low	Intermediate	Low
Ethofumesate	50	30	340	Intermediate	High	Low
Glyphosate,	900,000	47	24,000	Very Low	High	High
Phenmedipham + Desmedipham[5]	4.7	30	2,400	Low	Intermediate	Intermediate
Pyrazon	400	21	120	Intermediate	Intermediate	Low
Quizalofop-p-ethyl	0.31	216	510	High	Intermediate	High
Sethoxydim	4,390	5	100	Low	Intermediate	Low
Trifluralin	0.3	60	8,000	Low	Intermediate	High
Triflusulfuron-methyl	110	6	59	Low	Intermediate	Low

Source: (USDA-NRCS, 2011c)

Note: Based on the following herbicide inputs - Application Method – Surface applied; Application Area – Broadcast (applied to more than half of the field); Application Rate – Standard (a label rate greater than ¼ lb active ingredient per acre).

[1] Pesticide leaching potential indicates the tendency of a pesticide to move in solution with water and leach below the root zone. A low rating indicates a minimal movement.

[2] Pesticide solution runoff potential indicates the tendency of a pesticide to move in surface runoff in the solution phase. A high rating indicates the greatest potential for pesticide loss in solution runoff.

[3] Pesticide adsorbed runoff potential indicates the tendency of a pesticide to move in surface runoff attached to soil particles. A low rating indicates minimal potential for pesticide movement adsorbed to sediment.

[4] WIN-PST ranking range: Very Low, Low, Intermediate, High, and Extra High.

[5] Data are for phenmedipham only as desmedipham is already reported in the table.

Based on a study by Ali (2004), herbicides are used by virtually all sugar beet growers. In 2000 approximately 98 percent of planted acres received one or more herbicide applications (Ali, 2004). Prior to adoption of H7-1 sugar beets, growers regularly used multiple chemical herbicides to control weeds in conventional sugar beet fields (Kniss, 2010b; Wilson, 2010) In the post-widespread H7-1 sugar beet planting period after 2008, glyphosate was the main herbicide used on most sugar beet crops (Stachler et al., 2011). Glyphosate has a high K_{oc} value, relative to other herbicides, and adsorbs tightly to soil particles, which gives it a very low potential for leaching into groundwater (see table 3–53). Compared to other commonly used sugar beet herbicides, glyphosate has the highest K_{oc} value and the lowest potential for leaching into groundwater (see table 3–53). However, glyphosate has a high potential to move in surface water runoff during the solution phase and when attached to soil particles (see table 3–53), which could lead to glyphosate reaching and contaminating surface waters. Coupe et. al. (2011) estimate that about 1% of the glyphosate applied moves into surface water. Maximum glyphosate concentrations measured in surface water ranged from 1-430 μg/L depending on how much glyphosate was being applied locally and the time between application and rainfall.

Compared to other commonly used sugar beet herbicides, glyphosate has a higher potential than most sugar beet herbicides to move in runoff either in solution or adsorbed to soil (see table 3–53). But because of glyphosate's physical characteristics, soil and sediments of bodies of water are the main sinks for glyphosate residues from surface water, greatly reducing further transport (Cerdeira and Duke, 2006 citing Franz et al., 1997 and Goldsborough and Brown, 1993).

Once in surface water, glyphosate dissipates more rapidly than most other herbicides, and various studies have shown that glyphosate appears in surface water less than several alternative herbicides (Cerdeira and Duke 2006 citing Carpenter et al., 2002). Glyphosate is not readily broken down by water or sunlight (U.S. EPA 1993a), but micro-organisms (in soil, sediment, or natural water) degrade glyphosate quickly to the major metabolite AMPA, which is further degraded although at a slower rate than the parent glyphosate (U.S. EPA 1993a, 2006c). In a U.S. Geological Survey (USGS) monitoring study of surface water, groundwater, and soil conducted from 2001–2006, the metabolite AMPA was observed more frequently than the parent compound glyphosate and glyphosate and its metabolite AMPA were found in surface water more frequently than in groundwater (Scribner et al., 2007). About half of glyphosate use at the time was from agriculture (primarily soy beans and corn) and half from home gardening and other use.

F. Human Health and Safety

The areas of human health and safety described in this section are those potentially affected by the alternatives analyzed in chapter IV. These areas include all known aspects of direct and indirect human contact with sugar beets. People directly ingest the products of sugar beets in the form of sugar, food additives, and dietary supplements. In addition, people may inhale sugar beet pollen, usually on or near farms. People consume meat, dairy, and other products derived from livestock that are fed sugar beet pulp. Additionally, fungicides, insecticides, and herbicides are used on some sugar beets, which in turn can result in exposure to these substances. Within the context of H7-1 sugar beets and GE crops more broadly, people in the United States have been eating and otherwise coming into contact with GE crops since 1996, when herbicide-tolerant soybeans and other crops first became commercially available (Fernandez-Cornejo and Schimmelpfennig, 2004).

This section is organized by public health and safety (section III.F.1) and worker health and safety (section III.F.2). Sections III.F.1 and III.F.2 each include two main subsections: (1) sugar beets and related products, and (2) pesticides.

1. Public Health and Safety

Sugar beets are used for food, feed, and various other products to which people are exposed. One component of the affected environment is the direct human consumption of products derived from sugar beets, such as sugar and food additives, as described below. This section also addresses exposure to pesticides used on sugar beets.

a. Sugar Beets and Related Products

Regulatory and other controls on the safety of direct human consumption of sugar beets and related products are provided by the Food and Drug Administration (FDA) and EPA, as described below. This section also describes sugar beet products that people are exposed to, products that are genetically related to sugar beets, the composition of sugar beets, and the potential allergenicity and toxicity of sugar beet components.

(1) Regulatory Oversight

As described in section I.E, regulatory oversight of H7-1 sugar beets is provided by three Federal agencies – APHIS, FDA, and EPA. APHIS' role is described in detail in section I.E, but the roles of FDA and EPA warrant additional discussion in this section due to the focus of these agencies on human health.

FDA is the lead U.S. regulatory agency for oversight of plant-derived food and feed, including those developed from GE crops. FDA has authority to regulate food under the Federal Food, Drug, and Cosmetic Act (FFDCA) and the Public Health Service Act. Under FFDCA, it is the responsibility of food and feed manufacturers to ensure that the products they market are safe and properly labeled. In addition, any food additives, including those introduced into food or feed by way of plant breeding, must receive FDA approval before marketing. The term "food additive" includes substances, the intended use of which results in their becoming components of food. By definition, food additives do not include pesticides or substances that are generally recognized as safe under the conditions of their intended use. In general, when an intended expression product present in food is one that is already present at generally comparable or greater levels in currently consumed foods, there is unlikely to be a safety question that would call into question the presumed GRAS status of the naturally occurring substance. Likewise, minor variations in molecular structure that do not affect safety would not ordinarily affect the GRAS status of the substance and, thus, would not ordinarily require regulation of the substance as a food additive (U.S. FDA, 1992)

To help developers of foods and feeds derived from GE plants comply with their obligation to market safe food in accordance with FDA statutory and regulatory requirements, FDA encourages developers to participate in a voluntary FDA consultation process prior to commercialization.[30] In that process, developers submit data and information to FDA that provide the basis to support a conclusion that a food from a GE crop complies with FDA statutory and regulatory requirements. A consultation for H7-1 sugar beets has been completed (U.S. FDA, 2004), as described below in section III.F.1.a(5). FDA's approach to the regulation of foods derived from crops such as H7-1 sugar beet is described in the FDA policy statement concerning regulation of products derived from new plant varieties, including those varieties that have been genetically engineered, U.S. FDA, 1992).

Under FIFRA, EPA regulates the pesticides applied to GE crops, such as H7-1 sugar beets. Before a pesticide can be used on an herbicide-tolerant crop (or any crop other than those currently approved), the pesticide manufacturer must seek a label change for that pesticide. The label describes how the herbicide can be applied to the herbicide-resistant crop and any restrictions on the use of the herbicide. Growers of the herbicide-resistant crop must follow the EPA label when applying the registered herbicide to the crop. Under FFDCA, EPA sets tolerances for pesticide residues. Tolerances are the legal limit for a pesticide chemical residue in or on a food. Tolerances are set such that there is a reasonable certainty that no harm would result from aggregate exposure to the pesticide chemical residue, including all anticipated dietary exposures and all other

[30] FDA also provides guidance for the early food safety evaluation of new non-pesticidal proteins produced by new plant varieties intended for food use (U.S. FDA, 2006).

exposures for which there is reliable information. Section III.F.1.b provides additional detail about tolerances for sugar beets.

(2) Sugar Beet Products

Direct human ingestion of sugar beet product occurs primarily via white sugar, which is produced through a refinement process that is described further below. Sugar beets account for approximately 55 percent of total sugar produced in the United States, or about 4.6 million tons per year (USDA ERS, 2009a (USDA FSA (Farm Services Agency), 2010). Sugar from sugar beets, that is, "sugar obtained by crystallization from…sugar beet juice that has been extracted by pressing or diffusion, then clarified and evaporated," is GRAS, for the purposes and under the conditions prescribed (21 CFR § 184.1854). According to the National Health and Nutrition Examination Survey (NHANES) and using the Foods Analysis and Residue Evaluation (FARE) software, the average American consumes 16.7 grams of beet sugar daily (Monsanto/KWS, 2010).

During 2010, approximately 40,000 tons of sugar beets are reported to have been used for domestic food consumption via non-sugar food items (USDA FSA (Farm Services Agency), 2010). Human ingestion of sugar beets occurs via a variety of products, including food additives, baker's yeast, and pharmaceuticals. Sugar beet pulp is a key source for these products. It also has been used in recent years as a dietary fiber mainly marketed under the trade names Fibrex and Atlantis (Cho and Dreher, 2001). These products are generally reported to contain one third water-soluble fiber and two-thirds water-insoluble fiber (Cho and Dreher, 2001) and are reported to have shown general health benefits ((Langkilde et al., 1993) citing Hagander et al., 1988, 1989, Israelsson et al., 1988, Lampe et al., 1991, Tredger et al., 1991).

One of the principal non-sugar substances in sugar beet molasses is betaine, which is marketed as a pro-vitamin in the food, animal feed, and pharmaceutical industries (Dutton and Huijbregts, 2006). Betaine has been of interest for its role in osmoregulation (NCBI (National Center for Biotechnology Information), 2011). As a drug, betaine hydrochloride has been used as a source of hydrochloric acid in the treatment of hypochlorhydria. Betaine has also been used in the treatment of liver disorders, for hyperkalemia, for homocystinuria, and for gastrointestinal disturbances. Other sugar beet-derived products include citric acid and MSG, which are obtained from fermentation of sugar beet molasses. Citric acid, a common food additive used as a preservative and flavor enhancer, is commercially produced during the fermentation of sugar beet molasses by the mold *Aspergillus niger* (Ronzio, 2003). MSG, a widely used flavor enhancer, is also produced via industrial fermentation of sugar beet molasses (Davidson and Jaine, 2006). Although beet molasses is typically used in combination with cane molasses in these fermentation processes, beet molasses is generally preferred as it has lower ash content, which reduces the waste matter flow (FSANZ (Food Standards Australia New Zealand), 2010; Harland et al., 2006). Sugar beet molasses is also used in the production of baker's yeast and in certain chemicals and pharmaceuticals (CFIA, 2002); (SMBSC (Southern Minnesota Beet Sugar Cooperative), 2010a).

Humans consume meat and dairy from livestock that consume feed derived from sugar beet molasses, sugar beet pulp, or sugar beet leaves. Despite its suitability as feedstuff for a variety of animals, sugar beet-derived feed makes up only a small percentage of total animal feed consumed in the United States. Section III.C.1.a provides a description of livestock exposure to sugar beet products.

(3) Other Crops

Given the possibility of gene flow from sugar beets to related crops, the affected environment also includes direct and indirect consumption of Swiss chard, table beets, and fodder beets. These crops are discussed in sections III.B.2, III.B.3, and III.B.4, respectively. Swiss chard, a leafy plant, is grown for food and generally sold in fresh markets. In 2001, organic Swiss chard was grown on a total of 33 acres certified for organic production, with 100 percent of the harvest sold at a fresh market (Walz, 2004). Detailed information on non-organic certified Swiss chard production is unavailable, but one estimate is that upwards of 12,500 acres are planted in the United States (based on data from WSCPR, 2006, which states that Washington has <250 acres and that this represents <2 percent of U.S. acreage). Table beets are typically grown for their leaves and roots, and are prepared for consumption in a variety of ways. Although the leaves are typically steamed or stir-fried, table beet roots can be steamed, roasted, boiled, pickled, and eaten warm or cold as a condiment or salad. As described in section III.B.3, approximately 7,000 acres of table beets are planted in the United States, most of which grown for canning (Nolte, 2010). For comparison, nationwide data on sugar beets indicate that in 2010 approximately 1.2 million acres of sugar beets were planted(USDA-ERS, 2010b). Fodder beets, as their name suggests, are typically grown for use as livestock feed. Fodder beet (also called mangel) leaves and roots can be consumed by humans, although little information could be found regarding human consumption in the United States.

(4) Composition of Sugar Beets and Products

The nutritional composition of conventional sugar beets, including their pulp and molasses byproducts, has historically made them attractive for human and animal consumption. As noted in section III.B.1.a, sugar beet roots typically contain 75.9 percent water, 2.6 percent non-sugars, 18.0

percent sugar, and 5.5 percent pulp (CFIA, 2002). Sugar beet tops generally contain 16–18 percent dry matter (sugar beet solids, excluding water) and are good sources of protein, vitamin A, and carbohydrates (Harland et al., 2006). Sugar beets are rarely consumed in their raw state and are commonly processed into white sugar, pulp, molasses, and other products.

Sugar beet pulp is rich in digestible fiber and energy, which is primarily derived from the structural carbohydrates of the beet root (Harland et al., 2006). Dietary fiber in roots comes exclusively from its cell walls and does not contain resistant starch or other polysaccharides (Cho and Dreher, 2001). Sugar beet root fiber is not mature and thus not extensively lignified; it contains one-third pectin, one-third hemicellulose, and one-third cellulose (Harland et al., 2006). Sugar beet fiber is highly digestible, with a high hydration capacity and a high proportion of soluble dietary fiber (Cho and Dreher, 2001).

Molasses derived from sugar beets is high in energy, with a protein digestibility of around 77 percent and a dry matter digestibility of around 90 percent (Harland et al., 2006). The main component of sugar beet molasses dry matter is sugar, at approximately 50 percent as sold (Harland et al., 2006). Beet molasses can be well utilized by ruminant livestock, with a nitrogenous composition falling into three main categories: betaine (27 percent), amino acids (33 percent), and uncharacterized (35 percent). Small quantities of reducing sugars, raffinose, and ash are also present (Harland et al., 2006). Sugar beet molasses is high in the nutrients potassium and sodium, but low in vitamins (Harland et al., 2006).

The composition of the hybrid lines containing H7-1 produced through conventional breeding was compared by the petitioner to the composition of the corresponding conventional sugar beet control (Schneider and Strittmatter, 2003). The composition of food from GE plants is examined to assess whether there have been any unintended changes in the composition of the food that are important to nutrition or safety. These analyses included proximate analysis (crude ash, crude fiber, crude fat, crude protein, and dry matter), carbohydrates, quality parameters, saponins (naturally-occurring “anti-nutrients” that have a bitter taste and can act as a deterrent to foraging), and 18 amino acids. Quality parameters measured in root samples included percent sucrose, invert sugar, sodium, potassium, and alpha-amino nitrogen. All analyses were conducted as a single analysis for the root (brei) and top (leaf) samples collected as three replicate samples from each of five field trials sited. Fifty-five statistical comparisons were made with the control line, of which seven were found to be statistically different ($p < 0.05$). Six of these differences were due to amino acid levels in the sugar beet tops (alanine, histadine, phenylalanine, and tyrosine) and roots (alanine and glutamic acid) and one was due to dry matter mean level in top tissue. Based on the statistical methods, three of these seven would have been expected based on chance. In all seven cases, the ranges for the statistically different components in H7-1 significantly overlapped or fell completely within the range of values observed for the control, the conventional reference varieties, and for available published values from conventional sugar beet varieties.

(5) Allergenicity, Toxicity, and Related Hazards

Substances that are foreign to the human body, such as plant proteins, can elicit allergic or toxic responses ranging from mild irritation to death. These substances are found in many sources. Allergens can be found in or on animal hair, pollen, insects, dust mites, plants, pharmaceuticals, and food. Some allergens are simply storage proteins (reserves of metal ions and amino acids) that are harmless to most people but elicit an immune response in others. Toxins, however, cause an adverse health effect in most people when intake exceeds a toxin-specific threshold level. Toxins often accumulate in plants as defense compounds against pests or pathogens.

According to some estimates, humans might be exposed to hundreds of thousands of food proteins with antigenic and possibly allergenic potential (Taylor and Hefle, 2001). Characteristics of the primary structure of many of these substances have been entered into databases that can be searched for matches to substances for which allergenicity and toxicity are unknown (Metcalfe et al., 1996; Metcalfe et al., 2003). while most plant allergens come primarily from pollen and are classified as environmental (Luoto et al., 2008).

Allergic rhinitis, or hay fever, while relatively mild in terms of effects, causes respiratory and other morbidities in more than 10 percent of the U.S. population (CDC (Center for Disease Control and Prevention), 2009). Anaphylaxis, a much more serious allergic reaction, includes food-induced reactions that have been estimated to cause 150 to 200 deaths annually in the United States (Sampson, 2003). Food allergies as a group are more prevalent in children than adults, affecting approximately 4 percent of U.S. children under 18 years of age (CDC (Center for Disease Control and Prevention), 2009). From 1997 to 2007, the prevalence of reported food allergies in this group increased 18 percent.

It has been reported that two allergenic proteins, Beta v 1 and Beta v 2, have been identified in pollen from conventional sugar beets (Luoto et al., 2008). Sugar beet seed has been reported to induce allergy symptoms in sensitized individuals, although predominantly in occupational settings such as the animal feed industry, farms, and greenhouses (Steinman, 2008).

Sugar beets contain several substances that could be considered anti-nutrients, including oxalic acid and saponin (Duke, 1983). Saponins are actively eliminated in sugar processing. Saponins may cause feed intake to be reduced due to the bitter taste imparted by these compounds.

The primary product, sugar, is extracted during processes that result in purity levels of >99.9 percent (Dutton and Huijbregts, 2006; Potter and Mansell, 1992). Older studies have found that a small quantity of impurities trapped within the sugar's crystal lattice might have led to allergic responses in some people (Potter and Mansell, 1992; Richter et al., 1976). It is unclear whether these impurities were due to the sugar beets or the refining process, and whether processes today would result in this same level of impurity. More recent studies have reached mixed conclusions regarding the extent and identity of these beet sugar impurities (Klein et al., 1998; Oguchi et al., 2009; Parpinello et al., 2004; Potter et al., 1990).

Most sugar beets being grown in the United States in recent years are the GE variety designated as H7-1 sugar beets. H7-1 sugar beets were designed to be resistant to the herbicide glyphosate by the insertion of non-native genes through a well-established *Agrobacterium*-mediated process (Schneider and Strittmatter, 2003). The genes consist of a promoter sequence (35S of figwort mosaic virus), chloroplast targeting sequence (*ctp2*; from *Arabidopsis thaliana*), *cp4 epsps* coding sequence (from *Agrobacterium* sp. strain CP4), and terminator sequence (E9 3'). The intended purpose of the genetic modification is to develop a sugar beet variety that produces the CP4 EPSPS protein. There are variations in the amino acid sequences of EPSPS among different plants and bacteria. The EPSPS from *Agrobacterium* sp. strain CP4 is just one variant of EPSPS. In conventional plants, including sugar beets, endogenous EPSPS (without the modification due to CP4) regulates the synthesis of aromatic amino acids, such as tyrosine. Applied glyphosate binds to EPSPS and causes plant death by inhibiting EPSPS function. The CP4 EPSPS protein, however, is not inhibited in the presence of glyphosate and thus it continues to regulate the synthesis of aromatic amino acids. Mammals do not possess EPSPS proteins or make their own aromatic amino acids, but rather obtain these amino acids from the foods they consume.

In 1999, H7-1 sugar beet field trials were conducted at six distinct field locations distributed across Europe in the major sugar beet production areas. Samples of brei (root tissue processed using standard sugar beet industry methods) and top (leaf) tissues were collected and analyzed for levels of the CP4 EPSPS protein. On average across the sites, concentrations of the CP4 EPSPS protein on a fresh weight basis were found to be 181 µg per g (ranging from 145 to 202 µg per g) in root tissue and 161 µg per g (ranging from 112 to 201 µg per g) in leaf tissue (Schneider and Strittmatter, 2003). The differences in these ranges likely are not meaningful. For example, the range noted above for the root CP4 EPSPS protein spans 31 percent of the average, which is less than the range of crude protein obtained from controls (51 percent) and reference varieties (38 percent) reported by the petitioner (Schneider and Strittmatter, 2003). Also, APHIS notes that these ranges are similar to the ranges of the CP4 EPSPS protein in other crops expressing this protein (CERA (Center for Environmental Risk Assessment) and ILSI (International Life Sciences Institute) Research Foundation, 2010).

As noted above, sugar beets are farmed mostly for extraction of their sugar (sucrose) content, and most people consume some quantity of beet sugar. Refined sugar is more than 99.9 percent sucrose (Dutton and Huijbregts, 2006; Potter and Mansell, 1992). The crystalline structure of sucrose is identical regardless of plant source (conventional or GE, sugar beets or cane). Other sugars, minerals, and proteins have been known to be in refined sugar for some time (Parpinello et al., 2004) Klein et al., 1998; (Lew, 1972; Potter et al., 1990; Potter and Mansell, 1992). The refining process, however, removes these products to trace levels. According to one estimate, protein content in refined sugar is reduced by a minimum factor of 1.7×10^5 (ANZFA (Australia New Zealand Food Authority), 2001). Thus, while human exposure to (i.e., consumption of) protein gene products via both conventional and H7-1 sugar beets is conceivable, the high purity of the processed beet sugar indicates this exposure is negligible, especially compared to direct ingestion of sugar beet fiber and other products. Furthermore, as discussed in section III.F.1.a(1), FDA generally would consider such proteins, present at generally comparable or greater levels in currently consumed foods that are commonly and safely consumed in the diet, to be presumptively GRAS (Brackett, 2005). FDA has long held that "minor variations in molecular structure that do not affect safety would not ordinarily affect the GRAS status of the substances and, thus, would not ordinarily require regulation of the substance as a food additive (57 FR 22984 at 22990, May 29, 1992)." The modification of the *epsps* protein is such a minor variation in molecular structure.

Recently, assays have been developed to attempt to detect sugar beet genes in beet sugar, for purposes of identifying the source of the sugar and for labeling (Oguchi et al., 2009). While genetic material in refined sugar might be theoretically possible, the extraction and purification steps of the standard sugar production process are very efficient in removal of nucleic acids, and thus refined sugar does not appear to contain functional DNA (Klein et al., 1998; Oguchi et al., 2009). Japanese scientists, while trying to decide whether mandatory GE labeling would be applicable to sugar products imported to Japan, were unable to detect any DNA in processed sugar products using highly sensitive detection methods –PCR amplification designed to detect as few as five copies of the target DNA (Oguchi et al., 2009). Their studies indicated that sugar beet DNA is degraded early in the sugar purification process. Based on these findings, the Japanese government has determined that sugar does not contain sufficient amounts and/or quality of DNA to warrant labeling.

FDA considers transferred genetic material (nucleic acids) to be presumptively GRAS, and therefore, does not anticipate that such material would itself be subject to food additive regulation (57 FR 22984 at 22990, May 29, 1992). Thus, engineered DNA such as *cp4 epsps* would not ordinarily require regulation of the substance as a food additive. Humans have always consumed large amounts of DNA as a normal component of food and there is no evidence that this consumption has had any adverse effect on human health. H7-1 DNA is chemically no different than other DNA (non-recombinant DNA) found in food. The genetic engineering resulted in the insertion of DNA sequences but left the basic chemical structure unchanged.

Nonsugar products, such as fiber and other substances used in food from beet pulp and molasses, undergo much less processing or are the byproducts of sugar refining. These non-sugar products might contain sugar beet DNA and protein. Animals, but rarely are humans exposed to the fiber, pulp, or molasses directly through ingestion (U.S. FDA, 2004). The ingestion of CP4 EPSPS proteinby humans , was addressed as part of the FDA consultation (U.S. FDA, 2004), the USDA–APHIS EA (USDA–AHPIS, 2011c, section E.4), and the petitioner Environmental Report ((Monsanto/KWS, 2010), section 3.11.2) described previously. The following observations can be made based on the available data:

- The CP4 EPSPS protein expressed in H7-1 and other glyphosate-tolerant crops is equivalent to CP4 EPSPS protein expressed in *E. coli* and other glyphosate-tolerant (GT) crops based on molecular weight and by recognition by CP4 EPSPS-specific antibodies to CP4 EPSPS proteins in *E. coli*.

- Except for its reduced affinity for glyphosate, the CP4 EPSPS protein is equivalent to the family of EPSPS proteins that naturally occur in crops.

- No treatment-related adverse effects were observed in an acute toxicity test in which mice were gavaged (orally dosed) with up to 572 mg of CP4 EPSPS per kg of body weight, which would be equivalent to a human ingesting about 221 kg of beet root at one time (assuming a 70-kg adult and the 181-µg per g average noted above for CP4 EPSPS protein in root tissue). The study was designed to reflect a 1,000-fold factor of safety on the highest possible human exposure to CP4 EPSPS, based on assumed exposures to soybean, potato, tomato, and corn at the time the study was done (Harrison et al., 1996). (Note that the 572-mg per kg body weight high-end dose for CP4 EPSPS is the measured dose, as determined by ELISA [enzyme-linkedimmunosorbent serologic assay], while the 400-mg per kg body weight high-end dose noted in the EA (USDA-APHIS, 2011c) and Environmental Report (Monsanto/KWS, 2010) is the initial target dose. Also, these sources note that the daily CP4 EPSPS content in the maximum mouse exposure was equivalent to the amount in approximately 160 pounds [73 kg] of H7-1 sugar beets, which could not be independently verified and is about 32 percent of the 221 kg calculated above.)

- The CP4 EPSPS protein does not have biologically relevant amino acid sequence similarities to protein toxins known to cause adverse health effects in humans or animals, based on a comparison of the amino acid sequence of CP4 EPSPS to protein sequences in the ALLPEPTIDES database using the FASTA algorithm (Monsanto/KWS, 2010).

- There are no known reports of allergies or significant pathogenicities to *Agrobacterium* sp., the soil bacterium used as the source of the CP4 EPSPS coding sequence for H7-1 sugar beets and other glyphosate resistant plant lines (Swiss Institute of Bioinformatics, 2011). This bacterium has been known to infect people, but generally only locally (e.g., in tissues surrounding catheters) in immunocompromised patients, as with many other common bacteria (Van Baarlen et al., 2007).

- There is an absence of immunologically relevant amino acid sequence homology between CP4 EPSPS and known allergens, as determined by comparison using the FASTA algorithm of the amino acid sequence of the CP4 EPSPS to sequences in the ALLERGEN3 database (Monsanto/KWS, 2010) (Hileman et al., 2002), and as confirmed by APHIS using an updated FASTA database (FARRP (Food Allergy Research and Resource Program).

- The CP4 EPSPS protein is rapidly degraded in simulated gastric and intestingal fluids. In the first study, the CP4 EPSPS protein was exposed to simulated gastric and intestinal fluids (Harrison et al., 1996). The half-life of the CP4 EPSPS protein was reported to be less than 15 seconds in the gastric fluid, greatly minimizing any potential for the protein to be absorbed in the intestine. The half-life was less than 10 minutes in the simulated intestinal fluid. The second study, conducted under different experimental conditions, reported similar results, as noted in the FDA consultation (U.S. FDA, 2004).

Additionally, no adverse effects of CP4 EPSPS protein or gene consumption on the nutritional characteristics of dairy cattle, livestock, or poultry have been reported (Combs and Hartnell, 2007). EPA's review of the *cp4 epsps* gene and CP4 EPSPS protein as inert ingredients for a plant-incorporated protectant (PIP), pursuant to section 408(d) of FFDCA in a rulemaking unrelated to H7-1 (but informative nonetheless regarding the risk of H7-1 sugar beets), concluded that both the gene and protein present a low probability of risk to human health and thus warranted an exemption from the requirement for a pesticide tolerance in or on all raw agricultural commodities (40 CFR § 180.1174 and (U.S.EPA, 2005). The CFIA approved H7-1 sugar beets for livestock feed in 2005, noting that "this plant novel trait and novel feed does not present altered environmental risk nor does it present livestock feed safety concerns when compared to currently commercialized sugar beet varieties in Canada" (CFIA, 2005). The European Food Safety Authority has also concluded that food and feed from H7-1 sugar beets are as safe as food and feed from conventional sugar beets (EFSA, 2006).

Regarding allergenicity and toxicity more broadly, the current evidence from similar GE crops such as GT soybeans, GT corn, GT cotton, GT alfalfa, and GT wheat (not commercially grown) suggests that the transgenic CP4 EPSPS protein present in H7-1 sugar beets poses negligible risk to humans (Lemaux, 2009; NRC (National Research Council), 2004; Peterson and Shama, 2005). For example H7-1 sugar beets have been the subject of a completed consultation at FDA, As part of its consultation regarding H7-1 sugar beets, FDA concluded that the Agency had no questions about the developer's determination that H7-1 sugar beets are not materially different in composition, safety, or other relevant parameters from conventional sugar beets (U.S. FDA, 2004). Multiple countries that regulate the importation of biotechnology-derived crops and derived products have granted regulatory approval to H7-1 sugar beets for food and/or feed uses, including Japan, Canada, Mexico, EU, South Korea, Australia, New Zealand, Colombia, Russian Federation, Singapore, and the Philippines (Berg, 2010; FSANZ (Food Standards Australia New Zealand), 2005; Monsanto/KWS, 2007). These diverse regulatory authorities have all reached the same conclusion – that food and feed derived from H7-1 sugar beets are as safe and nutritious as food and feed derived from conventional sugar beets.

As described in section III.E.3, the use of tractors and other equipment to cultivate the soil and conduct other activities involved with growing sugar beets can result in engine emissions and fugitive soil particulates, some containing adsorbed pesticides and other agricultural chemicals, being carried by the wind to the neighboring public. These substances can cause serious health effects (Baker et al., 2005; Bennett et al., 2004). These emissions and particulates are an expected consequence of farming in general, but they can be reduced or increased due to changes in farming practices. As discussed more under worker health, section III.F.2.a, cultivation and equipment use has dropped substantially from the pre-2005/6 period of conventional sugar beet production to the more recent

2010/11 period of largely H7-1 sugar beet production. Subsequent reductions in health risks thus are possible.

b. Pesticides

The affected environment in terms of public health and sugar beet production includes the pesticides used in growing sugar beets (insecticides, herbicides, and fungicides). Pesticides are composed of active ingredients (a.i., the chemicals of primary toxicological concern) and inert ingredients (adjuvants, surfactants, preservatives, solvents, diluents, thickeners, and stabilizers). The terms a.i. and inert ingredient are defined by FIFRA, the federal law that governs pesticides. An active ingredient is one that prevents, destroys, repels, or mitigates a pest, or is a plant regulator, defoliant, desiccant, or nitrogen stabilizer. By law, the active ingredient must be identified by name on the pesticide product's label together with its percentage by weight. All other ingredients in a pesticide product are called inert ingredients. An inert ingredient means any substance (or group of similar substances) other than an active ingredient that is intentionally included in a pesticide product. Called “inerts” by the law, the name does not mean non-toxic. Inert ingredients play key roles in the effectiveness of pesticides, such as to prevent caking or foaming, extend product shelf-life, or allow herbicides to penetrate plants. The only inert ingredients approved for use in pesticide products applied to food (such as sugar beets) are those that have either tolerances or tolerance exemptions in the Code of Federal Regulations (CFR), 40 CFR part 180 (the majority are found in sections 180.910 – 960).

People can be directly exposed to pesticides in general via inhalation, oral, and dermal routes if they live on or near farms that use them. They can also be exposed to pesticide residues by ingesting the crops that are sprayed directly, or products derived from crops, including animals fed the crops and the products from these animals (e.g., milk). Consumption of adjacent crops affected by spray drift is also a possible route of exposure, as is inhalation and dermal exposure from spray drift to residents near those spraying operations. Aerial broadcast spraying would tend to increase exposure to nearby residents and bystanders compared to ground-level methods. Migration of pesticides to surface water or groundwater used for drinking water also is a potential pathway for exposure.

EPA evaluates pesticides before they can be marketed and used in the United States, to ensure that they will meet Federal safety standards to protect human health and the environment. EPA undertakes this analysis under the authority of FIFRA and FFDCA. Under FIFRA, EPA regulates the sale, distribution, and use of pesticides. Pesticide products must meet EPA requirements for registration ensuring that the products do not pose unreasonable risks to human health and the environment. Products meeting these requirements are granted a license or “registration” that permits their distribution, sale, and use according to specific use directions and requirements identified on the pesticide label.

FFDCA authorizes EPA to set a tolerance, or maximum residue limit, which is the amount of pesticide residue allowed to remain in or on each treated food commodity. The tolerance is the residue level that triggers enforcement actions. Agricultural products containing pesticide residues above the tolerance level are unlawful. In setting the tolerance, EPA must make a safety finding that the pesticide can be used with "reasonable certainty of no harm" from aggregate exposure to the pesticide chemical residue. To make this finding, EPA considers the following (U.S. EPA 2006d, 2010c):

- The toxicity of the pesticide and its break-down products;
- The cumulative effects from exposure to different pesticides that produce similar effects in the human body;
- Whether there is increased susceptibility to infants and children or other sensitive subpopulations from exposure to the pesticide;
- Whether the pesticide produces an effect in humans similar to that produced by a naturally occurring estrogen or produces other endocrine-disruption effects;
- How much of the pesticide is applied and how often;
- The aggregate, non-occupational exposure from the pesticide (exposure through diet, including from milk and other livestock products; from pesticide use in and around the home; and from drinking water); and
- How much of the pesticide (i.e., the residue) remains in or on food by the time it is marketed and prepared.

As discussed previously, sugar beets are an intensively managed crop, and are highly sensitive to pest pressure including weeds, diseases, and insect pests. Nationwide in 2000, 99 percent of the farms growing sugar beets used at least one pesticide application (Ali, 2004). The most recent year available from the National Agricultural Statistics Service (NASS) for pesticide use data for sugar beets is 2000 (USDA-NASS, 2008). In that year, 1.56 million acres of sugar beets were planted and approximately 11 million lb of a.i. of pesticides were used (sections III.B.1.c and f). For perspective:

- Fungicides contributed the largest fraction (8.1 million lb. a.i.;

73 percent), insecticides the second largest (1.7 million lb. a.i.; 15 percent), and herbicides the third (1.4 million lb. a.i.; 12 percent).

- Similarly, sulfur, a fungicide, contributed the single largest amount (7.6 million lb. a.i.; 68 percent); terbufos, an insecticide, contributed the second largest (1.2 million lb. a.i.; 10 percent); and desmedipham, an herbicide, contributed the third largest (0.3 million lb. a.i.; 2 percent).

As noted in section III.B.1.c(5), management practices for conventional sugar beets and H7-1 sugar beets would be expected to be similar with regard to insecticide and fungicide use. Herbicide use, however, is known to have changed substantially as a result of the adoption of H7-1 sugar beets. Therefore, the remainder of this section focuses on public health and safety related to herbicides. An overview of the use of herbicides in sugar beet production is provided, and several factors contributing to human health risks from the herbicides are introduced, including those related to exposure (e.g., quantity used) and those related to inherent toxicity. This discussion is then followed by detailed risk profiles of the primary herbicides used. Risk-based summary data have been compiled as part of the analysis of regulatory alternatives in section IV.F.

As noted in section III.B.1.d, both conventional and H7-1 sugar beet production uses several different herbicides. For 2000, herbicide use pattern data were available for 13 different herbicides used on sugar beet. Total herbicide use for conventional sugar beets prior to the introduction of H7-1 sugar beets was estimated at approximately 1.4 million lb. a.i. For more recent herbicide use, with H7-1 sugar beets planted on about 95 percent of the acreage, total herbicide use is estimated at approximately 2.6 million lb. a.i. Glyphosate use under the recent H7-1 sugar beet scenario is estimated to be about 34 times greater than previous use, while use of other herbicides is estimated to be about 10 times less (see tables 3-16 and 3-18). As described in section III.B.1.d, however, the use pattern for these herbicides is not straightforward, as many growers use "micro-rates" of herbicides in tank mixes to achieve the desired weed suppression. Growers might use up to three of the "micro-rate" applications through the growing season (USDA-APHIS, 2011b). Due to regional variations in weed pressures, specific herbicides might be more effective against certain weeds, and treatment is tailored based on the specific scenario.

FFDCA, section 408(b)(2)(A)(i), Tolerances and Risk, allows EPA to establish a tolerance – the legal limit for a pesticide chemical residue in or on a food – if EPA determines that the tolerance is "safe." Section 408(b)(2)(A)(ii) defines "safe" to mean that "there is a reasonable certainty that no harm will result from aggregate exposure to the pesticide chemical residue, including all anticipated dietary exposures and all other exposures for which there is reliable information." This includes exposure through drinking water and in residential settings, but does not include occupational exposure. Section 408(b)(2)(C) requires EPA to give special consideration to exposure of infants and children to the pesticide chemical residue in establishing a tolerance and to "ensure that there is a reasonable certainty that no harm will result to infants and children from aggregate exposure to the pesticide chemical residue."

Tolerances for herbicides used in conventional sugar beet production are listed in table 3–54. Tolerances exist for sugar beets throughout many stages of the sugar production process, including roots, tops, dried beet pulp, molasses, and refined sugar. Tolerances have not been established, or were not available in the Code of Federal Regulations (CFR) as of the date of publication of this EIS, for the a.i. trifluralin in sugar beets, although tolerances are available for closely related products.

The subsections below provide toxicity profiles relevant to both long-term and short-term (accidental) public exposure for each of the key herbicides used in the production of sugar beets. This information is intended to help characterize the inherent toxicity of these different herbicides based on laboratory tests of animals, not the actual human exposures and health risks resulting from the application of these herbicides on sugar beets or other crops and lands. The primary reports used for these profiles are cited in the headings. A limited literature search was conducted for each to confirm whether any substantial updates exist to EPA's understanding of the risks. Any additional literature is cited in the profile.

The profiles provided below primarily describe EPA's evaluation of each of the pesticide a.i. and present information on toxicity, metabolism, chances for exposure, and outcomes of long-term risk assessments for the general public. A key metric discussed in these profiles is the reference dose (RfD). The RfD is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily oral exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime (U.S. EPA 2011c). Another key metric is the chronic population adjusted dose (cPAD), which is the chronic oral RfD adjusted by a safety factor as described in the Food Quality Protection Act (FQPA). The cPAD is required by the FQPA, and takes into account exposures to sensitive subpopulations. Another metric is the acute dietary risk. The acute dietary risk is calculated based on quantity of food eaten in one day and maximum residue values in the food. A risk estimate that is less than 100% of the acute Population Adjusted Dose (aPAD) (the dose at which an individual could be exposed on any given day with no adverse health effects) are considered by the agency to not be of concern.

These profiles also address toxicity from short-term accidental exposures, such as from spills or misuse. Thus, these profiles refer to an EPA permanent damage classification system that organizes acute toxicity data on chemicals based on laboratory test results and route of exposure.

Table 3- 54. Tolerances for Herbicides Used in Conventional Sugar Beet Production

Agricultural Chemical (Herbicide)	Trade Name (typical)	WSSA Mechanism of Action Group No[1]	Tolerances in ppm:[2] (Dried Pulp/Molasses/Refined Sugar/ Roots/Tops)				
			Dried Pulp	Molasses	Refined Sugar	Roots	Tops
Clethodim	Select®	1	–	1.0	–	0.20	1.0
Clopyralid	Stinger®	4	–	10	–	2.0	3.0
Cycloate	Ro-Neet™	8	–	–	–	0.05	0.05
Desmedipham	Betanex®	5	–	–	–	0.1	5.0
EPTC	Eptam®	8	–	0.4	–	–	0.5
Ethofumesate	Nortron®	8	–	0.5	0.2	0.3	4.0
Glyphosate	(Several)	9	25	–	–	10	10
Phenmedipham	Betamix®	5	0.5	0.2	–	0.1	0.1
Pyrazon	Pyramin®	5	–	1.5	–	0.2	3.0
Quizalofop-p-ethyl	Assure® II	1	–	0.2	–	0.1	0.5
Sethoxydim	Poast®	1	–	10	–	–	3.0
Trifluralin	Treflan® HFP	3	No published tolerances for trifluralin in sugar beets[3]				
Triflusulfuron-methyl	Upbeet®	2	–	–	–	0.05	0.05

[1] Source: (USDA-APHIS, 2011b).
[2] Source: CFR, Title 40, Part 180, Subpart C – Pesticide Tolerances.
[3] Tolerances of 0.05 part per million (ppm) do exist, however, for "sugarcane, cane," "vegetable, leaves of root and tuber," and "vegetable, root and tuber, except carrot." For a further discussion of residues of trifluralin in sugar beets, see the public toxicity profile for trifluralin in section III.F.1.b(12).

The categories are defined in table 3–55, below. Toxicity categories range from I to IV, depending on how toxic a certain chemical is found to be. A chemical that is in toxicity category I for a specific route of exposure is more toxic than a chemical in category II, and so on. The categories for skin and eye irritation have specific definitions based on laboratory studies in animals, ranging from an effect that is short-term, all the way to one that causes

The toxicity categories for each of the chemicals in this analysis are presented in table 3–56 below. Additional details on the acute (short term) toxicities of these herbicides are provided in section III.F.1.b on worker risks

Table 3- 55 EPA Toxicity Categories (U.S. EPA 2007a)

Type of Study	Category I	Category II	Category III	Category IV
Acute Oral	Up to and including 50 mg/kg	>50 thru 500 mg/kg	>500 thru 5,000 mg/kg	>5,000 mg/kg
Acute Dermal	Up to and including 200 mg/kg	>200 thru 2,000 mg/kg	>2,000 thru 5,000 mg/kg	>5,000 mg/kg
Acute Inhalation	Up to and including 0.05 mg/liter	>0.05 thru 0.5 mg/liter	>0.5 thru 2 mg/liter	>2 mg/liter
Primary Eye Irritation	Corrosive (irreversible destruction of ocular tissue) or corneal involvement or irritation persisting for more than 21 days	Corneal involvement or other eye irritation clearing in 8–21 days	Corneal involvement or other eye irritation clearing in 7 days or less	Minimal effects clearing in less than 24 hours
Primary Skin Irritation	Corrosive (tissue destruction into the dermis and/or scarring)	Severe irritation at 72 hours (severe erythema or edema)	Moderate irritation at 72 hours (moderate erythema)	Mild or slight irritation at 72 hours (no irritation or slight erythema)

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Table 3- 56 EPA Toxicity Categories for Herbicides Used in Conventional Sugar Beet Production1

Active Ingredient	Oral	Dermal	Inhalation	Skin Irritation	Eye Irritation	Skin Sensitization
Clethodim	III	IV	III	I	III	No
Clopyralid	IV	IV	IV	No	I	No
Cycloate	III	IV	IV	III	III	Yes
Desmedipham	IV	III	IV	IV	II	No
EPTC	III	III	II	IV	III	Slight/Weak
Ethofumesate	IV	IV	II	IV	IV	No
Glyphosate	IV	IV	Study Waived	IV	III	No
Phenmedipham	III	III	IV	IV	IV	No
Pyrazon	III	IV	IV	IV	IV	No
Quizalofop-p-ethyl	III	IV	IV	IV	IV	No
Sethoxydim	IV	III	III	IV	III	Yes
Trifluralin	IV	III	III	IV	III	Yes
Triflusulfuron-methyl	III	III	II	IV	III	Slight/Weak

[1] The toxicity profiles in the subsections for each herbicide provide the data sources for these categories.

(1) Clethodim

Clethodim is a selective postemergence cyclohexanedione herbicide that is used to control annual and perennial grasses in broadleaf crops including soybeans, peanuts, cotton, flax, sunflowers, alfalfa, sugar beets, and others. Clethodim is of moderate to low acute toxicity by oral (III), dermal (IV), or inhalation (III) exposure. However, clethodim is a severe dermal irritant in EPA toxicity category I. Clethodim is not a skin sensitizer (a compound that causes a worsening allergic response with subsequent exposures), but does cause moderate eye irritation (toxicity category III). EPA reviewed animal studies that evaluated whether clethodim would be likely to cause cancer and concluded that clethodim is “not likely” to be a human carcinogen.(U.S. EPA 2008b)

The primary target organ (the organ in which the critical toxic effect is seen) for clethodim toxicity is the liver, based on studies in rats and dogs. Endpoints of toxicological concern in these chronic oral studies are: liver tissue changes without evidence of cancer, increased liver weight, and decreased body weight. A long-term study was also conducted in mice that were fed clethodim in their diet at high doses. The adverse effects noted included decreases in healthy blood parameters, decreases in liver weights with increased size of liver lobe cells, increased pigment of the bile duct, abnormal cell reproduction, and decreased survival by test subjects. Rats exposed to clethodim on their skin at the highest doses had anogenital discharge, decreases in body weight gains and weight gain relative to food consumption, and increased liver weight. Reproductive studies with clethodim in rats did not show adverse reproductive effects and clethodim did not cause developmental toxicity in rat studies.

In the metabolism and pharmacokinetics study, clethodim was readily absorbed, excreted mainly in the urine, was rapidly and extensively metabolized with the predominant metabolite as clethodim sulphoxide and less than 1% eliminated as the unchanged parent compound. In a skin absorption study in rats, researchers found that about 30 percent of the applied clethodim was absorbed by the body.

The chronic oral RfD for clethodim is 0.01 mg per kg per day and is based on changes in blood chemistry and increased absolute and relative liver weights from a chronic oral study in dogs. The cPAD for clethodim is the same as the chronic oral RfD, 0.01 mg per kg per day. If the exposure estimate from an EPA risk assessment exceeds the cPAD, then the exposure is deemed by the EPA to be of concern for the general population and more sensitive subgroups (U.S.EPA, 2000). EPA conducted a chronic dietary risk assessment for clethodim and found that the risk estimate for food and drinking water was 27 percent of the cPAD for the U.S. population in general, and 73 percent of the cPAD for children 1–2 years of age (the highest exposed population subgroup). There is no appropriate endpoint for assessing acute dietary exposure; therefore, no acute dietary assessments have been performed.

Tolerances for clethodim and its metabolites on sugar beet crops have been established for sugar beet roots, tops, and molasses from the processed beets, as stated in 40 CFR §180.458. The tolerance for roots is 0.2 ppm, and the tolerance for residues on molasses and sugar beet tops is 1.0 ppm (see table 3–54). EPA has established that adequate analytical methods exist for data collection and the enforcement of tolerances for clethodim.

EPA found that post-application exposure to clethodim is unlikely except following its use in transplanted sod, because application of clethodim as a spot treatment in grass—the likely public use—would result in minimal, if any, contact with clethodim residues. Although the EPA does not believe residential handler exposures are likely to occur, it does recommend that label revisions be made stating that such that products containing clethodim include the statement, “Recommended for Commercial Applicators Only.”

(2) Clopyralid

Clopyralid is an herbicide in the pyridine family and is used to control broadleaf weeds in a variety of crops, including Swiss chard, sugar beets, bushberries, cole crops, oats, strawberries, and others. Clopyralid is low in toxicity (EPA toxicity category IV) for oral, dermal, and inhalation exposure, and is not a skin irritant or skin sensitizer. The acid form of clopyralid is a severe eye irritant in EPA toxicity category I. No evidence of carcinogenicity was found in 2-year studies with mice and rats, nor were findings positive for mutagenicity or clastogenicity found in bacterial studies. Clopyralid has been classified by EPA as "not likely to be carcinogenic to humans."(U.S. EPA 2009b)

None of the animal toxicity studies that EPA evaluated indicated that there was a single organ that experienced the critical toxic effect when clopyralid entered the body. Adverse effects in various organs were noted in the test animals. These effects included: changes in blood cells and blood chemistry, lesions on the skin, liver weight increases, and decreased gains in body weight. No pre- or post-natal sensitivity was noted in response to clopyralid exposure in the animals tested, except at doses that caused severe toxicity to the maternal animals.

Clopyralid is absorbed into the body almost completely at both high and low doses, based on studies in rats. The absorbed clopyralid was eliminated by the animals mainly in the urine within 72 hours after exposure, though the majority of animals removed the clopyralid within

6 to 12 hours after they were exposed. In the studies conducted, there was no evidence that clopyralid was modified by the body, and only clopyralid was found in the urine and feces of the experimental animals.

The chronic, or long-term, oral RfD for clopyralid is 0.15 mg per kg per day and is based on tissue changes in the stomach of rats that were fed clopyralid in their diets for 2 years. Rats had evidence of abnormal cell growth in their stomachs and thickening of a specific part of the stomach, the limiting ridge. The limiting ridge is not found in primate or dog stomachs. However, researchers attributed the adverse effects to irritation, an effect which EPA concluded was relevant to humans. Stomach lesions were also found in long-term studies with rats and rabbits exposed to clopyralid.

The chronic cPAD is the chronic oral RfD adjusted by a safety factor as described in the FQPA. The cPAD is required by FQPA, and takes into account potential exposures for sensitive subpopulations. The cPAD for clopyralid is the same as the chronic oral RfD at 0.15 mg per kg per day. If an exposure estimate produced from an EPA risk assessment exceeds the cPAD, then the exposure is deemed to be of concern for the general population and sensitive population subgroups (U.S.EPA, 2000). An acute endpoint was also determined for clopyralid. The aPAD is the same as the acute RfD at 0.75 mg per kg per day (U.S. EPA 2009a). Both the EPA chronic and acute dietary risk assessment assumes that all crops in the model were treated with the herbicide, and that residues on all of the crops were at the tolerance level (the maximum pesticide residue allowed on a crop) for each commodity. Additionally, modeled estimates of clopyralid residues in drinking water were incorporated into the analyses. EPA's chronic dietary risk assessment estimate was at 9 percent of the cPAD for the general U.S. population and 23 percent of the cPAD for children 1-2 years old, the most highly exposed population subgroup, both of which are deemed to be not of concern for this compound. EPA's acute dietary risk assessment estimate was at 5 percent of the aPAD for the general U.S. population, and 9 percent of the aPAD for children 1-2 years old, the most highly exposed population subgroup, both of which are risks that are not of concern for this compound (U.S. EPA 2009a)

Tolerances have been established for clopyralid and its metabolites on sugar beet roots, tops, and molasses from the processed beets, as stated in 40 CFR §180.431. The tolerance for roots is 2.0 ppm, the tolerance for residues on sugar beet tops is 3.0 ppm, and the tolerance for residues in molasses is 10.0 ppm.

EPA conducted a residential exposure estimate in 2002 to address non-occupational risk, and did not update the estimate in the 2009 human health risk assessment because there were no new residential uses of clopyralid. In their assessment, EPA only considered oral and inhalation pathways of exposure to clopyralid for assessing non-occupational risk. Dermal exposures were not considered based on a lack of adverse effects at the highest dose tested in a 21-day dermal toxicity study in rabbits. EPA evaluated acute residential exposure from lawn treatment activities for handlers of the products, and for toddlers that might ingest granules applied to lawns. EPA noted that "…due to the episodic nature of granule ingestion, it is not appropriate to include this source of exposure in aggregate assessments." EPA concluded that acute residential exposures from these aggregated pathways were risks not of concern. In their assessment of long-term aggregate risk from clopyralid, EPA determined that there are no non-dietary exposure scenarios appropriate for assessing long-term exposures. As a result, the long-term aggregate risk from clopyralid is equivalent to the chronic dietary risk, and EPA concluded that the risks were also not of concern.

EPA evaluated the exposure potential from spray drift for residents living near spraying operations using products containing clopyralid. EPA worked with the Spray Drift Task Force (which includes representatives from industry, EPA Regional Offices, State Lead Pesticide Agencies, and other parties) to develop spray drift management practices. As a result, EPA is requiring interim mitigation measures to be placed on product labels and labeling for aerial applications. EPA is also considering further refinements of their policy to reduce off-target drift risks to the general public.

(3) Cycloate

Cycloate is a preemergent, broad spectrum herbicide that is used to manage multiple broadleaf weeds, annual grasses, and selective perennial grasses; it is primarily used on spinach, sugar beets, and garden beets. Cycloate is of low acute toxicity by oral (category III), dermal (category III), and inhalation (category IV) exposure. Cycloate is not an eye or skin irritant, or a dermal sensitizer. Based on the available data reviewed by EPA, it was concluded that cycloate is "not likely to be carcinogenic to humans."(U.S. EPA 2004)

Studies in several species indicate that the primary critical effect of cycloate is neurotoxicity of the central and peripheral nervous systems. Acute exposures in rats have shown nerve cell death in areas of the brain that control smell, memory, and stress responses. A chronic toxicity/carcinogenicity study reported wasting of the spinal nerves and changes to the femoral nerve in females dosed with 3.1 mg per kg per day of cycloate. Developmental toxicity studies have shown that cycloate does not cause developmental effects in rats or rabbits. Multi-generation reproductive studies showed decreased body weight in the offspring, decreased body weight gains, and decreased food consumption, as well as changes in the tissues of the nervous system, focusing on the brain and spinal cord.

Metabolism studies in the rat and mouse indicate that the primary route of elimination is through the urine and that N-ethylcyclohexylamine is the primary urinary metabolite. Cycloate and its metabolites do not bioaccumulate; however, oral administration half-lives indicate there are some slow metabolizers/excreters of this chemical. Absorption ranged from 61–68 percent. At 192 hours, tissue concentrations were low, with most remaining residues in the liver and kidneys.

The chronic oral RfD for cycloate is 0.005 mg per kg per day and is based on spinal nerve axonal atrophy and femoral nerve alterations in female rats. The acute RfD equals the aPAD and is 0.066 mg/kg.day for the general U.S. population. The cPAD for cycloate is the same as the chronic oral RfD. EPA conducted a chronic dietary risk assessment for cycloate and found that the risk estimate for food and drinking water was 2.4 percent of the cPAD for the U.S. population in general, and 5.5 percent of the cPAD for children 3–5 years of age (the highest exposed population subgroup) both risks of which are not of concern. The acute (food only) dietary exposure estimates are not of concern (<100% aPAD) for the general U.S. population and all population subgroups. The acute assessment resulted in an exposure estimate for the general U. S.

population at 0.000408 mg/kg/day, or <1% of the aPAD at 95% exposure. The most highly exposed subpopulation was children aged 3-5 years, at 0.000755 mg/kg/day, or 1.1% of the aPAD at 95% exposure.

In 2004, EPA reassessed the tolerances for cycloate residues on sugar beet tops and roots. EPA determined that the total toxic residues to be regulated in the target crops, including sugar beets, should consist of cycloate and its metabolites (breakdown products). Based on this determination, EPA then recommended that the tolerance expression and levels should be amended to reflect this determination. As a result, EPA recommended that the current tolerance (expressed as cycloate, per se) of 0.05 ppm for garden beet roots be reassessed at 0.50 ppm, expressed as cycloate and its 3HC and 4HC metabolites; and that the current tolerance (expressed as cycloate, per se) of 0.05 ppm for garden beet tops be reassessed at 1.0 ppm, expressed as cycloate and its 3HC and 4HC metabolites. However, these tolerances have not been officially adopted or codified as of 2010, and the tolerance level of 0.05 ppm remains for cycloate residues on sugar beet roots and tops. The established tolerances for cycloate on sugar beet roots and tops are stated in 40 CFR §180.212.

Products containing cycloate are not registered for residential use, or for use around public buildings, recreational areas, or schools. Since non-occupational and residential exposure are not expected, only dietary exposure sources were considered for aggregate risk assessment. EPA has established that no population or subgroup posed risks of concern for either acute of chronic dietary exposure to cycloate based on food and water exposure, and that no risk concerns for aggregate exposure exist.

(4) Desmedipham

Desmedipham is an herbicide used to manage annual weeds (including sowthistle, coast fiddleneck, common lambsquarters, nettleleaf goosefoot, prostrate pigweed, wild buckwheat, and wild mustard). Desmedipham is used primarily on non-food crops such as Swiss chard and table beets (both grown for seed), and for food crops such as sugar beets. Desmedipham is of low acute toxicity by oral (category IV), dermal toxicity(category III),dermal irriation (category IV), and inhalation (category IV) exposure. It is not a dermal sensitizer (category IV). It is an eye irritant (toxicity category II) and a mild skin irritant (category III). Desmedipham is classified as Group E for carcinogenicity, based on “evidence of non-carcinogenicity for humans.”(U.S. EPA 2005a)

Studies on the subchronic and chronic toxicity of desmedipham in rats and dogs indicate that this substance primarily affects the blood, as evidenced by consistent hematological effects (e.g., anemia and increases in methemoglobin formation). Several studies also reported effects in the spleen and the thyroid (decreases in thyroid hormones and thyroid weight). In a 2-year study in rats, authors reported significant decreases in body weights, dose-related anemia, increased methemoglobin formation (which indicates a decrease in the ability of the blood to carry oxygen); and significant decreases in red blood cell counts and hemoglobin (the blood protein that transports oxygen). Mild changes in the thyroid function of mid- and high-dose females and increased spleen weights in both sexes were also noted.

Several chronic and carcinogenicity studies in mice and rats indicate that desmedipham is not likely carcinogenic. Developmental studies indicate that *in utero* exposure to desmedipham may cause reduced body weight and increased incidence of external and skeletal defects in offspring of animals exposed at high dose levels. A two-generation reproduction study with desmedipham in rats showed no evidence of reproductive toxicity.

When animals were fed a low dose of desmedipham, absorption of the chemical was rapid but incomplete. In the studies, excretion (removal) of desmedipham occurred mainly via the urine. At the low single or repeated dose of 5 mg/kg, excretion was mainly through the urine where nearly

67-84% of the administered dose was collected by 30 hours post-exposure. Ninety-six hours after dosing, levels of desmedipham in the tissues were very small except in the blood and plasma, where measurable amounts were found. The major urinary metabolites identified were ethyl-N-(3-hydroxyphenyl) carbamate and 4-acetamidophenol, depending on how the metabolites were tracked.

EPA assessed occupational exposure for desmedipham and determined that there is the potential for short- and intermediate-term exposures from handling desmedipham products during the application process to sugar beets. The short- and intermediate- term Margins of Exposure (MOE) for some scenarios were not of concern for pesticide handlers. The addition of personal protective equipment and engineering controls resulted in exposures that were not of concern for all exposure scenarios. Post-application exposures may occur following applications to sugar beets during routine crop-production tasks; however, EPA concluded that health risks to handlers from post-application exposures would not pose a significant risk.

The chronic oral RfD for desmedipham is 0.04 mg/kg and the acute RfD is 0.1 mg/kg. Tolerances for desmedipham have been established for sugar beet roots and tops, as stated in 40 CFR §180.353. In 2005, the registrant of desmedipham products, Bayer CropScience, requested that the tolerance for sugar beet tops be raised from 0.2 ppm to 15 ppm, based on the registrant's submitted data from field trials. EPA required the registrant to submit additional field trial data before the tolerance could be reassessed. The tolerances for desmedipham on sugar beet tops and roots were updated in September of 2008. Additional supporting information on the action was not found. The updated tolerances for sugar beets are 0.1 ppm for roots and 5.0 ppm for tops.

EPA is required to conduct a residential exposure assessment for a.i. if certain toxicological criteria are observed and if there is potential for residential exposure. There are no residential uses of desmedipham, therefore the residential exposure/risk assessment was not conducted by EPA as part of the reregistration process for desmedipham.

(5) EPTC

The summary below is based on EPA's 1999 RED for EPTC.(U.S. EPA 1999) It should be noted that the EPA is currently reevaluating EPTC and therefore some of the information regarding the EPA assessment of EPTC may change.

EPTC (S-ethyl dipropylcarbamothioate) is a pre- and postemergence herbicide that is used to control germinating annual weeds (including sedges, grasses, and broadleaf weeds) in potatoes, peas, dry beans, corn, alfalfa, and snap beans. EPTC is of moderate toxicity (category III) by the dermal and oral routes and slightly irritating to the eyes (category III). EPTC is moderately toxic by inhalation (category II). EPTC is not carcinogenic, based on long-term studies in rats and mice and a lack of carcinogenic effect in other long-term studies. Long-term reproductive and developmental studies with EPTC have also not shown carcinogenic effects.

Studies in several species indicate that deterioration of the heart muscle and nerve cell death are the main adverse effects of chronic, or long-term, EPTC exposure. Toxicity of the heart muscle occurred in subchronic (a duration between short- and long-term) and long-term studies of exposure to EPTC. Rats and dogs fed EPTC showed signs of nervous system toxicity. In these studies, scientists reported dose-related increases in the number of occurrences and severity of nerve cell death and degeneration of the tissue in the brain, skeletal muscle, and various peripheral nerves. EPTC also interferes with cholinesterase (an enzyme that allows for normal nerve function) in the blood and brain, but these effects are reversible. Although EPTC is a primary eye and skin irritant, absorption through the skin is fairly low due to the relatively high evaporation of EPTC from the skin. Long-term studies have shown no evidence of carcinogenicity from exposure to EPTC. Developmental studies in rats and rabbits showed decreased fetal body weights and decreased litter sizes, but these effects were related to the significant maternal toxicity (decreased body weight and increased mortality) caused by EPTC exposure.

Studies of the metabolism of EPTC indicate it is rapidly absorbed and eliminated from the body. Studies have shown that very little EPTC accumulates in the body. Urine is the main route of elimination of EPTC, though lesser amounts are eliminated in feces and by exhalation. There were no observed difference in elimination of EPTC between males and females.

The chronic oral RfD for EPTC is 0.025 mg per kg per day and is based on dose-related increases in heart muscle deterioration in parent rats during a two-generation reproductive study. The cPAD for EPTC is 0.0025 mg per kg per day, and is based on the chronic oral RfD. EPA conducted a chronic dietary exposure assessment and found that the risk estimate based on exposure to residues of EPTC was 9.6 percent of the cPAD for the U.S. population in general, and 17.4 percent of the cPAD for children 1–6 years of age (the highest exposed sub-group). These levels are risks that are not of concern for chronic dietary exposure.

Tolerances for EPTC and its metabolites have been established for sugar beet tops and for molasses from the processed sugar beets, as stated in 40 CFR §180.117. The tolerance of 0.1 ppm for sugar beet roots, tops, and molasses was revoked in 1999 due to the removal of an outdated commodity classification system. The current tolerance for sugar beet tops is 0.5 ppm and the tolerance for residues in sugar beet molasses is 0.4 ppm.

Products containing EPTC are registered for use in residential gardens for vegetables and ornamental plants. In their risk assessment, EPA determined that residential handlers were more likely to transplant seedlings and plant seeds by hand, thus increasing their chances of exposure to EPTC. Additionally, EPA concluded there is potential oral exposure to children from ingestion of EPTC-treated soil. Skin and inhalation exposures for residential handlers can occur during handling, mixing, loading, and application, though these exposures are classified as short term because applications of EPTC typically only occur once per year. The four major residential exposure scenarios are as follows: loading/applying granular products with a push-type spreader, a belly grinder spreader, by hand/spoon, or by applying granular products with a shaker can. Post-application exposure scenarios include EPTC use in parks, recreational areas, and golf courses, in addition to private residential use.

For the four scenarios of residential exposure assessed by EPA, only the belly grinder spreader posed risks of concern for dermal exposure. None of the inhalation exposures evaluated posed risks of concern for residential exposure. As part of their risk assessment, EPA has required manufacturers of products that use the belly grinder spreader to remove that method of application from their labels.

In their assessment of aggregate risks from EPTC, EPA concluded that the acute, short-term (1–7 days), and lifetime aggregate risks from exposure to EPTC from the diet (food and drinking water) and from residential exposures do not pose risks of concern. EPA has concluded with reasonable certainty that no harm would result to the general public from acute or short or long-term dietary exposure to EPTC.

(6) Ethofumesate

Ethofumesate is a selective, pre- and postemergent terrestrial herbicide that is incorporated into the soil to manage grasses and broad-leaf weeds primarily in sugar and other beet crops, but also in carrots, garlic, onions, shallots, and certain grasses (such as grasses for feed and on golf courses). Ethofumesate is of low acute toxicity (category IV) by oral and dermal exposure, but is of moderate toxicity by inhalation exposure (category II). It is not a dermal (category IV) or eye irritant (category IV), and is not a dermal sensitizer. The U.S. EPA Health Effects Division (HED) RfD Committee in 1993 classified ethoumesate as having "inadequate information to classify as a carcinogen." However after evaluation by the HED Hazard Identification Assessment Review Committee (HIARC) in 2004, it was concluded that ethofumesate should be classified as "not likely to be carcinogenic to humans."(U.S. EPA 2006b)

The target organ of ethofumesate toxicity is the liver. The main effects reported in 90-day feeding studies in rats and dogs included decreases in body weight gain and liver toxicity. Mice are less sensitive to ethofumesate than rats, dogs, or rabbits. Reproductive and developmental toxicity has been reported in rabbits exposed to ethofumesate. Effects noted include abortions, resorptions of litters, and incomplete development of backbones in offspring of mothers that were treated. Maternal weight loss and death was also reported at high doses. However, developmental and reproductive effects have not been reported in rats. Tests to evaluate whether ethofumesate can cause DNA mutations, in living animals and in cell cultures grown in the laboratory, indicate that ethofumesate is not likely to be carcinogenic.

A metabolism study in rats indicated that ethofumesate is eliminated from the body mainly through the urine. In a study, most of the ethofumesate that was given to test animals (rats) was eliminated within 5 days after exposure. Breakdown products of ethofumesate are reported to have similar effects on the body as ethofumesate.

Based on the evidence of reproductive toxicity in animals exposed to ethofumesate, two chronic oral RfD values were developed by EPA. The first chronic oral RfD of 0.3 mg per kg per day was set for women ages 13–49 and is based on a developmental toxicity study in rabbits that found increased resorption of developing fetuses, loss of young after implantation, and incomplete development of the vertebrae bones. The second chronic oral RfD of 1.3 mg per kg per day for ethofumesate is set for the general population, including infants and children, and is based on decreased body weight gain in females in a long-term toxicity and cancer study in rats. The cPAD values for ethofumesate are 0.3 mg per kg per day for women ages 13–49 and 1.3 mg per kg per day for the general public including infants and children and are based on the same studies, respectively, as the RfDs. The estimated chronic dietary exposure from food and drinking water is less than 1 percent of the cPAD for all population subgroups. An acute dietary risk endpoint was identified for the population of females (13-49 years) based on a developmental toxicity study in rabbits. The aPAD value is 0.3 mg/kg/day The acute dietary estimates do not pose risks of concern at 4% of the aPAD at the 95^{th} percentile for the female (age 13-49 years old) subgroup population. No appropriate endpoint was identified for the general population and infants.

Tolerances for ethofumesate and its metabolites have been established for sugar beet roots, tops, refined sugar, and molasses from the processed beets, as stated in 40 CFR §180.345. The tolerance for tops is 4.0 ppm, the tolerance for roots is 0.3 ppm, the tolerance for refined sugar is 0.2 ppm, and the tolerance for residues in molasses is 0.5 ppm.

Residential exposure to ethofumesate is expected to be limited to exposure via food, drinking water, and potential short-term post-application exposure of adults and children from lawn care applications and time spent at golf course (e.g., incidental ingestion and dermal exposure). With the exception of women of child-bearing years, residential post-application MOE for toddlers and adults do not exceed EPA levels of concern for the most common rate of 1.5 lb a.i. per acre and the occasional rate of 3.0 lb per a.i. per acre.

With the exception of women of childbearing years, residential post-application MOEs for toddlers and adults to ethofumesate on treated turf, regardless of the pathway of exposure, do not exceed the Agency's levels of concern. For women of childbearing age, MOE values of 73 (application rate of 1.5 lb a.i. per acre) and 37 (application rate of 3.0 lb a.i. per acre) were estimated based on a developmental study in rabbits and a conservative assumption that dermal absorption will be 100 percent, and screening-level assumptions regarding exposure from the Agency's SOPs including high contact activities (Jazzercise) on turf immediately posttreatment. Additionally, the endpoint used for females 13+ years of age comes from a developmental study in rabbits that has a steep dose-response curve resulting from a NOAEL (30 mg/kg/day) that is 10X lower than the LOAEL (300 mg/kg/day); thus, a dose spacing issue may likely exists. EPA therefore, considers this a highly conservative estimate of post-application risk for the population females 13-49 years of age exposed to ethofumesate on turf. These MOE Values pose risks of concern for this exposure pathway. The MOE values also incorporated screening-level assumptions regarding exposure that included high contact activities (aerobics) on turf immediately post-treatment. No additional mitigation or data needs for exposure to ethofumesate for women of childbearing age were discussed by EPA.

(7) Glyphosate

Glyphosate is a systemic, non-selective herbicide that is used to control weeds in many crops including soybeans, corn, cotton, sugar beets, and canola. Glyphosate is of low acute toxicity (category IV) by oral and dermal exposure. The requirement for an acute inhalation study was waived by EPA in their assessment of glyphosate (U.S. EPA 2006d). Glyphosate caused moderate eye irritation that cleared within 7 days or less (category III). Glyphosate is a mild/slight skin irritant (category IV) and is not a dermal sensitizer. EPA reviewed animal studies that evaluated whether glyphosate would be likely to cause cancer and concluded that glyphosate is in Group E, "no evidence of human carcinogenicity (U.S. EPA 2006d)."

Glyphosate has shown adverse reproductive effects in two-generation developmental toxicity studies in rabbits and rats (U.S. EPA 2006d). Rabbits exposed to glyphosate showed mortality, diarrhea, and nasal discharge at 350 mg per kg per day in a developmental toxicity study. A developmental study in rats showed incomplete development of the sternebrae (a structure similar to the sternum or breastbone in humans) and decreased body weights in the offspring of mothers exposed at 3,500 mg per kg per day. At the same dose, the mothers were found to have mortality, decreases in the total number of viable offspring, decreases in implantation of fetuses in the uterus, decreased body weight gain, diarrhea, inactivity, and red matting on the head, forelimbs, nose, and mouth. On the basis of developmental studies in rats and rabbits and reproductive findings in rats, glyphosate exhibited no evidence of increased qualitative and quantitative susceptibility.

A chronic oral RfD of 1.75 mg per kg per day has been established by EPA based on the developmental study in rabbits that found death in maternal animals, along with diarrhea and abnormal nasal discharge (U.S. EPA 2006d). The cPAD for glyphosate is the same as the RfD, at 1.75 mg per kg per day (U.S. EPA 2006d). The EPA level of concern was 100 for short-, intermediate- and long-term incidental oral exposure, meaning that exposures equal to or greater than 175 mg per kg per day pose risks of concern. The risk estimate for short-, intermediate- and long-term dietary exposure to glyphosate does not pose risks of concern for the U.S. population in general, as well as population subgroups. The chronic exposure estimates for the U.S. population and infants <1 year old (the most highly exposed population subgroup) are 2% and 7% of the cPAD, respectively. There is no aRfD based on the absence of an appropriate toxicological endpoint attributable to a single exposure (dose), including maternal toxicity in developmental toxicity studies.

In lactating goats and laying hens that were fed a mixture of glyphosate and AMPA, a breakdown product, showed that the main route of elimination of glyphosate was through the urine and feces (U.S. EPA 2006d). Residues of glyphosate and AMPA were found in the eggs, milk, and in livestock meat in those studies. In similar studies with rats, 30–36 percent of the glyphosate that animals were exposed to was absorbed into the body. More than 97 percent of the glyphosate that the animals were given was eliminated unchanged from the feces and urine (U.S. EPA 2006d). Small amounts of the breakdown product AMPA were also detected in the feces and urine. Less than one percent of the glyphosate that the animals were exposed to was found in the animals' bones at the conclusion of the study (U.S. EPA 2006d).

On February 20, 1998, EPA issued a notice announcing the filing of two pesticide petitions by Monsanto/KWS SAAT AG in the *Federal Register*. No public comments were received in response to the notice of filing. The data EPA evaluated led to the increase in the tolerance levels for glyphosate because the agency was reasonably certain that no harm would result from residues of glyphosate below these levels. Therefore, on April 14, 1999, EPA issued a final rule that increased the tolerance levels for glyphosate in or on sugar beet dried pulp, sugar beet roots, and sugar beet tops. The tolerance for sugar beet pulp is now 25 ppm and for sugar beet roots and tops it is 10 ppm. Thus, while in EPA's reregistration eligibility decision (RED) for glyphosate in 1993, a tolerance of 0.2 ppm on sugar beets was assessed and found to be acceptable (U.S. EPA 1993a), in 1998, the tolerance for glyphosate on sugar beets was increased to 10 ppm for roots and tops, and to 25 ppm for dried pulp, which represents a 50- to 125-fold increase in allowable residues of glyphosate on sugar beets (EPA, 1998).

The qualitative nature of glyphosate residue in plants and animals appears to be adequately understood, and studies with a variety of plants indicate that uptake of glyphosate from soil is limited. The material that is taken up is readily translocated throughout the plant. In animals, whether ingested or absorbed, most glyphosate is essentially not metabolized and is rapidly eliminated in urine and feces. Enforcement methods are available to detect residues of glyphosate in or on plants. EPA conducted a dietary risk assessment for glyphosate based on a worst-case risk scenario, that is, assuming that 100 percent of all possible commodities or acreage was treated, and assuming that tolerance-level residues remained in or on all treated commodities. Based on the assessment, EPA concluded that the chronic dietary risk posed by glyphosate food uses is minimal (U.S. EPA 1993a). An appropriate endpoint attributable to a single dose was not identified in the glyphosate toxiclogical database; therefore, an acute anlaysis is unnecessary.

APHIS Biotechnology Regulatory Services (BRS) has also reviewed the data supplied to EPA and agrees with EPA's assessment regarding the reasonable certainty that no harm would result from residues of glyphosate below the tolerances. APHIS is not aware of any new peer-reviewed data that have demonstrated a need for reassessment of EPA's original decision to increase glyphosate tolerances for sugar beets.

(8) Phenmedipham

Phenmedipham is a selective herbicide used to manage broadleaf weeds. It is primarily used in sugar beets, table beets, and spinach, as well as Swiss chard grown for seed. Phenmedipham is of low acute toxicity by oral (category IV) and dermal (category III) exposure. The acute toxicity category for inhalation exposure has not been established, as EPA waived the original study for inhalation exposure in 1988. Phenmedipham is a non-irritant to eyes and skin (category IV) and is not a dermal sensitizer. EPA has classified phenmedipham as "not likely to be carcinogenic to humans," based on studies in rats and mice(U.S. EPA 2005g).

The target of phenmedipham toxicity is the red blood cells. Hemolytic anemia (a decrease in red blood cells due to the abnormal breakdown of the cells) is the main adverse effect. A long-term dietary study with phenmedipham showed that hemolytic anemia occurred in both sexes of rats. In the same study, males showed abnormal cell multiplication in the kidneys and deposits of calcium in the kidneys, a condition which decreases the kidneys' ability to function efficiently. Females showed decreases in body weight, body weight gain, and food efficiency (how well the animals use the food they ate to grow and mature). A pair of two-generation studies (one in rats and one in rabbits) indicated that there is no evidence of developmental toxicity from exposure to phenmedipham.

A skin absorption study in the rat showed that 10 percent of the applied phenmedipham was absorbed into the system. No additional information was found in the sources consulted on the distribution, metabolism, or excretion of phenmedipham.

The chronic oral RfD for phenmedipham is 0.24 mg per kg per day and is based on a combined chronic toxicity/cancer study in male and female rats that showed hemolytic anemia in both sexes, as well as changes in body weights and food efficiencies for females and kidney toxicity for males. The cPAD for phenmedipham is the same as the chronic oral RfD, at 0.24 mg per kg per day. EPA conducted a chronic dietary exposure assessment and found that the risk estimate for food and drinking water contribution was less than 1 percent of the cPAD for the general U.S.

population and all population subgroups. There are no studies that identify an acute hazard based on toxic effects observed for phenmedipham that would likely result from a single oral exposure. Therefore an acute analysis is unnecessary.

Tolerances were initially established for residues of phenmedipham on sugar beet roots and tops at 0.1 ppm for both commodities. In their reassessment of the tolerances, EPA concluded that phenmedipham residues from sugar beet dried pulp and molasses do not pose any risks of concern. However, EPA also concluded that phenmedipham concentrates in sugar beet pulp and molasses at 3X and 1.3X the rate, respectively, than in unprocessed sugar beet roots. Therefore, the final tolerance for phenmedipham in dried pulp is 0.5 ppm, for molasses is 0.2 ppm, and for both roots and tops is 0.1 ppm, as stated in 40 CFR §180.278.

To assess the risks to the public from exposure to phenmedipham, EPA conducted an assessment for aggregate exposure through food and drinking water. Residential exposures to phenmedipham were not considered, as there are no home-use products registered that contain phenmedipham. Based on their assessment of food and drinking water, EPA concluded that risks from exposure to residues below the tolerance levels for phenmedipham are within acceptable levels and thereby meet the FQPA safety standards.

According to the EPA dietary risk assessment, there are no dietary exposures of concern for phenmedipham. EPA considers their assessment to be protective of the general U.S. population, as well sensitive subpopulations, including infants and children.

(9) Pyrazon)

Pyrazon is used as a preplant, preemergence, and early postemergence herbicide. Pyrazon acts by preventing photosynthesis from happening normally in green plants. It is used primarily in sugar beet and table beet production, but is also registered for commercial use in ornamentals plants. Technical grade pyrazon (usually greater than 90 percent concentration) is of low acute toxicity (category III/IV) by oral, dermal, and inhalation exposure (U.S. EPA 2005c). It is not a dermal sensitizer, nor is it a skin or eye irritant (toxicity category IV for both pathways) (U.S. EPA 2005c). Pyrazon is classified by EPA as “not likely to be a carcinogen in humans (U.S. EPA 2005c).”

Studies in animals indicate that the most common effects of pyrazon exposure are reduced body weight and food consumption (U.S. EPA 2005c). High doses of pyrazon may also result in motor skill effects; however, these neurotoxic effects have been attributed to weight loss and poor condition of the rats, which may have been caused by malnutrition

(U.S. EPA 2005c). High doses of pyrazon in dogs caused the development of small cavities in parts of the kidney (U.S. EPA 2005c). Skin exposure to pyrazon does not result in systemic effects (effects throughout the body from a localized exposure) (U.S. EPA 2005c). Developmental and reproductive studies in the rat and rabbit showed no effects in parents or offspring (U.S. EPA 2005c). There was no evidence of carcinogenicity in rodent studies; thus, pyrazon is classified as "not likely to be carcinogenic in humans (U.S. EPA 2005c)."

In rats, pyrazon is absorbed in the digestive tract and eliminated mainly though urine, with some removal occurring through the bile to the stomach and thereby the feces (U.S. EPA 2005c). Most of the substance is eliminated from the body within 24 hours for low doses and within 48 hours for high doses. Sex differences in elimination of pyrazon have been noted; female rats removed pyrazon at a lower rate than males in a 14-day study (U.S. EPA 2005c). Only 3.3 percent of the pyrazon taken into the body reportedly remains in the tissues after administration (U.S. EPA 2005c). Metabolites, or breakdown products, from pyrazon have been found in the urine and feces of test animals (U.S. EPA 2005c).

The chronic oral RfD for pyrazon is 0.18 mg per kg per day and is based on decreased body weight and weight gain in females in a chronic rat toxicity study (U.S. EPA 2005c). The cPAD for pyrazon is the same value as the chronic oral RfD, 0.18 mg per kg per day (U.S. EPA 2005c). In a chronic dietary risk exposure assessment conducted by EPA, it was determined that estimated exposures to pyrazon residues from dietary sources account for less than 0.1 percent of the cPAD for all population subgroups (U.S. EPA 2005c). Nearly all (>99%) of the estimated dietary exposure is from drinking water (U.S. EPA 2005c). Exposures to residues of pyrazon from food and drinking water were estimated using two dietary exposure models, Lifeline and DEEM-FCID. The estimated chronic aggregate risk for infants, the population subgroup with the highest estimated exposure, ranges from 21% to 25% of the cPAD using the Lifeline and DEEM-FCID dietary models, respectively (U.S. EPA 2005c). An endpoint of concern attributable to a single dose was not identified for pyrazon; therefore, an acute RfD was not established and an acute dietary risk assessment was not conducted (U.S. EPA 2005c).

EPA has established tolerances for pyrazon and its metabolites on or in sugar beet roots and tops, as stated in 40 CFR §180.316. Prior to 2008, no tolerance existed for sugar beet molasses, and the tolerances for roots and tops were 0.1 ppm and 1.0 ppm, respectively. EPA concluded in their tolerance reassessment in 2005 that the current tolerances were not appropriate due to data deficiencies. EPA planned to revise the tolerances for pyrazon, and did so in 2008. The tolerance for roots is 0.2 ppm, for tops is 3.0 ppm, and for molasses it is 1.5 ppm (U.S.EPA, 2008).

No residential exposures to pyrazon were expected by EPA when they conducted their aggregate risk assessment for pyrazon. EPA evaluated exposures to food and drinking water, and focused on chronic exposure due to the lack of an identified acute toxicity endpoint. In EPA's estimate, more than 99 percent of the exposure to pyrazon residues for the public comes from drinking water. EPA concluded that the aggregate risk from exposure to pyrazon for the U.S. population, including sensitive subgroups, does not pose risks of concern (greater than 100 percent of the cPAD). EPA estimated the aggregate risk for infants, the highest exposed population group, to be between 21 percent and 25 percent of the cPAD.

(10) Quizalofop-p-ethyl

Quizalofop-p-ethyl is a selective preplant and preemergence herbicide used to manage annual and perennial grasses in canola, cotton, dry beans, peas, lentils, mint, soybean, and sugar beets. Quizalofop-p-ethyl is of low acute toxicity by oral (category III), dermal (category IV), and inhalation (category IV) routes. It is not an irritant of the eye or skin (category IV), and is not a skin sensitizer. EPA Cancer Peer Review Committee classified quizalofop-p-ethyl as Category D, "not classifiable as to human carcinogenicity."(U.S. EPA 2006e)

The liver is considered the target organ of quizalofop-p-ethyl. Several animal studies have shown increased liver weights and adverse tissue changes, including enlargement of the central part of the lobe of the liver of treated animals. Quizalofop-p-ethyl is not a skin or eye irritant and it shows low dermal toxicity and no systemic toxicity when applied to the skin. Rats and rabbits exposed to quizalofop-p-ethyl in utero and after birth have shown some signs of developmental toxicity. Observed developmental effects included an increase in the number of rats born with an extra rib, although this abnormality disappeared by the time the young rats were 8 weeks old, suggesting that the effect may not have been biologically significant. Reproductive effects of quizalofop-p-ethyl in rats include a decreased percentage of pups born alive and decreased body weights. Finally, the exposed mothers in both reproductive and developmental studies experienced decreased body weights during the study.

A metabolism study in rats showed that following oral administration, quizalofop-p-ethyl is absorbed from the digestive tract and eliminated in the urine and feces. Elimination is rapid and the major metabolite is an acid byproduct of quizalofop-p-ethyl, which is then metabolized further. No additional information were available on the fate of quizalofop-p-ethyl in the body, from the references consulted.

The chronic oral RfD is based on a long-term toxicity and carcinogenicity study in rats that were fed quizalofop-p-ethyl for 104 weeks. Males at the second-highest dose tested had mild anemia. Males and females at the highest dose tested had significant enlargement of the central part of the liver. These observed adverse effects were used as the basis of the chronic oral RfD of 0.009 mg per kg per day. The cPAD for quizalofop-p-ethyl is the same as the RfD at 0.009 mg per kg per day. In a chronic dietary risk exposure assessment conducted by EPA, it was determined that the highest chronic dietary risk from exposure to quizalofop ethyl is to

1-2 years old children (29% cPAD), which is not a risk of concern (100% of the cPAD). An acute dietary risk assessment was not conducted as there are no doses/endpoints selected for acute dietary risk assessment since there were no effects observed in oral toxicity studies that could attributable to a single dose exposure. There are no residential use products that contain quizalofop-p-ethyl, so EPA did not prepare a residential risk assessment. EPA has concluded that, based on their aggregate risk assessment, none of the evaluated exposures for quizalofop-p-ethyl pose risks of concern.

EPA has established tolerances for quizalofop-p-ethyl and its metabolites on or in sugar beet roots and tops, and in sugar beet molasses, as stated in 40 CFR §180.441. The tolerance for roots is 0.1 ppm, for tops is 0.5 ppm, and for molasses it is 0.2 ppm.

(11) Sethoxydim

Sethoxydim is a selective, postemergence herbicide in the cyclohexenone class of compounds and is used in the management of annual and perennial grasses in broadleaf crops. It is used in a variety of agricultural crops, such as fruits, vegetables, tree nuts, herbs, ornamental and flowering plants. Sethoxydim is also used in recreational areas and other non-agricultural outdoor areas. It is of low acute toxicity (category III) by oral, dermal, and inhalation exposure (U.S. EPA 2005h). It is not a skin or eye irritant (category IV) (U.S. EPA 2005h). Dermal sensitization for sethoxydim has not been classified since the supporting study was waived based on lack of sensitization in guinea pigs (U.S. EPA 2005h). Sethoxydim is classified as “not a likely human carcinogen” based on a lack of evidence of carcinogenicity in mice and rats (U.S. EPA 2005h).

The target organ of sethoxydim is the liver (U.S. EPA 2005h). A chronic toxicity study found significant increases in absolute and liver weight in dogs, as well as adverse chemical changes and tissue injury in the liver (U.S. EPA 2005h). Liver effects from exposure to sethoxydim have also been noted in oral studies in mice and inhalation studies in rats (U.S. EPA 2005h). Other effects in adult animals given high doses of sethoxydim include irregular walking behavior, decreased activity, and anogenital staining, although all of these effects except the staining were short-lived (U.S. EPA 2005h). There is evidence of developmental toxicity in rats and rabbits; the offspring of treated animals experienced skeletal anomalies and reductions in body weight (U.S. EPA 2005h). However, a two-generation reproductive study in rats did not show reproductive effects (U.S. EPA 2005h). Skin exposure did not result in local or systemic toxicity (U.S. EPA 2005h). Carcinogenicity studies in rats and mice found no increased tumor rates and sethoxydim is classified as "not a likely human carcinogen (U.S. EPA 2005h)." Endocrine disruption has not been observed following exposure to sethoxydim (U.S. EPA 2005h).

A metabolism study in rats indicated that sethoxydim is eliminated rapidly and has low accumulation in tissue (U.S. EPA 2005h). Excretion occurs mainly in the urine (78 percent), but also occurs through feces (20.1 percent) (U.S. EPA 2005h). Sex differences in metabolism were not reported for sethoxydim (U.S. EPA 2005h).

A combined chronic toxicity and carcinogenicity study in mice was used to derive the chronic oral RfD of 0.14 mg per kg per day for sethoxydim (U.S. EPA 2005h). Because the FQPA safety factor is 1X for sethoxydim, the cPAD is also 0.14 mg per kg per day. The endpoint for the RfD selection was the early onset of liver effects including abnormally increased liver cell size and fatty degeneration in the liver (U.S. EPA 2005h). The partially refined chronic dietary exposure (food only) estimates did not pose risks of concern (<100% cPAD) for the general U.S. population (2.7% of the cPAD) and all other population subgroups. The most highly exposed population subgroup was all infants (<1 year old), at 7.5% of the cPAD (U.S. EPA 2005h).

A rat developmental study was used to select the dose and endpoint for establishing the acute RfD of 1.8 mg/kg/day (U.S. EPA 2005h). The acute Population-Adjusted-Dose (aPAD) is also equal to 1.8 mg/kg/day (U.S. EPA 2005h). From the acute analysis, the exposure at the 99.9th percentile (99.9th percentile used because the assessment incorporated estimates of percent crop-treated, field trial data and some experimental processing data) was 5.3% of the aPAD for the general U.S. population and 9.2% of the aPAD for children 1-2 years old and also children 3-5 years old (the two most highly exposed population subgroups) (U.S. EPA 2005h).

EPA has established tolerances for sethoxydim residues in sugar beets at 10 ppm for sugar beet molasses and 3.0 ppm for sugar beet tops, as stated in 40 CFR §180.412. EPA has established that there are adequate analytical methods for enforcement of tolerances for sethoxydim.

Sethoxydim is registered for residential use on ornamentals and flowering plants, recreational areas, as well as around buildings and other structures (U.S. EPA 2005d). There is the potential for short term dermal and inhalation exposure to sethoxydim pre- and post-application during mixing, loading, and applying of liquid products (U.S. EPA 2005d).

There is also the potential for incidental oral exposure by children (U.S. EPA 2005d). While product labeling use instructions suggest only spot-treatment, which is not considered by HED to result in consequential exposures, there is no recommendation against broadcast lawn use of products containing sethoxydim (U.S. EPA 2005h). To account for this, EPA considered the potential use of backpack sprayers or low pressure handwand applicators. Incidental ingestion exposure is considered to be unlikely based on the infrequent use and application specified on product labeling(U.S. EPA 2005d). EPA did not identify a dermal endpoint of concern.; therefore, only exposure from inhalation (adult handlers) and incidental ingestion (children, postapplication) were assessed (U.S. EPA 2005d). An MOE of 100 or greater poses a risk of concern for all residential population groups. Estimated MOE values for adults range from 1.4E+6 to 1.6E+6., while MOEs estimated for children range from 26,000 (hand-to-mouth) to 7.6E+6 (soil ingestion). The resulting MOEs are above the target MOE of 100 and, therefore, are not of concern to EPA (U.S. EPA 2005d).

(12) Trifluralin

Trifluralin is a preemergence herbicide used to manage annual grasses and broadleaf weeds. It is used on a wide range of food and feed crops including: asparagus, cabbage varieties, chicory, kale, kohlrabi, lentils, hops, corn, wheat, melon varieties, onion varieties, barley, and sugar beets. Trifluralin is used in non food crops such as non-bearing fruit trees, and is used in a variety of non-agricultural settings. Trifluralin is of low acute toxicity by oral (category IV), dermal (category III), and inhalation (category III) exposure. It is a slight eye irritant (category III), but not a dermal irritant (category IV). Trifluralin is a dermal sensitizer. The OPP Carcinogenicity Peer Review Committee has classified trifluralin as Group C, “possible human carcinogen.”(U.S. EPA 1996c)Data indicate that trifluralin toxicity is species and sex dependent. Subchronic studies in rats have shown kidney and urinary system effects such as increased formation of protein droplets in the kidney and increased amounts of protein in the urine. Significant increases in bladder tumors in female rats and tumor formation in the kidney in males support the evidence for the bladder and urinary system as targets of toxicity in rats. Other studies have shown that the liver is also affected by trifluralin; one oral subchronic study in rats showed reductions in liver weight and a 1-year oral study in beagle dogs resulted in increased liver weight. A 31-day toxicity study in the rat indicated that dermal exposure can also cause increased liver weight. Despite the incidence of cancerous tumors in rats, two studies in mice suggest that trifluralin is not carcinogenic. EPA has based their determination on data from rat studies, and therefore trifluralin is considered a “possible human carcinogen” (Category C). In developmental studies, trifluralin exposure has been associated with reduced fetal body weight and increased runts in the litters of both rabbits and rats. In reproductive studies, trafluralin has caused reduced litter sizes at high doses.

Studies in rats indicated that after oral dosing, trifluralin is not readily absorbed from the digestive tract. Essentially all of the trifluralin that is absorbed is completely broken down and eliminated within 3 days of exposure. Fecal excretion is the main route of elimination (80 percent); while the remaining 20 percent is eliminated through the urine. There are between 30 and 40 different metabolites that have been detected in urine following exposure to trifluralin.

The chronic oral RfD for exposure to trifluralin is 0.024 mg per kg per day as determined from a one-year feeding study in dogs. EPA conducted a dietary assessment using the Dietary Risk Evaluation System (DRES), and found that even if all population subgroups were exposed to maximum residue concentrations, the total exposure values would still be well below the RfD. Thus, the chronic, non-carcinogenic dietary risk from exposure to trifluralin has been determined to be of minimal concern. EPA has also identified the potential for residential exposure to trifluralin through handling practices; however, data from the occupational exposure assessment indicate that the level of risk would be insignificant.

Tolerances for trifluralin have been established for a wide variety of agricultural commodities, but not specifically for sugar beets. However, EPA considers the processing studies submitted for sugar beets to be adequate to not require food/feed additive tolerances for residues of trifluralin for sugar beets. EPA has also established that available enforcement methods are adequate for the determination of trifluralin residues.

(13) Triflusulfuron-methyl

Triflusulfuron-methyl is an herbicide that is used almost exclusively in sugar beets (though it also has some usage in chicory and table beets) to manage a variety of grass and broadleaf weeds. Triflusulfuron-methyl is of low acute toxicity by oral (category IV), dermal (category III), and inhalation (category IV) exposure. Triflusulfuron-methyl is a slight dermal (category IV) and eye (category III) irritant. It is not a dermal sensitizer. Triflusulfuron-methyl has been classified as a Category C, “possible human carcinogen.”(U.S. EPA 2002a)

According to subchronic and chronic studies, the liver and testes appear to be the two organs most affected by exposure to triflusulfuron-methyl. Most studies also noted significant decreases in body weight and some evidence of adverse changes in the blood, including decreased red blood cell count. Liver toxicity was evidenced by increases in liver weights and microscopic changes in the liver, as well as an increased incidence of liver tumors in male mice. Testicular toxicity occurred in both subchronic studies with decreased testes weight and microscopic abnormalities including increased abnormal cell growth in the cells which secrete testosterone. Tumors in these cells (adenomas) have also been observed in male rats. Rat and rabbit studies indicate that there is no evidence that this chemical is developmentally or reproductively toxic. In dermal studies, no effects were seen, even at the highest doses.

In one metabolism study in rats where triflusulfuron-methyl was labeled with radioactivity, researchers showed that the liver had a large amount of radioactive triflusulfuron-methyl 5 days after exposure. Additional radioactivity was detected in the ovaries and skin of high-dose animals, indicating that triflusulfuron-methyl was moved there by the body. Elimination occurred mainly through the urine in low-dose animals, while elimination occurred mainly through the feces in high-dose animals.

The RfD for triflusulfuron-methyl is 0.024 mg per kg per day and is based on increased incidences of interstitial hyperplasia in the testes, decreased body weight gain, and alterations in hematology (mostly in males). In a chronic dietary risk exposure assessment conducted by EPA, it was determined that estimated exposures from triflusulfuron-methyl represent less than 1 percent of the cPAD for the general U.S. population and all population subgroups. The chronic RfD is considered by EPA to be adequately protective of these effects and indicates no concern for cancer risk. Therefore, a quantitative assessment of cancer risk using a cancer potency factor is not required.

Tolerances for triflusulfuron-methyl residues have been established at 0.5 ppm for sugar beet roots and tops as stated in 40 CFR §180.492. EPA considers the tolerance enforcement method available to be adequate for this commodity.

There are no current or pending uses for triflusulfuron-methyl that would result in residential exposure, though EPA notes that spray drift is always a potential source of exposure to residents near spraying operations. The agency has been working with the Spray Drift Task Force, EPA Regional Offices, and State Lead Agencies for pesticide regulation to develop spray drift management practices. Interim mitigation requirements for product labeling are currently in effect.

2. Worker Health and Safety

Workers are exposed to sugar beets and related products, including pesticides, during seed and crop production and processing. Workers also operate specialized equipment, which carry safety risks. Therefore, worker health and safety in terms of sugar beets and product production and pesticide use is described below.

a. Sugar Beets and Related Products

Sugar beet pollen, which is allergenic in some people, can be an occupational hazard (Ursing, 1968). It is reported that Luoto et al. (2008) identified two allergenic proteins, Beta v 1 and Beta v 2, in sugar beet pollen..

Regarding workers in sugar refineries, no data could be found indicating that such workers are experiencing adverse reactions as a result of sugar beet root processing. Another category of workers besides those on the farm and in sugar refineries are those processing, supplements, extracts, and other products. These workers likely would be exposed primarily during transport and initial processing. Exposures to equipment hazards and to extracting solvents are some of the risks these workers face.

The Occupational Safety and Health Administration (OSHA) was created by Congress with the Occupational Safety and Health Act of 1970 (OSH Act) to ensure safe and healthful working conditions by setting and enforcing standards to provide training, outreach, education, and assistance. Under the OSH Act, employers are responsible for providing a safe workplace devoid of serious health hazards and in accordance with all OSH Act safety and health standards. Compared to other private-sector occupations, however, agricultural workers and their families encounter a disproportionate number of injuries and diseases associated with physical, chemical, and biologic hazards (NIOSH (National Institute for Occupational Safety and Health), 2006). The Bureau of Labor Statistics (BLS) reports that there were 399 fatal occupational injuries in U.S. crop production, including support activities for crop production, in 2005 (BLS, 2011) and another 23,300 workers were temporarily or permanently disabled as the result of injuries related to crop production and support activities.

In sugar beet farming, an average rate of about 0.7 fatality occurred each year (or a fatality every 1.4 years) between 1992–2006, as seen in table 3–57. This estimate assumes that for years in which both sugar beets and sugarcane are reported (1992–2002), the sugar beet contribution was one-half the total, based on the approximately one-half market share of sugar beet sugar (section III.B). This estimate also does not differentiate fatalities for conventional versus H7-1 sugar beet farming, although APHIS expects that it primarily reflects conventional sugar beet farming because H7-1 sugar beets were not deregulated until March 2005 and were not widely grown until 2008 and beyond.

Data on injuries specific to sugar beet farming could not be readily found in the literature. Therefore, APHIS developed an estimate based on injuries from total crop production scaled to sugar beet production using acreage, assuming sugar beet farming hazards are similar to those of overall crop production and that equipment use contributes the bulk of the fatal and nonfatal injuries. This latter assumption is supported by BLS (2010b) data, which for 2005 indicate that over 90 percent of fatal farm injuries are equipment-related (i.e., excluding assaults and violent acts and fires and explosions). Thus, using 2005 acreage data from USDA NASS (2011c), 1.3 M acres of sugar beets in the United States divided by 318 M acres of all crops in the United States, or 0.041 sugar beet acre per total crop acres, times 23,300 total crop production injuries, equals approximately 95 annual injuries attributable to conventional sugar beet farming.

. **Table 3- 57 Reported Sugar Beet1 Farming Fatalities, 1992–2006**

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Reported Fatalities	3	8	0	0	5	0	0	0	0	0	0	0	0	0	3

Source: (BLS, 2010b).
[1] Sugar beet and sugarcane data are reported together between 1992–2002.

These injuries and fatalities could be caused in a variety of ways. For example, tractors are the leading cause of death and serious injury in agriculture (NIOSH (National Institute for Occupational Safety and Health), 2004) and thus likely would be major contributors in sugar beet farming also. Tractor accidents typically fall under the categories overturn, runover, collision, and entanglement. Overturns (also called rollovers) are responsible for over half of all tractor-related fatalities, and usually result in massive traumatic injuries to tractor operators. The impact of these accidents can be lessened by the use of seatbelts and ROPS-equipped (rollover protective structure) vehicles. Runovers occur when an operator or bystander is crushed under the tractor or attached equipment. An operator may be injured in a runover accident by falling from a moving tractor, or while standing on the ground and starting the vehicle. Bystanders may become victims of runover accidents when they are unseen by the operator or by slipping and falling under moving equipment wheels. Thus, the greater the number of farm workers in the field hand weeding, the greater the likelihood of runovers. Extra riders on moving tractors are also at risk for falling off the vehicle and being crushed. Children under 15 account for the majority of these latter victims. Runover injuries can be prevented by use of ROPS and seatbelts, and by prohibiting extra riders. Collisions occur when a tractor is operated on a public roadway and strikes, or is struck, by a motor vehicle or train. Entanglement occurs when an operator becomes entangled in the tractor's power take-off driveline. Use of proper machine shields and guards can prevent these injuries. The impacts of these accidents can be lessened by the protective measures already mentioned, and by community-wide safety efforts targeting motorists and tractor operators.

As discussed in detail in section III.B.1.c.(2) of this EIS, the adoption of H7-1 sugar beets has resulted a large reduction in equipment use. Section III.B.1.c(2) shows that between 2000 and 2010, rotary hoe and harrow usage in Minnesota and North Dakota, where the majority of sugar beets are grown, decreased from 62 percent of the acreage to 2.8 percent, a 95-percent reduction. During that same time period, use of electrical discharge systems (EDSs), weed pullers, mowing, and swathing decreased from 1.9 percent of the acreage to 0.4 percent, a 79 percent reduction. Between 2004 and 2009, hand weeding decreased from 28 percent of the acreage to 4 percent, an 86 percent reduction. Data on fuel used for cultivation and herbicide spraying (Hirnyck, 2007)indicate that tractor and related equipment use is 30 percent lower under H7-1 sugar beet crop production practices compared to conventional beets. Data in section III.B.1.c(2) also note that on average, farmers growing H7-1 sugar beet row crop cultivated their fields once as compared to 1.5 cultivations reported by conventional sugar beet growers. This would indicate a 33 percent reduction.

Decreases in farm equipment and machinery usage such as that described above have been linked to decreases in injuries and fatalities in the agricultural sector (Shutske, 2001). Therefore, APHIS used the reduction in equipment use under H7-1 sugar beet adoption to develop an estimate of a proportional reduction in injuries and fatalities. Using the most conservative of these estimates above for a reduction in equipment use, a 30% reduction in fuel use, by sugar beet crop agricultural workers can be reasonably expected to cause an approximately 30 percent decrease in sugar beet farming related injuries and deaths. Using the estimated fatality rate of approximately 0.7 per year for conventional sugar beets, APHIS would expect H7-1 sugar beet crop production to result in a fatality rate of approximately 0.5 per year. Similarly, using the estimated 95 nonfatal injuries for conventional sugar beets, APHIS would expect H7-1 sugar beet crop production to result in a nonfatal injury rate of approximately 66 per year, a decrease of about 29 non-fatal injuries per year.

As with agricultural workers in general, occupational-related injuries and illnesses are disproportionally high in beet sugar manufacturing plants compared to other industries (BLS, 2010a). In 2005, the beet sugar manufacturing industry had the highest incidence rate among private industry of total nonfatal occupational injury and illness cases, at 18.3 per 100 full time workers compared to 4.6 per 100 for all industries. In 2007, the rate for beet sugar workers was 11.7 per 100 full time workers compared to 4.4 per 100 for all industries. In 2009, the rate for beet sugar manufacturing was 10.0 per 100 full time workers compared to 3.6 per 100 for all private industry. While the rates for sugar beet workers dropped after adoption of H7-1 sugar beets, rates also dropped for all industries. The most common risks for accidents in sugar manufacturing facilities are trips and falls caused by slippery floors, incorrect use of packaging and transport equipment, contact with sharp edges on processing equipment, and explosions, as discussed above (International Finance Corporation, 2007). Other safety issues include hearing damage due to high noise levels and burns from steam lines and hot water.

Reductions in the use of tractors and other equipment to cultivate the soil and conduct other activities also results in reductions in engine emissions and fugitive soil particulates. Particulates have inherent toxicity, and they can also carry adsorbed pesticides and other agricultural hazardous chemicals. Worker exposure to engine emissions and particulates can cause serious health effects (Baker et al., 2005; Bennett et al., 2004). While such risks are an expected consequence of farming in general, they can be reduced (or increased) following changes in farming practices such as ready access to protective equipment, proximity to care facilities in the event of injury, improvements in equipment and working requirements. As discussed above, cultivation and equipment use has dropped substantially from the pre-2005/6 period of conventional sugar beet production to the more recent 2010/11 period of largely H7-1 sugar beet production. Subsequent reductions in worker health risks thus are possible.

Combustible dust is another worker hazard associated with sugar beets. In 2009, OSHA submitted an advance notice of proposed rulemaking requesting public input for the development of a proposed standard for combustible dust (74 FR 54334, Oct. 21, 2009), citing six recorded combustible dust incidents in the sugar beet industry since 1980. In 2008, a massive accumulation of combustible sugar dust at the Imperial Sugar refinery in Port Wentworth, Georgia fueled a massive explosion and fire that caused 14 deaths and 38 injuries, 14 of which were serious and life threatening (U.S. Chemical Safety Board, 2010). Although the Port Wentworth refinery processed cane sugar, sugar beet refineries also produce combustible sugar dust and are at risk for similar accidents.

b. Pesticides

Farm workers can be exposed to pesticides when:

- preparing the pesticides for use, such as by mixing a concentrate with water or loading the pesticide into application equipment;
- applying the pesticides;
- entering an area where pesticides have been applied;
- inhaling soil particulates with adsorbed pesticides;

Direct intake of or contact with pesticides by workers can be through the skin (dermal), by inhalation (to the lungs), orally (through the mouth), or into the eyes. Various indirect pathways exist, such as hand to mouth or eye contact and tracking pesticides from shoes and clothing into vehicles and homes. The intake amount can be affected by myriad factors, including form of the herbicide (liquid, powder, granulated), application method (backpack, boom, aerial), frequency and duration of application, use of protective equipment, and weather.

Virtually all sugar beet growers use herbicides; for example, in 2000 approximately 98 percent of planted acres received one or more herbicide applications (Ali, 2004). Hundreds of commercial herbicides are available, but only a fraction is labeled for use with sugar beets. As discussed in section III.B.1.d, all herbicides used on sugar beets, other than glyphosate, decreased during the transition from conventional sugar beet use to H7-1 sugar beet use between 2005 and 2010, while glyphosate use on sugar beets increased. Based on the last registration review, glyphosate has relatively low human health toxicity, as described in section III.F.1.b. Glyphosate is currently being evaluated by EPA for reregistration review and this level could possibly change. Based on EPA current understanding, with regard to subchronic and chronic toxicity at higher doses to which farm workers might be exposed, one of the more consistent effects of exposure of laboratory animals to glyphosate is reduced body weight gain compared to controls. Body weight loss has at times been noted in some chronic studies at excessively high doses ≥20,000 ppm in diet, though not in multiple subchronic studies (WHO (World Health Organization), 2005). Nevertheless, other general and non-specific signs of toxicity from subchronic and chronic exposure to glyphosate include changes in liver weight, blood chemistry (which might suggest mild liver toxicity), and liver pathology (USDA-FS, 2003). PPE and other safeguards should be used.

Glyphosate is not considered a carcinogen, as described in section III.F.1.b. EPA considered in its human health risk assessments the potential exposure to applicators and bystanders resulting from increased glyphosate use. Based on the toxicity of glyphosate and its registered uses, including use on GT crops, EPA concluded that occupational exposures (short-term dermal and inhalation) to glyphosate are not of concern because no short-term dermal or inhalation toxicity endpoints have been identified for glyphosate (71 *FR* 76180, 2006). Additional evidence to support the EPA conclusion can be found in the Farm Family Exposure Study, a biomonitoring study of pesticide applicators (Acquavella et al., 2004). This biomonitoring study determined that the maximum estimated systemic dose for farmer-applicators as the result of routine labeled applications of registered glyphosate-based agricultural herbicides to crops, including GT crops, was 0.004 mg per kg. This level is approximately 500 times lower than the RfD established for glyphosate of 1.75 mg per kg per day. Furthermore, as discussed in the previous section, the use of manual labor has declined substantially as growers adopted H7-1 sugar beets in recent years. APHIS would expect that these reductions have resulted in fewer workers being exposed to these herbicides.

The chronic (long term) toxicities of the key herbicides used for both conventional and H7-1 herbicides are described in section III.F.1.b. The acute toxicities for these herbicides used on sugar beets were summarized in the EA for sugar beets (USDA-APHIS, 2011b) and have been updated below in table 3–58. Many of these herbicides do have a human health risk and are labeled accordingly as to the measures needed to minimize the risk during handling and application on sugar beets.

Table 3–59, also updated from the EA, lists the herbicides used in conventional sugar beet production and their label contents (e.g., pre-harvest intervals (PHI), maximum use amounts, measures needed to mitigate exposure risks to humans). Information presented in the table was gathered from selected federal pesticide labels for the given EPA Registration Numbers. The selection of products is representative of products commonly applied to sugar beets. Some information on pesticide labels may vary from State to State, but signal words, precautionary statements, and exposure mitigation statements are required to remain consistent. Application rates may also vary slightly from product to product containing the same a.i., but total rates may not exceed the maximum rates determined by EPA.

Maximum application rates for single applications, as well as the maximum rate per season, are presented in table 3–59. The maximum application rates were derived from application amounts listed on the labels for sugar beets, which are typically in units of pints per acre. These values were converted to units of gallons, then to the number of pounds per gallon, based on the label for the product. When amounts were listed in pounds active equivalents (a.e.) per gallon, APHIS converted the amount to pounds a.i., based on equivalent information from the label. The impacts of these herbicides in terms of relative risks are analyzed for the regulatory alternatives in section IV.F.

The "signal words" on the labels for pesticide products can be either Caution, Warning, or Danger. Products bearing a Caution signal word are lowest in toxicity, those with Warning are of moderate toxicity, and those with Danger are highest in relative toxicity. Of the products listed in these tables, nine bear a Caution, three bear a Warning, and one (quizalofop-p-ethyl) bears a Danger. Signal words are based on acute toxicity testing of the concentrated product by oral, inhalation, dermal, skin sensitization, and eye exposures. The test results showing the highest toxicity are used to assign the signal word for the product (NPIC (National Pesticide Information Center), 2008).

Table 3- 58 Herbicide Acute Toxicity (Oral and Dermal) for Use on Sugar Beets

Active Ingredient	Trade Name (typical)	WSSA Mode of Action Group No.	Acute Toxicity Oral (mg/kg) LD_{50}	Acute Toxicity Dermal LD_{50} (mg/kg)	Source
Clethodim	Select®	1	1,630 (male rats) 1,360 (female rats)	>5,000 (rabbit)[1]	(U.S. EPA 2008b)
Clopyralid	Stinger®	4	>5,000 (male and female rat)	>5,000 (male and female rat)	(U.S. EPA 2009a)
Cycloate	Ro-Neet™	8	3,250 (male rat) 4,175 (female rat)	>5,000 (rabbit)	(U.S. EPA 2004)
Desmedipham	Betanex®	5	>5,000 (rat)	>4,000 (rat)	(U.S. EPA 1996b)
EPTC	Eptam®	8	1,294 – 1,976 (rat)	>2,000 (rabbit)	(U.S. EPA 1999)
Ethofumesate	Nortron®	8	>6,400 (rat)	>20,050 (rat/rabbit)	(U.S. EPA 2006b)
Glyphosate	Roundup® (WeatherMax, Ultra, Original)	9	>4,320 (rat)	>2,000 (rabbit)	(U.S. EPA 1993c)
Phenmedipham	Betamix®	5	>8,000 (rats)	>4,000 (rabbit, non-irritant)	(U.S. EPA 2005g)
Pyrazon	Pyramin®	5	2,140 (female rats) >3,930 (male rats)	>2000 (rat)	(U.S. EPA 2005c)
Quizalofop-p-ethyl	Assure® II	1	1,670 (male rats) 1,480 (female rats)	>5000 (rat)	(U.S. EPA 2006e)
Sethoxydim	Poast®	1	3,125 (male rats) 2,676 (female rats)	>5,000 (rats; non-irritant)	(U.S. EPA 2005d)
Trifluralin	Treflan® HFP	3	>5,000 (rat)	>2,000 (rats; non-irritant)	(U.S. EPA 2005d)
Triflusulfuron-methyl	Upbeet®	2	>5,000 (M & F rats)	>2,000 (M & F rats)	(U.S. EPA 2002a)

[1] The cited EPA reference lists the LD_{50} at ">5.0 mg/kg" and Toxicity Category IV. This value is amisprint, and should be >5.0 g/kg. Toxicity category IV is >5,000 mg/kg as defined. This change in numbers is also supported by the entry for clethodim in the Herbicide Handbook (WSSA, 2008), which lists >5000 mg/kg for this endpoint.

Of the products in table 3–59, those with Warning and Danger signal words may cause moderate to severe eye injury. Label warnings for all products on the list advise users to avoid contact with eyes, skin, or clothing, and to wear personal protective equipment when applying. Signal words may vary between products with the same a.i. Signal words are an indicator of the relative toxicity of the formulated product, which includes the a.i. and any other ingredients in the product. For this reason, some products may have signal words that reflect a higher toxicity value than is assigned to the a.i. alone.

The remainder of this section provides toxicity profiles relevant to worker exposure. Examples of accidental worker poisonings are described. APHIS would expect that some reductions in such poisonings have occurred in recent years due to fewer workers in the field and to the use of a less toxic herbicide profile.

(1) Clethodim

Details of the toxicity classifications and risk assessments for clethodim have been presented in section III.F.2.b(1). The EPA assessed occupational exposure for clethodim for multiple crops using the highest labeled application rate of 0.25 lb. a.i. per acre on the highest acreage treated. The short- and intermediate-term MOE on the day of treatment did not pose risks of concern for pesticide handlers (U.S. EPA 2008b). EPA also concluded that there was adequate information to address post-application exposures to clethodim, that no post-application exposures are of concern, and no new post-application assessments are required.

(2) Clopyralid

At the time that the clopyralid human health risk assessment for uses on Swiss chard, the bushberry subgroup, and strawberry was in development (U.S. EPA 2009a), EPA noted that an updated occupational risk assessment was in development. Based on a previous assessment conducted in 2002 (EPA, 2002), EPA expected that occupational risks would not pose risks of concern. The 2002 risk assessment assumed that "baseline" personal protective equipment (PPE) would be used by applicators. As clopyralid is a solid, workers that manufacture clopyralid may be exposed either by inhalation or dermal exposure. Given that clopyralid is applied in a liquid solution, the most likely route of exposure for applicators is by dermal exposure. No additional case reports or studies were found that addressed occupational exposure to clopyralid.

Table 3- 59 . Label Contents for Herbicides Used in Conventional Sugar Beet Production

Active Ingredient	Example Product Name, EPA Registration #	Label Signal Word	Sugar Beet PHI[2] (days)	Max lb a.i./acre - Single Application[3]	Max lb a.i./acre - Season[3]	Label Precautionary Statements /Special Directions[4]	Applicator and Handler PPE[5] Required to Mitigate Risks
Clethodim	Clethodim® 2E, 42750-72	Caution	40	0.25	0.5	Causes moderate eye irritation. Harmful if swallowed. Avoid contact with eyes, skin or clothing. Environmental hazard statements for surface water, runoff, drift, and disposal of equipment washwater or rinsate. "The use of this product may pose a hazard to the federally designated endangered species of Solano Grass and Wild Rice." Warnings for repeated use leading to selection of resistant weed biotypes. Crop injury warnings. Physical hazard: Combustible.	Long-sleeved shirt, long pants, shoes plus socks, chemical-resistant gloves, protective eyewear. Do not reuse heavily contaminated clothing.
Clopyralid	Stinger® , 62719-73	Caution	45	0.33	0.33	Causes moderate eye irritation. Harmful if absorbed through skin. Avoid contact with eyes, skin, or clothing. Warning for use near surface water, disposal of equipment washwaters, contamination of water used for irrigation or domestic purposes, and leaching to groundwater under certain conditions. Crop injury warnings for (1) use of treated plant material or manure from animals grazed in treated areas, as mulch or compost; and (2) spreading of treated soil. Up to 18-month rotation restrictions to many crops due to risk of injury; field bioassay recommended. Physical hazard: combustible	Long-sleeved shirt, long pants, chemical-resistant gloves made of waterproof material, shoes plus socks, protective eyewear.
Cycloate	Ro-Neet™ 6-E , 73637-5	Caution	Not Specified – Applied	4.0	4.0	Harmful if swallowed. Causes moderate eye irritation. Avoid contact with eyes, skin, or clothing. Environmental hazard statement	Long-sleeved shirt, long pants, chemical-resistant gloves and apron,

Active Ingredient	Example Product Name, EPA Registration #	Label Signal Word	Sugar Beet PHI[2] (days)	Max lb a.i./acre - Single Application[3]	Max lb a.i./acre - Season[3]	Label Precautionary Statements /Special Directions[4]	Applicator and Handler PPE[5] Required to Mitigate Risks
			preplant, at planting, immediately post-planting, or in fall before ground freezes.			for use near surface water, disposal of equipment washwaters, and drift. Soil incorporation or soil injection required. Crop injury concerns dependent on soil type.	shoes plus socks, engineering controls required for dermal penetration and inhalation protection. In California: For mixers, loaders, applicators and other handlers 93-gallon limit for handling in any 21-day period.
Desmedipham	Betanex®, 264–620	Warning	75	1.275	1.95	Harmful if swallowed or absorbed through the skin. Causes substantial eye injury. Avoid contact with eyes or clothing. Prolonged or frequently repeated skin contact may cause allergic reactions in some individuals. Avoid contamination of food and feedstuffs. This product contains the toxic inert ingredient isophorone. This product is toxic to fish. Environmental hazard statements for surface water, runoff, drift, and disposal of equipment washwaters. Physical hazard: Do not store near heat or open flame. Sugar beet injury possible under many situations.	Long-sleeved shirt, long pants, chemical-resistant gloves, shoes plus socks, protective eyewear.
Desmedipham / phenmedipham (product contains equal	Betamix®, 264-621	Warning	75	1.22	1.95	Causes moderate eye irritation. Harmful if swallowed or absorbed through skin. Do not get in eyes or on clothing. Avoid contact with skin. This product contains the	Long-sleeved shirt, long pants, chemical-resistant gloves, shoes plus socks, protective

Active Ingredient	Example Product Name, EPA Registration #	Label Signal Word	Sugar Beet PHI[2] (days)	Max lb a.i./acre - Single Application[3]	Max lb a.i./acre - Season[3]	Label Precautionary Statements /Special Directions[4]	Applicator and Handler PPE[5] Required to Mitigate Risks
concentrations, by weight, of both active ingredients)						toxic inert ingredient isophorone. This pesticide is toxic to fish and aquatic organisms. Warning against application to surface water, drift, runoff, and disposal of equipment washwaters. May be hazardous to fish and aquatic organisms. Physical hazard: Do not use or store near heat or open flame. Sugar beet injury possible under many situations; evening applications recommended. Rotation restriction of 120 days for cereals.	eyewear. Do not reuse heavily contaminated clothing.
EPTC	Eptam®, 10163–281	Caution	49	4.5	Not specified	Harmful if inhaled or absorbed through skin. Avoid contact with skin, eyes, or clothing. Avoid breathing dust. Toxic to mammals. Environmental hazard statement for use near surface water and disposal of equipment washwaters. Soil incorporation or soil injection required. Rotation restrictions of 6 to 12 months for crops other than sugar beets or ryegrass. Do not graze livestock on treated crops.	Long-sleeved shirt, long pants, shoes plus socks. For exposure to the concentrate: chemical-resistant footwear, gloves and apron; protective eyewear. Additional PPE requirements for chemigation systems, dry bulk fertilizer impregnation and application, backpack or hand-held application. In CA limit mixing/loading to a maxmimum of 1000 pounds per handler per 21 day period, not to

Active Ingredient	Example Product Name, EPA Registration #	Label Signal Word	Sugar Beet PHI[2] (days)	Max lb a.i./acre - Single Application[3]	Max lb a.i./acre - Season[3]	Label Precautionary Statements /Special Directions[4]	Applicator and Handler PPE[5] Required to Mitigate Risks
							exceed 100 pounds per handler per day
Ethofumesate	Nortron®, 264–613	Caution	90	3.75	4	Harmful if absorbed through skin. Avoid contact with skin, eyes, or clothing. Wash thoroughly with soap and water before eating, drinking, chewing gum, or using tobacco. This pesticide is toxic to fish. Environmental hazard statement for use near surface water. drift, runoff, and disposal of equipment washwaters. Rotation restrictions of 6 to 12 months for crops other than sugar beets, table beets, onions, shallots, carrots or ryegrass. Do not graze livestock on treated crops.	Long-sleeved shirt, long pants, shoes and socks, chemical resistant gloves, protective eyewear if system operates under pressure, chemical-resistant footwear and apron for use in emergenices.
Glyphosate	Roundup® Weather Max, 524-537	Caution	14 (conve n-tional sugar beet); 30 (H7-1 sugar beet)	4.51 (pre-emergence) ; 3.0 (assumed pre-emergence on H7-1, to maximize post-emergence use); 1.375 (emergence to 8-leaf stage); 0.95 (8-leaf stage to canopy closure)	7.29 (conventi o-nal and H7-1 sugar beet)	Causes moderate eye irritation, harmful if inhaled, avoid contact with eyes, skin, or clothing, avoid breathing vapor or spray mist. Environmental hazard statement: Do not apply directly to water. do not contaminate water when cleaning equipment or disposing of equipment washwater.Physical or chemical hazard statement: Do not mix, store, or apply product in galvanized or unlined steel containers or spray tanks. Product may be combustible, and could flash or explode, avoid proximity to heat and flame.	Long-sleeved shirt, long pants, chemical-resistant gloves, shoes plus socks. Keep and wash PPE separately from other laundry.

Active Ingredient	Example Product Name, EPA Registration #	Label Signal Word	Sugar Beet PHI[2] (days)	Max lb a.i./acre - Single Application[3]	Max lb a.i./acre - Season[3]	Label Precautionary Statements /Special Directions[4]	Applicator and Handler PPE[5] Required to Mitigate Risks
Phenmedipham (no products were found that contain only phenmedipham for use on sugar beet; the Spin-Aide label is presented here for reference)	Spin-Aide, 264-616 – a product for use only on red beets.	Warning	75	EPA RED lists max for sugar beets at 0.375–0.633.	1.0	Causes substantial, but temporary, eye injury. Harmful if swallowed or absorbed through skin. Do not get in eyes or on clothing. Avoid contact with skin. This product contains the toxic inert ingredient isophorone. This pesticide is toxic to fish and aquatic organisms. Do not apply directly to water; do not contaminate water when cleaning equipment or disposing of equipment washwater Drift and runoff may be hazardous to fish and aquatic organisms. Physical hazard: Combustible. Sugar beet injury possible under many situations; evening applications recommended. Rotation restriction of 120 days for cereals.	Long-sleeved shirt, long pants, chemical-resistant gloves, shoes plus socks, protective eyewear. Do not reuse heavily contaminated clothing
Pyrazon	Pyramin® DF, 7969-81	Caution	0	7.3	7.3	Harmful if swallowed, inhaled or absorbed through skin. Avoid breathing dusts or spray mists. Causes moderate eye irritation. Avoid contact with skin, eyes or clothing. Do not contaminate water used for irrigation or domestic purposes. Drift and runoff may be hazardous to aquatic organisms in water adjacent to treated areas. Warning for leaching to groundwater under certain conditions. Significant crop injury warning statements, depending on soil moisture level, soil type (organic matter content, loam, sandy, etc.), and temperature at time of application, application method, and tank mix products. Plant back restrictions of	Long-sleeved shirt, long pants, chemical-resistant gloves, shoes plus socks. Do not reuse clothing heavily contaminated with this product's concentrate.

Active Ingredient	Example Product Name, EPA Registration #	Label Signal Word	Sugar Beet PHI[2] (days)	Max lb a.i./acre - Single Application[3]	Max lb a.i./acre - Season[3]	Label Precautionary Statements /Special Directions[4]	Applicator and Handler PPE[5] Required to Mitigate Risks
						1 year for certain crops.	
Quizalofop-p-ethyl	Assure® II , 352-541	Danger	45 days, (60 days for feeding of tops)	0.0825	0.17	Causes irreversible eye damage. Harmful if swallowed, inhaled, or absorbed through the skin. Avoid contact with eyes, skin, or clothing. Avoid breathing vapor or spray mist. This product contains petroleum-based distillates. This pesticide is toxic to fish and invertebrates. Environmental hazard statements for use near surface water, drift, runoff, and disposal of equipment washwaters. Rotation restriction of 120 days for crops not labeled. Need spray adjuvant added. Special precautions for spray tank clean out. Physical hazard: Combustible.	Long-sleeved shirt, long pants, chemical-resistant gloves, shoes plus sock, protective eyewear. Do not reuse clothing heavily contaminated with this product's concentrate.
Sethoxydim	Poast®, 7969-58	Warning	60	0.47	0.94	Causes substantial, but temporary, eye injury. Causes skin irritation. Harmful if absorbed through skin or swallowed. Do not get in eyes, on skin, or on clothing. This product is toxic to aquatic organisms. Do not apply directly to water; do not contaminate water when disposing of equipment washwater. Adjuvant addition required. Crop injury warnings. Multiple confirmed resistant weed biotypes. Physical hazard: Combustible.	Coveralls over short-sleeved shirt and short pants, chemical-resistant gloves, chemical-resistant footwear plus socks, protective eyewear, chemical-resistant headgear for overhead exposure, chemical-resistant apron for cleaning, mixing, loading. Do not reuse clothing heavily contaminated with this product's concentrate.

Active Ingredient	Example Product Name, EPA Registration #	Label Signal Word	Sugar Beet PHI[2] (days)	Max lb a.i./acre - Single Application[3]	Max lb a.i./acre - Season[3]	Label Precautionary Statements /Special Directions[4]	Applicator and Handler PPE[5] Required to Mitigate Risks
Trifluralin	Treflan® HFP, 62719-250	Caution	NA; one applica-tion between first true leaf and 6-inch stage	0.75	0.75	Causes moderate eye irritation, harmful if swallowed, prolonged or frequently repeated skin contact may cause allergic reaction in some individuals. Avoid contact with eyes, skin, or clothing. Contains petroleum distillates. This pesticide is extremely toxic to freshwater marine and estuarine fish and aquatic invertebrates including shrimp and oyster. Do not apply directly to water; do not contaminate water when disposing of equipment washwater. Environmental hazard statement for aerial drift. Soil incorporation required within 24 hrs of application. Crop injury warnings. Crop rotation restrictions ranging from 5 to 21 months.	Long-sleeved shirt, long pants, shoes plus socks, chemical-resistant gloves, protective eyewear. Do not reuse clothing heavily contaminated with this product's concentrate.
Triflusulfuron-methyl	UpBeet®, 352-569	Caution	60	0.032	0.078	Avoid contact with skin, eyes and clothing. In case of contact with eyes, immediately flush with plenty of water. Get medical attention if irritation persists. Resistant weed biotypes; multiple MOA resistance. Need spray adjuvant added. Special precautions for spray tank clean out. Requires tank mix with another herbicide for broad spectrum weed control. . Do not apply directly to water; do not contaminate water when disposing of equipment washwater.	Long-sleeved shirt, long pants, chemical-resistant gloves, shoes plus socks.

NA indicates not applicable.
[1] Signal words for pesticide products listed in this table are from the product label represented by the EPA Registration Number.
[2] PHI – Post Harvest Interval
[3] Maximum application rates per single application per season were obtained from the labels. See the text for details on how these values were derived.

[4] All the labels for herbicides in the table have a form of the following statement: ”Do not apply directly to water, to areas where surface water is present or to intertidal areas below the mean high water mark. Do not contaminate water when [cleaning equipment or] disposing of equipment washwaters (or rinsate).” The text in bracket is excluded only for trifluralin and triflusulfuron. The text in parentheses is included for clethodim, cycloate, EPTC, pyrazon, and quizalofop-p-ethyl.

[5] PPE – Personal Protective Equipment.

(3) Cycloate

EPA determined that there is a potential for short- and intermediate-term exposures in for workers handling products containing cycloate during application activities including mixing, loading, and applying the products (U.S. EPA 2004). Because cycloate is incorporated into the soil within a short time after application, EPA expected any post-application exposures to be minimal. EPA has completed their occupational risk assessment for cycloate, and used the Pesticide Handler Exposure Database (PHED) to evaluate the exposures for pesticide handlers.

EPA established a MOE for inhalation and dermal exposure for five individual activities that workers might engage in while using products containing cycloate. When the risk estimate for an activity does not exceed the MOE, then that exposure is of concern to EPA. For cycloate application in sugar beets, activities whose risks were of concern included: closed mixing and loading for chemigation (fumigation application of a pesticide) – dermal and inhalation exposure; closed mixing and loading for ground boom application – inhalation exposure; closed mixing and loading for impregnation into dry bulk fertilizers – inhalation exposure; applying impregnated dry bulk fertilizers from an enclosed cab – inhalation exposure.

As the results of the EPA risk assessment indicate, risk from inhalation exposures remain a concern for some scenarios, even with maximum PPE and/or engineering controls. EPA has proposed some mitigation measures, including the voluntary cancellation of the chemigation application of cycloate, the requirement for engineering controls (including closed cabs and closed mixing/loading systems), and prohibiting the practice of on-farm impregnation of cycloate onto dry bulk fertilizer. EPA has also decided to require additional product use data to better characterize exposure from dry bulk fertilizer applications.

A review of human health incident data sources found two incidents that were due to workers not wearing label-specified PPE. A third incident was due to a worker being too close to a tractor while it was involved in spraying the soil.

(4) Desmedipham

After evaluating the occupational risks from exposure to desmedipham in 1996 (U.S. EPA 1996b), EPA determined that changes needed to be made in regulations governing occupational use of desmedipham. EPA was concerned about the MOE for dermal exposure risk for people who mix and load desmedipham products. EPA required that chemical-resistant gloves be worn by all mixers and loaders of wettable powder formulations of demedipham. An additional requirement was that a dust/mist respirator would be worn by mixers and loaders of wettable powders that were used for groundboom applications. Finally, EPA required engineering controls to mitigate risk, including water-soluble packaging or decreased application rates for applicators making or preparing for aerial applications of desmedipham.

(5) EPTC

In 1999, EPA evaluated occupational handler scenarios for workers that use products containing EPTC (U.S. EPA 1999). *It should be noted that the EPA is currently reevaluating EPTC and therefore some of the information regarding the EPA assessment of EPTC may change.* EPA determined that the intermediate-term endpoints from exposure to EPTC resulted in risks that were of concern to the agency. The risks for handlers that EPA was concerned about were based on dermal and inhalation exposure. To mitigate those exposures, EPA recommended that additional PPE, including double layer clothing and respirators, must be worn by mixers, loaders, and applicators. EPA also required that engineering controls such as enclosed cockpits are required during application of products containing EPTC. Of the 19 cases submitted to the California incident database (1982–1995) 17 involved use of EPTC alone and were judged to be responsible for the health effects.

(6) Ethofumesate

EPA conducted an occupational exposure assessment for ethofumesate and found that none of the potential occupational risks resulting from application of ethofumesate posed risks of concern (U.S. EPA 2006b). The agency based their conclusions on data from the PHED version 1.1. The re-entry interval (REI) established as a requirement of the worker protection standard (WPS) for ethofumesate is 12 hours, and EPA concluded that the interval is appropriate to protect workers from post-application exposure.

(7) Glyphosate

In their human health risk assessment for glyphosate, EPA noted that commercial handlers, applicators and growers that use glyphosate are expected to have short-term inhalation and dermal exposures to glyphosate (U.S. EPA 2006d). EPA did not conduct a short-term or a long-term handler or occupational exposure assessment because no short-term dermal or inhalation endpoints were selected by HIARC. Thus, EPA concluded that the assessment was not required. Labels for glyphosate products require applicators to wear PPE that consists of long-sleeved shirts, shoes with socks, long pants, and chemical-resistant gloves.

(8) Phenmedipham

In 2005, EPA assessed the occupational risks associated with application of phenmedipham for mixers, loaders, applicators, and flaggers (for aerial spray applications). All of the MOE estimates that EPA compiled were for combined dermal and inhalation exposure to phenmedipham. EPA found that if baseline PPE (the minimum required) was used by workers, the all of the handler exposure scenarios for pre- and post-application risks have MOEs greater than 100, which does not pose risks of concern(U.S. EPA 2005g).

(9) Pyrazon (EPA, 2005e)

EPA conducted an occupational exposure assessment for pyrazon and found that none of the potential occupational risks resulting from application of pyrazon posed risks of concern (U.S. EPA 2005c). The agency based their conclusions on data from the PHED version 1.1 and considered short- and intermediate-term inhalation exposures. EPA did not assess dermal exposure, since a dermal endpoint of concern has not been identified for pyrazon. The REI established as a requirement of the worker protection standard WPS for pyrazon is 12 hours, and EPA concluded that the interval is appropriate to protect workers from post-application exposure.

(10) Quizalofop-p-ethyl

EPA assessed the occupational risks from exposure to quizalofop-p-ethyl as part of their Human Health Risk Assessment for New Uses on Barley, Flax, Sunflower and Wheat (U.S. EPA 2006e). EPA did not calculate any quantitative risks for quizalofop-p-ethyl and concluded that no short-term dermal and inhalation toxicity endpoints were identified for estimating the occupational exposures to handlers and post-application workers. EPA Health Effects Division (HED) reported they had no concerns for occupational exposures associated with the proposed uses of quizalofop-p-ethyl based on the fact that the acute toxicity categories are IV for both dermal and inhalation routes of exposures (U.S. EPA 2006e). Under the WPS, a 12-hour REI is established.

In 2007, EPA conducted a review of incident reports for quizalofop-p-ethyl based on data from three sources: Poison Control Center data from the National Poison Center System (NPCS), the Office of Pesticide Programs (OPP) Incident Data System (IDS), and the National Institute of Occupational Safety and Health (NIOSH) Sentinel Event Notification System for Occupational Risks (SENSOR) (U.S. EPA 2007d). There were no reported cases in the SENSOR database. The NPCS data cover 1993 to 2005, and included ten total exposures to quizalofop-p-ethyl. Reported symptoms from the reports included headache, eye irritation, and throat irritation. There were eight reported cases from 1999 to 2007 in the IDS database. Symptoms reported in those cases included sinus and other headaches, nausea, leg cramps, rashes, diarrhea, fever and hypothermia. No information was available on the resolution of any of the eight cases from the IDS database.

(11) Sethoxydim

EPA assessed the potential for occupational exposure to sethoxydim in 2005 (U.S. EPA 2005h). The exposures EPA evaluated included the handling of sethoxydim during mixing, loading, and application processes. The potential for postapplication occupational exposure was also evaluated, due to workers entering into areas previously treated with sethoxydim. EPA concluded that short-term and intermediate-term exposures (1 to 6 months) may occur, but that long-term exposures were not expected. EPA only assessed the risks from inhalation exposures, as no dermal toxicity endpoints for sethoxydim were identified. The risk for inhalation exposures was based on values observed in a 28-day rat inhalation study. The MOE values generated from the risk assessment all posed risks of concern. The most common symptoms reported in incident reports included rash, eye and throat irritation, gastrointestinal symptoms, headache, and dizziness. Two of the more serious cases reported eye problems including visual defect and nonreactive pupils.

(12) Trifluralin

In the occupational exposure assessment for trifluralin, EPA identified the potential for exposure for mixers, loaders, applicators, or other handlers during normal use practices (U.S. EPA 1996c). EPA also found that their occupational cancer risk assessment for all uses shows that the level of risk does not exceed 10^{-5} for occupational handlers of products containing trifluralin or for post-application exposures. The REI for products containing trifluralin is 12 hours, and the minimum PPE required for early entry include coveralls, shoes, socks, and chemical-resistant gloves.

(13) Triflusulfuron-methyl

Due to a lack of chemical-specific data for assessing human exposures to triflusulfuron-methyl, used data from the PHED version 1.1 to complete their risk assessment (U.S. EPA 2002a). EPA concluded that the available data support an REI of 4 hours, but that the shorter REI would only be established following a request from the registrant and the submission of toxicity information on the product. In their risk assessment, EPA found that none of the MOEs for occupational exposure posed risks of concern for both application and postapplication activities.

IV. Environmental Consequences

A. Methodologies and Assumptions Used in Analysis

This chapter evaluates the potential effects of the selection of Alternatives 1 through 3, as presented in chapter II of this environmental impact statement (EIS).

This chapter considers the potential environmental consequences of implementing each alternative on the following: production and management of beet crops (including sugar beets, Swiss chard, table beets, and fodder beets, and gene flow); biological resources (including animals, micro-organisms, and plants); socioeconomics (including various sugar, sugar beet, and vegetable beet markets, and environmental justice); physical environment (including land use, soil, air quality and climate change, and surface water and groundwater quality); and human health (including public and worker health and safety).

1. Methodologies

This EIS analyzes the potential environmental impacts of various alternative options for determining the regulated status of H7-1 sugar beets. Models and assessments used for the analysis range from those discussed in the studies in the published literature that inform this EIS to those that the Animal and Plant Health Inspection Service (APHIS) developed or refined for the EIS. An example of the former is the GENESYS-BEET model, which is a computation model developed to examine numerous components of the cultivated beet and weed beet lifecycles (see section III.B.5). An example of the latter is the relative risk calculation APHIS used to relate the risks of herbicides to glyphosate.

In order to assess the potential for unintended gene flow between H7-1 sugar beet and vegetable beet seed production in the United States, APHIS determined the distribution of vegetable seed production in the Swiss chard and table beet sections (see sections III.B.2, III.B.3, IV.B.2, and IV.B.3). Because public data were not available for much of Swiss chard and table beet seed production, APHIS used publications from the Washington State Extension Office (du Toit et al., 2007; McMoran et al., 2010), and contacted regional extension agents and commercial seed producers of both vegetable beet crops (Falconer, 2011; Mcmoran, 2011a). Using these data, the estimated acreage and distribution of each crop type was mapped at the state level to preserve confidential business information. Additionally, using planting data supplied to APHIS as a permitting requirement, as of May 15, 2011, APHIS determined the county level distribution of H7-1 sugar beet seed production for 2011. Using these county level maps, APHIS determined the counties in which the overlap of sugar beet and vegetable beet seed production occurs.

In the gene flow section, section III.B.5, estimates of pollen cloud dissipation rates and competition at sink fields were assessed to determine the potential for unintended gene flow at the different isolation distances used in each of the alternatives. APHIS used published pollen dispersal distances from gene flow studies that were summarized in (Darmency et al., 2009). Using the best fit models for pollen dispersal and gene flow under conditions of no pollen competition (male-sterile receptor plants), APHIS determined the rate of pollen dilution up to 3,280 feet. APHIS also used published estimates of pollen production and ovule production for *Beta vulgaris* to determine the relative size of pollen clouds that have not dispersed (OECD (Organization for Economic Cooperation and Development)). APHIS did not extrapolate beyond the distances where empirical data are available; thus rates of gene flow are summarized at 3,280 feet, and did not attempt to determine gene flow potential at the 3- or 4-mile isolation distances utilized by the different alternatives. Previously published computational models that have estimated gene flow at 6 miles (Westgate, 2010) were used as a benchmark beyond the recommended isolation distances. Additionally, APHIS determined the approximate lifecycles, bolting period, and flowering period of sugar beet seed production, sugar beet root production, and wild beet through published data on production methods and through interviews with sugar beet experts (Beet Sugar Development Foundation et al., 2011). Flowering times and published data (Lewellen et al., 2003)were used to evaluate the potential for gene flow to occur between sugar beets and wild beets in California under Alternative 2.

Herbicide usage in sugar beets is an important aspect in assessing the environmental impacts of deregulation of H7-1 sugar beets. To assess herbicide use across the alternatives, APHIS used published herbicide data from U.S. Department of Agriculture–National Agricultural Statistics Service (USDA–NASS) and Stachler and colleagues (Stachler et al., 2011). These reports are described in chapter III in more detail. APHIS used application data from 2000 as a baseline and extrapolated those data to the acreage planted in 2010, namely 1,171,400 acres for Alternative 1. This was done by applying the same proportion of acres, rates per acre, and number of applications for each herbicide from 2000 (USDA-NASS, 2008) to the acreage planted in 2010. For Alternatives 2 and 3, APHIS used the rates per acre from USDA–NASS (2008a), and used the number of applications and percentage of acres treated from Stachler and colleagues (Stachler et al., 2011) for all herbicides other than glyphosate. To estimate usage of glyphosate in Alternatives 2 and 3, APHIS used application rates for glyphosate that were consistent with the rates presented in the Final EA (USDA-APHIS, 2011b), and by Stachler and colleagues (Stachler et al., 2011).

In the herbicide resistance section IV.C.3, APHIS examined what weeds could have the greatest potential to be problematic in sugar beets and in rotation crops under each of the alternatives. APHIS evaluated sugar beet weeds, and examined the distribution of glyphosate-resistant weed species in the States that produce sugar beets (Heap, 2011; Sprague and Everman, 2011) Stachler et al., (Stachler et al., 2011); and states that are immediately adjacent to sugar beet States. APHIS then expanded the analysis of these glyphosate-resistant weeds by examining the distribution of each species that has been noted as having biotypes that are resistant to conventional herbicides as well as the distribution of sensitive biotypes (USDA-NRCS, 2010). Finally, APHIS examined the distribution of all remaining glyphosate-resistant species that have occurred worldwide (Heap, 2011), noting if they have been identified as sensitive biotypes in any sugar beet producing States. Using a tiered system to qualitatively classify the different weed species, APHIS identified weeds with the greatest potential to shift into H7-1 sugar beets or other glyphosate-resistant crops in rotation with H7-1.

The biological resources analysis for animal and non-target plants includes an assessment of the composition and nutritional quality of H7-1 sugar beets. This analysis also includes a qualitative and quantitative assessment of the potential effects of sugar beet herbicides on animals and non-target plants. For glyphosate, the assessment incorporates information from the Tier 1 ecological risk assessment conducted by APHIS for the *Final Environmental Impact Statement for Glyphosate-Tolerant Alfalfa Events J101 and J163: Request for Nonregulated Status* (USDA-APHIS, 2010a). Appendix N of the alfalfa Final EIS analyzes the potential effects of glyphosate on plants and animals. For all of the herbicides used on conventional sugar beets, APHIS reviewed and presented available toxicity data for mammals, birds, fish, aquatic invertebrates, terrestrial invertebrates and both monocot and dicot plants and other relevant information published by EPA's Office of Pesticide Programs (EPA OPP), as well as other sources. Where appropriate, APHIS presented estimated environmental concentrations that might reach non-target plants and animals during and soon after herbicide application according to labels.

In analyzing the potential socioeconomic impacts of the alternatives, APHIS first identified potential issues raised by the existing literature, including the Final EA for partial deregulation of H7-1 sugar beets (USDA-APHIS, 2011b). APHIS then prepared relevant baseline information to enable assessing the issues raised. The baseline describes the supply and demand of the various markets along the sugar beet production chain, from seed to sugar, including foreign markets and niche markets such as the organic and non-genetically modified organisms (GMO) segments. The baseline also describes the U.S. vegetable beet market. Finally, APHIS assessed the existing evidence regarding potential impacts of each alternative on the various markets described. This was done mostly qualitatively and based on the existing literature, including recent expert studies and surveys.

The analysis of impacts on the physical environment draws on the analyses APHIS developed for production management, biological resources, and socioeconomic impacts. APHIS supplemented these analyses with data from the existing literature to identify relevant variables such as acreage planted, tillage practices, and the use of glyphosate- and non-glyphosate-herbicides. APHIS estimated the trends in and changes to the identified variables to assess the potential effects of the alternatives on land use, soil, air quality and climate change, and surface water and groundwater quality.

The human health and safety assessments in sections III.F and IV.F use both screening-level approaches to assess toxicity and compare exposure estimates with human health toxicity benchmarks. Specifically, the toxicity assessment of the CP4 EPSPS (5-enolpyruvylshikimate-3-phosphate synthase) protein, used a standard approach in toxicology assessment of applying an excess dose to a test animal and observing the effects. In this case, the dose of CP4 EPSPS was designed to reflect a 1,000-fold factor of safety on the highest possible human exposure to CP4 EPSPS, assuming multiple sources in the diet. The dose was equivalent to a human ingesting about 221 kilograms of beet root at one time. The CP4 EPSPS protein also is assessed for biologically relevant amino acid sequence similarities to protein toxins known to cause adverse health effects in humans or animals. This assessment is based on a comparison of the amino acid sequence of CP4 EPSPS to protein sequences in the ALLPEPTIDES database using the FASTA algorithm. A similar assessment is also made for allergens, using the FASTA algorithm in the ALLERGEN3 database.

Also, the U.S. Environmental Protection Agency (EPA) reference doses (RfD) for herbicides, including glyphosate – an herbicide which would be predominantly used in sugar beet root production under Alternatives 2 and 3 – generally include a 100-fold safety factor above the no-observed-adverse-effect level (NOAEL) from an animal study. EPA's aggregate dietary risk assessments use several models, including the Dietary Exposure Evaluation Model software with the Food Commodity Intake Database (DEEM-FCID™) and the Generic Expected Environmental Concentration (GENEEC) and Screening Concentration In Groundwater (SCI-GROW) models, along with conservative modeling assumptions such as the use of tolerance level residues, 100 percent crop treated, a water dilution model that does not take into account degradation in the water body and partitioning into the water column sediment phases, and maximum pesticide application rates (71 *FR* 76180, 2006). The human health and safety assessments also use a variety of methodologies for assessing and comparing overall risk from herbicides. These methodologies include the following:

- APHIS relative risk score (RRS), a metric developed by APHIS to provide an estimate of the risk of various herbicides, relative to a given herbicide (in this case glyphosate);

- The exposure adjusted toxicity category from the Windows Pesticide Screening Tool (WIN-PST), developed by the USDA Natural Resources Conservation Service (NRCS) as a risk screening tool for pesticides; and

- Environmental Impact Quotient (EIQ), a tool developed to integrate information on different types of environmental and human health impacts of individual pesticides into a single indicator value of impact.

2. Inherent Assumptions

APHIS expects that Alternative 1 (No Action) will result in conditions similar to those prior to the 2005 deregulation of H7-1 sugar beets. Data from years prior to 2005 were used to predict what conditions would eventually return for the affected environment.

APHIS expects that Alternative 2 (Full Deregulation) will result in conditions similar to 2009-2010 after H7-1 sugar beet deregulation and it’s widespread adoption. When available, data from those years were used to predict what conditions would occur should Alternative 2 be selected.

APHIS expects that Alternative 3 (Partial Deregulation) will result in similar “on the ground” foot prints of H7-1 sugar beet plantings as Alternative 2 (with the exception of California and western Washington), and that the plantings that would occur under Alternative 3 would be more similar to the conditions seen under deregulation than prior to deregulation. That is, the acreage of H7-1 sugar beets would be closer to 100 percent than to zero percent. It is difficult to predict what impacts the restrictions and conditions contained in Alternative 3 would have on grower choices and behaviors.

Other assumptions are stated where applicable throughout the individual resource sections of this EIS.

Data gaps or uncertainties are also discussed in the analysis of potential impacts. Where a complete evaluation of reasonably foreseeable environmental impacts on the human environment that could result from the proposed action and alternatives is precluded by a lack of data that cannot be obtained except at exorbitant prohibitive cost or by unknown means, APHIS acknowledges the inability to estimate the potential environmental impacts precisely that may result from the proposed action or alternatives.

B. Production and Management of Beet Crops

This section discusses the potential impacts of the environmental release of H7-1 sugar beets for the three alternatives analyzed in this EIS. Just like section III.B, it is divided into five main sections: sugar beets (IV.B.1), Swiss chard (IV.B.2), table beets (IV.B.3), fodder beets (IV.B.4), and gene flow in these *Beta* species (IV.B.5).

1. Sugar Beets

As described in section III.B.1, sugar beet production in the United States includes production of both seed and roots. Potential impacts of the environmental release of H7-1 sugar beets on both seed and root production are described separately below.

While chapter III describes all uses of sugar beets, it is important to note that none of these uses have caused there to be changes in sugar beet seed or root production with the adoption of H7-1 sugar beets. In some cases, H7-1 sugar beets are not allowed to be used in all applications (e.g., as mandated by the Monsanto Technology Use Guide (TUG), H7-1 sugar beets may not be used for wildlife habitat plots). However, as described in section III.B.1.b(11) and below, seed companies already have in place protocols to separate H7-1 from conventional seed and to reduce the possibility of accidental mixing of seed (Lehner, 2010; Loberg, 2010a), so this requirement has not resulted in any additional changes in seed production practices. In terms of other uses, there have been no changes in sugar beet seed or root production for the use of sugar beets in beet pulp, molasses, food additives, chemical manufacturing, deicing, feed for animals, the use of waste lime from sugar processing plants, and the production of sucrose from sugar beets.

The discussion that follows also does not address all aspects of sugar beet seed and root production, but rather focuses on only those aspects that differ from the No Action Alternative as a result of the two additional alternatives that are analyzed in this EIS. In terms of seed production, the majority of the practices used to produce sugar beet seed have not changed with the adoption of H7-1 sugar beets and therefore are not discussed below. For example, the companies that produce and market sugar beet seed, the requirement of seed variety approval by seed cooperatives, the lifecycle of seed production, the development of monogerm varieties, the methods of hybrid seed production including cytoplasmic male sterility, the planting of hybrid parents in the field, the use of pinning maps in areas where sexually compatible *Beta* species are grown, land preparation, the use of both the direct seeding and stecklings methods, fertilization, crop rotation, and disease management have all remained the same. Additionally, APHIS does not anticipate any changes in these production practices as a result of any of the three alternatives. Therefore, these sugar beet seed production practices are not discussed in detail below. For more information on these seed production practices, see the corresponding sections in III.B.1.b(1) through III.B.1.b(19).

The aspects of sugar beet seed production that have changed with the adoption of H7-1sugar beet and are predicted to vary among the three alternatives include: the counties in which sugar beet seed is produced, the isolation distances used between sugar beet seed production and other fertile *Beta* species, the guidelines used for sugar beet seed production by Betaseed and West Coast Beet Seed, herbicides used during seed production, the post-production processes used after seed has been harvested, and testing for LLP in seeds. These issues, and the associated changes that are expected to occur with each of the three alternatives, are discussed in detail below.

In terms of root production, some practices used to produce sugar beet roots also have not changed with the adoption of H7-1 sugar beets. These practices include root production location, the acreage of crops planted in each region, planting, bolting and harvesting dates, fertilization and pH adjustment, and pest management practices including disease and insect management. Additionally, APHIS does not anticipate any changes in these production practices among the three alternatives. Therefore, these sugar beet root production practices are not discussed in detail below. For more information on these root production practices, see the corresponding sections in III.B.1.c(1) through III.B.1.c(5).

The aspects of sugar beet root production that have changed with the adoption of H7-1 sugar beets and are predicted to be affected by the three alternatives include: the types of seed selected in each area, tillage and weed management, management of bolters, fertilizer application methods, and requirements related to transportation of sugar beet roots to processing facilities. These issues, and the associated changes that are expected to vary among the three alternatives, are discussed in detail below.

a. Seed Crop
The potential impacts of each of the alternatives on seed crop production practices are discussed in turn below.

(1) Alternative 1 – No Action

Under Alternative 1, APHIS would deny the petition seeking a determination of nonregulated status of H7-1 sugar beets. for nonregulated status to H7-1 sugar beets. Under Alternative 1, it is possible, but unlikely, that previously deregulated herbicide-resistance traits in sugar beets (event T120-7 and line GTSB77) could be bred into current sugar beet varieties and released for commercial production. However, both Monsanto/KWS SAAT AG and Bayer, the owners of these traits, have stated to APHIS that they have no intention to do so (see section II.B). For more information on regulatory approvals of event T120-7 and line GTSB77, see section III.B.1.a(4). APHIS assumes that under Alternative 1, no herbicide tolerant sugar beet will be available to growers.

Under Alternative 1, an adequate amount of conventional sugar beet seeds to sell to farmers might not be available until 2014 at the earliest (Miller, 2010). Conventional sugar beet seed that has been held in reserve by seed producers is at least 3 years old making it low quality and potentially unmarketable (Miller, 2010). Whether seed supply would be limited is unclear, as opinions on the topic differ (Miller, 2010; Pates, 2010).

Under Alternative 1, a lag in production of conventional sugar beet seeds would occur. Given that 8–12 years is required to develop a new sugar beet variety, and many sugar beet breeding lines currently contain the H7-1 transgene, several years would be needed to develop conventional varieties with the same trait combinations that currently exist in H7-1 lines (Miller, 2010). For more information on sugar beet seed breeding, see sections III.B1.b(1) though III.B1.b(14). Conventional seed varieties available to farmers in the short term (~1–10 years) would likely not contain the most desirable trait combinations for each region due to the breeding lag. APHIS believes that the lag would not continue in the long term as seed companies would continue to develop new, non H7-1 varieties with the trait combinations desired by farmers.

Additionally, as stated in section III.B.1.b(4), sugar beet farmers can only grow varieties that are approved by sugar beet seed committees after a 3-year trial period. Given the strong grower demand for H7-1 sugar beets, which comprised 95 percent of sugar beets grown in 2009-2010, most beet sugar processors have few to no conventional sugar beet varieties on the approved list. It is possible that an emergency exception would be made to allow growers to use conventional seed varieties that are not on the list but were listed in previous years (American Crystal Sugar Company, 2010). As the State of California has not yet adopted H7-1 varieties, they are not expected to have a shortage of conventional sugar beet seeds under Alternative 1.

As described in chapter III, for the most part, weed management in seed fields after the adoption of H7-1 sugar beets has not changed. The practices used in 2005 are similar to those used in 2010. The only difference is that H7-1 breeder and foundation seeds may have glyphosate applications for postemergence weed control as long as both parents carry the H7-1 gene (Loberg, 2010b). In general, glyphosate is not used in commercial seed production because at least one of the parents does not carry the resistance gene and could be damaged by glyphosate application. For more information on hybrid crosses in the field, see section III.B.1.b(9). Under Alternative 1, no H7-1 parents would be present in commercial seed fields; therefore, glyphosate could not be used for postemergence weed control.

In 2006, the West Coast Beet Seed (WCBS) Company implemented the Protocol for Genetically Modified (GM) Seed Production (Loberg, 2010a). Betaseed implemented similar protocols. Under Alternative 1, WCBS and Betaseed would no longer need to follow these protocols as H7-1 seed would no longer be produced. Seed companies would likely revert to pre-2005 practices to ensure that high-quality conventional hybrid seed was produced. For more information on WCBS and Betaseed guidelines, see section III.B.1.b(11).

As described previously in section III.B.1.b(19), sugar beet seed companies have always tested sugar beets seeds for genetic purity. Depending on the specific tests done, this type of testing can detect whether varieties have the intended mix of genetic traits and can also detect if the H7-1 trait is present in conventional lines (Anfinrud, 2010). Under Alternative 1, testing conventional seed for the low level presence of H7-1 would be expected to cease. Seed companies would continue to test for traits introduced by unintended crosses.

In summary, Alternative 1 would not change the basic principles behind sugar beet seed breeding, production practices, or variety development as described above. However, Alternative 1 may result in a short-term shortfall in availability of conventional seed to sell to farmers; the elimination of glyphosate use for postemergence weed control (Loberg, 2010b)(only used now for H7-1 breeder and foundation seeds where both parents carry the H7-1 gene); seed companies reverting back to pre-2005 practices to ensure high-quality conventional hybrid seed; and the elimination of testing for the low level presence of the H7-1 trait. Alternative 1 also would reduce the H7-1 gene flow potential to other *B. vulgaris* crops (Swiss chard and table beets). For more information on gene flow impacts, see section IV.B.5.a.

(2) Alternative 2 – Full Deregulation

Under Alternative 2, a determination of nonregulated status of H7-1 sugar beets would mean that H7-1 sugar beets would no longer be subject to the regulations at 7 CFR part 340.

APHIS does not track all sugar beet seed production acreage. For this EIS, APHIS assumes that seed acreage for domestic use would be in the same ratio (H7-1:conventional) as domestic root acreage. Therefore, if 95 percent of the root crop acreage is H7-1, then 95 percent of the seed acreage for domestic use would be H7-1. The proportion of H7-1 to conventional of the export seed crop is not known, because while USDA tracks overall exports, it does not track the type of varieties exported.

Both H7-1 and conventional varieties are exported. However, it should be noted that only Canada has approved H7-1 sugar beet seeds for root production, so H7-1 sugar beet seeds would likely not be exported to any country other than Canada. For more on H7-1 international approvals, see section III.B.1.a(5).

An adequate amount of H7-1 and conventional sugar beet seeds is expected to be available to farmers under Alternative 2.

Under Alternative 2, it is possible, but unlikely, that previously deregulated glufosinate tolerant sugar beet, event T120-7 could be bred into current H7-1 sugar beet varieties to create stacked dual herbicide resistant varieties. Both Monsanto and Bayer, the owners of these traits, have stated to APHIS that they have no intention to do so (see section II.B). Furthermore, glufosinate-tolerant sugar beet T120-7 is lacking many of the international approvals that H7-1 has, so stacking the two traits would reduce the marketability of processed food produced from GE sugar beets. For more information on regulatory approvals of event T120-7, see section III.B.1.a(4).

Monsanto's Technology Stewardship Agreement (MTSA) is based on the ability to license the H7-1 sugar beet technology to each grower under existing patents to produce one crop. There are a number of applicable patents, including patents on the H7-1 event, the use of technologies, and the germplasm or variety. The existence of patents is the underpinning of the contractual relationship between Monsanto or KWS SAAT AG and the grower. That contractual relationship is one basis for enforcement of stewardship requirements outlined in the TUG. Growers who fail to follow the TUG may be ineligible to purchase Monsanto seed in the future or in extreme cases legal action can be taken by Monsanto. The TUG is separate from the MTSA, and describes the broad range of stewardship activities that Monsanto recommends for the proper use of its biotech seed products. The TUG would be published and provided to growers to guide proper product stewardship whether or not an MTSA is in place.

Independent of grower obligations under the MTSA, the Sugar Beet Grower Cooperatives also impose certain stewardship requirements through grower contracts. Under Alternative 2, because the Grower Cooperatives would maintain control, APHIS concludes that patent expiration would have no impact on sugar beet root production.

Furthermore because all sugar beet seed is produced as hybrids, seed saving is not practical and available varieties would remain under industry control after patents expire for the following reasons. First, producing hybrid seed is a complex undertaking requiring specialized skills and resources including proprietary parental lines. Second, growers are obligated to plant only varieties that are entered into variety trials which would exclude a grower from producing his own varieties. Third, growers of the root crop are located in regions where it is difficult to grow a seed crop. As stated in section III.B.1.b(1),commercial sugar beet seed is mainly produced in Oregon and Washington where the climate is not too cold or too hot to meet the growing needs of a biennial crop. Sugar beet root production areas, with the exception of the Imperial Valley, are not conducive to seed production as the cold winters would kill sugar beet plants before seed stalks could form in the spring. The Imperial Valley is an undesirable seed production region due to the high spring and summer temperatures that impair pollen and seed development (see section III.B.1.5). As a result, varieties can be effectively removed after patent expiration and replaced with new varieties that are similarly patent protected. It is reasonable to expect that these replacement varieties, which may contain the H7-1 trait stacked with other new biotech traits, will also require stewardship agreements. Therefore, the agency does not anticipate any changes in stewardship requirements for growers after the H7-1 trait patent expires.

After patent expiration, vegetable beet breeders would not be prohibited from breeding the H7-1 trait into any compatible *Beta* species. However, as stated in sections III.B.2 and III.B.3, virtually all of the Swiss chard and some of the table beet seed produced in the United States are for GM-sensitive markets. Growers of table beets for canning might prefer varieties that are glyphosate resistant so it seems possible that this trait might oneday be used in other beet crops depending on the canning industy's perception of consumer sensitivity to GM.

In 2011, H7-1 sugar beet seed is being produced in Oregon, Washington, Idaho and a small amount in Colorado. Figure 3–1 shows counties in 2011 in which H7-1 sugar beet seed was planted (shaded) and proposed for planting but not planted (hatched). See section III.B.1.b(1) for more on seed production areas. As discussed above and in section III.B.1.b(1), climate constraints hinder sugar beet seed from being produced in other U.S. geographic locations outside of the Northwest. While seed production could move into northern California and western Washington under Alternative 2, APHIS believes areas of seed production would stay about the same as they are now for the following reasons:

- Sugar beet seed production has historically been confined to Oregon. The most recent expansion of sugar beet seed production has been into Eastern Washington, an area without Swiss chard and table beet seed production and not into areas such as western WA and northern.CA where vegetable beet seeds are produced. APHIS is not aware of any reason why sugar beet seed production would follow vegetable seed production into western WA and CA.

- There is a high level of economic motivation to keep pinning schemes and isolation distances in place. Seed producers want to produce seed with high purity and miminal LLP . For more information on LLP, see section III.B.1.b(19).

- Sugar beets are unlikely to be grown in western Washington State since this region is already utilized by seed producers for Swiss chard and table beet. Pinning priority for field placement involves seniority and incoming farmers would be less likely to find regions within western Washington that are sufficiently isolated.

- Postemergence weed control would likely continue similar to 2010 practices where H7-1 sugar beet parental lines can be treated with glyphosate. H7-1 breeder and foundation seed may have glyphosate applications for postemergence weed control. Application of glyphosate to all rows in a commercial seed production field is not possible as only one of the parents carries the H7-1 trait in a given cross and the other parent would be killed by the glyphosate. For more information on hybrid crosses in the field, see section III.B.1b(9).

As mentioned under Alternative 1, WCBS and Betaseed would likely continue to follow their strict guidelines to further minimize the potential for gene flow for H7-1 seed production. This includes guidelines from tracking the seed from the field to the final delivery at the processing facility in order to minimize the possibility of accidental mixing with other seeds (Lehner, 2010; Loberg, 2010a). In Willamette Valley, both Betaseed and WCBS follow the Willamette Valley Specialty Seed Association (WVSSA) guidelines for isolation distances of at least 3 miles between H7-1 sugar beet seeds and other sexually compatible *Beta* species. Betaseed has a mandatory more stringent requirement of 4 miles between H7-1 sugar beet seed and other compatible *Beta* species (Lehner, 2010). Examples of additional procedures include grower training, careful monitoring of seed production, prohibiting seed growers from growing other *Beta* species, cleaning equipment before and after harvesting a sugar beet seed crop, and monitoring for and eliminating volunteers after harvest (Lehner, 2010; Loberg, 2010a). The protocols are also updated as required. For example, as described by Loberg }(Loberg) regarding the WCBS protocol: “the protocol needs to be continually reviewed. During the review and handling of the crop, new areas of concern may become evident. When this occurs, the concern must be addressed and solutions implemented” (Loberg, 2010a). Under Alternative 2, these company protocols would remain in place and presumably be updated as needed. For more information on WCBS and Betaseed guidelines, see section III.B.1.b(11).

Under Alternative 2, in both the short and long term, sugar beet seed producers are expected to continue to test all types of sugar beet seed for varietal purity (Anfinrud, 2010). This includes specifically testing conventional sugar beet seed for the presence of the H7-1 trait. For more information on LLP, see section III.B.1.b(19).

In summary, with the exception of a few aspects, Alternative 2 would not change the basic principles behind sugar beet seed breeding, production practices, or variety development, as described above. Alternative 2 does not have any mandatory isolation distances for H7-1 sugar beet seed production, but it is expected that seed companies will continue to participate in regional pinning and isolation distance schemes to ensure that varietal purity pure is maintained. H7-1 sugar beet seed production could move to other areas where *Beta* species other than sugar beets have traditionally been grown (for example Skagit and Snohomish Counties in Washington state), although APHIS believes this is unlikely due to the increased possibility of gene flow to and from other sexually compatible *Beta* species into sugar beet fields as described above. Alternative 2 would result in higher potential levels of H7-1 gene flow to other *B. vulgaris* crops (Swiss chard and table beets) than Alternative 1 as more acres of H7-1 seed would be produced. For more information on gene flow impacts, see section IV.B.5(a).

(3) Alternative 3 – Partial Deregulation

Under Alternative 3, APHIS would authorize the environmental release of H7-1 seed for seed production under APHIS permits and movement of H7-1 sugar beet seed and stecklings under APHIS permits and notifications in accordance with 7 CFR part 340. APHIS would partially deregulate the H7-1 root crop indefinitely (with conditions, see section II.D).

The geographic distribution of H7-1 sugar beet seed fields would be evaluated and either denied or permitted by APHIS. The isolation distances for H7-1 sugar beet seed fields (as discussed in section II.D) would be determined and enforced by APHIS. These distances are 4 miles from H7-1 to table beet and Swiss chard seed production.

The conditions set forth in Alternative 3 were implemented on a temporary basis in February 2011. It is currently unknown whether these conditions will deter production of H7-1 sugar beet seed since sugar beet seed production and seed grower reporting has not yet been completed. Additionally, the percentage of H7-1 sugar beet seed being produced as compared to conventional sugar beet seed under the conditions proposed for Alternative 3 is not currently known. While APHIS can determine the acreage of H7-1 sugar beet seed production due to the mandatory reporting requirements contained in this alternative, APHIS has no regulatory ability to require companies to report nonregulated seed production acres.

The location of H7-1 seed production would likely be similar to 2011 seed production (see figure 3–1).

An adequate amount of H7-1 and conventional sugar beet seeds are expected to be available to farmers under Alternative 3.

Under Alternative 3, patent expiration would have no impact on how H7-1 sugar beet seed fields would be handled.

Similar to Alternative 2, postemergence weed control would likely continue similar to 2010 practices where H7-1 sugar beet parental lines can be treated with glyphosate for postemergence weed control. For more information on hybrid crosses in the field, see section III.B.1.b(9).

Alternative 3 has 18 mandatory permit conditions for seed production. These include conditions to limit gene flow through isolation distances, informing APHIS when H7-1 fields are planted and whether they produce H7-1 pollen, conditions to reduce the possibility of accidental co-mixing of H7-1 sugar beet seed with non H7-1 seed through recordkeeping and tracking of all seed from production through packaging, and required seed company training and management plans. For more detail on the mandatory conditions, see section II.D.

Alternative 3 would result in increased recordkeeping requirements and increased reporting requirements for seed producers. For example, seed producers would need to send a planting report mentioned above and would be subject to inspections to ensure compliance with mandatory conditions. Many of the permit requirements are similar or identical to practices already in place by Betaseed and WCBS (see section III.B.1.b(11), making it difficult to determine how much of a change in practice would be required. This alternative would not change the basic principles behind sugar beet seed breeding or production practices.

Alternative 3 would also limit the ability of seed producers to produce or sell H7-1 sugar beet seed to farmers in the above mentioned counties in Washington State and California. Given that H7-1 sugar beet seed was not produced in any of the restricted counties in 2011, it is unlikely that this alternative would impact sugar beet seed production in those States. The counties in which sugar beet seed cannot be produced are those in which sugar beet seed traditionally has not been produced. Alternative 3 is also unlikely to affect sales of sugar beet seed in Washington given that the state has very little sugar beet root production (one tenth of 1 percent of the U.S. production) and that production has not historically occurred in the counties in which H7-1 sugar beets are not allowed (Stankiewicz Gabel, 2010).

In 2011, no H7-1 sugar beet seed was produced in California. Therefore, it is unlikely that this alternative would impact sugar beet seed production in the state. Alternative 3 is likely to affect sales of sugar beet seeds in California. While no H7-1 sugar beet seed has been sold in California to date, California would, absent any prohibition, likely adopt H7-1 sugar beets to help manage the wild beet problem in Imperial Valley. Alternative 3, however, would prohibit sales of H7-1 sugar beets in California so that farmers would not have the choice to grow this crop even if they wanted. Sales of conventional sugar beet seed would likely continue.

Under Alternative 3, sugar beet seed production in Oregon would likely be similar to that of Alternative 2 with the exception that Alternative 3 has mandatory isolation distances of 4 miles between H7-1 seed production fields and and table beet and Swiss chard seed production fields. WVSSA guidelines require a 3 mile isolation distance between unlike hybrid seed production as well as between GE and any other *Beta* species, but under Alternative 3, the isolation distance between H7-1 and another hybrid such as table beets would be increased to 4 miles. Under both Alternatives, the isolation distance between hybrid sugar beets and open pollinated Swiss chard or table beets would be 4 miles. Isolation distances between H7-1 plants and conventional or organic sugar beet seed production would also be 4 miles, which is greater than the 3 miles recommended by the WVSSA. APHIS makes an exception when the same party is producing the H7-1 and non H7-1 sugar beet varieties. For more information on WVSSA guidelines and pinning rules, see section III.B.1.b(10).

As standard practices for evaluating seed purity and testing for LLP do not change as a condition of Alternative 3, testing practices for LLP under Alternative 3 are expected to be the same as those under Alternative 2.

In summary, the major differences between Alternatives 2 and 3 are that Alternative 3 has a mandatory isolation distance of 4 miles between H7-1 sugar beet fields and table beet and Swiss chard seed production fields, whereas Alternative 2 does not have any mandatory isolation distances (although producers do use isolation distances of 3–4 miles under Alternative 2 as described above). Additionally, Alternative 3 has mandatory seed production practices to reduce potential gene flow from H7-1 sugar beet seed production to other, sexually compatible species as well as to reduce LLP of H7-1 in conventional sugar beet seed lots. Alternative 3 would not allow the production of H7-1 in western Washington and the State of California. Both these states produce vegetable beet seed so the measure would create isolation distances that vastly exceed distances considered to be effective to minimize gene flow. Alternative 3 would likely result in similar, to slightly reduced, potential levels of H7-1 gene flow to other sexually compatible *B. vulgaris* crops (Swiss chard and table beets) as compared to Alternative 2 based on the mandatory measures and potentially higher compliance. For more information on gene flow impacts, see section IV.B.5(a).

b. Root Crop

The potential impacts of each of the alternatives on root crop production practices are discussed in turn below.

(1) Alternative 1 – No Action

As mentioned in section IV.B.1.a(1), in the short term APHIS expects the combined seed and root acreage for H7-1 sugar beets will return to pre-2005 levels, which was less than 1,000 acres (APHIS proprietary data). This area would comprise less than 0.09 percent of total sugar beet acres. The field locations would be controlled by APHIS. Possible small-scale seed planting under permit would not be geographically restricted except as permitted by climate and as approved by APHIS. Unlike commercially grown sugar beet roots, small-scale research plot locations may not be limited by transportation distance to a refinery. Therefore, research plots would not be limited to a 60-100 mile radius from a factory.

The use of the H7-1 sugar beet varieties comprised 95 percent of U.S. sugar beet production in 2010 (USDA-NASS, 2010d). Under Alternative 1, commercial root crop production of H7-1 would be stopped. For the Great Lakes, Midwest, Great Plains, and Northwest root growing regions, production practices that had been implemented after the adoption of H7-1 sugar beets would likely return to similar practices used in 2005 (pre-H7-1 sugar beet adoption).

As described above in section IV.B.1.a(1), it is possible that, under Alternative 1, there might not be an adequate amount of conventional sugar beet seeds to sell to farmers in the Great Lakes, Midwest, Great Plains, and Northwest regions until 2014 at the earliest (Miller, 2010). Whether seed supply would be limited is unclear, as opinions on the topic differ (Miller, 2010; Pates, 2010). This lag would not affect sugar beet root growers in the Imperial Valley since H7-1 sugar beets have not been grown in that region to date.

Conventional seed varieties available to farmers in the short term (~1–10 years) would likely not contain the most desirable trait combinations for each region due to the breeding lag. It is assumed that the lag will not continue in the long term as seed companies will continue to develop new, conventional varieties with the trait combinations desired by farmers.

As discussed more fully in section IV.B.1.c, Alternative 1 would change measures for controlling weeds in root fields in a variety of ways. In the Great Lakes, Midwest, Northwest, and Great Plains, such measures would likely return to practices used before H7-1 sugar beets were widely adopted. This would mean more rotary hoeing, hand hoeing, and mechanical cultivation in each of these regions along with a decrease in stale seed bed in the Great Lakes and a decrease in strip till for seed bed preparation in the Great Plains. It would mean a return to the use of conventional herbicides and more passes through the field to apply herbicides and perform mechanical cultivation. Alternative 1 would not impact measures for controlling weeds in root fields in the Imperial Valley region, since H7-1 sugar beets have not been adopted in California.

As described in III.B.1.c(2), adoption of H7-1 sugar beets has resulted in an increase in strip and other forms of conservation tillage in most of the sugar beet root producing regions. These reduced tillage methods can also affect the method of application and amount of fertilizer applied. For example, for band application of fertilizer on sugar beets, which is more commonly used with strip tillage than conventional tillage, the University of Minnesota recommends a one-third rate reduction for potassium and phosphorus (Overstreet, 2011). Additionally, banding fertilizer with strip-tillage may provide enhanced plant availability of phosphorus in phosphorus-fixing soil environments, which are common in the Midwest region (Overstreet et al., 2011). Under Alternative 1, fertilizer application methods and amounts are expected to return to those of 2005.

As described in III.B.1.c(2), sugar beets can bolt (produce a flowering stalk) in their first year of production under certain environmental conditions typically at a rate of about 0.01 percent or 4 plants per acre (Darmency et al., 2009; OECD (Organization for Economic Cooperation and Development)). Under Alternative 1, bolting sugar beet plants would not produce H7-1 pollen.

In summary, Alternative 1 would stop the commercial root crop production of H7-1, changing the production practices, i.e non-glyphosate herbicide use and tillage would increase and glyphosate use on sugar beets would decrease, that had been implemented after the adoption of H7-1 sugar beets in the Great Lakes, Midwest, Great Plains, and Northwest growing regions. In addition, there might be a short-term shortfall in availability of conventional seed to sell to farmersImperial Valley.

(2) Alternative 2 – Full Deregulation

Under Alternative 2, APHIS assumes that in the short term, H7-1 sugar beets would be adopted at approximately 2010 levels (95 percent of the root crop acres would be H7-1 sugar beets). In the long term, APHIS expects that H7-1 sugar beets will eventually be developed for California and other areas of the United States such that adoption would approach 100 percent.

Alternative 2 would impact weed control measures in root crops, as discussed in section IV.B.1.c. In the short term, weed control would be similar to what was observed in 2010, which is different than what occurred in 2005 (pre-H7-1 sugar beets). In the long term, as glyphosate-resistant weeds migrate into sugar beet fields or develop resistance, weed species with glyphosate-resistant biotypes would be expected to become the weeds of concern in sugar beets. This would likely increase the use of conventional herbicides, mechanical cultivation, and hand hoeing to control glyphosate-resistant weeds. There also would likely be a continued increase in conservation tillage in root fields in the Great Lakes, Northwest, and Great Plains (with less change in the Midwest). Assuming H7-1 sugar beets are adopted in the Imperial Valley, there would also be shifts from the other herbicides, hand hoeing, and between row cultivation methods to glyphosate applications to control weeds in that region. With the adoption of H7-1 sugar beets, two to three less cultivations would be needed (2011)

As described above and in section III.B.1.c(2), adoption of H7-1 sugar beets has resulted in an increase in strip and other forms of conservation tillage in most of the sugar beet root producing regions. These reduced tillage methods can also affect the method of application and amount of fertilizer applied. For example, for band application of fertilizer on sugar beets, which is more commonly used with strip tillage than conventional tillage, the University of Minnesota recommends a one-third rate reduction for potassium and phosphorus (Overstreet, 2011). Under Alternative 2, fertilizer application methods and amounts are expected to be similar to those of 2010. Sugar beet production in the Imperial Valley cannot utilize conservation tillage due to the unique aspects of irrigation in the Imperial Valley. Furrow tillage (crop is grown on raised furrows) is used so no change in tillage is expected in the Imperial Valley.

Bolting H7-1 sugar beets could be a potential source of gene flow as they could produce H7-1 pollen if the flowering occurred relatively early and the flowers were not killed by cold weather. Farmers typically remove bolters as bolting depletes the root of sugars and the woody roots that result from bolters can damage harvesting and processing equipment (Ellstrand, 2003). Additionally under the Monsanto TUG, farmers are required to remove bolters in H7-1 sugar beet fields (Monsanto, 2011a). APHIS expects that farmers would continue the practice of removing bolters for the reasons described above.

In summary, under Alternative 2, there would likely be a continued increase in conservation tillage in root fields in the Great Lakes, Northwest, and Great Plains, and an increase in glyphosate use (concurrent with decrease in cultivation and alternative herbicides). In the Imperial

Valley if H7-1 sugar beets are adopted there, glyphosate use would increase but conservation tillage would not be expected to increase. If glyphosate resistant weeds become more prevalent, weed control measures in root fields would likely require more use of conventional herbicides, mechanical cultivation, and hand hoeing.

(3) Alternative 3 – Partial Deregulation

Under Alternative 3, APHIS expects that the percentage of H7-1 sugar beets grown would be close to 2010 levels (95 percent) or slightly lower if some farmers or cooperatives find the mandatory conditions for production of H7-1 sugar beets to be burdensome. An adequate amount of H7-1 and conventional sugar beet seed is expected to be available to farmers under Alternative 3.

In terms of production locations, Alternative 3 would limit the ability of farmers to grow H7-1 sugar beet roots in western Washington State and the entire State of California. Alternative 3 is not likely to affect root production in Washington given that the production has not historically occurred in the counties in which H7-1 sugar beets are not allowed under Alternative 3 (Stankiewicz Gabel, 2010). In the Imperial Valley, H7-1 sugar beets have not been adopted so Alternative 3 would not cause any changes in root production among sugar beet farmers in the Imperial Valley. Alternative 3 would eliminate the choice of California growers to produce H7-1 varieties for California should they become available. In the absence of such a prohibition, it is likely that H7-1 would be widely adopted in the Imperial Valley as glyphosate would offer a simple and effective method to control weeds including wild beet populations, which are very difficult to control by existing methods.

Under Alternative 3, production methods would not change in terms of the adoption of glyphosate as an herbicide, the increased use of strip tillage, and a reduction in hand labor due to the use of H7-1 sugar beet root crop. Nevertheless, due to the requirement for compliance agreements and other mandatory requirements, the additional regulatory burden under Alternative 3 may discourage some growers from planting H7-1. However, over time with Alternative 3, other growers should make up the difference so the number of acres should remain the same.

Alternative 3 would impact weed control in root crops in the same manner as described in Alternative 2, except for the Imperial Valley region.

As root production practices are expected to be similar in the Great Lakes, the Midwest, the Great Plains, and the Northwest, Alternative 3 is expected to have the same changes in fertilizer application and amounts as described in Alternative 2.

Alternative 3 requires farmers to monitor for bolting crops every 3–4 weeks starting on April 1st in addition to maintaining records as to the presence of bolters for audit purposes. All bolters must be destroyed before flowering.

Under Alternative 3, sharing the equipment used for planting, cultivating, and harvesting H7-1 sugar beets would not be allowed for the production of Swiss chard and table beet in the same growing year. However, to APHIS' knowledge, this equipment is currently not shared as per BMP. In addition, harvesting and transport of H7-1 sugar beet roots could occur only in a manner that minimizes loss of beets. This practice is not different from current practices for moving sugar beets to the processing facilities as the goal of growers is to maximize yield and minimize loss. Detailed records of transport are also necessary for audit purposes.

In summary, Alternative 3 could result in a near-term decrease in the number of H7-1 sugar beet acres planted if the mandatory conditions for production of H7-1 sugar beets discourage some growers from planting sugar beets (this decrease is not expected to continue over the long term). It would alter weed control measures just like Alternative 2, except in the Imperial Valley, where H7-1 sugar beets would not be planted under Alternative 3. Additionally, Alternative 3 would require monitoring for bolters every 3–4 weeks,would impose mandatory restrictions on the equipment and practices used for handling H7-1 sugar beets, and would require third-party inspections and audits.

c. Weeds in Sugar Beet Seed and Root Crops

This section discusses the potential impacts of the action alternatives on weed management practices within sugar beet agriculture. Weed resistance to herbicides is discussed in section IV.C.3.a.

The production practices that influence weed control and the weed population include: herbicide use, seed bed preparation (such as tillage), crop rotation, hand weeding, in-crop mechanical cultivation, cover crops, irrigation, and fertilization. Neighboring fields and environments and the seed bank from previous growing seasons also influence weed prevalence. Herbicide usage is discussed in section IV.B.1.e. Control of sugar beet volunteers in agricultural settings is discussed in section IV.B.1.d. Although irrigation and fertilization influence weed dynamics, neither of these practices are specifically in place as weed control strategies for sugar beets, except for in the Imperial Valley where pre-irrigation and flat flood irrigation are used as a weed control prior to planting sugar beets (Meister, 2004b). The impact that the alternatives may have on these production practices is discussed in section IV.B.1.a (seeds) and IV.B.1.b (roots). The impact of crop rotation on the development of herbicide resistance in weeds is discussed in section IV.C.3.a.

The discussion below focuses on how rotations, seed bed preparation (such as tillage), hand weeding, in-crop cultivation, and cover crops as weed control approaches could be impacted by the alternatives. This discussion provides background information that informs several other impact assessments later in chapter IV.

(1) Alternative 1 – No Action

In general, glyphosate is not used in commercial seed production because at least one of the parents does not carry the resistance gene. For seed production, H7-1 sugar beet breeder and foundation seeds may have glyphosate applications for postemergence weed control as long as both parents carry the H7-1 trait (Loberg, 2010b). In this respect, Alternative 1, which would restrict the use of H7-1 to breed sugar beets, would change use of glyphosate during seed production under conditions mentioned above. For more information on hybrid seed production, see section III.B.1.b(9). Weed control measures such as seed bed preparation, crop rotation, hand weeding, and in-crop cultivation would be similar under all three alternatives because glyphosate is not used in these aspects of seed production. Cover crops are also not used in seed production.

For root production, since the adoption of H7-1 sugar beets, glyphosate has become the predominant herbicide used to control weeds and all the herbicides that were previously applied have diminished in use. In addition, while conventional tillage was extensively used for sugar beet root production prior to H7-1, conservation tillage and strip tillage have now become more prevalent. As explained in more detail below, Alternative 1 would alter weed control practices by altering herbicide use and tillage practices.

Under Alternative 1, commercial root crop production of H7-1 would be stopped. For the Great Lakes, Midwest, Great Plains, and Northwest root growing regions, weed control measures would likely return to similar practices used in 2005 (pre-H7-1 sugar beet adoption). In these regions, APHIS does not believe that farmers have changed rotation patterns to control weeds as a result of the adoption of H7-1. Therefore, Alternative 1 would not impact rotation selection from a weed control perspective at least in the short term. Possible long-term impacts of rotations with other Roundup Ready® crops on the development of herbicide-resistant weeds are discussed in section IV.C.3.a.

In the Imperial Valley, H7-1 sugar beets have not been adopted so Alternative 1 would not cause any changes in weed control for sugar beet farmers in the Imperial Valley. It would, however, stop the future adoption of H7-1 sugar beets and prevent growers from using glyphosate to control wild beets in sugar beet production fields.

In the Great Lakes region, the adoption of H7-1 sugar beets has resulted in less in-crop mechanical cultivation, less hand hoeing, and increased stale seed bed tillage. Stale seed bed is where fields are tilled in the fall, then directly planted in the spring. In 2010, about 25 percent of fields in the Great Lakes were stale seed bed tilled as compared to less than 5 percent in 2006–2007 (Lilleboe, 2011). Alternative 1 would likely result in a decrease in stale seed bed and an increase in hand hoeing and in-crop mechanical cultivation compared to current practice.

In the Midwest, the adoption of H7-1 sugar beets resulted in notable changes in postemergence weed control, but very little change in weed control measures used during seed bed preparation. For example, for both H7-1 and conventional sugar beets, the vast majority of farmers continue to use conventional tillage, which results in a 100-percent disturbance of the soil (USDA-NRCS, 2008). Only a few thousand acres of sugar beets are currently strip tilled (tilled in rows where the seeds are planted). Research conducted in the area indicates that the low rate of adoption of strip-tillage is largely due to the lack of equipment that is adapted for the local soils and cropping systems (Overstreet et al., 2011). It is likely that the practice will be adopted more widely as more appropriate equipment is developed and sold. The greatest area of change with H7-1 sugar beets has been seen with postemergence weed control. As stated in section III.B.1, adoption of H7-1 sugar beets has resulted in a dramatic decrease in the use of rotary hoeing, hand hoeing, and mechanical cultivation.

Alternative 1 would likely result in no changes to seed bed preparation in the Midwest. Postemergence weed control, however, would likely return to pre 2005 levels of rotary hoeing, hand hoeing, and mechanical cultivation. Growers that sold their cultivation equipment would have to reacquire such equipment (Stachler, 2011). Herbicide use is the major weed control approach in both conventional and H7-1 sugar beet production and is discussed in section IV.B.1.e.

In the Northwest and Great Plains, adoption of H7-1 sugar beets has had the largest impact on weeds as this region has the most difficult to control weed populations in sugar beet fields that were not effectively controlled with other herbicides (Hofer, 2010). Adoption of H7-1 sugar beets resulted in increased strip till during seed bed preparation, a reduction in in-crop mechanical cultivation, and a reduction in hand hoeing (Kniss, 2010a; Lilleboe, 2008). Alternative 1 would likely result in a return to in-crop mechanical cultivation, hand hoeing, and a reverse in the trend of increasing strip till for seed bed preparation.

Use of cover crops provides many benefits to soil quality as discussed in section III.B.1.d(2). APHIS was not able to find data on whether cover cropping practices have changed with the adoption of H7-1 sugar beets. Popular cover crops are grasses, which are easily controlled by herbicides specific for grasses. Adequate herbicides for killing grass cover crops exist for conventional sugar beets. However, grass cover crops in H7-1 sugar beets could be killed with glyphosate, which would also control broadleaf weeds that occur in the cover crop. There is anecdotal evidence that past problems with wind and water erosion can be minimized by planting H7-1 sugarbeets into the previous year's crop residue or cover crops of wheat and barley for crop and soil protection (Wilson, 2010). If cover cropping practices have increased or would eventually increase with the use of H7-1 sugar beets, then Alternative 1 would likely reduce these practices back to 2005 levels.

Crops that are grown in rotation with sugar beets occasionally appear in sugar beet fields as volunteers. In conventional sugar beet fields, these volunteers are managed with all the other weeds through herbicide mixtures, mechanical cultivation, and hand hoeing. If rotated to glyphosate-resistant crops, these same techniques would be used to control glyphosate-resistant crop volunteers. Under Alternative 1, all volunteers in sugar beets, including Roundup Ready® corn and Roundup Ready® soybean would be controlled through herbicides, mechanical cultivation, or hand hoeing.

In summary, Alternative 1 would not impact measures for controlling weeds in root fields in the Imperial Valley However, weed control measures in root fields in other regions would likely return to similar practices used before H7-1 sugar beets were widely adopted. In general, this would mean more rotary hoeing, hand hoeing, and mechanical cultivation in all of the other regions; a decrease in stale seed bed in the Great Lakes; and a decrease in strip till for seed bed preparation in the Great Plains. It is unclear if Alternative 1 would change current root production cover cropping practices. Rotation crop volunteers would be controlled through herbicides (glyphosate or not, depending on whether the volunteers are glyphosate-resistant), mechanical cultivation, or hand hoeing.

(2) Alternative 2 – Full Deregulation

Alternative 2 would not impact weed control in seed production because as described, glyphosate is seldom used for weed control on seed crops. .

Alternative 2 would impact weed control in root crops. In the short term, weed control would be similar to what was observed in 2010, which is different than what occurred in 2005 (pre-H7-1 sugar beets). As shown in table 3–9, several formerly problematic weeds (foxtail, barnyardgrass, wild oat, wild buckwheat, wild mustard, cocklebur, knotweed, nightshades, and mallow) are now controlled within H7-1 sugar beet fields by the application of glyphosate. The three top weed concerns in the Midwest (pigweed, lambsquarters, and kochia) have always been weeds of concern, but are reported as problems by fewer farmers since 2005 (Stachler et al., 2011). Under Alternative 2, APHIS expects that the weed control practices reported in 2010 would continue in the short term. In the long term, if glyphosate-resistant weeds migrate into sugar beet fields or evolve, weed species with glyphosate-resistant biotypes would be expected to become the weeds of concern in sugar beets. For discussion of the likelihood and impact of herbicide-resistant weeds, see section IV.C.3.a. For discussion of measures to mitigate evolution of herbicide-resistant weeds and methods for controlling herbicide-resistant weeds, see section III.C.3.a(3).

In the Great Lakes root production region, the adoption of H7-1 sugar beets resulted in increased conservation tillage. Under Alternative 2, APHIS expects that this trend of increased conservation tillage would continue. Hand hoeing and other weed control practices would likely continue at 2010 rates, which are reduced compared to the practices before the introduction of H7-1 sugar beets. In the long term, there may be an increase in tillage, hand hoeing, or use of additional herbicides to control glyphosate-resistant weeds.

As discussed above under Alternative 1, in the Midwest, preemergence weed control has not changed much between 2005 and 2010, although there has been a slight increase in conservation tillage (Lilleboe, 2010). However, there have been multi-year studies done to investigate the effects of strip till and other reduced tillage practices with H7-1 sugar beets on sugar beet yield and sugar content (Overstreet et al., 2011). The data generally indicate that strip tillage, if managed carefully, and conservation tillage have similar yields and sugar content as compared to conventional tillage. While these studies were not conducted to assess weed pressure, strip tillage can affect weed pressure and management. APHIS believes that in the long term, more farmers will adopt strip tillage as they become more familiar with the practice, as research demonstrates the benefits, and as they invest in the new equipment needed for strip tillage. However, because postemergence weed control in H7-1 sugar beets typically does not require rotary hoe, hand hoeing, or mechanical cultivation, these practices have declined between 2005 and 2010. Under Alternative 2, APHIS expects the continued use of H7-1 sugar beets, so rotary hoeing, hand hoeing, and mechanical cultivation would continue to be similar to 2010 rates.

As mentioned under Alternative 1, in the Northwest and Great Plains, adoption of H7-1 sugar beets resulted in increased strip till during seed bed preparation, a reduction in in-crop mechanical cultivation, and a reduction in hand hoeing (Kniss, 2010a; Lilleboe, 2008). Because H7-1 sugar beets would continue to be grown under Alternative 2, APHIS expects that in the short term, Alternative 2 would likely result in no hand hoeing and reduced mechanical cultivation similar to 2010 levels. In the long term if glyphosate resistant weeds become a problem, then APHIS expects that additional mechanical cultivation and herbicides will be used.

In the Imperial Valley, H7-1 sugar beets have not been adopted. Under Alternative 2, APHIS expects that H7-1 sugar beet varieties would be adopted by sugar beet farmers. APHIS expects that Imperial Valley sugar beet farmers would experience the same gains in ease of weed control as farmers in other regions of the United States and would modify their current weed control practices accordingly. California has wild beets that are weeds in sugar beet fields and are tolerant to the herbicides traditionally used on weeds that occur in sugar beets. Herbicide tolerance in wild beets is not due to evolved herbicide resistance or weed shifts (discussed in section IV.C.3.a); they are tolerant because of their close evolutionary relationship to sugar beets – what does not kill sugar beets does not kill wild beets. Adoption of H7-1 sugar beets would allow Imperial Valley sugar beet farmers to control wild weed beets with glyphosate. Currently, these wild beets are controlled with hand hoeing and mechanical cultivation. Control of wild beets through chemical methods would decrease time and labor costs for farmers. The likelihood that the wild beets will develop glyphosate resistance is discussed in section IV.B.5.b. In California aerial broadcast of herbicides is more common than in other regions because of the benefit of adding herbicides shortly after irrigation to optimize the impact on weeds. Aerial broadcast is used because when the ground is wet it is not possible to use heavy farm equipment which could damage the crop and the soil. Growers expect that the adoption of H7-1 sugar beets would reduce aerial application of herbicides in favor of ground broadcast because the timing of glyphosate application is less critical and farmers could wait for the ground to dry before herbicide application (Beet Sugar Development Foundation et al., 2011). Tillage, row width, and irrigation are not expected to change with the adoption of H7-1 sugar beets (Beet Sugar Development Foundation et al., 2011).

Under Alternative 2, farmers who adopt H7-1 sugar beets can easily kill cover crops with glyphosate, so the usage of cover crops and planting into crop residue could become more common (Wilson, 2010). However, cover crops are not used in California and would not be used with the adoption of H7-1 sugar beets (Beet Sugar Development Foundation et al., 2011).

In H7-1 sugar beet fields, Roundup Ready® volunteers need to be managed with conventional herbicides, mechanical cultivation, or hand hoeing. Under Alternative 2, Roundup Ready® volunteers in sugar beets, including Roundup Ready® corn and Roundup Ready® soybean, would be controlled through conventional herbicides (such as clethodim and clopyralid, respectively), mechanical cultivation, or hand hoeing. Volunteers that are not glyphosate-resistant would be controlled by glyphosate. The Midwest region is most likely to have a Roundup Ready® crop in rotation with sugar beets as common rotation crops in this region are corn and soybean ((SMBSC (Southern Minnesota Beet Sugar Cooperative), 2010b), table 3-6). APHIS is not aware of any growers changing rotation patterns with respect to Roundup Ready® crops as a result of H7-1 sugar beets. It is possible that farmers may decide to rotate to a different herbicide resistant variety instead of glyphosate.

In summary, Alternative 2 would not impact weed control measures in seed production but would impact weed control in root production. In all regions there would be an increased use of glyphosate and reduced use of other herbicides compared to 2005 usage rates. In the Midwest there might be an increased use of strip tillage. There would likely be an increase in conservation tillage in root fields in the Great Lakes, Northwest, and Great Plains. Assuming H7-1 sugar beets are adopted in the Imperial Valley, there would also be decreased use of other herbicides and increased use of glyphosate, while hand hoeing and mechanical cultivation would decrease. Also under Alternative 2, the use of cover crops and planting into crop residue is expected to become more common (except in California) and the expected increase in Roundup Ready® volunteers would likely increase the use of conventional herbicides, mechanical cultivation, and hand hoeing to control such volunteers.

(3) Alternative 3 – Partial Deregulation

Like Alternative 2, Alternative 3 would not impact weed control in seed beds. Alternative 3 would impact weed control in root crops in the same manner and for the same reasons as described in Alternative 2, except for the Imperial Valley region. It would differ from Alternative 2 in that H7-1 would not be adopted in the Imperial Valley and the future expected increased use of glyphosate would not happen.

In summary, Alternative 3 would impact weed control measures in the same way as described for Alternative 2, except in the Imperial Valley. Under Alternative 3, H7-1 sugar beets would not be permitted in California or western Washington, so weed control measures in those locations would remain as they are today.

d. Control for Volunteer H7-1 Sugar Beet Varieties

As discussed in section III.B.1.e, volunteers are plants from a previous crop that are found in subsequent crops. Volunteers are often considered a type of weed, not because they have any inherent weedy characteristics, but simply because the volunteer plants are growing where they are not wanted and might interfere, or compete with, the crop. In most cases, volunteers grow from seed left in the field after harvest of a seed crop (e.g., corn, soybean). This section discusses H7-1 sugar beets as volunteers. Volunteers that occur in H7-1 sugar beets are discussed in section IV.B.1.c above. Sugar beets that escape agricultural fields are not considered volunteers, but rather feral or wild (see section IV.C.3.c).

(1) Alternative 1 – No Action

Because sugar beet seed plants are prone to shattering during seed harvest, control of volunteers in seed production fields has been an essential component of production practices developed to maximize seed purity. WCBS has detailed requirements in its protocol for post-harvest field management, such as equipment cleaning, field inspections, measures to sprout and remove shattered seed, and crop rotation (see section III.B.1.e). In 2006, WCBS Company implemented the Protocol for Genetically Modified (GM) Seed Production (Loberg, 2010a). Under Alternative 1, in the short term the seed bank will still contain some H7-1 seed and could require several years for the seed bank to deplete. Therefore to control sugar beet volunteers, methods that do not utilize glyphosate would need to be continued. In the long term, seed companies could revert to pre-2005 practices to control sugar beet volunteers in former sugar beet seed fields.

Other *Beta* crops such as Swiss chard and table beets are not grown in the same fields as sugar beet seed, so sugar beet volunteers from a previous crop would not occur in Swiss chard or table beet fields. For a discussion of the likelihood of sugar beet volunteers in remote Swiss chard and table beet fields through geographic distribution of seed, see section IV.B.5.a. For a discussion of the likelihood of the H7-1 trait showing up in Swiss chard and table beet fields through gene flow resulting in off-types, see section IV.B.5.a.

Volunteers are much less of an issue in sugar beet root production fields than in seed production fields since the root crop is harvested before seed is produced. As discussed in section III.B.1.c, there are cases where a root crop "bolts" in the first year and produces a flowering stalk. With the exception of California, it is not expected that bolters from the root crop would grow long enough to produce seed because the growing season is too short. Furthermore, bolting sugar beets are tall and can easily be spotted and rogued from the field. Sugar beet root farmers are incentivized to remove bolters as roots that bolt become woody, have decreased sugar content, and can interfere with the harvest equipment. Imperial Valley is the only production area where sugar beets may go to seed if the sugar beet bolters are not removed. These seeds could disperse in the crop field and be a source of volunteers.

Vegetative root structures called groundkeepers may also be left in the field after harvest, and can grow in the next season if weather permits. In most parts of the United States where sugar beets are grown, beet roots would not be expected to survive the winter, so groundkeepers would be of little concern (Panella, 2003). In the Imperial Valley of California, ground keepers are unable to survive the summer and are also of little concern (2011).

Sugar beet volunteers do not compete well with crops used in rotation with sugar beets (CFIA, 2002), and are generally not a problem. If volunteer sugar beets were to grow in the following crop, they could be controlled by broadleaf herbicides or by other agricultural practices, such as tillage during seed bed preparation (Monsanto, 2007a).

Under Alternative 1, H7-1 sugar beet volunteers would be very unlikely. They could occur for several years in former sugar beet seed fields, but are not expected in root crops. In the long term, none would be expected under this alternative as H7-1 sugar beet production is phased out. Conventional sugar beet volunteers would be handled as they have always been handled. In Roundup Ready® crops, conventional sugar beet volunteers can easily be controlled with glyphosate.

(2) Alternative 2 – Full Deregulation

As mentioned under Alternative 1, the WCBS Protocol for GM Seed Production was implemented in 2006 (Loberg, 2010a). One of the provisions is: "For a minimum of five years or until no volunteers are observed and within a three mile radius of any Roundup Ready® field, West Coast Beet Seed Company will monitor for any volunteers in any fields used for past sugar beet production. This will protect [Swiss] chard, [table] beet, and sugar beet seed production in the area. The removal of the volunteers will be done under the supervision of West Coast Beet Seed Company representatives and will be recorded. The costs will be shared by West Coast Beet Seed Company and their growers" (Loberg, 2010a). The protocol also includes updating: "The protocol needs to be continually reviewed. During the review and handling of the crop, new areas of concern may become evident. When this occurs, the concern must be addressed and solutions implemented." Under Alternative 2, this company protocol would remain in place and presumably be updated as needed. The seed production protocol from Betaseed is similar to West Coast Beet Seed Company and is discussed in section III.B.1.b(11).

Other *Beta* crops such as Swiss chard and table beets are not grown in the same fields as sugar beet seeds, so sugar beet volunteers from a previous crop would not occur in Swiss chard or table beet fields.

In sugar beet root crops in the Great Lakes, Midwest, Great Plains, and Northwest, volunteer sugar beets have not been a problem most likely because bolters are rare and seed production from a bolter is not expected due to the short length of the growing season. Groundkeepers are not likely to survive the winters in the north or the summers of Imperial

Valley. Even if groundkeepers did survive the winter, they would easily be controlled in the subsequent crop prior to producing seed.

In the Imperial Valley, H7-1 sugar beets have not been adopted. Under Alternative 2, APHIS anticipates that H7-1 sugar beets would be grown in the Imperial Valley region. Because the growing season is much longer in the Imperial Valley, it is possible for a sugar beet to bolt and set seed. Sugar beet volunteers are easily controlled in other crops with broadleaf herbicides. Control of sugar beet volunteers is not expected to change upon the adoption of H7-1 sugar beets as none of the rotation crops with California sugar beets is Roundup Ready® with the exception of sugar beets that are grown two years in a row. In that case no further control is likely to be necessary for sugar beet volunteers in a sugar beet field. Otherwise, glyphosate is not used for crop weed control or to manage sugar beet volunteers there. Volunteers from groundkeepers are not a concern in California because the roots cannot survive the heat of the summer. For discussion of sugar beets that escape agricultural fields in mild climates and become feral or wild, see section IV.C.3.c.

(3) Alternative 3 – Partial Deregulation

Several permit conditions proposed under Alternative 3 could influence H7-1 sugar beet volunteer occurrence. For example, a visual identification system, such as labeling must accompany all H7-1 seed and stecklings throughout the production system. H7-1 seed and stecklings need to be contained during transport to avoid inadvertent release into the environment. Measures to force post-harvest sprouting of H7-1 shattered seed in seed production fields are required. Other *Beta* crops such as Swiss chard and table beets are not grown in the same fields as sugar beet seeds, so sugar beet volunteers from a previous crop would not occur in Swiss chard or table beet fields.

Alternative 3 requires surveying and removal of bolters from root production fields planted to H7-1 varieties, ensuring that H7-1 bolters do not produce seeds that could volunteer in rotation crops. Under Alternative 3, APHIS would enforce these requirements through inspections and third-party audits and compliance agreements can be terminated if compliance issues are a problem.

In the Imperial Valley, H7-1 sugar beets have not been adopted. Under Alternative 3, H7-1 would be prohibited in the Imperial Valley region, so Alternative 3 would not impact volunteer occurrence or control in the Imperial Valley region.

e. Herbicide Use Estimate for Sugar Beets

This section presents a discussion of the impacts of each of the alternatives on herbicide usage patterns and overall quantities. Data on regional herbicide use were only available for 2000, which is presented in the discussion of Alternative 1. Otherwise, discussion of the alternatives is limited to a national-scale analysis. Herbicide usage is also based on adoption rates, which are discussed in sections IV.B.1.a and IV.B.1.b. The impacts of the usage rate trend are discussed for each alternative.

The USDA National Agricultural Statistics Service (USDA–NASS) Agricultural Chemical Use Database (USDA-NASS, 2008) does not differentiate between sugar beet seed and root production acres; therefore the analysis presented below does not differentiate between the two.

(1) Alternative 1 – No Action

Historical application rates and quantities of herbicide use for conventional sugar beets are based on the USDA–NASS Agricultural Chemical Use Database (USDA-NASS, 2008) data from 2000, as presented in section III.B.1.d. These data reflect average use, including the relative quantity of each herbicide typically used in sugar beets, prior to the commercial availability of H7-1 sugar beets. These data, which represent the national and regional averages from 2000, are the most recent available from USDA–NASS. Although these data are used as a baseline, it should be noted that average usage data from 2000 do not demonstrate the range of possible inter-year variability.

Under Alternative 1, commercial root crop production of H7-1 sugar beets would be stopped. The herbicide application rates and total rates per acre used on conventional sugar beets under Alternative 1 is expected to be comparable to the average national and regional USDA data available from 2000, which were collected prior to the commercial availability of H7-1 sugar beets. This information is reported in table 3-15 and is based on planting of 1.565 million acres. More recently, the acreages for sugar beet production have declined and have ranged from 1.1 to 1.2 million acres for the past three years (see table 3–5).

In estimating herbicide use under Alternative 1, APHIS assumes that the acreage planted for conventional sugar beets would be equal to the acreage planted in 2010, 1,171 million acres, and that herbicide use would be equivalent to that used in 2000 but proportionally decreased based on acreage. These herbicide usage estimates for Alternative 1 are presented in table 4–1.

Table 4- 1. Total Herbicide Usage Comparison, 2000 Data and Alternative 1 Estimate

Agricultural Chemical (Herbicide)	Trade Name (Typical)	2000 Herbicide Usage Data (lb)	Estimated Herbicide Usage, Alternative 1 (lb)
Desmedipham	Betanex®	270,000	202,000
EPTC	Eptam®	171,000	128,000
Phenmedipham	Betamix®	170,000	127,000
Cycloate	Ro-Neet™	132,000	99,000
Clopyralid	Stinger®	102,000	76,000
Glyphosate	(Several)	75,000	56,000
Ethofumesate	Nortron®	82,000	61,000
Clethodim	Select®	76,000	57,000
Pyrazon	Pyramin®	66,000	49,000
Sethoxydim	Poast®	55,000	41,000
Trifluralin	Treflan® HFP	42,000	31,000
Triflusulfuron-methyl	Upbeet®	28,000	21,000
Quizalofop-p-ethyl	Assure® II	9,000	6,700
Total	**–**	**1,278,000**	**956,000**

The principal herbicides used in terms of pounds applied are expected to be Desmedipham (202,000 pounds), EPTC (128,000 pounds), Phenmedipham (127,000 pounds), and Cycloate (99,000 pounds). Glyphosate use is estimated to be 56,000 pounds. The herbicides are used at widely different application rates so pounds applied does not reveal how often an herbicide is used or its environmental impact. For example, EPTC is applied at a rate of 2.61 lb/application/acre while triflusulfuron-methyl is applied at 0.008 pounds/application/acre or over 325 fold lower pounds/acre application rate. Clethodim, Clopyralid, Desmedipham, Ethofumesate, Phenmedipham, and Trisulfuron-methyl are all expected to be applied on average 2–3 times/year based on 2000 use rates (see table 3-15). These herbicides are often used in combination at micro rates and applied several times as described in section III.B.1.d(3). Herbicide use varies regionally.

Table 3–14 shows the pounds of herbicide applied on a regional basis. Table 4–2 shows the regional use of the herbicides. In 2000, the Great Lakes region used the most pyrazon, an herbicide used to control broad leaf weeds. In the Midwest, clethodim was used preferentially to control annual grasses whereas annual grasses were preferentially controlled with sethoxydim in California. In the Northwest, EPTC is used but is not reported for any of the other regions. This regional effect is ascribed to soil type, where EPTC is avoided in regions with sandy soils due to potential injury to plants that may occur from leaching.

(2) Alternative 2 – Full Deregulation

Herbicide quantities recorded for 2000 and estimated for 2010 are presented in section III.B.1.f. Alternative 2 would likely result in herbicide usage patterns similar to what was estimated for 2010, as presented in III.B.1.f(2). Under Alternative 2, in the short term, H7-1 sugar beets would be expected to be planted on 95 percent of the sugar beet acreage, with conventional sugar beets planted on the remaining 5 percent. In the long term, APHIS expects H7-1 sugar beets will approach 100 percent adoption nationwide. Table 4–3 presents the average application rates in pounds a.i. per acre for each herbicide and the total herbicide use under Alternative 1 and Alternative 2. Alternative 2 would result in much larger quantities of glyphosate applied compared to Alternative 1 with about a 90% reduction in the non glyphosate herbicides.

Compared to the total herbicide usage data from 2000, herbicide use in sugar beets under Alternative 2 is expected to increase by 1.669 million pounds overall, a 175 percent increase. This is because glyphosate is used at a relatively high application rate of 0.915 pounds/application/acre (see table 3-17) compared to at least seven of the thirteen other herbicides used on sugar beets which are used at rates below 0.1 pounds/application/acre and it has become the predominant herbicide. Because glyphosate is replacing other herbicides used at lower rates, the total pounds of herbicide applied has increased. Table 4–3 also includes the estimated herbicide use under Alternative 1. Use of most other herbicides is expected to decrease by about 90%.

Herbicide use under Alternative 2 is expected to be largely dominated by glyphosate. As Alternative 2 assumes a 95 percent adoption rate, there is not room for much additional planting of H7-1 sugar beets. If California adopts H7-1 sugar beets, then the amount of glyphosate use would increase by another 2-3 percent and there would be a decline in the use of the other herbicides by the amounts predicted in table 3–16.

There is a potential for total glyphosate applied to increase by more than 3 times the current rate, under current pesticide labeling – the current rate estimate for Alternative 2 is 2.29 lb a.i. per acre per year and the maximum allowed rate of application (per EPA) is 7.32 lb a.i. per acre (see table 3–13). However, it is not expected that glyphosate would be applied, on average, at the maximum label rate, and a glyphosate rate increase is not expected. In addition, if glyphosate-resistant weeds become problematic or if means to delay the spread and evolution of glyphosate-resistant weeds, use of some of the alternative herbicides may increase.

(3) Alternative 3 – Partial Deregulation

As with Alternative 2, Alternative 3 would result in higher quantities of glyphosate applied and decreased quantities of all other herbicides applied as depicted in table 4–3 and described under Alternative 2.

Under Alternative 3, the Imperial Valley would not adopt H7-1 sugar beets, so for Alternative 3 there would likely be no differences in herbicide usage from that described for Alternative 1 in this region. Also there are no sugar beets grown in western Washington and under Alternative 3 this would remain the case.

Table 4- 2. Summary of National and Regional Average Herbicide Applications to Conventional Sugar Beet Acres[1, 2], for 2000

Agricultural Chemical (Herbicide)	Trade Name (Typical)	National Average Rate per Acre (lb/acre)	National Total Applied (lb)	Rate per Acre (lb/acre planted) Great Lakes Region	Rate per Acre (lb/acre planted) Midwest Region	Rate per Acre (lb/acre planted) Great Plains Region	Rate per Acre (lb/acre planted) Northwest Region	Rate per Acre (lb/acre planted) Imperial Valley Region
Clethodim	Select®	0.11	76,000	NR	0.08	0.04	0.01	ND
Clopyralid	Stinger®	0.09	102,000	0.05	0.09	0.05	0.04	NR
Cycloate	Ro-Neet™	1.84	132,000	0.08	0.23	0.14	0.31	NR
Desmedipham	Betanex®	0.18	270,000	0.11	0.02	0.10	0.14	0.11
EPTC	Eptam®	2.61	171,000	NR	NR	ND	0.61	NR
Ethofumesate	Nortron®	0.14	82,000	0.02	NR	0.1	0.12	0.03
Glyphosate	(Several)	0.43	75,000	NR	0.035	0.06	0.09	0.09
Phenmedipham	Betamix®	0.14	170,000	0.10	0.11	0.09	0.14	0.10
Pyrazon	Pyramin®	0.82	66,000	0.35	NR	NR	NR	NR
Quizalofop-p-ethyl	Assure® II	0.06	9,000	0.01	0.01	ND	0.01	NR
Sethoxydim	Poast®	0.33	55,000	NR	0.03	ND	0.03	0.26
Trifluralin	Treflan® HFP	0.66	42,000	NR	0.03	NR	0.05	0.07
Triflusulfuron-methyl	Upbeet®	0.02	28,000	0.01	0.01	0.02	0.03	ND
Total			**1,278,000**	**0.74**	**0.66**	**0.6**	**1.55**	**0.67**

Pesticide Usage Source: (USDA-NASS, 2008)
[1] 1.565 million acres were planted in the United States in 2000. All values are averages.
[2] Data on acres planted by region are from the USDA 2000 Crop Production Survey (USDA-NASS, 2001).
Abbreviations: NR = None reported, no use of the herbicide was reported in the region; ND = No data were reported for total herbicide applied per year (lb), although the available data indicated that the herbicide applied in the region; see [tables G1 through G11 in appendix G]

Table 4- 3. Comparison of Estimated Herbicide Use for Alternatives 1 and 2

Agricultural Chemical (Herbicide)	Trade Name (Typical)	Average (lb a.i./acre)	Total Herbicide Use, Alternative 2 (lb)	Total herbicide use,Alternative 1 (lb)	Difference	Change %
Clethodim	Select®	0.06	6,600	57,000	-50,400	-88
Clopyralid	Stinger®	0.039	7,300	76,000	-68,700	-90
Cycloate	Ro-Neet™	0.442	9,900	99,000	-89,100	-90
Desmedipham	Betanex®	0.022	10,100	202,000	-191,900	-95
EPTC	Eptam®	0.626	15,600	128,000	-112,400	-88
Ethofumesate	Nortron®	0.064	3,200	61,000	-57,800	-95
Glyphosate	(Several)	2.194	2,547,900	56,000	2,491,900	4450
Phenmedipham	Betamix®	0.017	6,700	127,000	-120,300	-95
Pyrazon	Pyramin®	0.197	4,900	49,000	-44,100	-90
Quizalofop-p-ethyl	Assure® II	0.054	2,900	6,700	-3,800	-57
Sethoxydim	Poast®	0.077	4,700	41,000	-36,300	-89
Trifluralin	Treflan® HFP	0.651	4,800	31,000	-26,200	-85
Triflusulfuron-methyl	Upbeet®	0.003	1000	21,000	-20,000	-95
Total			**2,625,446**	**956,000**	**1,669,446**	175

2. Swiss Chard

Potential impacts of the environmental release of H7-1 sugar beets on both Swiss chard seed and greens production are described separately below.

The discussion that follows does not address all aspects of Swiss chard seed and vegetable (greens) production, but rather focuses on only those aspects that are expected to change as a result of the four action alternatives. In terms of seed production, the majority of the practices used to produce Swiss chard seed have not changed with the adoption of H7-1 sugar beets and therefore are not discussed below. For example, the breeding methods used to produce Swiss chard seed, the planting and lifecycle of seed production, the use of formal or informal isolation distances and/or pinning maps in areas where sexually compatible *Beta* species are grown, land preparation, the use of both the direct-seeding and stecklings methods, fertilization, crop rotation, and disease management have all remained the same. Additionally, APHIS does not anticipate any changes in these production practices as a result of any of the three alternatives. Therefore, these Swiss chard seed production practices are not discussed in detail below. For more information on these seed production practices, see the corresponding sections in III.B.2.a(1) through III.B.2.a(11).

The aspects of Swiss chard seed production that have changed with the adoption of H7-1 sugar beet seeds, or are predicted to be affected by the three alternatives, include: the counties in which Swiss chard seeds are produced, the ratio of the steckling method used compared to the direct-seeded method, the isolation distances used between Swiss chard seed and H7-1 sugar beet seed production, roguing for off-types, testing for low level presence (LLP) in seeds, and cost of testing for LLP.[31] These production practices relate to the concern of organic seed and vegetable producers, of the potential for LLP of the H7-1 trait in Swiss chard seed or food crops. These issues, and the associated changes that are expected to occur with each of the three alternatives, are discussed in detail below.

In terms of vegetable production (leafy greens), most of the practices used to produce Swiss chard are believed to be unchanged with the adoption of H7-1 sugar beets. These practices include vegetable production location, planting, bolting, and harvesting dates, fertilization and pH adjustment, crop rotation and pest management practices including disease and insect management. As sugar beets are not planted in rotation with Swiss chard greens production, sugar beet volunteers do not occur in Swiss chard fields. Additionally, APHIS does not anticipate any changes in these production practices as a result of any of the three alternatives. Therefore, these Swiss chard vegetable production practices are not discussed in

[31] As discussed in section III.B.5.e, LLP testing includes strip tests that detect H7-1 protein, PCR tests that detect H7-1 DNA, and seed lot grow out that detects the phenotypic expression of the H7-1 trait.

detail below. For more information on these vegetable production practices, see the corresponding sections in III.B.2.b(1) through III.B.2.b(5).

The aspects of Swiss chard greens production that have changed with the adoption of H7-1 sugar beets, or are predicted to be affected by the three alternatives, include: enhanced attention to roguing for sugar beet/Swiss chard off-types in Swiss chard greens production, testing for LLP of the H7-1 trait in greens, and the costs associated with testing for LLP in greens. These issues, and the associated changes that are expected to occur with each of the three alternatives, are discussed in detail below.

a. Seed Production

As Swiss chard seed can be produced by both commercial and noncommerical growers, APHIS believes there could be the following four categories of Swiss chard seed producers:

(1) Commercial Swiss chard seed producers who produce and sell seeds seeds under contract and/or use industry mandated isolation distances and/or participate in pinning programs;

(2) Swiss chard seed producers who produce and sell seed but are not under contract and may or may not follow industry mandated isolation distances and/or participate in pinning (APHIS is not aware of any growers in this category);

(3) Swiss chard farmers who sell food crops and also produce seed for themselves, but do not sell seed (including, but not limited to hobby farmers); and

(4) Home gardeners who produce Swiss chard for greens and for seed for their personal use.

APHIS believes that the vast majority of Swiss chard seed sold and produced in the United States is produced by growers in category 1. As there are no available data regarding the acreage and location of producers in categories 2 through 4, the primary focus of the analysis in this chapter is on Swiss chard seed producers in category 1 above. When possible, growers in the other categories are also discussed.

As described in section III.B.2.a, in the United States in 2011, APHIS is aware of commercial Swiss chard seed production occurring on approximately 600[32] acres in Arizona, California, Washington, and Oregon.

(1) Alternative 1 – No Action

Isolation distances would remain under the control of pinning organizations and are expected to revert to pre-2005 isolation distances under Alternative 1. In the Willamette Valley, isolation distances between Swiss chard and other *Beta* crop species are described in section III.B.2.a(7) but briefly summarized here: 1 mile between open-pollinated fields, or between hybrid-pollinated fields of the same color and group; 2 miles between hybrid and open-pollinated of the same color and group and between stock-seed and hybrid; 3 miles between different colors within a group, between stock seed and open pollination, or between GMOs and any other *Beta* species (though with the removal of H7-1 sugar beets, this last category would be unneeded); 4 miles between hybrid and open pollination of different groups.

Some Swiss chard producers have reported testing for H7-1 LLP, however there is no evidence that LLP has been detected. Under Alternative 1, it is expected that testing will no longer be practiced by Swiss chard seed producers because H7-1 sugar beet seed production will cease.

Beta seed producers must remain vigilant in the removal of off-types in breeder lines so it is unlikely that practices for rouguing have changed since the introduction of H7-1 sugar beets or will change under Alternative 1.

Swiss chard seed growers that save seed for their own purposes, but do not sell it, also are likely to rogue off-types to maintain varietal purity. If they are located in Oregon or eastern Washington, or parts of Idaho, the only areas of the country where sugar beet seed production occurs, and if they do not participate in the pinning process and they end up inadvertently near a sugar beet seed field, then there is a possibility that their Swiss chard plants would cross pollinate with sugar beet. If the grower does not examine his plants for off-types, then it is possible that the grower will consume a sugar beet-Swiss chard hybrid or will continue to breed with one. Under Alternative 1, these growers would not have concerns that the sugar beet-Swiss chard hybrid has the H7-1 trait.

In summary, under Alternative 1 isolation distances are likely to revert to the guidelines that existed before the introduction of H7-1 sugar beets.

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[32] Note: the information APHIS received on acreage of Swiss chard production in California for Glenn, Colusa, and Butte Counties was aggregate data with combined acreage for Swiss chard and table beet. Therefore actual acreage of table beet and Swiss chard in each of the individual counties is not known. For the purposes of the EIS, APHIS will assume the highest possible acreage for both of the crops by estimating that the acreage of each is 125 acres.

Swiss chard seed producers would likely cease to test their seed for the H7-1 trait, and unsuspecting seed savers that fail to eliminate hybrid off types from their seed supply would not have the H7-1 trait in their off-types.

(2) Alternative 2 – Full Deregulation

The 600 known acres of commercial Swiss chard seed production in 2011 include 301 acres in Oregon, 150 acres in Washington, up to 125 acres in California, and 20 acres in Arizona.

The primary method that Swiss chard and other *Beta* crop seed producers utilize to ensure varietal purity, regardless of production area, are through isolation distances. Of the three main areas where multiple *Beta* species are grown, Oregon (Willamette Valley and Jackson County), western Washington, and California, Swiss chard seed production and H7-1 sugar beet seed production both occur only in the Willamette Valley and Jackson County, Oregon.

As described in III.B.1.b(2), all growers of commercial specialty seed in the Willamette Valley, including all commercial companies producing Swiss chard, table beet and sugar beet seeds, are members of the WVSSA that has strict (although not mandatory) isolation distances and pinning guidelines for growers to follow. The minimum isolation distance between Swiss chard and H7-1 sugar beets is 3 miles if both are hybrids and 4 miles if one of the crops is open pollinated (WVSSA, 2008). Note that the sugar beet seed producer Betaseed uses a minimum of a 4-mile isolation distance between H7-1 sugar beet seed production and other *Beta* species. For more information see section III.B.1.b(11).

In 2011, H7-1 sugar beet seed is being produced in all of the same counties in Oregon in which Swiss chard seed is being produced with the exception of Yamhill County (Dorsing, 2011) (USDA-APHIS, 2011d; Wahlert, 2011). These seven counties account for 38.9 percent of the total known U.S. commercial Swiss chard seed production in 2011. For a map of the counties in which H7-1 sugar beet seed and Swiss chard seed production both occur see figure 4–1 below.

As described in section III.B.1.b(6), all commercial sugar beet seed is produced using two different parents; a ‘male sterile’ seed parent and a male fertile, pollen parent. Gene flow from H7-1 sugar beet seed production to Swiss chard seed production can essentially occur only if the H7-1 trait is on the male, pollen producing plant. As described in sections III.B.1.b(6) through III.B.1.b(9), in the state of Oregon for 2011, 15 percent of the H7-1 sugar beet seed production acres was conducted with H7-1 pollinators. For more information on gene flow see section III.B.5.

As described in section III.B.5.b., there are two major factors that determine the likelihood of cross pollination. One is the relative size of the pollen clouds produced by the two fields, the other is the isolation distance.

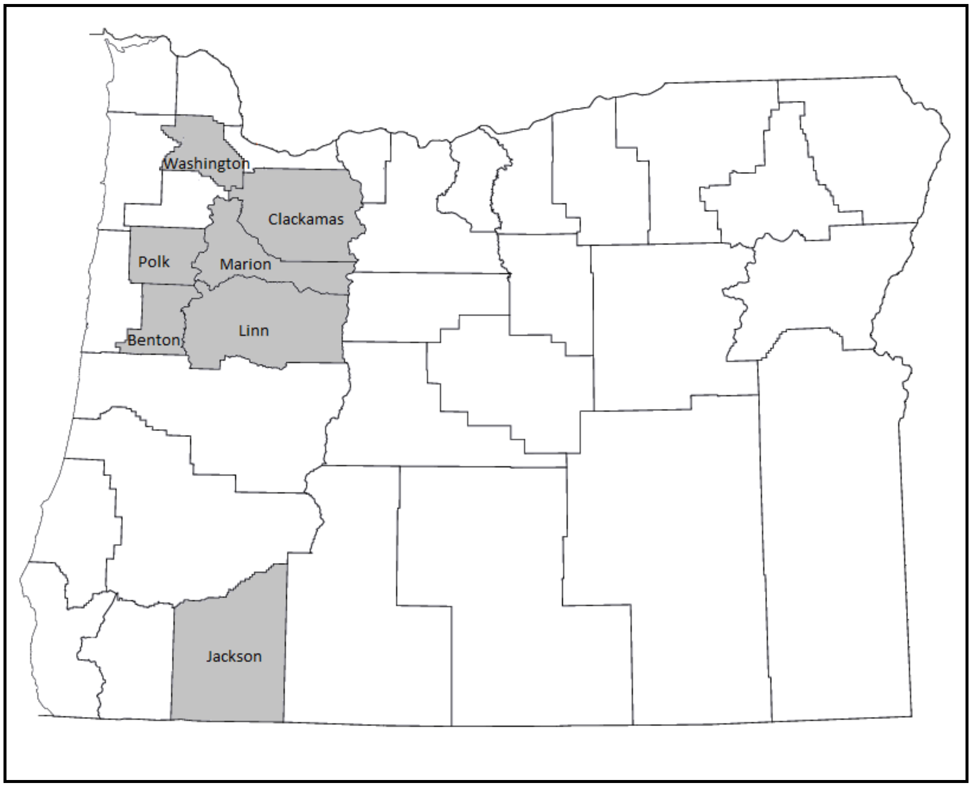

Figure 4- 1. Map of the counties in Oregon in which known commercial Swiss chard seed production and H7 1 sugar beet seed production are occurring (Sources: Benton, Clackamas, Jackson, Linn, Marion and Washington) in 2011 (McReynolds, 2011; USDA-APHIS, 2011d; Wahlert, 2011)

Acreage is a good indicator of the relative sizes of the two pollen clouds. Table 4–4 shows the ratio of the acreage of male fertile H7-1 sugar beet fields compared to Swiss chard fields. Only in Polk and Washington

Counties does the acreage of H7-1 male fertile sugar beet plants exceed that of Swiss chard. As mentioned in section III.B.2.a., hybrid fields typically produce 25 percent as much pollen as open pollinated fields because pollinators are planted every fourth row. Dividing the acreage ratios in table 4–4 by 4 provides a more realistic estimate of the relative pollen contribution of Swiss chard and sugar beet to the respective pollen clouds. Considering this difference in pollen production, only Polk County would be expected to produce more pollen with the H7-1 trait than Swiss chard pollen, and not by much. The fact that pollen with the H7-1 trait is typically in shorter supply than Swiss chard pollen suggests that

Swiss chard pollen can be an effective competitor against cross pollination by pollen with the H7-1 trait.

Another important consideration is the isolation distance between male fertile H7-1 sugar beet fields and Swiss chard fields. As stated previously, gene flow risk decreases quickly as the distance from the source increases (Darmency et al., 2009). All H7-1 sugar beet seed fields must be at least 4 miles away from any Swiss chard seed field. APHIS obtained sector locations of all vegetable beet seed fields planted in 2011 in the north and south ends of the Willamette Valley from the WVSSA pinning maps

Table 4- 4. Ratio of Acres of Male Fertile H7 1 Sugar Beet Seed and Known Commercial Vegetable Beet Seed Produced by County

Location	**Crop**	**Ratio Male Fertile H7-1 Acres/Veg Beet acres**
Benton	Swiss Chard	<0.2
Clackamas	Swiss Chard	<0.2
Jackson	Swiss Chard	<0.2
Marion	Swiss Chard	<0.2
Linn	Swiss Chard	1
Polk	Table Beet	<2
Washington	Swiss Chard	<3
Polk	Swiss Chard	<6

and used earthpoint to convert the sector locations into GPS data. Under the terms of the partial deregulation, APHIS obtained GPS information for each sugar beet seed field planted including those where the H7-1 trait was on the pollen producing parent. APHIS used Google Earth® to calculate a minimum and maximum distance from each sugar beet seed field ,that produces pollen containing the H7-1 trait, from the nearest vegetable seed field. Only one field was 4-5 miles away; the remaining fields exceeded this distance. On average, fields were somewhere between 8.7-9.6 miles apart (table 4-5). The median distance between fields was 7 to 7.7 miles. Considering the actual isolation distances between sugar beet fields producing H7-1 pollen and vegetable beet seed fields and the relative size of the pollen clouds, APHIS expects that gene flow from H7-1 sugar beets into Swiss chard will be below detectable levels (<1 in 10,000 seeds) throughout Oregon.

Table 4- 5. Distances between seed fields for vegetable beet and H7-1 male fertile sugar beet

Vegetable Beet Field Number	**Minimum Distance (miles)**	**Maximum Distance (miles)**

1	3.8	5.1
2	4.9	5.6
3	5.3	5.9
4	5.8	7.1
5	6.0	7.1
6	6.3	7.7
7	6.7	7.4
8	6.7	7.8
9	7.0	7.5
10	7.0	7.7
11	8.7	10.0
12	9.1	9.7
13	9.1	9.8
14	13.0	13.5
15	13.1	13.8
16	18.1	19.4
17	18.1	18.8
Mean	8.7	9.6
Median	7.0	7.7

Vegetable beet field locations were determined from WVSSA pinning map data and converted to GPS using earthpoint (http://www.earthpoint.us/townships.aspx)

Sugar beet field locations from APHIS proprietary data

Distances calculated using Google Earth

Industry best practices that have been established would still be in place under Alternative 2 (“Industry Provisions to Prevent Inadvertent Mechanical Mixing in Seed Production”). Although adequate isolation distances and pinning maps are used by commercial Swiss chard and other *Beta* seed producers, post-harvest seed cleaning and processing presents another opportunity for H7-1 sugar beet seeds to become mixed with Swiss chard seed. Such mixtures of seed can cause LLP of GE seed in an otherwise non-GE seed lot. LLP of the H7-1 trait is a serious concern for GE-sensitive Swiss chard seed purchasers. Such admixtures are unlikely as there are no commercial seed producers that grow H7-1 sugar beet seed and Swiss chard seed (Loberg, 2010a), and H7-1 sugar beet processing facilities do not process other *Beta* seed resulting in no opportunities for mechanical mixing of sugar beet seed with other *Beta* seed (Loberg, 2010a). Additionally, as discussed in section III.B.1.b(18), sugar beet seed producers do not share equipment with Swiss chard seed producers. This practice greatly reduces the potential for seed admixture and LLP.

Taken together, APHIS believes that there is a very low potential for unintended gene flow from H7-1 sugar beet seed production into Swiss chard seed production. APHIS recognizes that the distribution of both

Swiss chard and sugar beet seed fields are not static and will vary from year to year. APHIS assumes that the impacts discussed for the current county level overlapping distribution will likely also apply to future overlapping county distributions and that isolation distances recommended by the WVSSA will continue to be followed by its members.

GE-sensitive markets may require assurances from seed producers that gene flow or post-harvest seed mixing has not occurred, usually through LLP testing for the H7-1 trait. These tests may be requested as GE-sensitive markets may perceive current isolation distances to be inadequate even though LLP of the H7-1 trait has yet to be detected (Navazio et al., 2010). The result is that even though Swiss chard without detectible levels of the H7-1 trait can be produced in Willamette Valley, GE-sensitive markets may continue to insist on LLP testing for the H7-1 trait and GE-free certification. These tests can increase production costs. For more information on LLP testing see sections III.B.2.a(11) and III.B.5.e.

Under Alternative 2, Swiss chard seed producers could alter or enhance their practices for roguing off-types due to concern that any off-types may be the result of a cross with H7-1 sugar beets. However, as there is no indication that practices for roguing off-types have changed between 2005 and 2010 (the period of H7-1 sugar beet deregulation), this is unlikely.

As described in sections III.B.2.a(4) through III.B.2.a(6), Swiss chard seed can be produced using either the steckling method or the direct-seeded method. While the steckling method is more labor intensive, it allows Swiss chard seed producers to consider root appearance when roguing for off-types. Under Alternative 2, producers who produce Swiss chard seed near H7-1 sugar beet seed production and are concerned about LLP may choose to use the steckling method over the direct-seeded method. The percentage of producers who might switch to the steckling method and the associated costs of switching methods are unknown.

If LLP of the H7-1 trait were found in Swiss chard breeder stock, it can be removed as described in III.B.5(e). If seed companies that produce Swiss chard seed for GE-sensitive clients discover LLP of the H7-1 trait in their seed, such companies could be required to recall products, to replace products, to handle losses from customers, or suffer losses to their business reputation (Stearns, 2010).

Because there are vegetable beet seed producing areas such as western Washington, California, and Arizona where no H7-1 sugar beet seed is produced, it is possible that seed producers in Oregon will be disadvantaged relative to their out of state competitors in the GE-sensitive marketplace concerned about potential LLP. Consequently, it is possible that under Alternative 2, negative market perceptions may induce Swiss chard seed producers to contract their vegetable beet seed operations with growers outside of the Willamette Valley.

As described previously, under Alternative 2, H7-1 sugar beet seed production could occur anywhere in the United States. However, as described in IV.B.1.a(2) it is very unlikely that H7-1 sugar beet seed producers would move to locations where other *Beta* seed crops are currently being produced.

Under Alternative 2, Swiss chard seed growers that save seed, but do not sell it, might worry that LLP of the H7-1 trait is in their seed stock. This is only a concern for Swiss chard seed growers who are producing seed near areas where male fertile H7-1 sugar beet plants are grown (Oregon, Washington, and Idaho). Options for these seed savers would be either to participate in pinning to maintain isolation distances or to avoid seed saving and purchase seeds from a trusted source that produced seed in regions that H7-1 sugar beets are not grown or purchase seed tested for the presence of the H7-1 trait. It is also possible that they could inspect their vegetables and rogue out hybrid off-types that resulted from a sugar beet swiss chard cross. Such plants would have a mix of morphological traits that are intermediate to both Swiss chard and sugar beets.

In summary, Alternative 2 would be expected to result in a continuation of the current rate of potential gene flow of the H7-1 trait into Swiss chard seed, which, to date, has not been detected. The only counties which have the aforementioned potential impact of gene flow are those in which both crops are grown, which currently occurs only in Willamette Valley. Given that 3 to 4 mile isolation distances are used (depending on whether the Swiss chard crops are hybrid or open pollinated), only 15 percent of H7-1 sugar beet seed production acreage produces pollen with the H7-1 trait, pollen clouds from these sources are generally smaller that Swiss chard pollen clouds, and commercial seed producers currently follow production practices to reduce accidental admixtures of seed, APHIS believes that there is a very low potential for unintended gene flow from H7-1 sugar beet seed production into Swiss chard seed production.

Swiss chard seed producers that are perceived to have fields that are "too close" to H7-1 sugar beet seed producers may be required to test for LLP of the H7-1 trait to satisfy the concerns of GE-sensitive customers. This perception may occur regardless of whether or not gene flow from H7-1 sugar beets into Swiss chard seed has actually occurred, or is likely to occur (see above and section III.B.5). Evidence to date suggests that while gene flow is possible, it currently does not occur at levels that are detectable. Although detectable gene flow is very unlikely, if a Swiss chard seed producer sells seeds to clients in a zero-tolerance market and LLP of the H7-1 trait was detected, then the producer may lose his customer, damage his reputation, and have to sell that seed lot at a loss to a more tolerant market.

(3) Alternative 3 – Partial Deregulation

Under Alternative 3, APHIS would extend the partial deregulation of the H7-1 root crop indefinitely, as long as certain specific mandatory conditions are complied with. Similar to a permit, the compliance agreements would impose certain mandatory conditions and be used to authorize the movement and release into the environment of H7-1 sugar beet seed for root crop production. H7-1 sugar beet seed production activities such as breeding and production of commercial seed for the planting of the root crop would be allowed only under permit.

Under Alternative 3, planting of H7-1 sugar beets for root or seed production would not be allowed in California and western Washington: Outside of California and western Washington, APHIS would issue permits with specific conditions for nonflowering steckling production, and seed production from flowering stecklings or directly from seed. The isolation distances for H7-1 sugar beet seed fields (as discussed in section II.D) would be determined and enforced by APHIS. These distances are 4 miles between H7-1 plants and table beet and Swiss chard seed production. In addition to the geographic restrictions, no H7-1 sugar beet seed would be cleaned or processed in any processing facility that also cleans and processes Swiss chard seed or table beet seed.

Under Alternative 3, Swiss chard seed growers in California and western Washington would likely not experience impacts from H7-1 sugar beet seed production as sugar beet seed has not traditionally been produced in those regions and H7-1 sugar beet seed would not be allowed to be produced in these regions.

The greatest potential for impact from H7-1 sugar beets produced under Alternative 3 would likely be on Swiss chard seed producers in the Willamette Valley, which would be similar to Alternative 2, resulting in increased testing for LLP and the potential loss of customers from the perceived but unsubstantiated risk of LLP.

Under Alternative 3, highly GE-sensitive markets may choose to purchase seed from production areas other than Willamette Valley due to fears of LLP. As a result, Swiss chard seed companies may contract Swiss chard seed production outside the Willamette valley, which, in turn, could result in increased competition for Swiss chard seed production fields in these areas. Ultimately, the amount that production could increase in these areas would be limited by the isolation distances required. Growers in the Willamette Valley who had previously raised Swiss chard seed may instead grow alternate seed crops.

Alternative 3 has mandatory isolation distances of 4 miles between H7-1 plants and table beet and Swiss chard seed production which is greater than the 3-mile isolation distance required by the WVSSA. This increase in mandatory isolation distance could result in Swiss chard seed producers having fewer land options available to them (Hoffman, 2010) Additionally, small producers are likely to have lower priority in the WVSSA pinning schemes. However, as some of the H7-1 sugar beet seed producers already require a 4-mile isolation distance between H7-1 sugar beet seed production and other *Beta* species (Lehner, 2010) the actual impact of this mandatory increase in isolation distance on Swiss chard seed producers is expected to be low. For more information, on WVSSA guidelines and pinning rules, see section III.B.1.b(10).

Under Alternative 3, the impacts on Swiss chard seed producers in Arizona would likely be minimal because H7-1 sugar beet seed is not produced in Arizona.

Under Alternative 3, similar to Alternative 2, Swiss chard seed producers in areas close to H7-1 sugar beet seed production might alter their practices for roguing off-types due to concerns about LLP. Also, Swiss chard seed growers that save seed near areas close to H7-1 sugar beet production would face the same concerns as described in Alternative 2.

In summary, for Swiss chard seed producers in the counties that overlap with H7-1 sugar beet seed production in Willamette Valley and southern Oregon, implementation of Alternative 3 would likely not result in impacts different from those expected under Alternative 2. Swiss chard seed producers could be required by their GE-sensitive customers to test their seed lots for LLP despite the likelihood of detection being low. If seed producers sell to a zero-tolerance market, then detection of LLP would likely result in the seed company having to sell the seed lot to a more tolerant market. Growing Swiss chard seeds in Oregon may become less attractive compared to growing it in other areas where no H7-1 sugar beet seed is produced. Swiss chard seed producers in the counties of overlap with H7-1 male fertile sugar beets also might be more vigilant about roguing off-types due to concerns about LLP. APHIS would continue to oversee conditions that mitigate gene flow.

b. Vegetable Production

As Swiss chard grown for leafy greens can be produced by both commercial and noncommerical growers, APHIS believes there could be the following three categories of Swiss chard vegetable producers:

(1) Commercial growers who purchase seed and sell their vegetable crop,

(2) Farmers who grow their own seed (save seed) and sell their vegetable crop, and

(3) Home gardeners who grow Swiss chard as a vegetable but do not sell it. These farmers may purchase seed or grow their own (save seed).

The potential impacts of each of the alternatives on root crop production practices of each of these grower types are discussed below.

(1) Alternative 1 – No Action

Because Swiss chard grown for vegetables is harvested prior to flowering, there is no potential for H7-1 sugar beets to directly impact the production of Swiss chard vegetable production through gene flow. Vegetable beet producers who cater to a GE-sensitive market may want to ensure that their seed does not test positive for the H7-1 trait. Under Alternative 1, where no H7-1 sugar beet seed is produced, these producers are unlikely to be concerned with LLP in Swiss chard seed. In terms of LLP, there is no indication that practices for roguing off-types when growing Swiss chard for greens have changed between 2005 and 2010 (the period of H7-1 sugar beet deregulation). Therefore, Alternative 1 is not expected to have any effect on these practices.

Under Alternative 1, farmers who save seed and sell their Swiss chard vegetable crop and home gardeners who either buy seed or save seed would not be expected to have concerns that their crops contain LLP.

(2) Alternative 2 – Full Deregulation

Under Alternative 2, because H7-1 sugar beet root crops are harvested prior to flowering, there is no potential for H7-1 sugar beets to directly impact the production of Swiss chard as a vegetable. Additionally, sugar beet root growers do not rotate their fields with other *Beta* species so it is extremely unlikely there would be any H7-1 sugar beet volunteers in a commercial Swiss chard vegetable field.

Swiss chard vegetable growers who cater to a GE-sensitive market may decide to only purchase seed from areas where no H7-1 sugar beet is grown or seed that has been tested.

Under Alternative 2, farmers and home gardeners who save seed and sell or directly consume their Swiss chard vegetable crop may have concerns that their crops contain the H7-1 trait. Farmers or gardeners located near H7-1 sugar beet seed production who save their seed and are concerned about H7-1 gene flow could purchase seeds from producers who are not near H7-1 sugar beet seed production, or they could continue to save their own seed and rogue off-types, eliminating potential LLP (except in baby greens where off-types are difficult to detect).

In summary, Alternative 2 is expected to have minimal impact on Swiss chard vegetable producers.

(3) Alternative 3 – Partial Deregulation

As with Alternative 2, there are minimal impacts on Swiss chard vegetable crop producers under Alternative 3.

3. Table Beet

Unlike Swiss chard, which is mostly grown for the fresh market, the majority of table beets grown in the United States is for canning (see section III.B.3.) which is not a GE-sensitive market. However, table beet seed is produced for export and domestic fresh market use, both of which can be GE-sensitive markets. As with all other *Beta* crops commercially grown in the United States, table beet is grown for both seed and food (root and greens), and it is also produced by home gardeners.

Potential impacts of the environmental release of H7-1 sugar beets on both table beet seed and vegetable production are described separately below.

As with Swiss chard in section IV.B.2, the discussion that follows also does not address all aspects of table beet seed and root production, but rather focuses on only those aspects that are expected to change as a result of the three action alternatives. The same production practices that did not change for Swiss chard seed production are also not expected to change for table beet seed production.

The aspects of table beet seed production that have changed with the adoption of H7-1 sugar beet seed or are expected to be affected by the three alternatives are the same as described for Swiss chard. These include: the counties in which table beet seed is produced, the ratio of the steckling method used compared to the direct seeded method, the isolation distances used between table beet seed and H7-1 sugar beet seed production, roguing for off-types, testing for LLP in seeds, and cost of testing for LLP.

Much like with Swiss chard vegetable production, most of the practices used to produce table beet vegetables are believed to be unchanged with the adoption of H7-1 sugar beets.

The aspects of table beet vegetable production that have changed with the adoption of H7-1 sugar beets or are expected to be affected by the three alternatives are the same as those listed for Swiss chard vegetable production. These include enhanced attention to roguing for off-types in table beet production, testing for LLP, and the costs associated with testing. For more information see section IV.B.2

a. Seed Production

As table beet seed can be produced by both commercial and noncommercial growers, APHIS believes there could be the same four categories of table beet seed producers as there are for Swiss chard seed producers:

(1) Commercial table beet seed producers who produce seed under contract and/or use industry mandated isolation distances and/or participate in pinning programs;

(2) Table beet seed producers who produce and sell seed but are not under contract and may or may not follow industry mandated isolation distances and/or participate in pinning;

(3) Table beet farmers who sell fresh vegetables and also save seed, but do not sell seed (including, but not limited to, hobby farmers); and

(4) Home gardeners who produce table beet for greens, roots, and/or for seed for their personal use.

APHIS believes that the vast majority of table beet seed sold and produced in the United States is produced by growers in category 1. As there are no available data regarding the acreage and location of producers in categories 2 through 4, the primary focus of the analysis in this chapter is on table beet seed producers in category 1 above. When possible, growers in the other categories are also discussed.

As described in section III.B.3.a, in the United States in 2011, APHIS is aware of commercial table beet seed production occurring on up to 550[33] acres in California, Washington, and Oregon.

(1) Alternative 1 – No Action

The effects of Alternative 1 on table beet seed production are expected to be similar to those described for Swiss chard seed production as described in IV.B.2.a(1). In summary, Alternative 1 would allow isolation distances to revert to pre-2005 distances, would eliminate the need for table beet seed producers to conduct LLP testing, and would reduce concerns about roguing off-types. Growers would still need to be concerned about roguing phenotypic off-types from hybrids to conventional sugar beet and Swiss chard.

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[33] Note: the information APHIS received on acreage of Swiss chard production in California for Glenn, Colusa, and Butte Counties was aggregate data with combined acreage for Swiss chard and table beet. Therefore actual acreage of table beet and Swiss chard in each of the individual counties is not known. For the purposes of the EIS, APHIS will assume the highest possible acreage for both of the crops by estimating that the acreage of each is 125 acres.

(2) Alternative 2 – Full Deregulation

The approximately 550 known acres of commercial table beet seed production in 2011 include 27 acres in Oregon, 405 acres in Washington, and up to 125 acres in California.

Like other *Beta* crops, table beet seed producers also use isolation distances to keep their seeds genetically pure. Of the *Beta* seed producing regions listed in III.B.2.a(7), Willamette Valley has the only county in which both table beet seed production and H7-1 sugar beet seed production is occurring in 2011. Therefore, if gene flow between H7-1 sugar beet seed production and table beet seed production were to occur, it is most likely to occur in Willamette Valley.

In 2011, H7-1 sugar beet seed production and table beet seed production are both occurring in Polk County, Oregon (see Figure 4-2). It is possible that in other years, table beet seed production would occur in other counties in the Willamette Valley.

As stated above and in sections III.B.1.b(6) though III.B.1.b(9) in Willamette Valley, only 15 percent of the H7-1 sugar beet seed production acres was conducted with H7-1 pollinators. For more information on gene flow see section III.B.5. Furthermore, the ratio of the acreage of male fertile H7-1 sugar beet fields compared to table beet fields is less than 2.0 (see table 4–4). Table beet may be produced as hybrids or open pollinated so the ratio of pollen producing sugar beet to table beet plants is likely under 1.0. From this information the agency concludes that there are comparable amounts of pollen producers with the H7-1 trait and table beet pollen producers, and with a 4 mile isolation distance, APHIS expects that gene flow from H7-1 sugar beets into table beets will be below detectable levels (<1 in 10,000 seeds) in Polk County.

As described in section IV.B.2., seed admixtures between sugar beet and table beet are unlikely as there are no commercial seed producers that grow H7-1 sugar beet seed and table beet seed (Loberg, 2010a), H7-1 sugar beet processing facilities do not process other *Beta* seed, and neither sugar

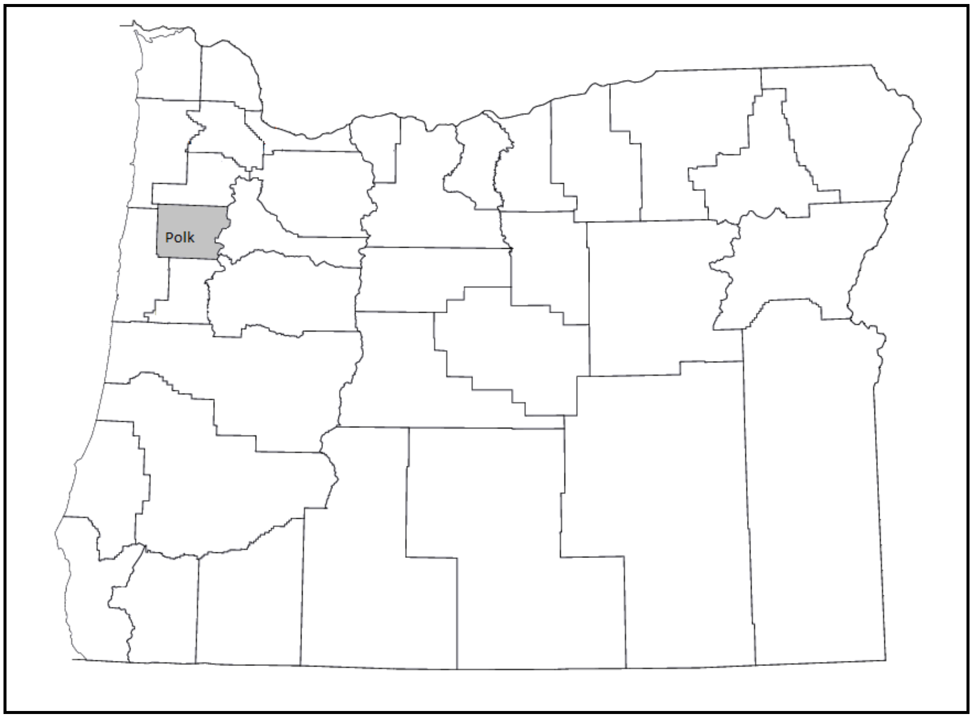

Figure 4- 2. Map of the county in Oregon in which known commercial table beet seed production and H7 1 sugar beet seed production are occurring (Polk) in 2011 (McReynolds, 2011; USDA-APHIS, 2011d).

beet seed producing companies or table beet seed producers share equipment for the planting, harvest, and cleaning of seed. For more information see section III.B.1.b(18),

Taken together, APHIS believes that there is a very low potential for unintended gene flow from H7-1 sugar beet seed production into table beet seed production. APHIS recognizes that both table beet and sugar beet seed field distributions are not static and will vary from year to year. Given the widespread use of male sterile H7-1 sugar beet lines, the relative sizes of the sugar beet and table beet seed production fields, and the isolation distances routinely employed, APHIS concludes that LLP is unlikely to be detected in Oregon vegetable beet seed crops.

Under Alternative 2, the rest of the potential impacts on table beet seed producers are expected to be the same as those for Swiss chard seed producers. See section IV.B.2.a(2) for more information.

As discussed for Swiss chard seed producers in section IV.B.2.a, table beet seed producers in the Willamette Valley who cater to a GE-sensitive market may be disadvantaged compared to producers outside the state of Oregon. The impact on table beet seed producers may be less than on Swiss chard seed producers given the sizeable beet canning industry.

(3) Alternative 3: Partial Deregulation

Under Alternative 3, the potential impacts on table beet seed producers are expected to be the same as those for Swiss chard seed producers. See section IV.B.2.a(3) for more information.

b. Vegetable Production

As table beet grown for its root and or leafy greens can be produced by both commercial and noncommerical growers, APHIS believes there could be the following three categories of table beet vegetable producers:

(1) Commercial growers who purchase seed and sell their vegetable crop,

(2) Farmers who grow their own seed (seed savers) and sell their vegetable crop, and

(3) Home gardeners who grow table beets as a vegetable but do not sell it. They may purchase seed or grow their own (save seed).

The potential impacts of each of the alternatives on vegetable crop production practices of each of these grower types are discussed below.

(1) Alternative 1 – No Action

Impacts on table beet vegetable producers are expected to be similar to the impacts described on Swiss chard greens producers. For more information see section IV.B.2.b(1).

In summary, Under Alternative 1, commercial farmers who produced table beets, farmers who save seed and sell their table beet vegetable crop, and home gardeners who either buy seed or save seed would not have concerns that their crops contain LLP.

(2) Alternative 2 – Full Deregulation

As was described for Swiss chard vegetable producers in section IV.B.2.b(2), no impacts are expected on table beet vegetable producers under Alternative 2.

(3) Alternative 3 – Partial Deregulation

As for Alternative 2, no impacts on table beet vegetable producers are expected under Alternative 3.

4. Fodder Beets

There is no evidence that commercial fodder beet seed production (Wahlert, 2011) or root production is currently occurring in the United

States. APHIS also assumes that since fodder beets have not been widely used for livestock feed in the United States since the Second World War, there is no reason to expect that they would be adopted for such use in the future. Therefore there are no expected impacts of H7-1 sugar beets on fodder beet seed or root production on any of the alternatives.

5. Gene Flow in ***Beta*** sp.

Gene flow, hybridization, introgression and the distance that pollen, seeds, or vegetative tissues move in the landscape will not change under any of the alternatives presented in chapter II. Gene flow will continue to occur between different plant populations whenever conditions conducive to successful pollen movement and cross fertilization occur.

While gene flow itself does not change under the different alternatives, the likelihood of successful gene flow between any population of H7-1 sugar beets and other fields or populations of *Beta* spp. does vary between alternatives. In the discussion below, the factors that contribute to or limit the potential impact of H7-1 on gene flow between sugar beets, vegetable beets, and wild beets are discussed. Table 4–6 provides an overview of the likelihood of gene flow between different *Beta* spp. populations under present-day conditions. These determinations are based on the current geographic distribution of sugar beets, vegetable beets, and wild beets. Additionally, factors including flowering time, potential for aberrant bolting and flowering, and vegetable crop versus seed crop are considered. The terms used in the table are intended to provide more of a relative ranking than an absolute conclusion, with "unlikely" indicating several factors currently act to limit the potential for seed or pollen flow between populations (e.g., extremely limited flowering potential in root crops), "possible" indicating overlap of distribution or flowering occurs, "not currently possible" indicating that current conditions enforced by the regulatory mechanisms of the Final EA prevent gene flow from occurring (e.g., geographic restrictions), and "not possible" indicating no chance of pollen mediated gene flow due to lack of flowering (USDA-APHIS, 2011b).

The most important properties that limit gene flow among sugar beets, vegetable beet, and wild beet populations are the standard isolation distances that have been adopted and used in the past and present by growers to maintain seed crop purity.

As discussed in detail in section III.B.5, the following conditions could contribute to gene flow between *Beta* crop species:

- **Wind pollination.** Sugar beet pollen is small and light, and is released in large "pollen clouds" from actively flowering seed production fields. Sugar beet pollen has been observed to move up to 6 miles from source fields (Fénart et al., 2007). Insects can move sugar beet pollen but are not considered a major mechanism for gene flow in *Beta* crop species (Desplanque et al., 2002; Free et al., 1975; OECD (Organization for Economic Cooperation and Development)).

- **Cytoplasmic male sterility (CMS) hybrid production**. CMS hybrid sugar beet production results from the mixed planting of a 14:4 (3.5:1) ratio of male-sterile: male-fertile plants. As such, pollen is primarily produced by one quarter of the plants and the local pollen cloud generated by CMS hybrid fields is smaller than the pollen cloud from open-pollinated *Beta* crops. As a result, local pollen competition is lower than at open pollination fields and incoming pollen has a (slightly) higher potential for successful pollination. Additionally, CMS hybrid production sometimes uses tetraploid male-fertile plants. Tetraploid male-fertile plants have been observed to have delayed pollen release, and also produce pollen with lowered competitive ability. These properties contribute to a higher potential for CMS fields to act as gene flow sinks.

- **Open pollination.** Open-pollinated *Beta* crops produce very large pollen clouds. Because the success of long-distance pollination increases with size of pollen cloud simply due to increased pollen in the air, open pollination fields have higher potential as gene flow sources.

- **Field size.** Similar to the differences between open-pollinated crops and hybrid production, fields of different sizes would be expected to produce different sized pollen clouds. Large fields would thus be expected to produce pollen clouds that are both more competitive at the local source and disperse at higher concentrations of pollen over distance.

Table 4- 6. Matrix of Potential H7 1 Pollen Sources and Gene Flow Sinks Qualitative Assessment of Likelihood of Gene Flow Under Present-day Conditions Indicated.

		Pollen Sources	
	Pollen Sinks	H7-1 Sugar Beet Seed Production	Bolters H7-1 Root Production
A	H7-1 Sugar Beet Seed	NA	Unlikely because: No proximity Different flowering times Bolters infrequent and usually removed
B	Conventional Sugar Beet Seed Production	possible in OR, WA, ID	Unlikely because: No proximity Different flowering times Bolters infrequent and usually removed

C	Swiss Chard/Table Beet Seed Production	possible in OR	Unlikely because: No proximity Different flowering times Bolters infrequent and usually removed
D	Seed Savers (Farmers who save Seed and Home Gardeners)	possible in OR, WA, ID	Proximity unknown Unlikely because: Different flowering times Bolters usually removed
E	Wild Beets	No proximity	Possible in CA. Unlikely because different flowering times Poor sexual compatibility
F	Bolters H7-1Sugar Beet Root Production	Unlikely No proximity Different flowering times Bolters infrequent and usually removed	NA
G	Bolters Conventional Sugar Beet Root Production	Unlikely No proximity Different flowering times Bolters infrequent and usually removed	Unlikely Bolters infrequent and usually removed
H	Bolters Swiss Chard/Table Beet Vegetable Production	Unlikely Vegetables usually harvested prior to flowering Different flowering times	Unlikely Vegetables usually harvested prior to flowering Bolters infrequent and usually removed
I	Bolters Home Gardens	Unlikely Different flowering times	Possible if proximity If occurred, seeds not valuable because selects for annual habit.
J	<u>Nonflowering Populations:</u> Stecklings, Nonbolting Vegetable Beet, Nonbolting Vegetable Swiss Chard, Nonbolting Sugar Beet Root, Commercial or Nonbolting Home Gardens	Not possible-no seed produced	Not possible-no seed produced

- **Aberrant bolting.** All *Beta* crop species have the potential to bolt and flower in the first year of cultivation if vernalization conditions are met or if crop-weed hybrid seed is planted. Plants that successfully bolt and flower can act as both a gene flow source and a sink. The percentage of bolting plants within root crop fields is very low, 0.01 percent in most growing regions. Bolting is higher in California due to the length of the growing season. Bolters are easily identifiable and standard practice is for farmers to remove them, although standard practice is not always followed as noted below.

- **Seed dispersal.** Gene flow of H7-1 sugar beets is possible if seeds are accidentally dispersed from transportation trucks, seed separation in storage is lacking, or via extreme weather conditions. Sugar beet seeds can shatter during harvest (drop from mother plants) and dispersed seeds have the ability to persist in seed banks for several years.

- **Seed bank persistence.** *Beta* crop species produce a seed ball that can survive in the soil for several years. These seeds can germinate in subsequent years as volunteers in other crop rotations or fallow fields. If left unmanaged, these plants could act as pollen donors or recipients and contribute to gene flow.

- **Vegetative reproduction.** *Beta* crop species have a very limited ability to reproduce vegetatively from root and top remnants which are typically referred to as groundkeepers. Successful persistence via this mechanism requires survival of winter conditions and subsequent flowering in order to represent a significant vector for gene flow.

- **Sexually compatible weeds.** Hybridization from sugar beets into wild beets is possible if the distributions between H7-1 sugar beet production and wild species overlap. Sexually compatible wild species of *Beta* are found only in California. Hybridization between wild species and *Beta* crop species is possible if other conditions for gene flow occur, such as wind pollination, flower synchrony, self incompatibility, fertile pollen, chromosomal stability, and proximity. Hybrids produced by gene flow from wild populations into sugar or vegetable beets would introduce the bolting gene into crop fields if bolters escape roguing and disperse seeds into the seed bank.

- **Farmers that grow their own seed (seed savers).** These farms are a potential source of gene flow, predominantly as a source for pollen that would exist without adherence to pinning rules. These farmers primarily grow *Beta* crop species as vegetable crops. If these farmers bulk their own seeds for replanting, hybrid "off-types" could occur. Because hybrid plants are a mix of morphological traits, they would likely be weeded out. Because these farms might not follow rigorous industry seed production protocols, they could be subject to less oversight and thus unharvested vegetable crops could be left for longer than the first year, flowering in the second. These flowering *Beta* crops could act as pollen donors or recipients.

- **Lack of adherence to best management practices.** If growers do not abide by best management practices such as following isolation distances between fields or do not remove aberrant bolting plants, potential for gene flow would increase. Additionally, seed producers that cultivate sugar beets or vegetable beets outside of areas that utilize pinning maps and isolation distances may be unaware of local pollen sources that could cross pollinate their crops.

As discussed in detail in section III.B.5, the following conditions could decrease the likelihood of gene flow between *Beta* crop species:

- **Isolation distances.** Farmers are aware of the cross-compatibility of sugar beets, Swiss chard, table beets, fodder beets, and wild beets. To maintain crop purity, farmers have traditionally adopted isolation distances ranging from 0.49 to 4 miles between fields. Isolation is maintained between both different crop types (sugar beets versus Swiss chard) and open-pollinated versus hybrid production of the same crop type. Isolation distances suggested for the production of H7-1 sugar beets have increased to 3–4 miles, depending on whether it is hybrid production or open pollination production.

- **Pollen dispersal.** Rates of pollen dispersal vary by experiment but all studies to date indicate that the rate of pollen dispersal and dilution in the environment decreases rapidly with distance from the pollen source. Effective pollen concentration at distances greater than 3,280 feet (0.6 mile) are estimated to be less than 0,1 percent of the original concentration.

- **Local pollen cloud competition.** Open-pollinated sugar beet (and other *Beta* crop) seed production fields produce very large "pollen clouds" during the flowering period. Pollen that has been released from other sugar beet or vegetable beet fields must travel from the donating field and consequently disperses in the air. When this incoming pollen reaches a sink field of sugar beets, it must compete with the local "pollen cloud."

- **CMS hybrid production.** CMS hybrid seed production uses mixed fields of male-sterile and male-fertile plants. Pollen is produced only by male-fertile plants, reducing the quantity of pollen in the "pollen cloud" and thus reducing the donation and competiveness of long-distance pollen from these fields. Specifically, in regard to H7-1 sugar beets, if the male-sterile plants carry the genetically engineered (GE) gene, then CMS hybrid production greatly reduces the risk of unintended release of pollen with the H7-1 trait. In CMS hybrid production, male-fertile plants are destroyed after flowering to prevent seed contamination, further reducing the potential for successful gene flow. H7-1 sugar beet progeny from a cross consisting of a tetraploid male plant and a diploid female plant will be triploid. If a root crop is sown with triploid seed, plants that bolt will predominantly be sterile.

- **Hybrid "off-types."** Hybrids that form between sugar beet and vegetable beet cultivars are a 50:50 mix of both crop species. If hybrid seeds form and are planted for root or seed crops, these hybrid plants manifest a mixture of the morphological traits of both parents. As the different crops are cultivated for different properties, sugary root, edible leaves, and edible root, "off-types" are easily identifiable. Standard practice is to remove "off-types" in seed production and the production of mature vegetables.

- **Geographic restriction of wild species.** Wild sexually compatible beet species in the United States occur only in California. Overlap between sugar beet root production and these species occurs only in the Imperial Valley of California. Currently, no sugar beet or vegetable beet seeds are produced in the Imperial Valley. Thus flowering is restricted to bolting plants in root or vegetable production fields. In the Imperial Valley, currently the only region in California that grows sugar beets, the predominant wild species, *B. macrocarpa*), has limited compatibility with sugar beet. Furthermore, flowering time is not typically synchronous between sugar beet root bolters and *B. macrocarpa* in the Imperial Valley.

- **Best management practices (BMPs) regarding seed storage, cleaning, and field cleanup.** Growers of H7-1 sugar beets are subject to contract restrictions imposed by the Monsanto TUG and grower cooperatives which necessitate stewardship requirements. As shattering of seed is common in sugar beet seed production, seed growers utilize specialized postharvest protocols to germinate and remove dispersed seeds in fields (see section III.B.1.b(18)). Additionally, BMPs used by sugar beet seed producers limit the potential for adventitious presence of seeds by prohibiting cross-equipment usage and storage.

- **Weediness.** Sugar beets are not considered a competitive weed species (see section III.C.3.c). Since H7-1 sugar beets do not have altered competitive ability compared with conventional sugar beets, H7-1 sugar beet plants that successfully disperse into another habitat area not expected to be more competitive than conventional sugar beets unless they are sprayed with glyphosate.

Sugar beets have a limited ability to vegetatively propagate (see section III.B.5) and several factors would have to occur in sequence to contribute to gene flow via this mechanism. First, small viable root fragments would have to be left behind after sugar beet harvest. Second, the groundkeepers would have to survive winter conditions (or solarization [extreme soil heat] in summer in California). Third, the plant would then have to survive the following year's crop rotation and tillage practice. Finally, the plant would have to survive farmer surveys to remove weeds and maintain crop purity. As such, gene flow between crop fields and other plant populations by H7-1 sugar beets via vegetative propagation of groundkeepers or other tissues is extremely unlikely.

The greatest potential for effective gene flow in regard to H7-1 sugar beet and vegetable beet crop production in the United States is via pollen-mediated gene flow. As sugar beets and other *Beta* crop species are wind-pollinated species and require the movement of pollen to set the seeds necessary for vegetable production, gene flow is necessary for sugar beet seed production. However, several factors need to be concurrently met for successful, unintended, pollen-mediated gene flow between beet populations (see section III.B.5). The potential for this occurring under each action alternative is analyzed below.

The following assumptions were used in the analysis:

- Previously measured pollen dispersal rates (reviewed by (Darmency et al., 2009)) and models (Westgate, 2010) accurately describe the dilution and dissipation of pollen as it leaves a field of flowering *Beta* spp.

- Pollen competition at open pollination sink fields is greater than that measured in gene flow studies using CMS male sterile receptor plants.

- A single sugar beet plant produces 1 billion pollen grains and approximately 10,000 seeds (10,000 ovules) (OECD (Organization for Economic Cooperation and Development)). Pollen to ovule ratio is 100,000:1.

- In determining pollen clouds and competition, all *Beta* crops are assumed to produce equivalent pollen and seeds per plant.

- Isolation distances imposed by seed producers and the use of pinning maps are effective at reducing gene flow between sexually compatible *Beta* spp. Hybrids between different *Beta* crops are recognizable and undesirable, and isolation distances have evolved to minimize cross pollination even prior to the introduction of H7-1 sugar beets.

- 85 percent of H7-1 sugar beet seed production in the Willamette Valley is CMS with the H7-1 trait on female (male sterile) plants (APHIS proprietary data). Pollen producing plants rarely occur in the male sterile background (Lehner, 2010) and are rogued to improve the efficiency of the desired crosses.

- The remaining 15 percent of H7-1 sugar beet seed production has the H7-1 trait on male fertile pollinators. The pollen cloud from these fields is less than one fourth the density of open-pollinated *Beta* crops.

- BMPs (e.g., voluntary, Monsanto TUG) and economic incentives regarding quality seed production contribute to field monitoring and methods to remove dispersed sugar beet seed and control volunteers.

- Wild beet populations do not occur in sugar beet seed production areas.

- Wild beet populations in the sugar beet root production area of Imperial Valley are predominantly if not exclusively *Beta macrocarpa*, a different species than sugar beets (*Beta vulgaris*), and do not readily cross pollinate.

- *Beta macrocarpa* flowers before *Beta vulgaris* and is highly self-fertile.

- Crop rotations are used in both seed and root production for all *Beta* crop species. Weed control in subsequent crops will limit volunteers.

a. Impacts of Gene Flow Between H7-1 Sugar Beets and Conventional Sugar Beets or Vegetable Beets
(1) Alternative 1 – No Action

In the short term, gene flow potential from H7-1 sugar beets would be limited to gene flow into or out of APHIS permitted research plots. These plots are assumed to be very small in comparison with current seed production fields and thus represent a much reduced pollen source. Additionally, in the counties where sugar beet and vegetable beet seed production currently overlap (see section III.B.5.c, figure 3–12), research plots would be subject to both APHIS approval, and pinning and isolation distance rules. Pinning and isolation distances in the Willamette Valley of Oregon are administered by the WVSSA. While membership is voluntary, all current seed producers of *Beta* spp. crops are members of the WVSSA. Under the rules of the WVSSA, different isolation distances are used between sexually compatible crop types. For *Beta* spp. crops, the isolation distances are: 1 mile between open-pollinated fields and between hybrid fields for crops within a same color or group; 2 miles between open and hybrid production within the same group; 3 miles between crops of different colors within a group (e.g., orange versus red table beets), and also between any genetically modified crop (including H7-1) and non – GM crop; and 4 miles between hybrid and open pollination of different crop groups. For more information on the WVSSA and isolation distances, see the discussion in section III.B.1.b(10), table 3–3).

In the long term, it is assumed that H7-1 sugar beets would disappear from the landscape as the lack of ability to move the product to commercialization would limit the utility of further research. Under these conditions, gene flow between H7-1 sugar beets and other sugar beet cultivars is not expected to occur.

Based on the above assumptions and analysis, Alternative 1 is expected to result in no gene flow from H7-1 sugar beets to conventional *Beta* spp. because H7-1 sugar beet seed production would not be expected to occur in proximity to vegetable beet seed production. Since the introduction of H7-1 sugar beet seed production in the Willamette Valley, vegetable beet seed producers may have felt compelled to test their seeds for the presence of the H7-1 trait, though they are under no obligation to do so (Stearns, 2010). Some seed companies that cater to the GE-sensitive market expect seeds to be tested when grown in proximity (within 10 miles) of a sexually compatible GE crop (Morton, 2010). Under Alternative, 1, it is likely that growers of GE-sensitive crops would not have the burden to test for cross pollination.

(2) Alternative 2 – Full Deregulation

There are two potential sources for gene flow of the H7-1 trait: (1) H7-1 sugar beet seed production, the majority of which occurs in the Northwest; and (2) H7-1 sugar beet root production, which currently occurs in the Northwest, Great Plains, Midwest, and the Great Lakes regions. Each of these sources is discussed below.

H7-1 Sugar Beet Seed Production. As discussed in section III.B.5, pollen-mediated gene flow between H7-1 sugar beets and other *Beta* spp. crops requires synchronously flowering plants grown in proximity. These conditions are most likely to occur during seed production where every plant is expected to flower as opposed to vegetable production where flowering plants are discouraged, and purposefully removed from fields. As discussed in section III.B.1.b, the vast majority of sugar beet seed is produced in the Northwest, and specifically in the Willamette Valley of Oregon and eastern Washington. If H7-1 sugar beets were deregulated in whole, farmers could hypothetically grow H7-1 sugar beet seeds in any region of the United States. However, the use of new seed growing regions is not expected because conditions for growing *Beta* crop species are optimal in the Northwest. Winter weather is cold enough to vernalize first year plants and induce flowering without killing plants. Additionally, dry summers reduce the occurrence of disease.

Currently, the only area in the United States where H7-1 sugar beet seed production overlaps with the seed production of conventional sugar beet and vegetable beet seed production is in six counties of the Willamette Valley in Oregon (see figure 3–12) and in Jackson County in southern Oregon. In these seven counties and any adjacent counties (e.g., Yamhill County), there is the potential for gene flow to occur. Additionally, under Alternative 2, there would be no restrictions on where H7-1 sugar beet seed production could occur. H7-1 sugar beet seed production could expand to western Washington or other counties where vegetable beet seed is produced. However, H7-1 sugar beet seed production is unlikely to move into western Washington because (1) this region uses pinning maps; (2) pinning priority is determined by historical precedent, so the vegetable seed production in the area would have priority over incoming sugar beet seed production; (3) similar to vegetable beet seed producers, sugar beet seed producers do not want to produce seeds near vegetable beet seed fields due to pollen flow concerns. In areas where pinning maps are not used, coordination between neighboring farms is more difficult to achieve and unintended gene flow is a more likely possibility. APHIS is not aware of competing vegetable and sugar beet seed production interests outside of Oregon.

The potential for gene flow between commercial seed fields is limited by isolation distances and pinning practices of seed producers as well as the management practices under the Monsanto TUG and grower cooperatives. In the Willamette Valley, the primary region of H7-1 sugar beet seed production, all commercial seed producers and growers of *Beta* crops utilize a pinning map and established isolation distances between sexually compatible species, in accordance with guidelines provided by the WVSSA. This use of pinning and isolation distances is not unique to *Beta* crops. Under these guidelines, any sexually compatible *Beta* crop species must be isolated by a minimum of 3 miles from any field of H7-1 sugar beet seed production (see section III.B.1.b(10)). This is the same isolation distance used to maintain isolation between stock seed production and open-pollinated crops and between color variants within a group (e.g., orange and red table beet). These isolation distances have been adopted and successfully utilized by farmers even prior to the introduction of H7-1sugar beets because hybridization and the resulting off-types between any two different *Beta* spp. populations are undesirable. Additionally, some seed producers have adopted isolation distances in excess of 3 miles (e.g., Betaseed uses 4 miles.). the WVSSA isolation guidelines also recommends 4 mile isolation distance between a hybrid species and open pollinated crop from different groups.

The potential for gene flow between commercial seed fields is also greatly limited by the use of the CMS hybrid method in H7-1 sugar beet seed production (see section III.B.1.b(8)). In Oregon, 85 percent of H7-1 sugar beet seed production utilizes the H7-1 trait on the female plant. These fields contain pollen parents that lack the H7-1 trait so pollen produced from these sources does not have the H7-1 trait. The female parent on occasion may produce pollen. However these occurrences are rare, are watched for, and plants are rogued when detected. Because pollen is released over a period of 2–3 weeks, these plants are typically identified and removed from fields using established BMPs, before most of their pollen is released. Additionally, there are economic incentives to monitor and rogue pollen producers from the female lines to assure that the hybrid seed produced results from the planned crosses. At most, only minute amounts of H7-1 pollen are expected to be produced in these fields and they will be substantially diluted by the non H7-1 pollen. Thus the management of the H7-1 hybrid fields to minimize unwanted hybrid seed ensures that these fields pose a negligible risk for cross pollinating nearby vegetable beet seed with H7-1 pollen. The remaining 15 percent of 2011 H7-1 sugar beet seed production in Oregon uses male pollinator plants with the H7-1 trait. These plants produce and release H7-1 pollen into the environment and represent the greatest potential source for unintentional gene flow of the H7-1 trait into other *Beta* spp. seed production.

Several important factors regarding pollen production decrease the impact of this pollen source. Isolation distances used for H7-1 sugar beet seed fields in the Willamette Valley are currently 3 miles, while distances between unlike hybrid and open pollinated crops is 4 miles. Using best available data, estimates of pollen cloud dissipation from open pollination fields into open pollination fields of equal size at 3,280 feet (0.6 mile) indicate that pollen competition likely reduces pollen-mediated gene flow potential to <0.01 percent, or less than 1 in 10,000 seeds (see section III.B.5). Three miles is 15,840 feet, or roughly 5 times this distance. Because gene flow is expected to drop below 0.01 percent at 3,280 feet, APHIS expects that at 5 times this distance gene flow will be substantially lower than can be detected using current PCR testing. The PCR detection limit of the H7-1 trait is 1 in 10,000 seeds (0.01 percent).

Furthermore the amount of pollen produced in a hybrid production field is less than that produced in open pollination fields because the pollinator plants typically constitute only one third to one fourth of the plants (see section III.B.1.b(8)). More importantly, most of the pollen produced in a source is rapidly dissipated with distance from the source. Within a given field there is a 100,000-fold excess of pollen to ovules, but according to (Darmency et al., 2009), by 0.6 mile, pollen density was reduced such that there was a 1,000-fold excess of ovules to pollen. That means that the pollen concentration was diluted by a factor of 100 million through the process of dispersal over this distance (0.6 mile). In a nearby field, the local pollen cloud is thus very concentrated relative to the incoming pollen cloud, further reducing the likelihood of a successful cross pollination. The isolation distances used by the WVSSA are expected to reduce gene flow to below detectable levels which APHIS defines as less than one seed in 10,000 seeds by PCR testing. This does not mean that seeds are GE free. A typical beet field may be planted with up to 80,000 plants per acre (see section III.B.1) and so a 1-acre field may contain a few off-types even if the seeds used to plant that field tested negative with a sensitive PCR test.

One of the methods the sugar beet industry uses to evaluate the purity of their seed is to grow out a lot of seed and score for off-types. Hybrid off-types to Swiss chard and table beets are easily recognizable. Occasionally these off-types occur even though the nearest known vegetable seed production meets or exceeds the WVSSA guidelines. Industry experts have suggested that the most likely explanation for the cross pollination is an unidentified local pollen source (Anfinrud, 2010). APHIS agrees for several reasons. First, gene flow experiments where the pollen source is known supports the conclusion that isolation distances used by the WVSSA should be adequate. Second, in most cases and in most years the isolation distances are found to be adequate. Third, when off-types occur, the pollen source is not known. Fourth, unknown sources could include unpinned and unmanaged fields and gardens which can be expected to occur from time to time. .Based on the available data, APHIS concludes that the currently used isolation guidelines are sufficient to prevent detectable gene flow.

The potential for gene flow between commercial seed fields and home gardens, or farmers who save seed is discussed separately because these sources may not follow pinning rules or isolation distances and also do not report to any of the recording agencies in regard to planting. As such, the geographic distribution of these sources may be different than that of commercial conventional sugar beet and vegetable beet seed production. It is also important to note that commercial *Beta* crop seed production utilizes crop rotations. As such, any pair of H7-1 sugar beet seed fields and fields where farmer save seed may only be in sufficient proximity for gene flow to occur once every 5 to 8 years (see section III.B.1.b (16)).

If fields where farmers save seed are close enough to fields of male fertile H7-1 sugar beet seed production and also have synchronously flowering *Beta* spp. crops, there is a chance that gene flow could occur. Farmers who save seed could be affected in certain parts of Oregon, Washington, and Idaho where male fertile H7-1 sugar beet seed production fields occur.

Successful gene flow would only occur if the plants were harvested for seeds and replanted in subsequent years (farmers who save seed). In these cases, hybrid seeds could result and could carry the H7-1 trait. These plants would also be intermediate in morphology between sugar beets and whatever variety of vegetable beet was being grown by the farmer who is saving seed. These “off-types” have undesirable mixed characteristics and would likely be detected when the user of the seed grew the vegetable. For example, table beets have a deep red or yellow color but hybrids to sugar beets have a white interior with concentric rings of color (2011) (see figure 4-3). If the grower were producing micro greens, off-types would be difficult to detect. Farmers that usually save seed and are concerned about consuming GE crops may be discouraged from producing their own seed in favor of purchasing vegetable beet seed that has been tested for the

H7-1 trait or has been produced in an area such as Washington or Arizona where no H7-1 sugar beet seed production currently occurs. Gene flow could also occur to flowering beets in abandoned fields; any hybrid seed that formed could potentially shatter and disperse in the field. If the seed survives winter conditions, the hybrid plant would have to compete with other weed species in the following year. As discussed in section III.C.3.c, sugar beets are not competitive weeds and hybrid plants would also not be expected to be any more competitive than sugar beets. If vernalization conditions were met in the overwinter period, it is possible that hybrid plants could flower. These plants would thus represent a potential source of H7-1 pollen. However, the same conditions of pollen competition, flower synchrony, and proximity would have to be met for this source to represent a legitimate gene flow source. Feral populations of *Beta vulgaris* have not occurred anywhere in the United States except in California. Therefore beet seeds released into abandoned fields are unlikely to persist anywhere except California. However, in California, feral population of *Beta vulgaris* do not coincide with sugar beet production areas as *Beta vulgaris* has not naturalized in the Imperial Valley (the only area of California where sugar beets are still produced). Therefore, no feral populations of H7-1 sugar beets are expected to result in the United States from gene flow into beets in abandoned fields.

In the opposite direction, pollen from fields where farmers are producing their own seeds or home gardens could result in gene flow and hybridization with CMS male-sterile plants in H7-1 sugar beets seed production fields. Many of the commercial seed producers regularly scout regions surrounding sugar beet fields and pin any fields where farmers are growing their own seed (2011). However, if flowering vegetable beets are nearby, hybrid seed could form and end up in a commercial seed bag for use in sugar beet root production areas. Off-types could then occur in sugar beet root production fields. Sugar beets are harvested mechanically so off-types are typically harvested with the rest of the crop. When off-types occur at the expected low frequencies of less than one off-type per 10,000 seeds, this level of impurity is not a problem.

The potential for transfer of the H7-1 trait between commercial seed fields due to seed movement is limited by the use of BMPs to control seed dispersal and adventitious presence. Currently, producers of H7-1 sugar beet seed implement both voluntary and mandated management practices designed to prevent admixture of seeds during harvest, seed cleaning, storage, and shipping of H7-1 sugar beets seeds (see section III.B.1.b(18)). These methods include watering fields after seed harvest to germinate

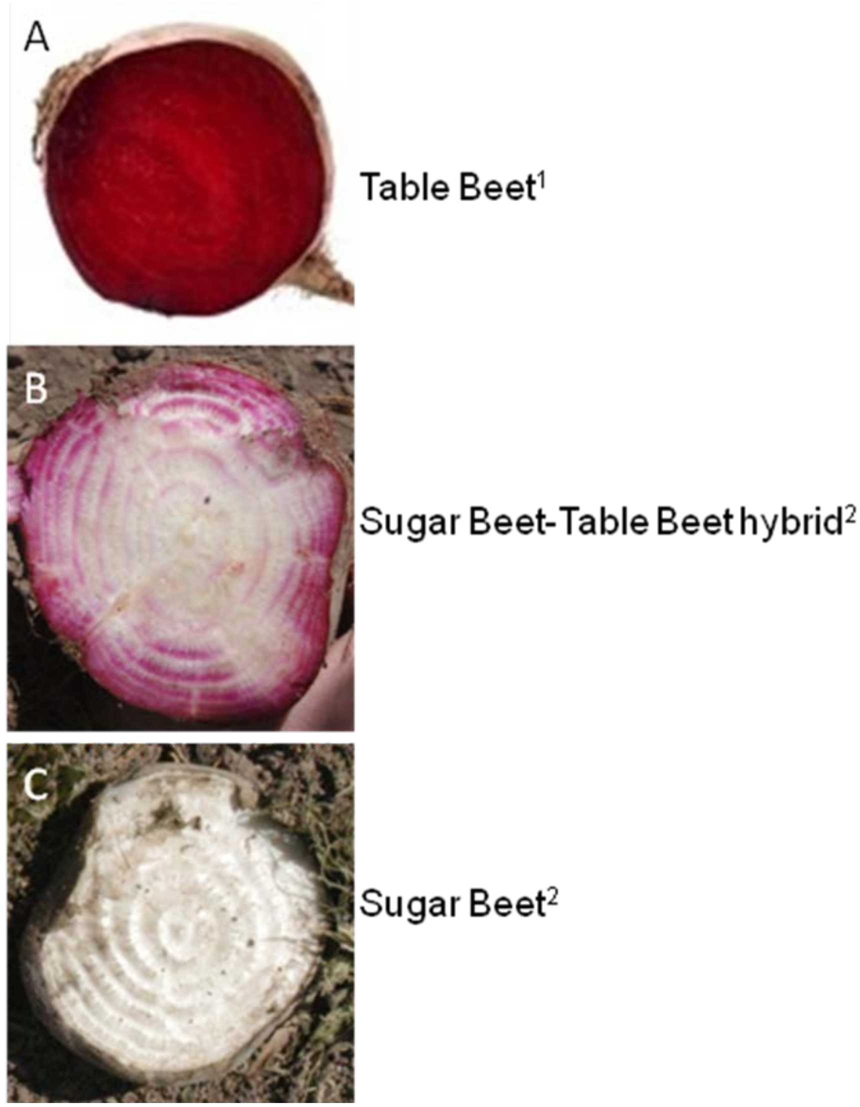

Figure 4- 3. Sugar Beet Photos
[1]http://us.cdn1.123rf.com/168nwm/skolodkin/skolodkin0709/skolodkin070900018/1738507-a-section-of-a-beet-isolated-on-a-white-background.jpg accessed June 21, 2011.
[2]photo provided by Neil Hoffman

shattered seeds in seed production fields followed by tillage or herbicide treatment to reduce the H7-1 sugar beet seed bank (see section III.B.1.b(18)). Additionally, field inspections of past sugar beet fields are conducted to monitor and destroy volunteers. Multi-year crop rotations are used in both sugar beet seed and root production, to facilitate the detection and elimination of sugar beet volunteers. While such BMPs may not always be followed or 100 percent effective, they help reduce the likelihood of gene flow.

H7-1 Sugar Beet Root Production. Because flowering plants are essential for pollen-mediated gene flow, gene flow between sugar beet root production fields and any other *Beta* spp. population would only occur if the very low percent of bolting plants in a given field, estimated at 0.01 percent of plants, is left unmanaged by farmers and plants survive to produce pollen and seeds. Standard practice is for farmers to remove bolting plants from the field to prevent harvest reductions of the sugary root crop. Similarly, bolters are undesirable to Swiss chard and table beet vegetable producers as the flowering process diminishes the quality of the vegetable. Typically Swiss chard and table beets are harvested prior to flowering in the crop. As such, if plants are harvested prior to bolting or if flowers are removed before pollen is released (which would be true in the overwhelming number of cases), there can be no gene flow of the H7-1 trait. Even if there were proximity between an H7-1 root crop and a vegetable beet crop and the two crops both contained bolters that were not removed and cross hybridized, then the resulting seeds would be unlikely to be saved for planting purposes because early bolting is an undesirable trait. If the seeds were abandoned in the field, they would not likely persist because *Beta vulgaris* has not naturalized anywhere in the United States except in coastal California. Additionally, if these seeds survived winter conditions and volunteered in subsequent years, they would likely be identified as weeds in rotational crops and be removed.

Gene flow is not likely from the H7-1 root crop to the vegetable beet seed crop for several reasons. First, there are no data to suggest that sugar beet root crop is grown in proximity to any commercial vegetable beet seed crop. Second, even if there were proximity, sporadic flowering of the root crop is not in synchrony with the flowering of the seed crop. For example the root crop in all regions, except the Imperial Valley, is typically planted in April or May. If these plants bolt, pollen would not likely be released until August or September. The seed crop meanwhile is planted in September and would not be receptive to pollination until May and June, several months prior to the release of the pollen by the flowers in the root crop. In the Imperial Valley, flowering of the root crop could be in phase with the seed crop, as the root crop is planted in September. However, commercial production of vegetable beet seeds does not occur in the Imperial Valley; it has been attempted but abandoned because of poor results (2011).

For the reason stated above, managing bolters is not needed to prevent gene flow to another vegetable crop or another seed crop in the Great Lakes, Midwest, Great Plains, and Northwest regions. In the Imperial Valley it is conceivable that gene flow could occur between bolters in the root crop and a vegetable seed crop. This possibility is not a concern if no vegetable beet seed production is occurring and could be managed with isolation distances.

Even though sugar beet and vegetable beet seed production both occur in the Willamette Valley, the fact that isolation distances are estimated to be in excess of distances needed for detectable gene flow rates, that pollen clouds dissipate and are faced with high local pollen competition, and BMPs act to prevent seed admixture and seed dispersal, Alternative 2 is unlikely to result in LLP of the H7-1 trait in other *Beta* seed crops. However, as a result of the ability to test for the H7-1 trait, under Alternative 2, companies that produce seed for a GE-sensitive market would probably be required by their customers to test for LLP of the H7-1 trait (see section III.D.3).

(3) Alternative 3 – Partial Deregulation

The most important restriction with regard to gene flow under Alternative 3 is that isolation distances are enforced by APHIS and are increased beyond the currently WVSSA-adopted distances of 3 miles, to 4 miles. Alternative 3 also has mandatory conditions for production, processing and transport of H7-1 sugar beets, that are not present in other Alternatives, including reporting requirements, inspections, and audits.

Alternative 3 includes an increase in isolation distance to 4 miles in certain circumstances. For example, under the current WVSSA guidelines, 3 miles would be used between hybrid table beets and hybrid sugar beets but this distance would be increased to four miles if H7-1 sugar beets are introduced. In the Willamette Valley, this increase in isolation distance may slightly reduce the potential for gene flow into or from H7-1 sources compared to Alternative 2. Though low enough to result in nondetectable levels by PCR, a small amount of gene flow might occur and therefore the potential for gene flow is expected to be greater than under Alternative 1. Under Alternative 3, sugar beet seed production would not be allowed in western Washington whereas under Alternative 2, it would be allowed, but is unlikely to occur based on historical precedent. Under Alternative 3, no H7-1 sugar beet root production would be allowed in the Imperial Valley reducing the possibility of gene flow to wild beets compared to Alternative 2. As mentioned in Section IV.B.5.b., gene flow from H7-1 sugar beet to wild beet is not likely because of sexual incompatibility and flowering asynchrony. Alternative 3 includes mandatory measures that could reduce the possibility of seed admixture relative to Alternative 2 where these procedures are voluntary. Under Alternative 3, companies that produce GE-sensitive seed in regions other than western Washington or California may be required by their customers to test for LLP of the H7-1 trait.

b. Impacts of Gene Flow Between H7-1 Sugar Beets and Wild Beets

Currently, wild beet populations have only been identified in California and Pennsylvania. However, no sugar beet production occurs in Pennsylvania and the species detected, *B. procumbens*, is not sexually compatible with *B. vulgaris*, so gene flow between H7-1 sugar beets and wild beets is not an issue. Because there are no wild beets in any of the sugar beet seed or root growing regions other than California, only California is discussed in this section. California wild beets are either *B. vulgaris ssp. maritima*, which is fully compatible with sugar beets, or *B. macrocarpa*, which does not readily cross (see section IV.5.b.(2)). *B. vulgaris ssp. maritima* grows along the coast and San Francisco Bay area whereas *B. macrocarpa* is found within sugar beet fields in the Imperial Valley. A detailed survey by the USDA failed to detect feral populations of *B. vulgaris* in the Imperial Valley. (2011).

(1) Alternative 1 – No Action

There is currently no H7-1 sugar beet seed or root production in California. Thus, there is currently no potential for gene flow between H7-1 sugar beet and wild beet species. Under Alternative 1, H7-1 sugar beets would not be present in California, so Alternative 1 would result in no change from the current situation.

In the short term, gene flow potential would be limited to gene flow into or out of research plots. These plots are assumed to be very small in comparison with current seed production fields and thus represent a much reduced pollen source. APHIS would maintain permit oversight and could restrict use of H7-1 sugar beets in California. In this case, gene flow potential would be zero.

In the long term, it is assumed that H7-1 sugar beet occurrence would be zero as the lack of ability to move the product to commercialization would limit the utility of further research. Alternative 1 would thus result in no gene flow between H7-1 sugar beets and wild beets.

(2) Alternative 2 – Full Deregulation

As discussed in the affected environment section (see III.B.5), the chances of unintended gene flow are greatest when there is limited isolation distance between H7-1 sugar beet seed production fields and populations of wild *Beta* spp. If H7-1 sugar beets were deregulated in whole, farmers could hypothetically grow sugar beets in any region of the United States. The only geographic region of the United States that currently has sexually compatible wild beet species, *B. vulgaris ssp. maritima*, is California, specifically the San Francisco Bay area and southern coastal areas. A second wild species that has marginal compatibility with sugar beet, *B. macrocarpa*, grows in the Imperial Valley. Currently, only conventional sugar beets for root production are cultivated in California, and only in the Imperial Valley. Sugar beet production formerly occurred in the Central Valley of California but has been discontinued for economic reasons. It is unlikely to resume and the sugar beet processing plants in the area have closed. In the long term, APHIS assumes that H7-1 sugar beets will eventually be developed for California's Imperial Valley. This assumption is supported by the use of H7-1 sugar beets in a variety trial and the interest of California sugar beet growers to grow H7-1 sugar beets in the Imperial Valley to control wild beets in their sugar beet root production fields (2011).

If farmers choose to cultivate H7-1 sugar beets for seed production in California, there would be potential for gene flow between H7-1 sugar beet and wild *B. vulgaris ssp. maritima* or *B. macrocarpa*. It is unlikely that sugar beet seeds would ever be grown in California because climatic conditions are not favorable and therefore this possibility is not reasonably foreseeable.

If farmers choose to cultivate H7-1 sugar beets for root production in California's Imperial Valley, which is very likely, there would be a potential for gene flow of the H7-1 trait to *B. macrocarpa*.

Varieties of sugar beets currently cultivated in the Imperial Valley have been specifically bred for very long vernalization times in an effort to reduce bolting (Lewellen, 2011). Nevertheless concern has been raised that the Imperial Valley root crop could cross pollinate to wild beets that grow in sugar beet fields. If H7-1 sugar beets were grown in the Imperial Valley and cross pollination occurred, this gene flow would be a concern to the sugar beet growers in the area because it would render glyphosate ineffective to control wild beets. The wild beet in the Imperial Valley is thought to be exclusively *Beta macrocarpa* which is a different species than sugar beet, *Beta vulgaris*, and the two species do not readily cross. Some evidence that introgression between sugar beet and *B. macrocarpa* occurred in one population of wild beets in the Imperial Valley has been reported (Bartsch and Ellstrand, 1999). This evidence, based on isozyme analysis, requires further testing with current and more sensitive molecular DNA markers before a conclusion can be reached. Several observations are inconsistent with introgression of *B. vulgaris* into *B. macrocarpa*. First, greenhouse crosses using sugar beet as the pollen parent were unsuccessful with *B. macrocarpa* female plants. The reciprocal cross using *B. macrocarpa* pollen onto sugar beet was successful but the progeny were abnormal and showed signs of chromosomal instability (Lewellen et al., 2003). Second, *B. macrocarpa*, unlike *B. vulgaris*, is highly self-fertile and much less prone to outcrossing. Third, *B. macrocarpa* begins to flower in January and has largely gone to seed by May. Aberrant bolters of *B. vulgaris* root crop begin to flower in April, so there is little if any flowering overlap. If H7-1 sugar beets were to be grown in the Imperial Valley, it is expected that wild beets would be effectively controlled in sugar beet fields and would not have the opportunity to flower. Indeed, wild beet is effectively controlled in sugar beet rotation crops such as alfalfa or Sudan grass using several different herbicides. Surveys of the Imperial Valley by the USDA have failed to find *B. macrocarpa* growing outside sugar beet production fields (2011). Thus it is reasonable to expect that most if not all *B. macrocarpa* will be controlled in the valley through the use of glyphosate. Under Alternative 2, based on the poor hybridization potential between *B. macrocarpa* and *B. vulgaris*, the different flowering times, the likelihood that *B. macrocarpa* plants would be effectively eliminated from sugar beet production fields by glyphosate treatment, and the scarcity of *B. macrocarpa* plants elsewhere in the valley, APHIS concludes that the H7-1 trait is not likely to hybridize and introgress into *B. macrocarpa* populations. As a special precaution, growers may choose to manage sugar beet bolters in their fields in April and May to further limit the likelihood that any cross pollination occurs to late flowering *B. macrocarpa*.

If *B. vulgaris ssp. maritima* were to be established in the Imperial Valley, and it were not controlled by herbicide treatment because it was growing outside a beet field, gene flow to *B. vulgaris ssp. maritima* could occur between root crop bolters and the wild beet plants. If the trait did move into wild species, these wild beets would become resistant to glyphosate and could not be controlled with glyphosate in H7-1 sugar beets. As glyphosate is not used to control wild beets in other *Beta* crops and other herbicides are effective to control wild beets in non *Beta* crops, the impact would be limited to H7-1 sugar beets. Because feral beets have not established in other sugar beet growing regions of the U.S,, the potential for wild beets having an H7-1 trait to establish in other sugar beet growing regions is low. Furthermore, the likelihood of such cross pollination between sugar beet root crop and *B. vulgaris ssp. maritima* is expected to be low because the latter has not been confirmed to grow in the Imperial Valley, presumably because the climate is too hot and dry (2011) and the sugar beet root crop only occasionally flowers.

(3) Alternative 3 – Partial Deregulation

As sexually compatible wild beets have only been identified in California, Alternative 3 effectively prevents gene flow to wild beet populations. If wild beets expand their distribution beyond California into regions that grow H7-1 sugar beets then gene flow could occur. The likelihood of this occurring is low. Wild beets have been present in California for over 100 years (Bartsch and Ellstrand, 1999) and have not demonstrated a tendency to expand in range. Alternative 3, would be expected to result in no gene flow from H7-1 sugar beets to wild beets.

C. Biological Resources

In this section, APHIS evaluates how different aspects of sugar beet production under each of the three alternatives could impact biological resources. Potential direct and indirect environmental impacts of the alternatives on biological resources are discussed by resource area in sections IV.C.1 through IV.C.3 (i.e., impacts on animals, microbial communities, and plants, respectively). Cumulative impacts are discussed in section IV.H.

In section IV.C.1, for animals, potential impacts from H7-1 sugar beets and the amounts and toxicity of the herbicides applied (direct effects) or impacts on habitat (indirect effects), as well as the accompanying tillage practices for the three alternatives, are evaluated for different groups of organisms separately: (a) livestock, (b) mammals, (c) birds and reptiles, (d) amphibians and fish, (e) aquatic invertebrates, and (f) terrestrial invertebrates. These impacts are generally described qualitatively, although quantitative analyses of herbicide toxicities and application rates are presented to support conclusions about the risk tradeoffs of the different herbicides and action alternatives.

In section IV.C.2, for micro-organisms, possible impacts from the H7-1 sugar beet transgene DNA, including HGT or gene product, are examined. The potential for the different herbicide applications and tillage practices associated with conventional and H7-1 sugar beets to alter soil microbial communities is examined for each alternative.

For plants, the possible impacts of gene flow from H7-1 sugar beets to closely related agricultural and wild species are analyzed in section IV.B.5. In section IV.C.3, three additional impact areas are considered: (a) development of herbicide resistance in weeds, (b) herbicide impacts on non-target plants, and (c) sugar beet weediness potential in non-agricultural settings.

Potential herbicide impacts are part of each section and the characteristics of the herbicides used on sugar beets sugar beets are listed in table 4–7 below. Only glyphosate is used differently on H7-1 sugar beets where it is additionally used as a post emergent herbicide and non glyphosate herbicides are used much less frequently on H7-1 sugar beets (see Table 4-3). Table 4-7 defines each herbicide's pre- or postemergence use, target weed groups, and mechanism of action. Application methods used on sugar beets and the maximum single application allowed are listed next. The maximum single application allowed is the benchmark for possible worst-case acute exposures at and soon after an application event. A value representing the half-life of each herbicide under typical agricultural conditions provides an indication of persistence in the environment. Finally, known degradation products in soil are listed, and those that might cause impacts beyond impacts of the parent herbicide are identified.

APHIS does not address insecticides and fungicides in any detail. As noted in section III.B.1.c(5), insecticides and fungicides are believed to be similar across alternatives in terms of type, quantity, and potential impact. Herbicides, however, are expected to be used differently between the alternatives, especially between Alternative 1 and Alternatives 2 and 3.

1. Animals

As discussed in section III.C.1, animals that could be affected by the alternatives include livestock and wildlife including mammals, birds, reptiles, amphibians, fish, and terrestrial and aquatic invertebrates. The potential effects of the alternatives on these animal groups are discussed below.

a. Livestock

APHIS analyzed the potential effects on livestock from the availability and nutritional quality of sugar beet byproducts used as feed for livestock under the three alternatives.

(1) Alternative 1 – No Action

Under Alternative 1, farmers of commercial sugar beets would have to replace their H7-1 varieties with conventional sugar beets, and there might be a short-term shortage of sugar beet product (sugar beet tops, pulp, and molasses) for livestock feed. Several factors could influence farmers' decisions to replace H7-1 sugar beets immediately with conventional sugar beets, including availability and cost of herbicides, availability and cost of special cultivating equipment, short-term and longer-term availability of varieties of sugar beets with selected genetic traits (e.g., disease resistance, drought tolerance) suitable for the growing region, and the potential penalty or lost ownership shares in a sugar production cooperative for not growing sugar beets.

Table 4- 7. Characteristics of Herbicides Used on Sugar Beet Root and Seed Crops

Active Ingredient (CAS number) [Formulated Product] References[1]	Use for Sugar Beet Production; Type of Herbicide – Mechanism of Action (MOA) on Target Weeds	Application Methods. Amounts and Frequency[2]	Half-life;[3] Toxic Degradation Products (TDP)
Clethodim (99129-21-2) [Select®] EPA-HQ-OPP-2008-0658	USE: Postemergence grass (monocot) control, annual and perennial, in a range of broadleaf crops. MOA: Cyclohexanedione herbicides; inhibits ACCase (in WSSA Group 1), which kills growing points of grasses – grasses are more sensitive than broadleaf weeds to these herbicides.	Broadcast or microrate (with Betamix® and Progress®). Maximum single application of 0.25 lb a.i./acre.	3 days for parent compound; 30–38 days for sulfoxide and sulfone metabolites.
Clopyralid (1702-17-6) [Stinger®] EPA-HQ-OPP-2009-0092; CHP 3/85	USE: Postemergence thistle and cocklebur control, applied after sugar beets are past cotyledon stage. MOA: Plant auxin mimic (in WSSA Group 4) – Causes rapid disorganized plant growth leading to death, with selective action on thistles, knapweeds, sunflower family, legumes, and knotweed families.	Broadcast, band, or microrate (with Betamix®, Progress®, or Poast®). Maximum single application of 0.33 lb a.i./acre.	30 days; degraded almost entirely by soil microbes.
Cycloate (1134-23-2) [Ro-Neet™] 2004 RED; CHP 3/85	USE: Selective herbicide for preplant incorporation 3–4 inches into soil to inhibit seed germination for annual grasses and a few specific types of broadleaf weeds. MOA: Thiocarbamate (in WSSA Group 8) – Inhibits a single key enzyme in the biosynthesis of very-long-chain fatty acids, which are essential parts of plant waxes and other plant structures.	Broadcast, band, lay-by, or sprinkler at end of irrigation cycle to penetrate to 3–4 inches. Maximum single application of 4 lb a.i./acre.	30 days; 3HC and 4HC.
Desmedipham (13684-56-5) [Betanex®] 1996 RED	USE: Selective, postemergence control of various dicot weeds of sugar beets. MOA: Carbanilate herbicide (in WSSA Group 5) – Inhibits photosynthesis. EPA concluded that the adjuvants in the TEPs are required for the a.i. to express toxicity to plants. Egg shell thinning – effect in birds.	Broadcast, band, or microrate. Maximum single application of 1.28 lb a.i./acre.	30 days; MHPC and conjugated O- and N-glucosides of MHPC and desmedipham.
EPTC (759-94-4) [Eptam®] 1999 RED; 1969 RED; CHP 10/83	USE: Preplant control of annual grasses and broadleaf weeds primarily in corn, potatoes, peas, dry beans, alfalfa, and snap beans. Also can be applied after October 15, before freeze or snow. MOA: Thiocarbamate (in WSSA Group 8) – Inhibits key enzyme in fatty acid synthesis.	Must be incorporated into soil prior to planting by disking, applied with subsurface injection equipment, or metered into irrigation water (highly volatile). Maximum single application of 4.6 lb a.i./acre.	6 days; primary soil and water degradates are EPTC-sulfoxide and dipropylamine.

Table 4–7. (continued)

Active Ingredient (CAS number) [Formulated Product] References[1]	Use for Conventional Sugar Beet Production; Type of Herbicide – Mechanism of Action (MOA) on Target Weeds	Application Methods. Amounts and Frequency[2]	Half-life;[3] Toxic Degradation Products (TDP)
Ethofumesate (26225-29-6) [Nortron®] 2007 Revised RED; 2005 RED; EFED Risk Assess.	USE: Preplant and preemergent control of annual grasses, dicots, fungi, bacteria, and viruses in sugar beets and cool-season turf grasses. MOA: Thiocarabamate (in WSSA Group 8) – Inhibits key enzyme in fatty acid synthesis.	Soil incorporation for sugar beets. Maximum single application of 3.75 lb a.i./acre.	30 days; two benzofuranyl methanesulfonate metabolites.
Glyphosate (1071-83-6) [Roundup®, several others] EPA-HQ-OPP-2009-0361; EPA OPP EFED 2009; Tu et al., 2001	USE: Non-selective systemic herbicide to control both monocot and dicot weeds for a wide variety of agricultural crops and in silviculture and weed control along transportation routes and utility corridors. For agriculture, used preplant any time prior to crop emergence; postemergence foliar application on GT varieties. MOA: Phosphanoglycine herbicide (WSSA Group 9) – Inhibits the enzyme EPSPS synthase in the shikimate pathway essential for biosynthesis of aromatic amino acids in algae, higher plants, bacteria, and fungi. Vertebrate animals obtain those amino acids from their diet.	Broadcast or banded preplant; broadcast or banded postemergence only on GT crops or by direct application to soil between rows of conventional varieties. Maximum single application to sugar beets assumed to be 4.5 lb a.i./acre preemergence for conventional sugar beets and 3.0 lb a.i./acre preemergence for H7-1 sugar beets. H7-1 sugar beets also can receive 1.37 lb a.i./acre postemergence to 8-leaf stage, 0.94 lb a.i./acre later up to a total maximum of 7.32 lb a.i./acre/yr.	47 days; primary microbial degradate in environment AMPA; AMPA appears to be less toxic than parent compound, EPA has not assessed AMPA in past.
Phenmedipham (13684-63-4) [Spin Aid®] 2005 RED	USE: Postemergence broadleaf herbicide for foliar application to weeds; 98% of amount used annually is on sugar beets, primarily in North Dakota and Minnesota. MOA: Carbamate (in WSSA Group 5) – Photosynthesis inhibitor	Broadcast or spray when no water present. Maximum single application of 0.63 lb a.i./acre.	30 days; primary degradate is MHPC.

Table 4–7. (continued)

Active Ingredient (CAS number) [Formulated Product] References[1]	Use for Conventional Sugar Beet Production; Type of Herbicide – Mechanism of Action (MOA) on Target Weeds	Application Methods. Amounts and Frequency[2]	Half-life;[3] Toxic Degradation Products (TDP)
Pyrazon (1698-60-8) [Pyramin®] 2005 RED; CHP 2/85	USE: Pre- and early-postemergence control for annual broadleaf weeds (e.g., mustard, ragweed) in beet fields only (i.e., 100% of use is on sugar beet fields). MOA: Substituted pyridazinone herbicide (in WSSA Group 5) – Photosynthesis inhibitor. Beets have ability to transform parent compound to less toxic metabolites in the leaves.	Broadcast or banded, with moisture present. Preemergence maximum single application of 7.3 lb a.i./acre.	21 days; primary degradate in soil = dephenylated pyrazon “Metabolite B-1.”
Quizalofop-p-ethyl (100646-51-3) [Assure® II] EPA-HQ-OPP-2007-1089	USE: Postemergence application to control annual and perennial grass weeds in a small number of broadleaf crops. MOA: Aryl-oxy-phenoxy herbicide (in WSSA Group 1) – Complex action with inhibition of ACCase and essential amino acid and lipid biosynthesis as well as inhibition of mitosis.	Broadcast or microrate. Maximum single application of 0.0825 lb a.i./acre.	Parent compound 1 day; degradate quizalofop acid half-life of 216 days, very persistent.
Sethoxydim (71441-80-0, 74051-80-2) [Poast®] 2005 RED	USE: Postemergence control of annual and perennial grasses in a large number of broadleaf crops. MOA: Cyclohexenone herbicide (in WSSA Group 1) – Inhibits ACCase enzyme, which is key in lipid biosynthesis; grass species ACCase more sensitive than dicots.	Broadcast, banded, or microrate applications. Maximum single application of 0.47 lb a.i./acre.	5 days; sulfoxide and sulfone, which have longer half lives.
Trifluralin (1582-09-8) [Treflan® HFP] 1996 RED; Health Canada 1999 Regulatory Note REG 99-03	USE: Preemergence application for control of annual grasses and certain broadleaf weeds primarily in soybean and cotton, but also approved for other crops. MOA: Dinitroaniline herbicide (in WSSA Group 3) – Inhibits mitosis and cell division, stops growth.	Broadcast, banded, lay-by (does not need irrigation to activate), or via irrigation. Maximum single application of 0.75 lb a.i./acre.	60 days; degradation products in soil primarily trifluoromethyl; also some benzene-1,2-diamine.

Table 4–7. (continued)

Active Ingredient (CAS number) [Formulated Product] References[1]	Use for Conventional Sugar Beet Production; Type of Herbicide – Mechanism of Action (MOA) on Target Weeds	Application Methods. Amounts and Frequency[2]	Half-life;[3] Toxic Degradation Products (TDP)
Triflusulfuron-methyl (126535-15-7) [Pinnacle®, Upbeet®] EPA-HQ-OPP-2002-0082	USE: Postemergence selective herbicide for several annual broadleaf weeds (e.g., kochia, redroot pigweed, common lambsquarters, nightshades, and mustards). MOA: Sulfonylurea herbicide (in WSSA Group 2) – Inhibits ALS enzyme, thereby inhibiting amino acid synthesis.	Broadcast, banded, or microrate (with Betamix® or Progress®). Maximum single application of 0.032 lb a.i./acre.	6 days; major soil degradation products triazine amine, methyl saccharin, NDM-DPX-66037, and NFM-triazine amine.

Sources: U.S. Environmental Protection Agency (EPA) Office of Pesticide Programs (OPP) Reregistration Eligibility Decision (RED) documents and associated ecological risk assessment documents included in online herbicide dockets named in the first column. Additional references cited in first column.

[1] Sources: Identified in first column.

[2] Data from tables 3–15 and 3–11.

[3] Sources for half-life values: USDA NRCS, 2011c. Note that degradation/dissipation rates due to photolysis, hydrolysis, biodegradation, and other loss processes in the field depend on many factors, including sunlight, microbial communities in soils, soil texture and moisture, soil pH, and others.

Abbreviations: MOA = Mechanism of action, TDP = Toxic degradation products, ACCase = acetyl-CoA carboxylase (enzyme), WSSA =Weed Science Society of America, RED = Registration or Reregistration Eligibility Decision, CHP = CHP = Cornell University Herbicide Profile (http://pmep.cce.cornell.edu/profiles), 3HC = cis-+trans-3-hydroxycycloate, 4HC = cis+trans-4-hydroxycycloate, TEP = typical end-use product or formulation, MHPC = N-(3-hydroxylphenyl)-methylcarbamate, EFED = Environmental Fate and Effects Division (EPA/OPP), EPSPS = 5-enolpyruvylshikimate 3-phosphate (enzyme), AMPA = Amino methyl phosphonic acid, Some farmers might allow H7-1 fields to lie fallow for a year or two while waiting for appropriate conventional sugar beet varietal development. Some sugar beet growers have found that incorporating a fallow year into crop rotations in sugar beet fields can improve the productivity of sugar beets in the year following (Cattanach et al., 1991). Where farmers opt to include one (or more) fallow years, a temporary shortage of livestock feed from sugar beet root crop byproducts might occur, and farmers reliant on those feeds would have to supplement their livestock feed from other sources. In the longer term, if farmers returned to producing conventional sugar beets, availability of beet tops, pulp, and molasses could return to 2005 levels of availability for animal feed. Under Alternative 1, almost all (if not all) of the sugar beet product fed to livestock would come from conventional sugar beets. As discussed in more detail under Alternative 2 below, several studies have shown that the composition and nutritional quality of H7-1 sugar beets is similar to conventional sugar beet plants with the exception of the presence of the EPSPS enzyme. Also as discussed under Alternative 2 below, feeding trials designed to identify adverse effects of feed products from H7-1 sugar beets (e.g., nutritional deficits or toxic compounds) did not detect adverse effects.

In summary, no long-term impacts on livestock are anticipated under Alternative 1. The availability and quality of sugar beet root crop byproducts for livestock feed over the long run would be comparable with pre-2005 conditions. Some short-term shortages of sugar beet tops and pulp might occur where farmers choose to leave fields fallow for a few years.

(2) Alternative 2 – Full Deregulation

Alternative 2 would avoid any potential short-term shortage of sugar beet byproduct for livestock feed. Farmers could grow either conventional or H7-1 sugar beet varieties. It is anticipated that most farmers will choose H7-1 sugar beets based on the widescale adoption during the past three years. This EIS assumes close to 100% of sugar beet crops will be H7-1.

To evaluate the potential for impacts on livestock from Alternative 2, APHIS assessed whether any nutritional differences exist between livestock feed products from H7-1 sugar beets and conventional sugar beets. Such differences might result from either unintended nutritional changes associated with the H7-1 gene event in sugar beets or from possible adverse effects of the gene product itself. APHIS considered the assessments conducted by the U.S. Food and Drug Administration (FDA), EPA, the European Food Safety Authority (EFSA), and the Canadian Food Inspection Agency (CFIA).

FDA published a policy in 1992 on foods derived from new plant varieties, including those derived from biotechnology (U.S. FDA, 1992).

FDA's policy requires that foods produced using biotechnology meet the same rigorous safety standards as is required of all other foods. The FDA completed a consultation on H7-1 sugar beets with a memorandum dated August 7, 2004, and a response letter to the developer dated August 17, 2004 (U.S. FDA, 2004). FDA stated, "The notifiers conclude that glyphosate tolerant sugar beet event H7-1 is not materially different in composition, safety, or other relevant parameters from sugar beet now grown, marketed, and consumed. At this time, based on the notifiers' data and information, the agency considers the notifiers' consultation on glyphosate-tolerant sugar beet H7-1 to be complete." In summary, as part of its consultation regarding H7-1 sugar beets FDA concluded that the Agency had no questions about the developer's determination that H7-1 sugar beets are not materially different in composition, safety, or other relevant parameters from conventional sugar beets (U.S. FDA, 2004).

EPA sets tolerances to ensure food safety. A tolerance is the maximum amount of pesticide that EPA determines is allowable in or on foods. Foods above the tolerance level are unlawful. The CP4 EPSPS present in H7-1 is also present in other crops that have been evaluated by EPA. On August 2, 1996, EPA granted a tolerance exemption for the CP4 EPSPS protein in all raw agricultural commodities (U.S. EPA 1996a). This regulation eliminates the need to establish a maximum permissible level for the EPSPS protein in any agricultural commodity based on the lack of toxicity of the protein,

In Europe, EFSA's Scientific Panel on Genetically Modified Organisms (GMO) compared the reported safety and nutritional value of H7-1 sugar beets with conventional sugar beets (EFSA, 2006). The Scientific Panel concluded that "products from sugar beet H7-1 are safe as food and feed, and, that the nutritional value of the sugar beet H7-1 and the derived sugar beet products is comparable to that of analogous products from conventional sugar beet." (Hartnell et al., 2005)reported a similar finding. In response to EFSA information requests, Monsanto/KWS SAAT AG conducted a 90-day dietary study providing processed pulp as feed to rats and found no indication of any adverse effects. Monsanto/KWS SAAT AG's assessment of H7-1 sugar beets and non-genetically engineered sugar beets suggested no difference in the composition and nutritional quality of H7-1 sugar beets compared with conventional sugar beets, apart from the presence of the EPSPS enzyme (Schneider and Strittmatter, 2003). The EFSA GMO Scientific Panel reported on additional studies of feeding sugar beet pulp to sheep that similarly indicated no adverse effects (EFSA, 2006).

The CFIA approved H7-1 sugar beets for livestock feed in 2005. As summarized in Decision Document DD2005-54, the CFIA "determined that this plant with a novel trait (PNT) and novel feed does not present altered environmental risk nor does it present livestock feed safety concerns when compared to currently commercialized sugar beet varieties in Canada" (CFIA, 2005).

The EPSPS enzyme that confers glyphosate tolerance is from the bacterium *Agrobacterium* sp. strain CP4. The gene that produces this protein is similar to the gene that is normally present in sugar beets and is not known to have any toxic property. Schneider and Strittmatter (Schneider and Strittmatter, 2003) considered the environmental consequences of the introduction of H7-1 sugar beets and concluded there is no reason to believe that the H7-1 plant would harm nontarget animals because, among other reasons, the EPSPS family of proteins, and specifically CP4 EPSPS as produced in several glyphosate-tolerant crops (corn, soybean, canola, cotton, and sugar beet), has been shown to be comparable to the EPSPS proteins present in other food crops and common microbes. An acute toxicity study was conducted in mice where the mice were dosed by gavage with up to 572 mg/kg of CP4EPSPS and no adverse events were observed at any dose level. Furthermore the amino acid sequence of the CP4 EPSPS protein was compared to protein sequences in the ALLPEPTIDES data base and no biologically relevant sequence similarities were observed between CP4 EPSPS and known toxins. The high specificity of the enzyme for its substrates makes it unlikely that the introduced enzyme would metabolize endogenous substrates (i.e., nontarget substrates within plants or animals) to produce compounds toxic to other organisms, including livestock. Based on the lack of known toxicity for this enzyme, the absence of sequence similarity to known toxins, and the high enzyme substrate specificity, the potential for adverse effects in livestock feed is low. The potential for the CP4 EPSPS protein to be a food allergen is discussed further in section III.F.1.a.(5).

In summary, as part of its consultation regarding H7-1 sugar beets FDA concluded that the Agency had no questions about the developer's determination that H7-1 sugar beets are not materially different in composition, safety, or other relevant parameters from conventional sugar beets (U.S. FDA, 2004). Also, EFSA's GMO Panel concluded that "products from sugar beet H7-1 are safe as food and feed, and, that the nutritional value of the sugar beet H7-1 and the derived sugar beet products is comparable to that of analogous products from conventional sugar beet" (EFSA, 2006). Furthermore, the CFIA approved H7-1 sugar beets for livestock feed in 2005, because it determined that H7-1 sugar beets do not present altered environmental risk or livestock feed safety concerns compared with conventional sugar beets.

Under Alternative 2, no adverse effects on livestock are expected from feeding on H7-1 sugar beet tops, pulp, and molasses compared with conventional sugar beets, as discussed above. In contrast to Alternative 1, no short-term sugar beet byproduct shortages are expected under Alternative 2.

(3) Alternative 3 – Partial Deregulation

Under Alternative 3, farmers would have increased costs associated with growing H7-1 sugar beets which may lead to a decreased adoption rate compared with Alternative 2. Some of the sugar beet products fed to livestock under this alternative could come from H7-1 varieties.

As discussed above for Alternative 2, regardless of whether the food products are H7-1 or conventional sugar beets, there would not be any impact to livestock since both products have been determined to be safe for food and feed and nutritionally equivalent. Also under Alternative 3, no short-term shortages of sugar beet byproducts for livestock feed are anticipated.

b. Mammals

For each alternative, APHIS analyzed the potential effects on mammalian wildlife from (1) exposure to the H7-1 gene product, (2) herbicide use, and (3) crop management practices such as tillage. Agricultural production practices prevent wildlife from consuming crops where possible.

(1) Alternative 1 – No Action

Impacts on Mammals from Exposure to the H7 1 Gene Product. If mammalian wildlife consumed H7 1 sugar beet plant parts (seeds, leaves, stems, or roots) in permitted fields, no adverse effects from consumption are expected because event H7-1 sugar beet is not materially different in composition, safety, or other relevant parameters from conventional sugar beet. Similarly, the replacement of H7-1 sugar beets with conventional sugar beets under Alternative 1 are not expected to change the quality of animal browse.

Impacts on Mammals from Herbicide Use. Under Alternative 1, H7-1 sugar beets would be replaced with conventional varieties, resulting in greater use of nonglyphosate herbicides. The proportion of sugar beet acreage on which glyphosate is used and the rates of glyphosate applications on sugar beet crops would likely decrease to the levels that existed prior to the deregulation of H7-1 sugar beets (approximately 13 percent of acres based on 2000 data; see table 3–15).

Small mammals, including voles, mice, and shrews, which might use sugar beet fields for transit between habitats (e.g., migration, dispersal), could be exposed to herbicides in-field as they are applied. For small mammals, like shrews, that feed on soil-dwelling insects (e.g., grubs), substantial time might be spent in-field under cover of the beet top canopy, increasing the possibility of an in-field exposure or exposure to residues on insects that might remain for some days. Mice typically feed on seeds and therefore would not likely be found in sugar beet root crop fields. However, there may be mice in the limited locations where sugar beet seed crop is grown.

Larger mammals (e.g., deer) might pass through beet fields during foraging or migration travels. Herbivorous mammals (e.g., deer, rabbits) might attempt to forage on beet tops during the growing season, although farmers would try to minimize that possibility. Mammals also could be exposed to herbicides in the immediate vicinity of sugar beet fields from aerial drift during applications or from runoff to small water bodies, particularly soon after rain storms, but those exposure levels should be lower than in-field exposures.

Table 4–8 below describes the likely extent and quantities of application of the 13 herbicides used on sugar beets under Alternative 1. The estimates of total acres treated are based on the assumption that total sugar beet acreage remains at 1.18 million acres (as reported in 2010, see section III.B.1.a(2)) and that 100 percent of the total is returned to conventional sugar beet production.

Table 4-8 displays some mammalian (primarily tested on rats) toxicity parameters for the herbicides commonly used on sugar beets. The comparisons are all made on the technical grade active ingredient (TGAI) or the technical grade acid equivalent (TGAE). Most herbicides are formulated with other ingredients to improve their effectiveness. The formulated product is called the typical end-use product (TEP). APHIS did not think it was meaningful to compare the typical end-use products for the sugar beet herbicides for two reasons. First, APHIS was unable to find toxicity data for most of the TEPs. In some cases, a formulated product is more toxic than the technical grade active ingredient. This is likely to be true when the active ingredient is practically non-toxic. Therefore it is not valid to compare toxicity data of the TEP of one herbicide with the TGAI/TGAE of another. Second, the formulations are proprietary introducing an additional unknown into the comparison. For these two reasons, APHIS compared the toxicity of the known active ingredients in the herbicides.

In Table 4-8, the first column lists the LD_{50}, the dose of the herbicide that kills half the members of a test population. EPA describes a substance as very highly toxic when the LD50 is <10 mg/kg. It is rated highly toxic when the LD_{50} is 10-50 mg/kg, moderately toxic when 51-500 mg/kg, slightly toxic when 501-2,000 mg/kg, and practically non- toxic when >2,000 mg/kg. As shown in Table 4-8, most of the herbicides are in the practically non- toxic category with respect to mammals. Clethodim, quizalofop-p-ethyl, and sethoxydim are all considered to be slightly toxic.

In cases where acute toxicity can be measured, chronic studies are also performed where animals are exposed to lower doses of the herbicide for months to years. In chronic studies two additional parameters are often reported. NOAEL, the no observed adverse effect level is the highest dosage at which chronic exposure to the substance shows no adverse effects. LOAEL, the lowest observed adverse effect level, is the lowest dosage at which chronic exposure to the substance shows adverse effects. Table 4-8 also reports the mammalian NOAEL/LOAEL values for the thirteen herbicides. The lower the value, the greater the risk to wildlife. Values range from a low of <1 for trifluralin to a high of 500 for glyphosate and phenmediphan.

For this EIS, a quantitative comparison of the relative toxicity and relative risks of the 13 herbicides used on sugar beets is presented in table 4–9 below. The toxicity of the nonglyphosate herbicides are normalized to the toxicity of glyphosate TGAI to estimate their toxicity relative to glyphosate in the second column. For example, EPTC has an acute LD_{50} value approximately 6.4 times lower than the value for glyphosate a.i., and so could be considered to be 6.4 times more toxic than glyphosate to mammals, with the caveat that only rats have been tested. The glyphosate LD_{50} was estimated to be *greater than* 5,586 mg a.i./kg body weight; how much higher is not known because higher doses were not tested. Thus, EPTC is *at least*, and possibly more than, 6.4 times more toxic than glyphosate. The relative toxicity values are listed in column (A).

As shown in table 4–9 , for an acute exposure, the a.i. clethodim, EPTC, and quizalofop-p-ethyl are 4.3, 6.4, and 6.7 times more toxic, respectively, to mammals than glyphosate. Pyrazon and sethoxydim are 2.7 and 2.19 times more acutely toxic to mammals, respectively.

Table 4- 8. Toxicity Values and EPA OPP Toxicity Category of Herbicides for Mammalian Wildlife[1]

Active Ingredient	Lowest Toxicity Value		EPA OPP Acute Toxicity Category	Chronic Endpoints
	Acute LD_{50} (mg a.i./kg bw)[2]	Chronic NOAEL/LOAEL (mg a.i./kg-bw day)		
Clethodim	1,360	25[3] / NL	Slightly toxic	No reproductive effects up to 2,500 ppm in diet
Clopyralid	4,300	ND / 50	Practically nontoxic	Developmental: skeletal abnormalities in rabbits
Cycloate	>2,150	50/400	Practically nontoxic	Reproduction
Desmedipham	>5,000	5.4/20	Practically nontoxic	Blood effects/hemolytic anemia
EPTC	916	50 / NL	Slightly toxic	ND
Ethofumesate TGAI	>6,400	>50 / 250[3]	Practically nontoxic	Decreased pup weight
Glyphosate TGAE	>4,800	500 / 1,500	Practically nontoxic	Reduced reproduction
Phenmedipham	>8,000	500 / ND	Practically nontoxic	2-generation study
Pyrazon TGAI	2,140	10 / 50	Practically nontoxic	Reduced maternal body weight
Quizalofop-p-ethyl	878	5 / NL	Slightly toxic	Decreased pup weight
Sethoxydim TGAI	2,676	30 / 150	Practically nontoxic	2-generation study, malformations in pups
Trifluralin	>5,000	0.75/3.75	Practically nontoxic	Increased liver weight
Triflusulfuron-methyl	>5,000	6/130	Practically nontoxic	decreased body weigh gain

Sources: EPA OPP RED documents and EPA OPP Ecological Fate and Effects Division (EFED) ecological risk assessment documents available from the herbicide dockets.

[1] Categories of acute toxicity to terrestrial birds and mammals from EPA's Office of Pesticide Programs: LD_{50} (mg/kg bw-day): <10 very highly toxic; 10-50 highly toxic; 51-500 moderately toxic; 501-2,000 slightly toxic; >2,000 practically non-toxic.

[2] Unless otherwise noted in row header as acid equivalents (AE or a.e.).

[3] Converted from ppm in diet assuming rats consume 5 percent of their body weight daily.

[4] In this table, glyphosate toxicity values are reported using the units as initially reported, in mg acid equivalent (a.e.)/kg body weight. The active ingredient (a.i.) equivalent would be approximately 1.22 times greater.

Abbreviations: EPA OPP= Environmental Protection Agency Office of Pesticide Programs; LD_{50}= dose required to kill half the members of a test population; LOAEL=Lowest Observed Adverse Effect Level; NOAEL=No Observed Adverse Effect Level; NR = Test not required because of low acute toxicity; ND = no data; NL = not listed; might be unbound NOAEL; TGAI = technical grade active ingredient; TGAE = technical grade acid equivalent.

Table 4- 9. Relative Risk of Herbicides to Mammalian Wildlife for Herbicides Used on Sugar Beets[1]

Herbicide	**Acute Oral Toxicity**		**Maximum Single Application Rate**		**Relative[5] Risk (RR) = (A) x (B)**
	LD_{50}[1] (mg a.i./kg bw)	**(A)[2] Relative to Glyphosate TGAI**	**Rate[3] (lb a.i./ acre/ app)**	**(B)[4] Relative to Glyphosate TGAI**	
Clethodim	1,360	**4.31**	0.25	0.056	0.239
Clopyralid	4,300	**1.36**	0.33	0.073	0.100
Cycloate	>2,150	>2.72	4.0	0.889	>2.42
Desmedipham	>5,000	>1.17	1.28	0.338	>0.333
EPTC	916	**6.39**	4.6	1.02	**6.54**
Ethofumesate	>6,400	>0.92	3.75	0.833	>0.763
Glyphosate AI[6]	>5,856	1.00	4.5	1.000	>1.000
Phenmedipham	>8,000	>0.73	0.63	0.140	>0.102
Pyrazon	2,140	**2.74**	7.3	1.622	**4.439**
Quizalofop-p-ethyl	878	**6.67**	0.0825	0.0183	0.122
Sethoxydim	2,676	**2.19**	0.47	0.104	0.229
Trifluralin	>5,000	>1.17	0.75	0.167	>0.195
Triflusulfuron-methyl	>5,000	>1.17	0.032	0.00711	>0.00833
TOTAL					

Sources: Identified in endnotes for column headers.

[1] Toxicity values from table 4–8. Where greater than sign (>) precedes the value, the LD_{50} value was higher than the listed value, either because a smaller proportion of animals died (e.g., 30%) at the highest dose tested or because no excess mortality was observed at the highest dose tested. (EPA generally only requires testing up to approximately 5,000 mg a.i./kg animal body weight.)

[2] Column (A): Acute oral toxicity relative to glyphosate, calculated as (1/herbicide LD_{50}) / (1/glyphosate LD_{50}). Numbers bolded are relative toxicity values for which a definitive LD_{50} was determined for the nonglyphosate herbicide. For the remaining herbicides and glyphosate, LD_{50} values were not reached at the doses tested, and so the number reflects doses tested, not relative toxicity.

[3] Maximum rate allowed for a single application of the herbicide in pounds of active ingredient (a.i.) per acre for that application.

[4] Column (B): Maximum single application rate relative to (divided by) the maximum single application rate for glyphosate TGAI applied preemergence.

[5] Relative risk (RR) = relative toxicity in column (A) multiplied by relative acute exposure in column (B). Values in bold are for herbicides that show higher RR values than glyphosate a.i. to mammals based on a definitive LD_{50} value (not a > value) for that herbicide.

[6] Toxicity values for glyphosate were converted from mg acid equivalents (a.e.) presented in table 4–16 to mg a.i. – glyphosate a.i., for the salts of glyphosate most commonly applied, = a.e. x 1.22 (see table 3–14).

Abbreviations: "–" = blank cell (value is either pre or postemergence, not both). LD_{50} = lethal dose for 50% of animals in a toxicity test. ND = no data. NR = not relevant because glyphosate pre and postemergence are in two different rows. NC = not calculated because row is for a formulation, not the active ingredient alone. TGAI = technical grade active ingredient or test materials close to that (e.g., >98% a.i.). PRE = preemergence. POST = postemergence. a.i. = active ingredient. RR-WTQI = relative-risk weighted total quantity index. mg/kg bw = mg chemical/kg animal body weight. lb a.i./acre/app = pounds of active ingredient per acre per single application.

To estimate relative risk (RR), relative exposure values are also needed for the herbicides. The highest concentrations of herbicides in the environment should occur during and shortly after herbicide application events. To compare risks of acute toxicity to mammals among the herbicides, an exposure metric is needed. Either the typical herbicide application rate (i.e., rates actually used as summarized in section III.B.1.f. from data compiled by the National Agriculture Statistics Service in its Agricultural Chemical Use Database) or the maximum allowed single application rate could serve as the metric for exposure. Actual use rates might change (e.g., increase) over time with changes in climate, increases in herbicide-resistant weeds, and other factors. The maximum single application rate is the upper bound on what EPA allows. The maximum single application also represents the "worst-case" scenario for all of the herbicides. For those reasons, the maximum allowed single application rate is the metric used to represent relative acute exposures among the herbicides. The maximum single application rates relative to (normalized to) glyphosate are listed in column (B) in table 4–9.

Relative risk (RR) is the product of relative toxicity value (A) and the relative maximum single application rate value (B). For glyphosate technical grade a.i. (TGAI), relative toxicity, relative application rate, and RR equal 1.0, because glyphosate a.i. is the herbicide to which toxicity and exposure values were normalized for the remaining herbicides. With a maximum single application rate similar to that of glyphosate, the risk relative to glyphosate (RR) calculated for EPTC, for example, is 6.5 times higher. Values in the RR column in bold are those that are higher than glyphosate and those for which an LD_{50} could be calculated for the herbicide (i.e., mortality at the highest dose tested exceeded 50 percent, and so the LD_{50} is not indicated as a "greater than" value). Note that a significant assumption for glyphosate in the RR analysis is that the maximum single application allowed (4.5 lb a.i./acre) equals the total allowed for all preemergence applications. It is more likely that farmers would use two or more applications (with less glyphosate in each) a week or two apart to catch weeds emerging at different times. In that case, the relative risk is over estimated by this assumption. Based on this analysis, EPTC and pyrazon have the potential to be more toxic to mammals than glyphosate.

In evaluating some of the herbicides, EPA has estimated the environmental concentration (EEC) on food sources or in water. From the estimated environmental concentration (EEC), an acute risk quotient (acute RQ) or a chronic risk quotient (chronic RQ) is calculated by dividing the EEC by an acute toxicity measure (such as LD50 or LC 50) or a chronic toxicity measure (such as NOAEL) listed in table 4-8. For mammals, if the acute RQ > 0.5, EPA presumes there is a potential acute risk (U.S. EPA 2004) If the acute RQ > 0.2, EPA presumes there is a potential risk that may be mitigated through restricted use. If the chronic

RQ > 1, the EPA presumes that potential chronic effects may occur in mammals. Table 4–10 lists EPA-estimated risk quotients (RQs), both acute and chronic, for mammals adjacent to crop fields to which the herbicide is applied according to the scenarios listed in the first data column. For example, a single application of cycloate of 4 lb. ai./acre results in an estimated environmental concentration of 960 ppm on grass, 540 ppm on broadleaf plants, and 60 ppm on seeds. As cycloate is practically non toxic for mammals (Table 4-8), an LD50 endpoint was not determined and so no acute RQ value was calculated. However the dosage for no observed adverse effect (NOAEL) for effects on reproduction was determined and a chronic RQ was calculated. Depending on the food source, the chronic RQ was estimated to range from 1.2 to 19.2; thus a potential chronic risk exists for mammals in or near cycloate treated fields. Examining the other herbicides, EPTC is the only sugar beet herbicide that poses a potential acute risk for mammals. The potential acute risk is overestimated for sugar beets because the maximum rate allowed on sugar beets, 4.6 lb. a.i/acre. is less than the rate used for this calculation (6.1 lb.a.i./acre). In addition to cycloate, glyphosate, pyrazon, and quizalofop-p-ethyl pose a potential chronic risk depending on the dosage. For glyphosate, the RQ did not pose risks of concern for application rates of 1.55 lb a.e/acre or 1.89 lb a.i./acre or less.

From the data in table 4–10, EPTC might pose acute risks to individual mammals in or adjacent to conventional sugar beet crops when used within label limits. Similarly EPTC, pyrazon and cycloate pose potential sublethal or chronic effects to individual mammals in or adjacent to conventional sugar beet crops. All three herbicides are used pre-emergence so there is more risk to mammals from this use. Herbicides could also cause indirect effects due to depletion of prey for birds and reptiles that might feed on small mammals. In areas where natural areas abut agricultural land used to raise sugar beets, there is a potential that runoff or drift from lands treated with EPTC, pyrazon, and cycloate may reduce the numbers of mammals in that area and animals that feed off mammals, such as birds and reptiles, will not have access to that resource in that very localized area.

Impacts on Mammals from Crop Management Practices. Under Alternative 1, for those agricultural lands that would no longer be allowed to grow H7-1 sugar beets, farmers could allow the land to become fallow (unplanted) for a few years until local varieties of conventional sugar beets are available, plant an immediately available variety of conventional sugar beets, plant other agricultural crops (e.g., a crop used in rotation with sugar beets), or use the land for other purposes. Growers would be unlikely to adopt a different crop over the long term because sugar beets are usually the most profitable crop in the rotation and because most

Table 4- 10. EPA Estimated Environmental Concentrations (EECs) of Herbicide Residues and Risk Quotients (RQs) for Mammalian Wildlife from Exposures Following Herbicide Applications[1]

Herbicide	Scenario (lb a.i./acre)	Max EEC short grass (ppm)	Max EEC tall grass (ppm)	Max EEC broadleaf forage, small insects (ppm)	Max EEC fruit, pods, seeds, lrg insects (ppm)	Acute EEC (ppm)	Chronic EEC (ppm)	Acute Risk Quotient (RQ)	Chronic Risk Quotient (RQ)
Clethodim	2 x 0.25	105	48.34	59.33	6.59	105	105	<0.1	<0.1
Clopyralid	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cycloate	1 x 4	960	ND	540 (broadleaf) 440 (insects)	60 (seeds)	ND	ND	NC	**1.2–19.2**
Desmedipham	2 x 0.98	348	≈162	194 (insects)	21.7 (seeds)	ND	ND	<0.00070–<0.043	NC
EPTC [2]	1x 6.1 1 x 3	1,464 720	671 330	823 405	9 45	91–1,464 45-720	ND	0.6 (granular) <0.1–**1.5** (spray) 0.3 (granular) <0.1-0.7 (spray)	ND
Ethofumesate	1 x 3.75	900	413	506	56.3	ND	ND	<<0.01–<0.13	<<0.01–<0.27
Glyphosate[3]	1 x 4.5	900	413	506	56.3	ND	ND	<0.01–<0.08	0.01–**2.23** (dose-based)
Phenmedipham[4]	1 x 0.975	ND	ND	ND	ND	ND	234	NC	0.47
Pyrazon	1 x 7.3	1,754	804	987	109.7	ND	ND	0.00–0.35 (dose-based)	0.43–**75.83** (dose-based)
Quizalofop-p-ethyl	1 x 0.17	40.8	18.7	23.0	2.55	ND	ND	<<0.01–0.02	0.02–**3.54**
Sethoxydim	2 x 0.47	240	110	135	15	ND	ND	NC	0.5
Trifluralin	1 x 2	480	ND	250 (fruit/veg leaves) 116 (legumes, insects)	24 (seeds) 14 (fruits)	ND	ND	0.002–0.15	ND
Triflusulfuron-methyl	1 x 0.03	ND	ND	ND	ND	25.22	ND	0.143–0.252	ND

Sources: EPA Registration or Reregistration Eligibility Documents (REDs), EPA OPP EFED ecological risk assessment documents in EPA docket online, and other sources.

[1] EPA-estimated EECs on four mammalian food types or unspecified food type (labeled acute and chronic EEC).

[2] Postemergence applications are a maximum of 3.0 lb a.i./acre; however, fall treatment applications are a maximum of 4.6 lb a.i./acre. Therefore, 6.1 lb a.i./acre is an overestimation while 3 lb a.i./acre may be an underestimation.

[3] Scenario single application rate lower than maximum single application assumed for conventional sugar beet preemergence application but higher than maximum single application assumed for H7-1 sugar beet preemergence.

[4] Maximum rate for sugar beets is actually 1.012 lbs a.i./acre, but this rate not assessed.

Abbreviations: EEC = estimated environmental concentration (herbicide residue) on indicated plant and animal groups. lb a.i./acre = pounds active ingredient/acre. lrg = large. ND = no data. NC = not calculated (when toxicity data indicated that the RQs would be far below any level of concern, EPA did not calculate the quotient). ppm = parts per million or mg/kg diet. RQ = risk quotient (EEC/toxicity value).

growers are shareholders that have a mandatory supply relationship growers with sugar beet processing facilities. Changes in land use are not expected because the land is likely to remain agricultural for crop production (see table 3–6 in section III.B.1.c(4) for a list of rotational crops). Available data indicate that the amount of U.S. sugar beet crop area has remained approximately the same since 2005 (see table 3–5). Therefore, the potential impacts of using the land for other purposes were not analyzed for this EIS.

Several factors could influence growers' decisions if and when to begin growing conventional sugar beets, including availability of herbicides, availability and cost of specialty cultivating equipment, availability of desirable varieties of sugar beets, and the potential penalty or lost ownership shares in the cooperative for not growing sugar beets. APHIS assessed the potential impacts on mammals from either (1) farmers allowing the land to go fallow for a few years or (2) farmers immediately planting conventional sugar beets (or another rotational crop).

Farmers are not likely to allow the land to go fallow for long for the reasons described above. APHIS assessed potential short-term impacts of allowing the land to go fallow for a few years to improve the yield of sugar beets once planted. Some farmers have found that incorporating a fallow year into crop rotations in sugar beet fields can improve the productivity of sugar beets in the year following (Cattanach et al., 1991). If a farmer allows the land to become fallow and continues to plow the land in spring and fall to prevent establishment of weed populations, the amount of groundcover available for mammalian wildlife (e.g., rabbits, mice, voles, and other small mammals) that use the agricultural field for foraging or transit during the growing season would be reduced (relative to planting sugar beets or another crop). During the nongrowing season, no plant cover would be available because the fall tillage would eliminate free-standing stalks.

Most small mammals would not move into an open field without cover, and those that do would be susceptible to predation (e.g., hawks). The population density of small mammals adjacent to plowed fallow fields might temporarily increase during the growing season due to movement from the fields to surrounding areas. This may increased inter- and intra-specific competition for resources (e.g., soil insects). Where local populations of small mammals are isolated in habitat fragments with few to no effective transit corridors to other populations in other habitats, the smaller populations might crash in numbers. They would likely recover rapidly once normal crop rotations were reestablished.

Where farmers allow fallow land to rest unplowed for a few years, grasses and herbaceous plants could become established. Continual cover of the fields with live or dead tall grasses and associated herbaceous plants stems and leaves would offer year-round cover for small mammals. Such fields also would provide more diversified forage for small insectivorous, gramnivorous (seed-eating), herbivorous, and omnivorous small mammals, and would likely support more diversified and abundant small mammal populations than planted sugar beets or fallow plowed lands. Availability of plant seeds could allow small mammal population increases in the fields. These changes would, however, be short term and last only until the fields are retilled and treated for weed removal and another crop is planted.

If farmers immediately plant conventional sugar beets (or another rotational crop) rather than allowing the land to go fallow, the potential for the short-term impacts discussed above with respect to groundcover would be eliminated or reduced. Vegetation/groundcover would be present during the growing season, but not over the winter, for small mammals for foraging on insects and hiding from predators. Areas that have H7-1 sugar beets will have slightly more vegetation cover since the management practices allow the rows to have narrower spacing. The availability of browse for larger mammals (e.g., rabbits, deer) is not considered under any of the alternatives, because farmers generally take measures to discourage herbivorous wildlife from browsing any parts of growing crops in their fields.

Alternative 1 Summary and Conclusions. In summary, under Alternative 1, herbicide use patterns would likely return to the patterns characteristic of each growing region before the large scale introduction of H7-1 sugar beets. Acute exposures are possible from EPTC used as a pre-emergence herbicide. Sublethal or chronic effects are possible from pre-emergent use of EPTC, pyrazon, and cycloate.

Over the short-term, allowing fields to remain fallow, yet plowed, in preparation for arrival of conventional sugar beets suited for the location, might result in no vegetative cover year-round for a short time. Small mammals would be unlikely to use such fields for migration or dispersal until crops were again planted and at least summer cover is available. Whatever impacts restricted travel might cause over the short term, no long-term impacts are expected from crop-management practices under Alternative 1.

(2) Alternative 2 – Full Deregulation

As mentioned previously, Alternative 2 would result in the greatest adoption rate of H7-1 sugar beets. In the long term, it is expected that up to 100 percent of the sugar beet crop would be H7-1. Under Alternative 2, the overall acreage under sugar beet production is not expected to change substantially from current levels. Regulation of the U.S. sugar market is likely to keep the contractual requirements for sugar beet roots for sugar production approximately constant.

Impacts on Mammals from Exposure to the H7-1 Gene Product. Exposure of mammalian wildlife to the H7-1 gene product would be greatest under Alternative 2. Mammals would only be exposed to the H7-1 gene product by consumption of H7-1 sugar beet crop material. As discussed in section IV.C.1.a(2), impacts on livestock under Alternative 2, several agencies have concluded that products from H7-1 sugar beets are safe for food and feed, and there are no adverse nutritional or toxicological effects expected for mammals that might consume H7-1 sugar beet plant parts (seeds, leaves, stems, or roots).

Impacts on Mammals from Herbicide Use. Alternative 2 would result in higher amounts of glyphosate-based herbicides used on sugar beets than under Alternative 1 and a large reduction in all non glyphosate herbicides (see table 3-19, table 4-3). As a result, Alternative 2 would lead to larger areas over which mammals might be exposed to glyphosate incidentally compared with Alternative 1 but would significantly reduce their exposure to nonglyphosate herbicides including EPTC which could result in acute and chronic effects under Alternative 1 and pyrazon and cycloate which could cause chronic effects to mammals under Alternative 1. Glyphosate is not expected to cause any direct effects on mammals so indirect effects from reducing prey populations are similarly not expected.

As discussed under Alternative 1, different groups of mammals could be exposed to herbicides used on sugar beet fields in different ways. In-field exposures could occur at herbicide application for small mammals in a sugar beet field at the time, most likely for small mammals that forage on soil-dwelling insects (e.g., shrews). Mammals transiting through fields when herbicides are applied also would be exposed. A wider variety of mammals might be exposed to herbicides in the immediate vicinity of sugar beet fields from aerial drift during applications or from runoff which may enter small water bodies, particularly soon after rain storms, but those exposure levels should be lower than in-field exposures.

Glyphosate is considered to be a toxicologically and ecologically low-risk herbicide (Cerdeira and Duke, 2006). As noted in Table 4-10, the acute RQ does not pose risks of concern for mammals. The chronic RQ does pose risks of concern for high applications of glyphosate (>3.75 lbs a.e./acre or 4.51 lb/a.i./acre) for food sources consisting of short grasses and broadleaf plants. However glyphosate is not registered for such high application rates on sugar beet. The maximum application rate for post emergent use of glyphosate on sugar beet is 1.55 lbs a.e/acre (lbs a.i./acre). At this level of application, the chronic RQ does not pose risks of concern for all food sources for mammals. Under Alternative 2, glyphosate could be applied multiple times to the H7-1 sugar beets, on average 2.5 times per year, with 1.4 applications on postemergence sugar beet plants. Thus, under Alternative 2, the timing and dosage of applications of glyphosate are different than they are under Alternative 1. Under Alternative 2 the applications are more likely to occur when mammals are rearing offspring born in the early spring. However, the dosages are lower and do not pose risks of concern. Therefore, APHIS does not expect glyphosate to result in chronic effects on mammals.

Under Alternative 2, use of cycloate, EPTC, and pyrazon would each decrease by 90%. Each of these herbicides pose greater potential chronic risks to mammals than does glyphosate. Therefore, Alternative 2 poses less potential risk to mammals than does Alternative 1.

Impacts on Mammals from Crop Management Practices. As discussed in section III.B.1, growing H7-1 sugar beets generally does not require in-crop tillage due to the use of glyphosate. Thus, use of conservation tillage, including no-till systems, will be higher under Alternative 2 than Alternative 1. Under strip-till systems during the growing season, growers can plant sugar beets closer together than if spaces between rows are required for tillage-based weed control. Thus, Alternative 2 would allow more extensive sugar beet groundcover earlier in the season and total groundcover from the sugar beet foliage canopy for the latter part of the growing season than Alternative 1. The extended cover offered by growing sugar beets in strip-till systems would facilitate small mammals foraging on ground insects or dispersing or migrating between habitats separated by the sugar beet fields. Availability of browse for larger mammals (e.g., lagomorphs or rabbit, deer) would be slightly higher for H7-1 sugar beet fields than for conventional sugar beets; however, farmers generally take measures to discourage herbivorous wildlife from browsing in their fields.

Alternative 2 Summary and Conclusions.

In summary, exposure to or consumption of H7-1 sugar beet plant materials under Alternative 2 is not expected to impact mammalian wildlife. H7-1 and conventional sugar beets are similar in nutrition and equally nontoxic. Herbicide use patterns would be different under Alternatives 1 and 2. Potential acute and chronic risks to mammals from EPTC and potential chronic risks attributable to pyrazon and cycloate would be diminished 90% under Alternative 2. Potential chronic risks from use of glyphosate at high doses as a pre-emergent herbicide would also be diminished under Alternative 2 because glyphosate would be used more frequently and at lower application rates than under Alternative 1.

(3) Alternative 3 – Partial Deregulation

Impacts on Mammals from Exposure to the H7-1 Gene Product.

No adverse effects on mammals from exposure to the H7-1 gene product are expected for Alternative 3 as was described for Alternative 2.

Impacts on Mammals from Herbicide Use. Under Alternative 3, the extent of potential impacts on mammals from herbicide use would be very similar to Alternative 2 where glyphosate use would increase and use of non glyphosate herbicides would substantially decrease except in Imperial Valley where non glyphosate herbicides would continue to be used. In the Imperial Valley, the . three herbicides identified as posing risks of concern for mammals when used as directed, EPTC, cycloate, and pyrazon, are not among the non glyphosate herbicides commonly used (Table 3-14). Therefore Alternative 3 is expected to result in a similar reduction, as Alternative 2, of the three herbicides with the greatest potential risk to mammals. Alternative 3 is expected to result in less glyphosate use than Alternative 2 but more use of non glyphosate herbicides that similarly do pose risks of concern for mammals as described under Alternative 1.

Impacts on Mammals from Crop Management Practices. Under Alternative 3, in those areas where H7-1 sugar beets are grown, the potential impacts on mammals from crop management practices would be similar to Alternative 2. Due to glyphosate use to control weeds, farmers could plant H7-1 sugar beets closer together than if space for tillage were maintained between rows. Thus, areas planted in H7-1 sugar beets would provide earlier and more extensive groundcover for small mammals for foraging on soil-dwelling insects or moving between habitats with some protection from visual predators compared with conventional sugar beets.

In those areas where H7-1 sugar beets would not be grown (California, western Washington, and areas where farmers choose to plant conventional sugar beets), the potential impacts on mammals from crop management practices would be similar to Alternative 1, except that H7-1 sugar beets have not yet been planted commercially in those areas. Thus, there should be no short-term effects likely from growers in those areas allowing land to go fallow during the growing season while waiting for varietal conventional sugar beets suitable for those two areas.

Alternative 3 Summary and Conclusions

In summary, exposure to or consumption of H7-1 sugar beet plant materials under Alternative 3 is not expected to impact mammalian wildlife. Herbicide use patterns would be very similar under Alternatives 2 and 3. Potential acute and chronic risks to mammals from EPTC and potential chronic risks attributable to pyrazon and cycloate would be diminished 90% under Alternative 3 compared to Alternative 1. Potential chronic risks from use of glyphosate at high doses as a pre-emergent herbicide would also be diminished under Alternative 2 because glyphosate would be used more frequently and at lower application rates than under Alternative 1.

c. Birds and Reptiles

As for mammals, APHIS analyzed the potential impacts of each alternative on birds and reptiles from (1) exposure to the H7-1 gene product, (2) herbicide use, and (3) crop management practices.

(1) Alternative 1 – No Action

Impacts on Birds and Reptiles from Exposure to the H7-1 Gene Product. Under Alternative 1, birds and reptiles would not be likely to be exposed to the H7-1 gene product so no impacts are expected.

Impacts on Birds and Reptiles from Herbicide Use. As discussed previously for mammals, under Alternative 1, there would be a rapid transition to greater use of non-glyphosate herbicides and much less use of glyphosate as H7-1 sugar beets are replaced with conventional sugar beets. Birds and reptiles that might use sugar beet fields as foraging areas and cover could be exposed directly to herbicides at the time of application; however, farmers generally discourage wildlife from using crop fields as feasible. If non-agricultural habitats are adjacent to sugar beet fields, birds and reptiles using those areas for foraging, shelter, cover, and nesting or egg laying could be exposed to herbicides via spray drift or direct inadvertent overspray during herbicide application.

The toxicity of the herbicides used on sugar beets to birds has generally been assessed using mallard ducks and bobwhite quail. As illustrated in table 4–11, most of the herbicides used on sugar beets are practically nontoxic to birds on an acute basis (i.e., the LD_{50} value was not reached at the highest dose or dietary concentration tested). In addition, the herbicides used on sugar beets are generally in spray liquid aerosols or incorporated into the soil. The form of pesticide products that generally is most toxic to birds are granular particles, which birds consume as they would grit for digestive purposes (Best, 1992). For the acute LD_{50} determination, the birds are administered a single bolus of carrier vehicle containing the herbicide and observed for several days following. For the subacute dietary test, the herbicide is mixed homogenously throughout a standard feed, and birds are exposed 5 to 8 days via their feed.

Table 4–11 below lists the acute (LD_{50}), subacute (LC_{50}), and chronic (NOAEC/LOAEC) avian toxicity values, as available, for herbicides commonly used on sugar beets. The subacute LC_{50} is the concentration of the herbicide in the birds' diet in units of ppm a.i. (or mg a.i. per kg diet)

Table 4- 11. Toxicity Values and EPA OPP Toxicity Category of Herbicides for Birds[1]

Active Ingredient	Lowest Toxicity Value			EPA OPP Toxicity Category	
	Acute LD_{50} (mg a.i./kg bw)	Subacute Dietary LC_{50} (ppm diet)	Chronic NOAEC/ LOAEC (ppm diet)	Acute Toxicity Category	Subacute Dietary Toxicity Category
Clethodim[2]	>2,000	>4,000	250 / NL	Practically nontoxic	Practically nontoxic
Clopyralid	1,465	ND	ND	Slightly Toxic	ND
Cycloate	>2,150	>5,395	NR	Practically nontoxic	Practically nontoxic
Desmedipham	>2,000	>5,000	90 / 450	Practically nontoxic	Practically nontoxic
EPTC	>2,510	>5,280	ND	Practically nontoxic	Practically nontoxic
Ethofumesate	>3,445	>5,000	3,069 / >3,069	Practically nontoxic	Practically nontoxic
Glyphosate TGAE[5]	>3,196	>4,971	830 / >830	Practically nontoxic	Slightly toxic
Phenmedipham	> HDT	> HCT	>1,200	Practically nontoxic	Practically nontoxic
Pyrazon	>2,000	4,254	ND	Practically nontoxic	Practically nontoxic
Quizalofop-p-ethyl	>2,000	>5,000	500 / 1,000	Practically nontoxic	Practically nontoxic
Sethoxydim	>2,510	>5,620	<100 / 100	Practically nontoxic	Practically nontoxic
Trifluralin	>2,000	>5,000	452 / 910	Practically nontoxic	Practically nontoxic
Triflusulfuron-methyl[4]	>2,250	>1,535 mg/kg-d	ND	Practically nontoxic	Slightly toxic

Sources: EPA OPP RED documents and EPA OPP Ecological Fate and Effects Division (EFED) ecological risk assessment documents available from the herbicide dockets.

[1] Categories of acute toxicity to birds (EPA OPP 2004): LC_{50} (ppm in diet): <50 very highly toxic; 50-500 highly toxic; 501-1,000 moderately toxic; 1,001-5,000 slightly toxic; >5,000 practically non-toxic. LD_{50} (mg/kg bw): <10 very highly toxic; 10-50 highly toxic; 51-500 moderately toxic; 501-2,000 slightly toxic, >5,000 practically nontoxic.

[2] Clethodim reproduction study in table not accepted by EPA OPP as fulfilling guideline; accepted study had NOAEL of >833 ppm diet.

[3] In this table, glyphosate toxicity values are reported using the units as initially reported, in mg acid equivalent (a.e.)/kg body weight. The active ingredient (a.i.) equivalent would be approximately 1.22 times greater.

[4] Triflusulfuron-methyl: No avian toxicity data provided in EPA OPP docket. Data in this table from University of Hertfordshire, 2011d.

Abbreviations: NR = Data not required by EPA OPP because acute toxicity very low; ND = no data identified; > HDT = higher than highest dose tested (not stated), and therefore considered not acutely toxic; > HCT = higher than highest dietary concentration tested (not stated), considered not toxic that results in 50 percent mortality over a 5- to 8-day period of exposure. For glyphosate, a.e. units are used instead of a.i. because the latter includes inert salt materials. The chronic data are expressed as no-observed-adverse-effect concentrations (NOAEC) and lowest-observed-adverse-effect concentrations (LOAEC) in the diet in ppm.

For registration and reregistration of pesticides in general, including herbicides, EPA OPP assumes that birds serve as an adequate surrogate species for reptiles and terrestrial-phase amphibians (U.S. EPA 2011d). Thus, testing the toxicity of herbicides to reptiles generally does not occur.

The NOAEC/LOAEC values generally are assessed for long-term exposures assessing reproductive and developmental toxicity. Table 4–11 also presents the corresponding EPA OPP acute avian toxicity categories for the herbicides. Most of the herbicides in the table are practically nontoxic to birds, although clopyralid is slightly toxic in the acute avian toxicity category and trisulfuron-methyl is slightly toxic in the subacute avian toxicity category. The LD_{50} value for clopyralid is 1,465 mg a.i. per kg body weight. Clopyralid (Stinger®) is one of the most widely used herbicides on sugar beets. Under Alternative 1, it is expected to be used on 74% of acreage used to produce sugar beets (table 3-15). For the other herbicides tested on birds, an LD_{50} value was not reached at the highest dose tested. EPA OPP generally does not require acute oral tests above 2,000 mg a.i. per kg bw or above 5,000 ppm in the diet.

With respect to chronic toxicity, generally a long-term reproductive test is used in which the herbicide is mixed in feed and administered at mating through egg-laying and hatching, and subsequent chick morphology and vigor are evaluated. Chronic effects were noted for birds administered three herbicides: desmedipham, trifluralin, and sethoxydim. Birds administered desmedipham and trifluralin exhibited an increased incidence of egg-shell cracking (U.S. EPA 1996c, 2005e). Sethoxydim is associated with a reduction in the number of eggs laid (U.S. EPA 2005b).

Table 4-12 lists the acute and chronic risk quotients (RQ) for herbicides where determined. As stated in the section on mammals, the risk quotient is based on dividing the estimated environmental concentration by an acute or chronic toxicity value. Three herbicides had RQ values that posed risks of concern and could therefore pose a potential risk to birds and reptiles. These are pyrazon, which has an acute RQ of 1.41 under certain scenarios, sethoxydim, which has a chronic RQ of up to 1.98, and trifluralin, which has a chronic RQ of up to 1.06. These three herbicides are expected to be used on 5-11% of the sugar beet acreage under Alternative 1. Desmedipham, which resulted in egg cracking but is expected to not pose risks of concern based on its RQ, is the most widely used herbicide under Alternative 1 where it is used on 94% of the acreage. These three herbicides may also result in indirect effects on predators that feed on birds or reptiles. In natural areas that abut sugar beet production fields, runoff or drift into natural areas may reduce populations of birds and reptiles in that local habitat so predators will not have that resource in the local area.

No toxicity data for reptiles are available for the herbicides used on sugar beets. In general, EPA OPP considers toxicity data for birds adequate to serve as surrogate toxicity data for egg-laying reptiles. Because reptiles are cold-blooded instead of warm-blooded, their metabolic rates generally are much lower than that for birds. They therefore consume far less food per unit body weight, and so are expected to experience lower oral exposure overall. Nonetheless, the lack of information on lizards, snakes, and turtles is a large data gap.

Previous EPA reports did not reveal evidence that sugar beet herbicides are endocrine disruptors. However all these herbicides will be reexamined under the EPA endocrine disruptor screening program. Therefore no conclusions can be drawn from this absence of evidence.

Impacts on Birds and Reptiles from Crop Management Practices. As discussed previously, on those agricultural lands that would no longer be allowed to grow H7-1 sugar beets, farmers could allow the land to become fallow (unplanted), plant conventional sugar beets, plant a rotational crop, or use the land for other purposes. If farmers allow the land to go fallow for only a few years and continue to plow the land, the amount of groundcover for reptiles such as snakes and lizards that might use the agricultural field to forage on ground-dwelling insects, to feed on plants, or to transit fields to other habitats would be reduced. Also, allowing the land to go fallow for a few years and continuing to plow the land would temporarily reduce the amount of prey (e.g., small mammals, lizards, snakes, and large insects) available for predatory birds (e.g., hawks and owls). As described for mammals, small animals that are vulnerable to predation from the air in particular tend not to venture very far from cover. Predatory birds that include sugar beet field in their foraging range would have to forage in other nearby vegetative fields or forests until another crop was planted and the prey returns.

If farmers do not continue to plow the fallow lands, reversion to more natural habitats (e.g., grasses and herbaceous growth) might provide more diversified foraging habitat for birds and reptiles and possibly year-round cover for small birds. Maintenance of cover for small animals year-round

would keep local populations which could provide prey for raptors, although the cover would likely reduce opportunities for raptors to spot

Table 4- 12. EPA-Estimated Environmental Concentrations (EECs) of Herbicide Residues and Risk Quotients (RQs) for Avian Wildlife from Exposures Following Herbicide Applications[1]

Herbicide	Scenario (lb a.i./acre)	Max EEC short grass (ppm)	Max EEC tall grass (ppm)	Max EEC broadleaf forage, small insects (ppm)	Max EEC fruit, pods, seeds, large insects(ppm)	Acute EEC (ppm)	Chronic EEC (ppm)	Acute Risk Quotient (RQ)	Chronic Risk Quotient (RQ)
Clethodim	2 x 0.25	105	48.3	59.3	6.59	105	105	<0.1	<1
Clopyralid	ND	ND	ND	ND	ND	ND	ND	ND	ND
Cycloate	1 x 4.0	ND	ND	ND	ND	ND	ND	NC	ND
Desmedipham	2 x 0.98	353	162	198	22.1	ND	ND	<0.0044–<0.071	ND
EPTC[2]	1 x 6.1	1,464	671	823	9	ND	ND	NC	ND
Ethofumesate	1 x 3.75	900	413	506	56.3	ND	ND	<0.01–<0.17	0.02–0.28
Glyphosate[3]	1 x 3.75	900	413	506	56.3	ND	ND	<0.01– <0.09 <0.02– <0.09 (diet-based)	0.06–0.9 (diet-based)
Phenmedipham	1 x 0.975	ND	ND	ND	ND	ND	234	NC	0.195
Pyrazon	1 x 7.3	1,754	804	987	109.7	ND	ND	0.01–**1.41**[4] 0.03–0.41 (diet-based)	ND
Quizalofop-p-ethyl	1 x 0.17	40.8	18.7	23.0	2.55	ND	ND	NC	<<0.01–0.08
Sethoxydim	2 x 0.47	240	110	135	15	ND	ND	NC	>0.12– >**1.98** (max) >0.06->0.70 (mean)
Trifluralin	1 x 2 lb	480	ND	250 (fruit/veg/leaves) 116 (legumes, insects)	24 (seeds) 14 (fruits)	ND	ND	0.003–0.096	0.03–**1.06**
Triflusulfuron-methyl	1 x 0.03	ND	ND	ND	ND	1.69–4.15	ND	0.0003–0.0166	ND

Sources: EPA Registration or Reregistration Eligibility Documents (REDs), EPA OPP EFED ecological risk assessment documents in EPA docket online, and other sources; see table 4–6, Characteristics of Herbicides Used on Sugar Beet Root and Seed Crops, for each herbicide.

[1] EPA-estimated EECs on four avian food types or unspecified food type (labeled acute and chronic EECs).

[2] Scenario single application rate higher than maximum single application rate of 4.6 lb a.i./acre for EPTC for sugar beets.

[3] Scenario single application rate for glyphosate lower than maximum single application assumed for conventional sugar beet preemergence, but higher than maximum single application rate assumed for H7-1 sugar beet preemergence. Glyphosate scenario expressed in lb. a.e./acre

[4] Bold value indicates a Risk Quotient that exceeds the Level of Concern (1.0) for non-federally listed species.

Abbreviations: EEC = estimated environmental concentration (herbicide residue) on indicated food/prey groups. lb a.i./acre = pounds of active ingredient/acre. ND = No data identified. NC = not calculated (when toxicity data indicated that the RQs would be far below any level of concern, EPA did not calculate the quotient).

small animals. Additionally, this would temporarily increase the amount of groundcover available year-round. Gramnivorous birds could consume seeds from grasses in fall through spring. Reptiles are likely to be in hibernation for the winter, but early spring cover would assist offspring in safe dispersal from where they were born. Several species of birds that nest in grasslands also might temporarily find expanded habitat for reproduction; however, that would cease once crops are again planted in the field.

If farmers immediately plant conventional sugar beets (or another rotational crop) rather than allowing the land to go fallow, the potential for the impacts discussed above with respect to lack of groundcover for reptiles and available prey for raptors would be eliminated or reduced. Vegetation/groundcover would be present for reptiles for foraging, dispersal, and migration, and existing prey populations would be maintained for raptors.

Conventional sugar beets are planted in rows with space between the rows to allow for in-crop tillage. Therefore, the amount of groundcover available for birds and reptiles feeding on the ground depends upon the sugar beet row width. The wider the rows, the lesser the ground coverage, and the greater the chances of being spotted by predators, which decreases the probability of long-term survival and reproduction.

Alternative 1 Summary and Conclusions. In summary, under Alternative 1, no H7-1 sugar beets would be commercially planted and herbicide use patterns would likely return to the patterns characteristic of each growing region prior to the widescale adoption of H7-1 sugar beets. The change from H7-1 sugar beets to conventional sugar beets could increase the risk of sublethal or chronic effects on birds (and possibly reptiles) from the application of sethoxydim postemergence and trifluralin applied preemergence (or early postemergence), at some locations. In addition, there could be a risk of acute effects on birds from the application of pyrazon at some locations. .

(2) Alternative 2 – Full Deregulation

Alternative 2 would result in the greatest adoption rate of H7-1 sugar beets. In the long term, it is expected that up to 100 percent of the sugar beet crop would be H7-1. Thus, the potential for bird and reptile exposure to the H7-1 gene product would be greatest under Alternative 2.

Impacts on Birds and Reptiles from Exposure to the H7-1 Gene Product. In general, birds and reptiles are not expected to use sugar beets as a food source. Some aquatic birds such as geese consume leaves and could potentially forage on beet tops. Some birds might be attracted to sugar beet grown for seed production. Of the reptiles, many turtle species are herbivorous (e.g., box turtle, painted turtle) and could consume sugar beets. Lizards are primarily insectivorous, but some are herbivores and would also consume sugar beets. Snakes are exclusively carnivorous, and so would not consume any parts of beet plants. Geckos require warmer climates than most areas that are conducive to growing sugar beets, with the exception of California.

If birds or reptiles do happen to consume the beets, byproducts from H7-1 sugar beets are reported as safe for food and feed for livestock and were found not to be toxic or nutritionally deficient to rats. APHIS anticipates that birds and reptiles would similarly be unaffected by the H7-1 CP4 EPSPS protein and consumption of H7-1 sugar beet plant parts given the lack of toxicity of the protein and the overall similarity in composition between H7-1 and conventional sugar beets.

Impacts on Birds and Reptiles from Herbicide Use. Birds and reptiles could be exposed to herbicides via spray drift or direct overspray if they were present within the sugar beet field during herbicide application. As described under Alternative 2 for mammals, Alternative 2 would lead to larger areas over which birds and reptiles might be exposed to glyphosate incidentally compared with Alternative 1 but would significantly reduce their exposure to nonglyphosate herbicides. All scenarios of glyphosate use do not pose risks of concern for birds and reptiles. Use of three herbicides on sugar beets, trifluralin, pyrazon ,and sethoxydim, are expected to decline in use by about 90%. As these herbicides are not used extensively on sugar beets in Alternative 1 (5, 6, and 11% respectively), the potential risks to birds and reptiles from herbicide use is expected to be slightly less under Alternative 2 compared to Alternative 1. As direct effects on birds and reptiles are not expected from glyphosate use, indirect effects are similarly not expected.

Impacts on Birds and Reptiles from Crop Management Practices. As discussed in section III.B.1, growing H7-1 sugar beets often is accompanied by increasing conservation tillagethus reducing the amount of tillage compared to Alternative 1. Growers therefore can plant H7-1 sugar beets closer together compared to conventional sugar beets that require in-crop tillage. Under this conservation tillage system, there would be more extensive groundcover for reptiles to forage, disperse, and migrate than under Alternative 1, thus decreasing the probability of individuals being killed by predators and increasing chances of long-term survival and reproduction. More groundcover during the growing season potentially also could increase the amount of prey available for foraging raptors. Any increases in the numbers of prey, however, are not likely to substantially improve the hunting success of predators because of the increased cover.

Alternative 2 Summary and Conclusions. In summary, exposure to or consumption of H7-1 sugar beet plant materials under Alternative 2 is not expected to impact avian or reptilian wildlife. Short-term impacts from land management practices are possible where farmers allow fields to lie fallow for a few years, but continue to plow them. Those impacts, however, would be short-lived, and no longer-term impacts are anticipated for avian and reptilian wildlife from differences in crop management practices. Increases in conservation tillage might provide more food and habitat for birds and reptiles.

Herbicide use patterns would be different under Alternatives 1 and 2 where Alternative 2 would result in more use of glyphosate which is not expected to pose acute and chronic risks to birds and reptiles and less use of three herbicides that under certain scenarios have the potential to pose acute and chronic risks.

(3) Alternative 3 – Partial Deregulation

Impacts on Birds and Reptiles from Exposure to the H7-1 Gene Product. Under Alternative 3, the potential for exposure to the H7-1 gene product would not exist for birds and reptiles in California and western Washington, as well as those areas where growers decide to plant conventional varieties. As discussed previously, exposure to the H7-1

gene product is not expected to have an adverse effect on birds or reptiles. Similarly, APHIS anticipates no adverse effects on birds and reptiles from exposure to the H7-1 gene product for Alternative 3.

Impacts on Birds and Reptiles from Herbicide Use. Alternative 3 would result in substantially higher amounts of glyphosate-based herbicide use than under Alternative 1 but less than under Alternative 2 due to the mandatory restrictions in two states. Similarly the reduction in the use of non glyphosate herbicides would be less under Alternative 3 than under Alternative 2. Of the three herbicides that under certain scenarios have the potential to pose acute and chronic risks to birds and reptiles, sethoxydim and trifluralin are extensively used in Imperial Valley (Table 3-14). Thus, the extent of potential impacts on birds and reptiles from sethoxydim and trifluralin use would be somewhat higher under Alternative 3 than under Alternative 2, but lower than Alternative 1.

Impacts on Birds and Reptiles from Crop Management Practices. Under Alternative 3, in those areas where H7-1 sugar beets are grown, the potential impacts on birds and reptiles from crop management practices would be similar to Alternative 2. Due to glyphosate use to control weeds, farmers could plant H7-1 sugar beets closer together than if space for tillage were maintained between rows. Thus, areas planted in H7-1 sugar beets would provide earlier and more extensive groundcover for ground-foraging small birds and reptiles. Moreover, reptiles moving between habitats would be afforded more protection from visual predators compared with conventional sugar beets.

Because conservation tillage would not be used to grow sugar beets in California under Alternative 2, the potential impacts on birds and reptiles from crop management practices in California under Alternative 3 would also be similar to Alternative 2.

Alternative 3 Summary and Conclusions. In summary, exposure to or consumption of H7-1 sugar beet plant materials under Alternative 3 is not expected to impact avian or reptilian wildlife. Alternative 3 would result in substantially higher amounts of glyphosate-based herbicide use than under Alternative 1 but less than under Alternative 2 due to the mandatory restrictions in the sugar beet growing area in California. Similarly the reduction in the use of non glyphosate herbicides would be less under Alternative 3 than under Alternative 2. Of the three herbicides that under certain scenarios have the potential to pose acute and chronic risks to birds and reptiles, sethoxydim and trifluralin are extensively used in Imperial Valley. Thus, the extent of potential impacts on birds and reptiles from sethoxydim and trifluralin use would be somewhat higher under Alternative 3 than under Alternative 2, but lower than Alternative 1. Increases in conservation tillage might provide more food and habitat for birds and reptiles under Alternative 3 relative to Alternative 1.

d. Amphibians and Fish

For each alternative, APHIS analyzed the potential impacts on amphibians and fish from (1) exposure to the H7-1 gene product, (2) herbicide use, and (3) crop management practices.

(1) Alternative 1 – No Action

Impacts on Amphibians and Fish from Exposure to the H7-1 Gene Product. Under Alternative 1, amphibians and fish would not be likely to be exposed to the H7-1 gene product so no impacts are expected.

Impacts on Amphibians and Fish from Herbicide Use. There would be a rapid transition to greater use of non-glyphosate herbicides and much less use of glyphosate as H7-1 sugar beets are replaced with conventional sugar beets. Amphibian and fish exposure to herbicides is possible due to spray drift, inadvertent direct overspray, or transport (via wind or water flow from rainfall) of soil particulates with adsorbed herbicides and water runoff with dissolved herbicides.

Table 4–13 provides data on the acute toxicity of herbicides used on sugar beets to both coldwater (rainbow trout) and warmwater (bluegill sunfish) fish, as available. Table 4–13 includes the EPA OPP toxicity categories corresponding to the LC_{50} values. Many of the herbicides exhibit acute toxicity to fish. Trifluralin is the most severe as it is in the very highly toxic category for both species of fish. Quizalofop-p-ethyl is highly toxic to both species. Ethofumesate is highly toxic to trout and moderately toxic to sunfish. Cycloate, desmedipham, and phenmedipham, are all in the moderate toxicity category. Clethodim and pyrazon are slightly toxic to both species. EPTC is slightly toxic to trout and practically non toxic to sunfish. Glyphosate is listed as practically non toxic to trout and slightly toxic to sunfish. Clopyralid, sethoxydim, and triflusulforn-methyl are all listed in the practically non-toxic category.

Table 4- 13. Acute (96-hr) Toxicity Values and EPA OPP Toxicity Categories of Herbicides to Freshwater Fish[1]

Herbicide Active Ingredient	Rainbow Trout (Coldwater)		Bluegill Sunfish (Warmwater)	
	LC_{50} (mg a.i./L)	Toxicity Category	LC_{50} (mg a.i./L)	Toxicity Category
Clethodim	15	Slightly toxic	ND	ND
Clopyralid[2]	350	Practically nontoxic	125	Practically nontoxic
Cycloate	4.5	Moderately toxic	4.6	Moderately toxic
Desmedipham	1.7	Moderately toxic	6.0	Moderately toxic
EPTC	14	Slightly toxic	125	Practically nontoxic
Ethofumesate	0.75	Highly toxic	2.5	Moderately toxic
Glyphosate (a.e.) [3]	140	Practically nontoxic	43	Slightly toxic
Phenmedipham	1.7	Moderately toxic	ND	ND
Pyrazon [4]	38[6]	Slightly toxic	88.7	Slightly toxic
Quizalofop-p-ethyl	0.87	Highly toxic	0.460	Highly toxic
Sethoxydim	170	Practically nontoxic	265	Practically nontoxic
Trifluralin	0.041	Very highly toxic	0.058	Very highly toxic
Triflusulfuron-methyl	730	Practically nontoxic	ND	ND

Sources: EPA OPP RED documents and EPA OPP Ecological Fate and Effects Division (EFED) ecological risk assessment documents available from the herbicide dockets.

[1] EPA OPP categories of acute toxicity for aquatic organisms based on LC_{50} values in mg a.i./L: <0.1 very highly toxic; 0.1-1 highly toxic; 1-10 moderately toxic; 10-100 slightly toxic; >100 practically nontoxic.

[2] Rainbow trout LC_{50} from Fairchild et al., 2007. Bulltrout LC_{50} was 458 mg a.i./L; less sensitive than rainbow trout. Bluegill sunfish LC_{50} of 125 mg/L source TNC profile for the herbicide.

[3] Glyphosate Rainbow trout 48-hr LC_{50} with 83% pure glyphosate = 86 mg/L; rainbow trout 48-hr LC_{50} with 96.7% glyphosate = 140 mg/L; use latter because of possibility of surfactants in former.

[4] Pyrazon rainbow trout LC_{50} values ranged from 32 to 46 mg a.i./L; geometric mean of those two values (38) is used to represent the rainbow trout LC_{50}. Pyrazon metabolite B-1 less toxic (LC_{50} >105 mg/L) than parent pyrazon compound to rainbow trout; therefore, EPA OPP did not evaluate metabolite B-1 toxicity further.

Abbreviations: ND = no data; a.e. = acid equivalent; a.i. = active ingredient

For registration and reregistration of pesticides in general, including herbicides, EPA indicates that fish serve as an adequate surrogate species for aquatic life stages of amphibians (U.S. EPA 2008d). Thus, testing the toxicity of herbicides to amphibians generally only occurs if there is specific reason for concern, such as listed endangered or threatened species in the vicinity of fields on which the herbicide is used.

APHIS compared the relative toxicities of the herbicides to glyphosate a.i. in table 4–14, which reveals that glyphosate a.i. alone is one of the least toxic herbicides to fish on an acute basis. Several herbicides are orders of magnitude more toxic to fish than glyphosate including trifluralin (1280 times), ethofumesate (70 times), quizalofop-p-ethyl (60 times), phenmedipham (31 times), desmedipham (31 times), and cycloate (12 times). Maximum application rate was used as an indicator of exposure. The risk of each sugar beet herbicide relative to glyphosate was calculated by dividing the maximum application rate by the acute toxicity value and dividing that risk value by the risk value of glyphosate. Considering application rate as well as toxicity, all the above herbicides, with the exception of quizalofop-p-ethyl, are expected to pose greater acute risks to fish than glyphosate.

EPA OPP has estimated risks to aquatic organisms from herbicide applications per label instructions. Exposure is represented by estimated environmental concentrations (EECs) in surface waters. EPA calculated EECs for all herbicides and the application scenarios indicated in the first column of the table. EPA calculated risk quotients by dividing each EEC by the appropriate toxicity value (acute or chronic) from tests with fish for each active ingredient. For acute RQs, EPA used 96-hour LC_{50} values, that is the concentration of the chemical in water required to kill 50 percent of fish over a 96-hour exposure period. For chronic RQ values, EPA used no-observed-adverse effect concentration/lowest-observed adverse effect concentration (NOAEC/LOAEC) data as available. The results of comparing the EECs to the benchmark toxicity values are listed in table 4–15 below.

Even though many of the herbicides used on sugar beets are toxic to fish, when considering the estimated environmental concentrations of the herbicides based on use according to EPA label instructions, the potential risk to fish does not pose risks of concern for each herbicide. These results are summarized in Table 4–15 which indicates that all RQs are less than 1.0. EPA OPP's environmental assessment for clopyralid was not available, and EPA OPP did not report some of the EEC values used to develop the RQ values shown in the table (e.g., acute EECs for cycloate

Table 4- 14. Alternative 1: Relative Toxicity and Risk of Herbicides Used on Sugar Beets to Fish

Herbicide	Acute Toxicity		Maximum Single Application Rate		Relative[5] Risk (RR) = (A) x (B)
	96-hr LC_{50}[1] (mg a.i./L)	(A)[2] Relative to Glyphosate TGAI	Rate[3] (lb a.i./ acre/app)	(B)[4] Relative to Glyphosate TGAI	
Clethodim	15	**3.5**	0.25	0.0554	0.19
Clopyralid	350	0.15	0.33	0.0732	0.011
Cycloate	4.5	12	4.0	0.887	10.3
Desmedipham	1.7	31	1.28	0.284	8.8
EPTC	14	3.8	4.6	1.02	3.8
Ethofumesate	0.75	70	3.75	0.831	58
Glyphosate T[6] PRE	52.5	1.00	4.51	1.000	1.0
Phenmedipham	1.7	31	0.63	0.140	4.3
Pyrazon	38	1.4	7.3	1.62	2.2
Quizalofop-p-ethyl	0.87	60	0.0825	0.0183	1.1
Sethoxydim	170	0.31	0.47	0.104	0.032
Trifluralin	0.041	1280	0.75	0.166	213
Triflusulfuron methyl	730	0.072	0.032	0.00710	0.00051

[1] Data from table 4–13.
[2] Relative acute toxicity calculated as (1/LC_{50} herbicide) divided by (1/LC_{50} glyhosate a.i.). Numbers bolded are relative toxicity values for which a definitive LD_{50} was determined for the nonglyphosate herbicide.
[3] Maximum single application rate allowed from table 4–9.
[4] Relative single maximum application rate calculated as rate for herbicide divided by rate for glyphosate a.i., assumed to be 4.5 lb a.i./acre preemergence in one application, although multiple applications of smaller amounts of each are more likely.
[5] Relative risk (RR) is the product of relative toxicity (A) and relative maximum single application (B). Bold numbers indicate herbicides exhibiting higher relative risks that glyphosate
[6] Toxicity values for glyphosate have been adjusted from values for acid equivalent (a.e.), as shown in table 4–11, to active ingredient (a.i.) in this table by multiplying the a.e. value by 1.22.
Abbreviations: a.i. = active ingredient. PRE = preemergence application; glyphosate is not applied postemergence to conventional sugar beets. TEP

and pyrazon). Additional data limitations are evident in the table. Data on the chronic toxicity of herbicides to fish are lacking for several herbicides used on conventional sugar beets. Most significant, however, is the lack of consideration of the "inert" ingredients in formulated herbicides when estimating surface water concentrations. Even if surface water concentrations of the inert ingredients also were estimated, toxicity data on formulated products for comparison with EECs are sparse. EPA announced that glyphosate formulations containing the surfactant polyethoxylated tallow amine (POEA) will be considered in the ecological and endangered species risk assessment to be conducted for the registration review for glyphosate (U.S. EPA 2009c). EPA's regulations specifying data requirements for pesticide testing, now require data to be submitted on typical end use products (TEP) to assess ecological effects of the formulated product on aquatic nontarget organisms (40 CFR 158.630).

Trifluralin is highly toxic to fish and has the highest RQ value of the herbicides (chronic RQ of 0.4), although it does not pose risks of concern (<1.0) for non-listed fish. Trifluralin also has a longer half-life (e.g., 60 days) in the environment than the other herbicides, and a high bioaccumulation potential (see table 3–23). Therefore, under Alternative 1, trifluralin appears to be the herbicide applied to conventional sugar beets that is of most concern, although none of the herbicides used are expected to cause adverse impacts, either acute or chronic, to fish populations in nearby surface waters.

As no direct impacts on fish and amphibians are expected from any of the herbicides used on sugar beet, indirect impacts on predator species from reducing prey species are not expected. either.

Impacts on Amphibians and Fish from Crop Management Practices. On those agricultural lands that would no longer be allowed to grow H7-1 sugar beets, farmers could allow the land to become fallow (unplanted), plant conventional sugar beets (or a rotational crop), or use the land for other purposes. If farmers allow the land to go fallow for a year and continue to plow the land, the amount of groundcover for terrestrial-phase adult amphibians that use the agricultural field to forage on ground-dwelling insects would be reduced. Individuals of these species likely would use adjacent areas of similar habitat. If farmers do not continue to plow the fallow lands, these fallow lands would revert to more natural grasslands/shrublands, which could provide groundcover and more diverse habitat for terrestrial-phase amphibians than planted sugar beets or fallow, plowed lands. This potentially could enhance local population size; however, that effect would be short term and only last until another crop is planted.

Allowing the land to go fallow for a year and continuing to plow the land could increase the erosion of topsoil via wind or rainfall, thereby indirectly

Table 4- 15. EPA-Estimated Environmental Concentrations (EECs) of Herbicides in Surface Waters from Drift and Runoff and Risk Quotients (RQs) for Fish

Herbicide	Scenario (lb a.i./acre)	Acute EEC in Surface Water (ppm)	Longer-Term EEC in Surface Water (ppm)	Acute Risk Quotient (RQ) for Fish	Chronic Risk Quotient (RQ) for Fish
Clethodim	2 × 0.25	0.007	ND	<0.05	ND
Clopyralid	ND	ND	ND	ND	ND
Cycloate	1 × 4.0	ND	ND	0.003 – 0.007	ND
Desmedipham	2 × 0.98	0.0145 (aerial) 0.0141 (ground)	ND	0.0024 – 0.0086 (aerial) 0.0024-0.0083 (ground)	NC
EPTC[1]	1 × 6.1	Refined aquatic exposure modeling resulted in a maximum peak concentration of 0.04 ppm. This is far lower than the lowest fish LC_{50} (14 ppm). This indicates that EPTC is unlikely to have acute effects on aquatic animals.			ND
Ethofumesate	1 × 3.75	0.0527	0.0438	0.07	0.02
Glyphosate a.e.[2]	1 × 3.75	0.028 (peak)	0.011 (90-day)	0.0006	0.0008
Phenmedipham	1 × 0.975	0.01695 (24-hr)	0.0135 (90-day)	<0.01	ND
Pyrazon	1 × 7.3	ND	ND	<0.001 – <0.00062	ND
Quizalofop-p-ethyl	1 × 0.165	.00257	.00203 (60-day)	<0.01	<0.01
Sethoxydim	2 × 0.47	0.087	ND	0.0005	ND
Trifluralin	1 × 2.0	0.00701	0.00039 (90-day)	0.03 – 0.08	0.3 – 0.4
Triflusulfuron-methyl	1 × 0.03	0.016068	ND	0.000134 – 0.0000766	ND

Sources: EPA Registration or Reregistration Eligibility Documents (REDs), EPA OPP EFED ecological risk assessment documents in EPA dockets online, and other sources; see table 4–7 for each herbicide.

[1] Scenario single application rate higher than maximum single application rate of 4.6 lb a.i./acre for EPTC for sugar beets.

[2] Scenario single application rate for glyphosate lower than maximum single application assumed for conventional sugar beet preemergence, but higher than maximum single application rate assumed for H7-1 sugar beet preemergence.

Abbreviations: EEC = estimated environmental concentration. ND = no data. mg a.i./L = milligram active ingredient per liter water.

NC = not calculated (when toxicity data indicated that the RQs would be far below any level of concern, EPA did not calculate the quotient).

impacting aquatic species that year. Soil erosion can result in the release of sediment and fertilizers into nearby surface waters, which could increase turbidity, contribute to algal blooms, and decrease dissolved oxygen concentrations, ultimately affecting fish and aquatic-phase amphibians. For flowing waters, increased turbidity and reduced concentration of dissolved oxygen might force fish and other mobile organisms to avoid such areas. For small isolated ponds and lakes, however, total kills of fish and amphibians that use the water for reproduction is possible. Also, any chemical that is bound to the eroded soil particles would be transported to the water bodies. Depending on the amount, concentration, and toxicity of the chemical(s) (e.g., insecticides, fungicides, rodenticides) bound to the eroded soil particles, fish and amphibians might experience toxic effects. Under Alternative 1, it is likely that plowed lands will be planted with conventional sugar beets or other crops (eventually) limiting these potential short-term impacts. If farmers do not continue to plow the fallow lands, the fallow lands would revert to more natural grasslands/shrublands, which could result in less soil erosion when compared to land that is planted with sugar beets or is fallow and plowed.

In the longer term, once farmers replace H7-1 sugar beets with conventional varieties, in-crop tillage practices would be required for weed control. Conventional sugar beet tillage generally results in more erosion of topsoil via wind or rainfall than conservation or strip-till options that are possible for H7-1 sugar beets. Alternative 1 therefore has the potential to increase adverse effects on fish and aquatic life stages of amphibians compared with the 2010 conditions of 95 percent of sugar beet acreage planted with H7-1 varieties.

Alternative 1 Summary and Conclusions.

EPA OPP considers fish and early life-stage toxicity tests on fish adequate to define pesticide toxicity to amphibians for purposes of pesticide registration. If used according to label instructions, under Alternative 1, none of the herbicides are expected to pose risks of adverse effects in aquatic-stage amphibians or in fish. Trifluralin is the most likely herbicide to affect fish if mitigations from the label are not followed. Depending on location, use of conventional tillage across all sugar beet acreage could result in indirect adverse effects on aquatic life-stage amphibians and fish from soil erosion, including movement of herbicides, fertilizers, and other pesticides as well as soil particles into nearby surface waters. Small ponds are more susceptible than larger ponds or lakes or flowing waters.

(2) Alternative 2 – Full Deregulation

Alternative 2 would result in the greatest adoption rate of H7-1 sugar beets. In the long term, it is expected that approximately 100 percent of the sugar beet crop would be H7-1. Thus, the potential for amphibian and fish exposure to the H7-1 gene product would be greatest under Alternative 2.

Impacts on Amphibians and Fish from Exposure to the H7-1 Gene Product. Fish and aquatic phases of amphibians would not be directly exposed to the H7-1 gene product. Terrestrial amphibians are carnivores and thus would not consume any part of the sugar beet plant. Terrestrial amphibian exposure to the H7-1 gene product would only occur if the individual consumed prey that had recently eaten part of an H7-1 sugar beet plant and the protein had survived intact in the digestive tract of the prey. As discussed previously, exposure to the H7-1 gene product is not expected to have an adverse effect on birds and reptiles. Simliarly, APHIS also anticipates no adverse effects on fish and amphibians from exposure to the H7-1 gene product.

Impacts on Amphibians and Fish from Herbicide Use. Alternative 2 would result in higher amounts of glyphosate-based herbicide used on sugar beets compared to Alternative 1 and greatly reduced levels of non-glyphosate herbicides. As described under Alternative 1, glyphosate is much less toxic to fish than are the non glyphosate herbicides. However, exposure of fish to any of the herbicides is expected to be limited when the herbicides are used according to the label. Although, the potential chronic and acute risk to fish under Alternative 2 is expected to be reduced compared to Alternative 1, no unreasonable risks are expected under either Alternative.

Compared to glyphosate tested as an acid or isopropylamine (IPA) salt, amphibians exhibited greater sensitivity to Roundup® formulations, likely due to the surfactant POEA, which has been used for a long time in agricultural formulations. POEA has been found to be more toxic to amphibians and other aquatic animals than glyphosate a.i. alone (Lajmanovich et al., 2003) Some researchers have suggested that, in combination with POEA, Roundup® could cause high rates of mortality to amphibians, including species of frogs and toads that could lead to eventual population declines (Relyea, 2005) However, glyphosate formulations containing POEA are not permitted in aquatic habitats so the these studies may not be relevant. Glyphosate products, such as Rodeo® are specifically designed for aquatic uses. At least one glyphosate formulation that contains surfactant is approved for use over or near surface waters. The label for this glyphosate product (Nufarm Credit Duo Herbicide, EPA Reg. No. 71368-25) contains use instructions for glyphosate-tolerant sugar beets (Nufarm Inc., 2010). The label instructs the user to apply the product over-the-top of sugar beets. The label states, "For terrestrial uses, do not apply directly to water, to areas where surface water is present or to intertidal areas below the mean high water mark."

Therefore, when using this product for weed control in sugar beet fields, farmers should not be applying the product directly over surface waters. Also, like the labels for Roundup Orginal MAX® (Monsanto, 2007b) and Roundup Weather MAX® (Monsanto, 2009), the label states “The pesticide should only be applied when the potential for drift to adjacent sensitive areas (e.g., residential areas, bodies of water, known habitat for threatened or endangered species, non-target crops) is minimal (e.g., when wind is blowing away from the sensitive areas),” and “Avoid direct application to any body of water.”

Large numbers of amphibians are not expected to be present in sugar beet fields where direct application of surfactant-containing herbicide would occur. Thus, notable decreases in local populations of amphibians are not expected. Additionally, under current agricultural practices, runoff and erosional movement of soils with sorbed glyphosate and the surfactant to surface waters should be limited to storm events (Borggaard and Gimsing, 2008).

There is a potential that indirect impacts to amphibians and fish could occur from glyphosate use under Alternative 2 if natural areas occur in proximity to sugar beet fields.As stated in the pesticide effects determination of the risks of glyphosate use to Federally Threatened California Red-legged frog (U.S. EPA 2008c), “Aquatic plants serve several important functions in aquatic ecosystems Non-vascular aquatic plants are primary producers and provide the energy base for aquatic ecosystems (U.S. EPA 2008c).. Vascular plants provide structure as attachment sites and refugia for many aquatic invertebrates, fish, and juvenile organisms, such as fish and frogs. In addition, vascular plants also provide primary productivity and oxygen to the aquatic ecosystem Rooted plants help reduce sediment loading and provide stability to nearshore areas and lower streambanks.” EPA further concluded that glyphosate is not expected to indirectly affect the aquatic-phase of the frog through the diet or habitat from aquatic non-vascular plants (U.S. EPA 2008c).

Also stated in US EPA 2008, “Terrestrial plants serve several important habitat-related functions for the CRLF. In addition to providing habitat and cover for invertebrate and vertebrate prey items of the CRLF, terrestrial vegetation also provides shelter for the CRLF and cover from predators while foraging. Terrestrial plants also provide energy to the terrestrial ecosystem through primary production. Upland vegetation including grassland and woodlands provides cover during dispersal. Riparian vegetation helps to maintain the integrity of aquatic systems by providing bank and thermal stability, serving as a buffer to filter out sediment, nutrients, and contaminants before they reach the watershed, and serving as an energy source.” At high aerial application rates of 3.85 lbs a.e./acre and ground application rates of 7.5 lbs. a.e./A, glyphosate may cause indirect effects on habitat that could adversely impact the California red-legged frog. However they suggested that impacts on habitat could be mitigated by sufficient buffers. For ground applications of 0.75 lbs.a.e./A, a typical application rate used for post emergent applications to sugar beet, the buffer estimated to dissipate the adverse impact of glyphosate on habitat is 25 feet. For ground applications of 1.54 lbs, a.e/A, the estimated buffer distance is 53 feet. For ground applications of 3.75 lbs. a.e./acre, the maximum amount permitted for pre emergent applications per season, the estimated buffer is 125 feet. For aerial applications of 0.75 and 3.75 lbs, a.e/A, the estimated buffers are 312 and 1768 feet respectively.

Under Alternative 2, there is the potential for indirect effects on habitat for fish and amphibians from glyphosate use on lands that abut natural areas when the distance between the sugar beet field and the natural area is less than that recommended for mitigation. According to Stachler (Stachler et al., 2011) for the Midwest region, greater than 99% of sugar beet growers only use glyphosate for post emergent applications. The maximum amount of glyphosate allowed on post emergent applications of sugar beets is 1.125 lbs. a.e./application. At this application rate, it is predicted that a buffer of greater than 25 but less than 53 feet will mitigate potential impacts to habitat for ground applications of glyphosate and a buffer of greater than 312 feet but less than 1768 feet for aerial applications. According to Stachler (Stachler et al., 2011), glyphosate is applied aerially to about 3% of sugar beet acreage. It is uncertain what number of sugar beet production fields are within 53 feet of natural areas for the 97% of acreage where glyphosate is applied by ground sprayers and within 1768 feet of natural areas on lands that are sprayed by air. As data is lacking for the non-glyphosate herbicides, there is uncertainty whether similar indirect effects on habitat would occur under Alternative 1.

Where H7-1 sugar beets are cultivated, use of soil conservation measures such as strip-till or low-till practices when planting H7-1 sugar beets and during crop rotations should mitigate the likelihood of offsite migration of glyphosate and associated surfactants by erosion or runoff. For example, a survey conducted in 2000, before H7-1 sugar beets became available, found that use of conventional tillage for sugar beet production varied by region from 64 to 96 percent of acreage (not including California where conventional tillage is routinely practiced). Because weeds can be effectively controlled with glyphosate applications, the adoption of H7-1 sugar beets from 2006 to 2010 significantly reduced the amount of tillage needed to produce a sugar beet crop (Stachler et al., 2011). Because H7-1 sugar beets generally do not require soil tilling, benefits to surface water quality (and thus amphibians and other aquatic organisms) in the watershed of their cultivation could include decreased turbidity and sedimentation from soil erosion and decreased contamination with other pesticides and nutrients sorbed to soil particles.

Impacts on Amphibians and Fish from Crop Management Practices. As discussed in section III.B, growing H7-1 sugar beets does not require in-crop tillage due to the use of glyphosate, thus reducing the amount of tillage compared to Alternative 1. Growers therefore can plant H7-1 sugar beets closer together compared to conventional sugar beets that require in-crop tillage. Under this conservation tillage system, there would be more extensive groundcover for terrestrial-phase amphibians to forage and disperse compared to Alternative 1, thus decreasing the probability of an individual being preyed upon and increasing the individual's chances of long-term survival and reproduction.

Additionally, compared to tillage practices associated with conventional sugar beets, conservation tillage systems benefit fish and aquatic-phase amphibians by reducing the potential for topsoil erosion via wind or rainfall, thereby reducing the amount of sediment released into nearby surface waters and improving water quality. As discussed above, soil erosion can result in turbidity and decreased dissolved oxygen concentrations in the water body, ultimately affecting fish and aquatic-phase amphibians by impairing growth, reproduction, development, and long-term survival. Also, soil erosion can result in the transport of chemicals that are bound to soil particles to surface waters. Compared to Alternative 1, these potential impacts would be reduced under Alternative 2 in both the short and long term.

Alternative 2 Summary and Conclusions

EPA OPP considers fish and early life-stage toxicity tests on fish adequate to define pesticide toxicity to amphibians for purposes of pesticide registration. If used according to label instructions, under Alternative 2, none of the herbicides are expected to pose risks of adverse effects in aquatic-stage amphibians or in fish. There is potential for TEPs of glyphosate to be more toxic to both fish and amphibians than glyphosate a.i., but how much more would depend on which surfactants are used in each formulation. As a consequence, strict label warnings are required on glyphosate products designed to be used on terrestrial crops to help farmers minimize the possibility of off-crop movement of glyphosate with surfactant.

(3) Alternative 3 – Partial Deregulation

Impacts on Amphibians and Fish from Exposure to the H7-1 Gene Product. As discussed under Alternative 2, fish and aquatic phases of amphibians would not be directly exposed to the H7-1 gene product. Indirect ingestion of the H7-1 gene product via consumption of plant-eating insects is not expected to cause adverse effects, because the protein is not known to have adverse effects on animals. Therefore, no adverse effects on fish and amphibians are expected from exposure to the H7-1 gene product under Alternative 3.

Impacts on Amphibians and Fish from Herbicide Use. Under Alternative 3, H7-1 sugar beets could be grown across the United States with the exception of California and western Washington. The amount of H7-1 sugar beet acreage likely would be similar to Alternative 2 except that no H7-1 sugar beets would be grown in California. Glyphosate would be the predominant herbicide applied in these locations, resulting in the same potential for impacts as described for Alternative 2.

Currently, no H7-1 sugar beets are grown in California. However, as discussed in section III.B.1., in the 2010–2011 crop year, there were 25,000 acres of conventional sugar beets planted in California. Alternative 3 would not change the current risk to amphibians and fish in these localized fields in California, since a mix of conventional sugar beet herbicides would continue to be applied. Trifluralin is the herbicide of most concern.

Impacts on Amphibians and Fish from Crop Management Practices. In those areas where H7-1 sugar beets are grown, the potential impacts on amphibians and fish from crop management practices would be similar to Alternative 2. Due to glyphosate use to control weeds, famers can plant H7-1 sugar beets closer together compared to conventional sugar beets, which provides more extensive groundcover for terrestrial-phase amphibians to forage and disperse compared to Alternative 1. Additionally, where conservation tillage is employed, fish and aquatic-phase amphibians would benefit from improved water quality as a result of reduced soil erosion.

In those areas where H7-1 sugar beets would not be grown (California, western Washington, and areas where farmers choose to plant conventional sugar beets), the potential impacts on amphibians and fish from crop management practices would be similar to Alternative 1. One difference, however, is that in California, there would be no short-term impacts from transitioning from H7-1 sugar beets to conventional sugar beets because H7-1 sugar beets have not yet been established in California.

e. Terrestrial Invertebrates

For each alternative, APHIS analyzed the potential impacts on terrestrial invertebrates from (1) exposure to the H7-1 gene product, (2) herbicide use, and (3) crop management practices.

(1) Alternative 1 – No Action

Impacts on Terrestrial Invertebrates from Exposure to the H7-1 Gene Product. Under Alternative 1, levels of the H7-1 gene and its product in the environment eventually would return to pre-deregulation levels. Terrestrial invertebrates would have limited to no exposure to the H7-1 gene product. No adverse effects on terrestrial invertebrates are expected from exposure to the H7-1 gene product under Alternative 1.

Impacts on Terrestrial Invertebrates from Herbicide Use. There would be a transition to greater use of non-glyphosate herbicides and much less use of glyphosate as H7-1 sugar beets are replaced with conventional sugar beets. Terrestrial invertebrate exposure to herbicides is possible due to spray drift or direct overspray if they were present within the sugar beet field during herbicide application. Table 4–16 includes toxicity test data for herbicides to honey bees and earthworms where data were available. EPA OPP generally requires toxicity tests with honey bees as both a key pollinator species and as a surrogate species representing other beneficial insects. In general, most herbicides show slight to practically no toxicity to insects and earthworms. An LD_{50} from either contact over 24 h or an oral dose for 48 h was not achieved at the maximum concentrations tested for each herbicide. Earthworm toxicity is not a regular part of pesticide toxicity testing for EPA. As no direct impacts on terrestrial invertebrates are expected from herbicide use, no indirect impacts are also expected on animals that consume terrestrial invertebrates.

Impacts on Terrestrial Invertebrates from Crop Management Practices. Under Alternative 1, if farmers allow the land to become fallow for only a few years and continue to plow the land, the amount of ground cover/vegetation for terrestrial invertebrates that might use the agricultural field would be reduced; however, farmers generally try to prevent insect consumption of any parts of their crop that have commercial uses, as does all of the sugar beet root crop. In addition, sugar beet root crop growers have no need of pollinating insects. Under Alternative 1, however, conventional tillage would repeatedly disrupt the soil-dwelling invertebrates' habitat, which might reduce populations of beneficial invertebrates such as earthworms and grubs of predatory beetles.

If farmers do not continue to plow the fallow lands, these fallow lands would revert to more natural grasslands/shrublands, which could provide more diverse habitat for terrestrial invertebrates than planted sugar beets or fallow, plowed lands. Additionally, habitat conditions would be more stable (no plowing). This would be short term and only last until another crop is planted.

If farmers immediately plant conventional sugar beets (or another rotational crop) rather than allowing the land to go fallow, there would not be a reduction in ground cover/vegetation as discussed above. However,

Table 4- 16. Toxicity of Herbicides Used on Sugar Beets to Non-Target Terrestrial Invertebrates and EPA OPP Toxicity Category

Herbicide	Lowest Honey Bee Acute Toxicity Value		EPA OPP Toxicity Category Honey Bee	Earthworm Data (mg a.i./kg soil)
	LD_{50} 24-hr contact (µg/bee)	LD_{50} 48-hr oral (µg/bee)		
Clethodim TEP (26% a.i.)	>100	ND	Practically nontoxic	ND
Clopyralid	ND	ND	ND	ND
Cyloate	ND	>29	Practically nontoxic	ND
Desmedipham	>50	>50	Practically nontoxic	ND
EPTC	>12	ND	Relatively nontoxic	ND
Ethofumesate	>50	ND	Practically nontoxic	ND
Glyphosate	ND	>100[1]	Practically nontoxic	ND
Phenmedipham[2]	ND	242	Practically nontoxic	21-d LC_{50} = 129 21-d LOAEC = 51.8 21-d NOAEC = 1.6
Pyrazon	ND	>193[2]	Practically nontoxic	ND
Quizalofop-p-ethyl	50	ND	Practically nontoxic	ND
Sethoxydim	NR	NR	Practically nontoxic	ND
Trifluralin	>100	>50	Practically nontoxic	14-d LC_{50}: >500[3] 14-d LOEC: 14.19[3]
Triflusulfuron-methyl	>100	ND	Practically nontoxic	14-d LC_{50}: >1,000[4] 14-d LOEC: 250[4]

Sources: EPA OPP RED documents and EPA OPP Ecological Fate and Effects Division (EFED) ecological risk assessment documents available from the herbicide dockets unless noted otherwise.
[1] EPA/OPP/EFED 2009 Ecological Risk Assessment Problem Formulation document in the glyphosate docket did not specify a.i. or a.e.
[2] Source: Van Gestel et al., 1992.
[3] Source: EFSA, 2009.
[4] Source: Health Canada, 1999.
Abbreviations: ND = no data available, a.i. = active ingredient only – not including additional chemicals used in formulations, TEP = Typical end-use product with typical additives to enhance fficacy, NR = not reported

periodic disruption to terrestrial invertebrate habitat still would occur when farmers till the fields.

Alternative 1 Summary and Conclusions

Any exposure to H7-1 sugar beets is not expected to have adverse effects on terrestrial invertebrates. All of the herbicides typically used on H7-1 or conventional sugar beet fields have been tested on honey bees (except clopyralid), with the results categorized as practically nontoxic by EPA. Sugar beet root crops do not need pollinators. Conventional tillage under Alternative 1 might disrupt soil habitats for some beneficial invertebrates.

(2) Alternative 2 – Full Deregulation

As mentioned previously, Alternative 2 would result in the greatest adoption rate of H7-1 sugar beets. In the long term, it is expected that up to 100 percent of the sugar beet crop would be H7-1. Farmers are expected to try to prevent herbivorous insects from consuming sugar beet plants equally for H7-1 sugar beets and conventional sugar beets.

Impacts on Terrestrial Invertebrates from Exposure to the H7-1 Gene Product. The potential for terrestrial invertebrate exposure to the H7-1 gene product would be greatest under Alternative 2. Terrestrial invertebrates could be exposed to the H7-1 gene product if they consumed a part of the H7-1 sugar beet plant (e.g., leaves). Honey bees also could be exposed to nectar and pollen of H7-1 sugar beets, but only in the small areas where H7-1 sugar beet seed crops are in production. The EPSPS protein is part of a metabolic pathway found in plants, fungi, and some bacteria, but not in animals. As discussed previously, exposure to the H7-1 gene product is not expected to have an adverse effect on animals.

Even though the likelihood of toxicity is low for the CP4 EPSPS protein, some researchers have conducted laboratory investigations with different types of arthropods exposed to genetically engineered crops containing the CP4 EPSPS protein (Goldstein, 2003; Harvey et al., 2003; Jamornman et al., 2003) Representative pollinators, soil organisms, beneficial arthropods, and pest species were exposed to tissues (pollen, seed, and foliage) from genetically engineered crops that contain the CP4 EPSPS protein. These studies, although varying in design, all reported a lack of toxicity in species exposed to these crops.

Impacts on Terrestrial Invertebrates from Herbicide Use. Alternative 2 would result in higher amounts of glyphosate-based herbicide and reduced amounts of non glyphosate herbicides used on sugar beets compared to Alternative 1, because Alternative 2 would result in the greatest adoption of H7-1 sugar beets. This would lead to larger areas over which terrestrial invertebrates might be exposed to glyphosate compared with Alternative 1. However, glyphosate is practically nontoxic to terrestrial invertebrates, and therefore no adverse impacts are expected on terrestrial invertebrates from Alternative 2. Similarly, other non glyphosate herbicides are practically nontoxic to terrestrial invertebrates so no differences in impacts on terrestrial invertebrates are expected from herbicide use between Alternatives 1 and 2. As no direct impacts on terrestrial invertebrates are expected from herbicide use, no indirect impacts are also expected on animals that consume terrestrial invertebrates. As described under the section "Impacts on Fish and Amphibians," there is the potential for indirect effects on habitat for terrestrial invertebrates from glyphosate use on lands that abut natural areas when the distance between the sugar beet field and the natural area is less than that recommended for mitigation. The extent of this indirect effect is uncertain because the number of sugar beet farms that are within the recommended mitigation distance from natural areas is not known. Other non glyphosate herbicides may have similar indirect effects if used in proximity to natural areas.

Impacts on Terrestrial Invertebrates from Crop Management Practices. As discussed in section III.B, growing H7-1 sugar beets may not require in-crop tillage during the growing season to control weeds, and facilitates the adoption of conservation tillage, including the strip-till option. Under conservation tillage systems, there would be more extensive groundcover/vegetation for terrestrial invertebrates compared to Alternative 1. Also, disruption or modification to the terrestrial invertebrate's soil habitat from tilling would not occur as often, which could lead to greater abundance and diversity of terrestrial invertebrates, including beneficial species.

Alternative 2 Summary and Conclusions. Exposure of terrestrial invertebrates to H7-1 sugar beets and glyphosate is not expected to have adverse effects on terrestrial invertebrates. Glyphosate is considered practically nontoxic to terrestrial invertebrates, as are the non glyphosate herbicides used on sugar beet, and no differences are expected on the impacts to terrestrial invertebrates from herbicide use under Alternatives 1 or 2. The additional conservation tillage expected under Alternative 2 relative to Alternative 1 is expected to benefit soil invertebrates.

(3) Alternative 3 – Partial Deregulation

Impacts on Terrestrial Invertebrates from Exposure to the H7-1 Gene Product. Under Alternative 3, terrestrial invertebrates could be exposed to the H7-1 gene product if they consumed a part of an H7-1 sugar beet plant (e.g., leaves). As discussed under Alternative 2, exposure to the H7-1 gene product is not expected to have an adverse effect on terrestrial invertebrates.

Impacts on Terrestrial Invertebrates from Herbicide Use. No direct impacts to terrestrial invertebrates from herbicide use are expected under Alternative 3, as for Alternatives 1 and 2, as all of the sugar beet herbicides are considered practically non toxic to terrestrial invertebrates. .

Impacts on Terrestrial Invertebrates from Crop Management Practices. In those areas where H7-1 sugar beets are grown, the potential impacts on terrestrial invertebrates from crop management practices would be similar to Alternative 2 as explained above. In California, where H7-1 sugar beets are not grown, the potential impacts on terrestrial invertebrates from crop management practices would also be similar to Alternative 1 and 2 because conservation tillage is not expected to be practiced in California sugar beet production even with the adoption of H7-1 sugar beet.

Alternative 3 Summary and Conclusions. As for Alternatives 1 and 2, no differences in impacts to terrestrial insects are expected from exposure to H7-1 sugar beet or herbicides under Alternative 3. As for Alternative 2, under Alternative 3, benefits are expected to soil invertebrates from increased practice of conservation tillage.

f. Aquatic Invertebrates

For each alternative, APHIS analyzed the potential impacts on aquatic invertebrates from (1) herbicide use and (2) crop management practices. Regarding exposure to the H7-1 gene product, in general, the majority of H7-1 plant pieces that might reach surface waters would derive from detritus particles in soils and be transported from sugar beet fields by soil erosion and runoff from rain events. This material usually would have started to decompose on land. The integrity of plant cell membranes and contents would have degraded to the point that no appreciable, if any, intact and correctly configured H7-1 gene product proteins should remain in the material. If some proportion of freshly cut beet tops left in the field were to wash into nearby surface waters with a storm event (e.g., immediately after the farmer cuts the tops off the sugar beets prior to root removal from the ground), some aquatic invertebrates might be exposed to and consume fresh pieces of leaves that might contain H7-1 gene product. In most freshwater aquatic invertebrate communities, species or types of animals that are herbivorous and can consume pieces of fresh leaves (e.g., crayfish, some isopods, some amphipods) comprise a small fraction of the community. As discussed previously, exposure to the H7-1 gene product is not expected to have an adverse effect on animals. Therefore, no adverse effects on aquatic invertebrates are expected from exposure to the H7-1 gene product for all alternatives.

(1) Alternative 1 – No Action

Impacts on Aquatic Invertebrates from Herbicide Use. As discussed previously, under Alternative 1, there would be a transition to greater use of non-glyphosate herbicides and much less use of glyphosate as H7-1 sugar beets are replaced with conventional sugar beets. Aquatic invertebrate exposure to herbicides is possible due to spray drift or transport (via wind or water flow from rainfall) of soil particulates loaded with adsorbed herbicide.

Table 4–17 displays acute toxicity values and EPA toxicity categories of the sugar beet herbicides for aquatic invertebrates, as measured in laboratory tests. Almost all of the acute toxicity tests and the few chronic tests were conducted with the water flea *Daphnia magna*. Clopyralid, pyrazon, and trisulfuron-methyl are practically non toxic. Clethodim, ethofumesate, glyphosate, and sethoxydim are slightly toxic. Cycloate, desmedipham, EPTC, phenmedipham, and quialofop-p-ethyl are moderately toxic. Trifluralin is highly toxic.

APHIS analyzed the relative acute risk of herbicides used on conventional sugar beets on aquatic invertebrates. Relative toxicities of the herbicides compared with glyphosate a.i. were calculated as the inverse of the herbicide toxicity divided by the inverse of glyphosate a.i. toxicity. The results are displayed in table 4–18, column (A), below for both Alternatives 1 and 2. The main difference is that glyphosate is used at lower maximum rates under Alternative 2 for pre emergence applications and is also used for post emergence applications. Table 4–18 indicates a similar pattern of acute toxicity and RRs for freshwater aquatic invertebrates under Alternative 1 as estimated for freshwater fish under Alternative 1 (see table 4–14). As for fish, glyphosate a.i. alone is one of the least toxic herbicides to aquatic invertebrates on an acute basis. The potential risk to aquatic invertebrates relative to glyphosate is greater from cycloate, desmedipham, EPTC, phemedipham, and trifluralin. Desmedipham and phenmedipham are expected to be widely used herbicides on sugar beets with 94% and 80% of crop acreage treated, respectively (Table 3-15). As such, potential adverse impacts to aquatic invertebrates from herbicide use are more likely under Alternative 1 than under Alternative 2 based on a comparison of the active ingredients. Certain glyphosate formulations are known to be more toxic to aquatic organisms than the active ingredient alone. A comparison of the glyphosate formulated product to the formulated products of the other sugar beet herbicides, however is not possible because in most cases their toxicity has not been evaluated and the composition of the ingredients are proprietary.

EPA OPP has estimated risks to aquatic organisms, living in small water bodies adjacent to sugar beet fields, from the application of herbicides per EPA label instructions based on the estimated environmental concentration in surface waters and acute or chronic toxicity values (see Table 4-19). EPA OPP's environmental assessment for clopyralid was not available, and EPA OPP did not report some of the EEC values used to develop the RQ values shown in the table (e.g., acute EECs for cycloate and pyrazon). Chronic toxicity values were only available for ethofumesate, glyphosate, and trifluralin. All acute RQ values were below 0.05 and all chronic RQ values were below 1 meaning that for each herbicide the potential risk does not pose risks of concern for fish and aquatic species (U.S. EPA 2004)Therefore, even though the non glyphosate herbicides are more toxic to aquatic organisms than is glyphosate, exposure levels for all herbicides are expected to be low so the potential risk to aquatic invertebrates does not pose risks of concern under both Alternative 1 and 2. As no direct impacts on aquatic invertebrates are

Table 4- 17. Acute and Chronic Herbicide Toxicity Values and Acute EPA OPP Toxicity Categories for Freshwater Aquatic Invertebrates[1]

Herbicide	Lowest Toxicity Value (species)		EPA OPP Acute Toxicity Category
	Acute (48-hr)[2] LC_{50} (mg a.i/L)	Chronic NOAEL/LOAEL (mg a.i./L)	
Clethodim	20.2	ND	Slightly toxic
Clopyralid	225	NR	Practically nontoxic
Cycloate	2.6	ND	Moderately toxic
Desmedipham	1.88	ND	Moderately toxic
EPTC	3.5	ND	Moderately toxic
Ethofumesate	64	0.25/0.75	Slightly toxic
Glyphosate a.e.	53.2	49.9/95.7	Slightly toxic
Phenmedipham	3.2	ND	Moderately toxic
Pyrazon	>131[3]	10/NL[4]	Practically nontoxic
Quizalofop-p-ethyl	2.12–6.4	ND	Moderately toxic
Sethoxydim	78	ND	Slightly toxic
Trifluralin	0.56	0.0024/0.0072	Highly toxic
Triflusulfuron-methyl	>960	11/NL	Practically nontoxic

Sources: EPA OPP RED documents and EPA OPP Ecological Fate and Effects Division (EFED) ecological risk assessment documents available from the herbicide dockets unless noted otherwise

[1] EPA OPP categories of acute toxicity for aquatic organisms based on LC_{50} values in mg a.i./L: <0.1 very highly toxic; 0.1–1 highly toxic; >1–10 moderately toxic; >10–100 slightly toxic; >100 practically nontoxic.

[2] Column header Acute LC_{50} assumes that immobility in small invertebrates, like water fleas, is equivalent to death. Values often reported as EC_{50}'s for immobilization because "death" not confirmed.

[3] Pyrazon metabolite B-1 is no more toxic than parent compound; water flea EC_{50} for pyrazon metabolite B-1 >100 mg/L.

[4] Chronic invertebrate test from comments on ecological risk submitted to EPA by BSAF Corp.

Abbreviations: a.e.=acid equivalent, a.i= active ingredient, NR = data not required by EPA OPP because acute toxicity very low, ND = no data available, NL = LOAEL not listed, TGAE = technical grade acid equivalent, TGAI = technical grade active ingredient,

Table 4- 18. Alternatives 1 and 2: Relative Acute Toxicity and Risk of Herbicides Used on Sugar Beets to Freshwater Aquatic Invertebrates

Herbicide	Acute Toxicity		Alternative 1: Maximum Single Application Rate		Alternative 2: Maximum Single Application Rate		Alt 1: Relative[6] Risk (RR) = (A) × (B)	Alt 2: Relative[6] Risk (RR) = (A) × (C)
	LC_{50}[1] (mg a.i./L)	(A)[2] Relative to Glyphosate TGAI	Rate[3] (lb a.i./acre/ app)	(B)[4] Relative to Glyphosate TGAI	Rate[3] (lb a.i./acre/ app)	(C)[5] Relative to Glyphosate TGAI		
Clethodim	20.2	**3.2**	0.25	0.055	0.25	0.083	0.18	0.27
Clopyralid	225	**2.9**	0.33	0.073	0.33	0.110	0.021	0.032
Cycloate	2.6	**25**	4.0	0.89	4.0	1.333	**22**	**33**
Desmedipham	1.9	**35**	1.28	0.28	1.28	0.427	**9.8**	**15**
EPTC	3.5	**19**	4.6	1.0	4.6	1.533	**19**	**28.4**
Ethofumesate	64	1.0	3.75	0.83	3.75	1.25	0.83	**1.25**
Glyphosate[7] PRE	65	1.0	4.51	1.00	3.00	1.00	1.0	1.0
Glyphosate[7] POST	65	1.0	0	0	1.37	0.46	0	0.46
Phenmedipham	3.2	**20**	0.63	0.14	0.63	0.21	**2.8**	**4.26**
Pyrazon	>131	<0.50	7.3	1.6	7.3	2.43	0.80	**1.21**
Quizalofop-p-ethyl	2.12	**30.6**	0.083	0.018	0.083	0.028	0.56	0.84
Sethoxydim TGAI	78	0.83	0.47	0.10	0.47	0.16	0.087	0.13
Trifluralin	0.56	**116**	0.75	0.17	0.75	0.25	**19**	**29**
Triflusulfuron-methyl	>960	<0.068	0.032	0.00710	0.032	0.011	0.00048	0.00072

[1] Acute toxicity data from table 4–17; reported as mg a.i./L

[2] Relative acute toxicity calculated as ($1/LC_{50}$ herbicide a.i.) divided by ($1/LC_{50}$ glyphosate a.i.). Numbers in bold indicate acute toxicity values greater than glyphosate a.i.

[3] Maximum single application rate allowed from table 4–9.

[4] Relative single maximum application rate calculated as rate for herbicide divided by rate for glyphosate a.i., assumed to be 4.5 lb a.i./acre preemergence in one application for Alternative 1 and 3.0 lb a.i./acre in one application preemergence for Alternative 2.

[5] Relative risk (RR) is the product of relative toxicity (A) and relative maximum single application (B for Alternative 1 and C for Alternative 2).

[6] Toxicity values for glyphosate have been adjusted from values reported on an acid equivalent (a.e.) basis (in table 4–11) to active ingredient (a.i.) in this table by multiplying the a.e. value by 1.22. Bold numbers indicate herbicides exhibiting higher relative risks than glyphosate.

Abbreviations: EC_{50} = Effective concentration for endpoint for 50 percent of organisms, endpoint is immobility or death, which cannot readily be distinguished with water fleas; LC_{50} = lethal concentration to 50 percent of animals; PRE = preemergence application, glyphosate is not applied postemergence to conventional sugar beets; TEP = typical end-use product; TGAI = technical grade active ingredient; NR = not relevant, maximum application rates not reported and no data on adjuvants in formulation

Table 4- 19. EPA-Estimated Environmental Concentrations (EECs) of Herbicides in Surface Waters (from Drift and Runoff) and Risk Quotients (RQs) for Freshwater Aquatic Invertebrates

Herbicide	Scenario (lb a.i. /acre)	Acute EEC in Surface Water (ppm)	Longer-Term EEC in Surface Water (ppm)	Acute Risk Quotient (RQ)	Chronic Risk Quotient (RQ)
Clethodim	2 x 0.25	0.007	ND	<0.05	ND
Clopyralid	ND	ND	ND	ND	ND
Cycloate	1 x 4.0	ND	ND	0.001–0.012	ND
Desmedipham	2 x 0.98	0.0141(ground) 0.0145 (aerial)	ND	0.0075 (ground) 0.0077 (aerial)	NC
EPTC[1]	1 x 6.1	Refined aquatic exposure modeling resulted in a maximum peak concentration of 0.04 ppm. This is far lower than the lowest aquatic invertebrate EC_{50} (6.5 ppm). This indicates the EPTC is unlikely to have acute effects on aquatic animals.			ND
Ethofumesate	1 x 3.75	0.0527	0.0491	<0.01	0.16
Glyphosate[2]	1 x 3.75	0.028 (peak)	0.011 (90-day)	0.0005	0.0004
Phenmedipham	1 x 0.975	0.01695 (24-hr)	0.01351 (90-day)	<0.01	ND
Pyrazon	1 x 7.3	ND	ND	<0.0007– <0.0015	ND
Quizalofop-p-ethyl	1 x 0.165	.00257	.00257 (60-day)	<<0.01	ND
Sethoxydim	2 x 0.47	0.087	ND	0.001	ND
Trifluralin	1 x 2.0	0.00701	0.00039 (90-day)	0.006	0.2
Triflusulfuron-methyl	1 x 0.03	0.016068	ND	0.0000167	ND

Sources: EPA Registration or Reregistration Eligibility Documents (REDs), EPA OPP EFED ecological risk assessment documents in EPA dockets online, and other sources; see table 4–7 for each herbicide.
[1] Scenario: single application rate higher than maximum single application rate of 4.6 lb a.i./acre for EPTC for sugar beets.
[2] Scenario: single application rate for glyphosate lower than maximum single application assumed for conventional sugar beet preemergence, but higher than maximum single application rate assumed for H7-1 sugar beet preemergence.
Abbreviations: EEC = estimated environmental concentration; ND = no data; mg a.i./L = milligram active ingredient per liter water

expected from herbicide use, no indirect impacts are also expected on animals that consume terrestrial invertebrates.

Impacts on Aquatic Invertebrates from Crop Management Practices. On those agricultural lands that would no longer be allowed to grow H7-1 sugar beets, farmers could allow the land to become fallow (unplanted), plant conventional sugar beets (or a rotational crop), or use the land for other purposes. Under Alternative 1, allowing the land to go fallow for a year and continuing to plow the land could increase the erosion of topsoil via wind or rainfall, thereby indirectly impacting aquatic invertebrates that year. Soil erosion can result in movement of herbicides, fertilizers, and other pesticides as well as soil particles from the fields into nearby surface waters, with a variety of indirect effects occurring in aquatic animals. Small ponds are more susceptible than larger ponds or lakes or flowing waters.

It is likely that plowed lands will be planted with conventional sugar beets or other crops (eventually) limiting these potential short-term impacts. If farmers do not continue to plow the fallow lands, the fallow lands would revert to more natural grasslands/shrublands, which could result in less soil erosion compared with land that is planted with sugar beets or is fallow and plowed. In the longer term, once farmers replace H7-1 sugar beets with conventional varieties, in-crop tillage practices could result in erosion of topsoil via wind or rainfall, thereby periodically indirectly affecting aquatic invertebrates as discussed in the paragraph above.

Alternative 1 Summary and Conclusions

If used according to label instructions, under Alternative 1, the potential risks of all herbicides used on sugar beets are not expected to pose risks of concern for freshwater aquatic invertebrates. Cycloate, EPTC, and trifluralin are the herbicides that are most toxic to aquatic invertebrates. Phenmedipham and desmedipham are widely used sugar beet herbicides that are also more toxic to aquatic invertebrates than is glyphosate. The additional conventional tillage expected under Alternative 1 could result in indirect adverse effects on freshwater invertebrates from soil erosion, including movement of herbicides, fertilizers, and other pesticides as well as soil particles into nearby surface waters. Small ponds are more susceptible than larger ponds or lakes or flowing waters.

(2) Alternative 2 – Full Deregulation

Impacts on Aquatic Invertebrates from Herbicide Use. Alternative 2 would result in higher amounts of glyphosate-based herbicide used on sugar beets compared to Alternative 1 because Alternative 2 would result in the greatest adoption of H7-1 sugar beets. The geographic extent to which aquatic invertebrates might be exposed incidentally to glyphosate would be greater under Alternative 2 than under Alternative 1. The non-glyphosate herbicides would be used over much smaller areas compared with Alternative 1 (see table 3-19, table 4-3).

As described under Alternative 1, table 4–18 (above) compares the relative risks of acute impacts on aquatic invertebrates from single applications of herbicides as used on H7-1 sugar beets under Alternative 2 with single applications of herbicides as used on conventional sugar beets under Alternative 1. Under Alternative 2, glyphosate is used at lower maximum application rates than under Alternative 1 so the relative risk of using glyphosate is diminished relative to the non glyphosate herbicides. As described under Alternative1, several widely used sugar beet herbicides are more toxic to aquatic invertebrates than is glyphosate and when considering the maximum application rate, the potential risk is also much greater. As mentioned above, these herbicides are cycloate, EPTC, desmedipham, phenmedipham, and trifluralin. Though these herbicides are more toxic, their corresponding acute RQ values do not pose risks of concern so no unreasonable adverse impacts are expected to aquatic invertebrates from either Alternative 1 or 2.

As described under the section “Impacts on Fish and Amphibians,” there is the potential for indirect effects on habitat for aquatic invertebrates from glyphosate use on lands that abut natural areas when the distance between the sugar beet field and the natural area is less than that recommended for mitigation. The extent of this indirect effect is uncertain because the number of sugar beet farms that are within the recommended mitigation distance from natural areas is not known. Other non glyphosate herbicides may have similar effects if used in proximity to natural areas.

Impacts on Aquatic Invertebrates from Crop Management Practices. As discussed in section III.B.1, growing H7-1 sugar beets would allow farmers to reduce the amount of tillage required under Alternative 2 compared with Alternative 1. Compared to tillage practices associated with conventional sugar beets, conservation tillage systems expected to be prevalent under Alternative 2 benefit aquatic invertebrates by reducing the potential for topsoil erosion via wind or rainfall. Depending on location, use of conservation tillage can reduce movement of herbicides, fertilizers, and other pesticides as well as soil particles into nearby surface waters. Adverse indirect effects on aquatic invertebrates from glyphosate spraying Thus, Alternative 2 would reduce potential indirect impacts on aquatic invertebrates in surface waters compared with Alternative 1.

Alternative 2 Summary and Conclusions. If used according to label instructions, under Alternative 2, none of the herbicides are expected to pose unreasonable adverse effects in freshwater aquatic invertebrates even though non-glyphosate herbicides (cycloate, desmedipham, EPTC, phenmedipham, and trifluralin) are more toxic to aquatic organisms than is glyphosate. Alternative 2 would reduce potential indirect impacts on aquatic invertebrates compared with Alternative 1 due to the increased use of conservation tillage practices.

(3) Alternative 3 – Partial Deregulation

Impacts on Aquatic Invertebrates from Herbicide Use. Under Alternative 3, glyphosate would be the principal herbicide applied to H7-1 sugar beets and non glyphosate herbicide use would be reduced in all areas of the country except Imperial Valley. If used according to label instructions, none of the herbicides are expected to pose unreasonable adverse effects to aquatic invertebrates as discussed for Alternative 2. Of the five herbicides that pose a higher potential risk to aquatic invertebrates than glyphosate, desmedipham, phenmedipham, and trfluralin are all extensively used in Imperial Valley. Thus potential risk to aquatic invertebrates is greater under Alternative 3 than Alternative 2 but less than Alternative 1. Indirect effects from herbicide impacts on vegetation near streams and small water bodies are not expected to pose risks of concern as described under Alternative 2.

Impacts on Aquatic Invertebrates from Crop Management Practices. In those areas where H7-1 sugar beets are grown, the potential impacts on aquatic invertebrates from crop management practices would be similar to Alternative 2. Where conservation tillage is employed, aquatic invertebrates would benefit from improved water quality as a result of reduced soil erosion and sedimentation. Reduced erosion and runoff under conservation tillage would reduce input of herbicides, insecticides, fungicides, other pesticides, as well as excess nutrients from fertilizers, into surface waters. Benefits would include improved water quality and likely improved diversity and stability of aquatic invertebrate communities. In Imperial Valley, the potential impacts on aquatic invertebrates would also be similar to Alternative 2 because conservation tillage is not expected to be practiced in Imperial Valley regardless of whether H7-1 sugar beets are grown.

2. Micro-organisms

For each alternative, APHIS analyzed the potential effects on micro-organisms from (1) exposure to the H7-1 gene and gene product, (2) herbicide use, and (3) crop management practices. (See section IV.E.2 for a discussion of soil quality changes as a result of impacts on micro-organisms.)

a. Alternative 1 – No Action

(1) Impacts on Micro-organisms from Exposure to the H7-1 Gene and its Product

Micro-organism exposure to the H7-1 gene might occur from residual H7-1 DNA in any plant materials remaining in the field that are tilled into soils after the final harvest of H7-1 sugar beets and from previous tillage of H7-1 plant remains into the soils. Similarly, exposure of soil microbial populations to the CP4 EPSPS protein is possible from tillage of H7-1 plant materials into soils.

Detailed discussion of potential impacts on micro-organisms from exposure to the H7-1 gene and its product is presented below under Alternative 2, because H7-1 sugar beets would be phased out of U.S. agriculture under Alternative 1, and Alternative 2 would result in the greatest adoption of H7-1 sugar beets. Under Alternative 1, there would be little to no exposure of micro-organisms to the H7-1 gene and its product.

(2) Impacts on Micro-organisms from Herbicide Use

Under Alternative 1, there would be a rapid transition to greater use of conventional herbicides and much less use of glyphosate as H7-1 sugar beets are replaced with conventional sugar beets. The proportion of sugar beet acreage on which glyphosate is used and the rates and volumes of glyphosate applications on sugar beets would likely decrease to the level of use that existed prior to the deregulation of H7-1 sugar beets (approximately 13 percent of acres based on 2000 data; see table 3–15). Micro-organism exposure to such herbicide applications would occur in the sugar beet fields and possibly in areas adjacent to the fields due to spray drift or direct overspray.

Agricultural practices that involve high disturbance and reliance on chemical additives can result in limited micro-organism diversity or elimination of some biological groups (Kennedy et al., 2004), as well as reduced micro-organism activity (Blasioli et al., 2011). Some herbicides are toxic to biota in general, while others show low toxicity to non-target organisms or even contribute to short-term stimulation of bacteria (Damin and Trivelin, 2011; Ratcliff et al., 2006). However, generalizations regarding herbicide impacts on microbial populations from specific active ingredients in the absence of available data are complicated by the fact that the effect is influenced by a wide range of factors. These factors include the physical and chemical properties of the herbicides, the species of micro-organism exposed (and therefore the metabolic route of impact), the rate of herbicide application, soil properties, and climatic factors (Damin and Trivelin, 2011). Table 3–53 displays the half-lives of the sugar beet herbicides. Clethodim, EPTC, sethoxydim, and triflusulfuron-methyl all have half-lives that are less than 10 days, indicating they are either degraded by soil micro-organisms relatively quickly or do not persist in the soil. The remaining herbicides have similar half-lives, ranging from 21 to 60 days, except for quizalofop-p-ethyl, which has a half-life of approximately 216 days.

Depending on the herbicides used under Alternative 1, micro-organisms might experience adverse effects from herbicide application to sugar beet fields. Phenmedipham, pyrazon, ethofumesate, and a phenmedipham-ethofumesate mixture have been found to temporarily adversely affect soil micro-organisms, as evidenced by decreased nitrification (phenmedipham-ethofumesate mixture) and reduced adenosine triphosphate (ATP) levels (ethofumesate, pyrazon, phenmedipham, and mixture) (NLM (National Library of Medicine), 2007). Some variation in inhibitory effect and duration was observed according to soil type (sandy clay versus sandy loam), though general trends were consistent with phenmedipham, ethofumesate, and pyrazon, respectively, demonstrating increasingly greater microbial inhibition (NLM (National Library of Medicine), 2007). EPTC also has been shown to be toxic to bacteria (Virág et al., 2007), and cycloate has been shown to significantly reduce fungi growth even with other nutrient additions (Campbell and Altman, 1977).

Not all observed effects on micro-organisms exposed to conventional sugar beet herbicides have been adverse, however. For example, in conducting a biological assessment on behalf of the U.S. Forest Service to consider the site-specific environmental consequences of treating invasive plants with herbicides, Scott and Haines (Scott and Haines, 2008)reported that no adverse effects on soil organisms were expected from application of sethoxydim at rates of 0.3 lb a.i. per acre (recall that the typical application rate of sethoxydim on sugar beets is 0.33 lb a.i. per acre as presented in table 3–15). They reported that assays of soil micro-organisms noted transient shifts in species composition at soil concentration levels far exceeding concentrations expected from U.S. Forest Service application. Similarly, Roslycky (1986, as cited (Tu et al., 2001)) studied the effects of sethoxydim on populations of soil microbes. At sethoxydim concentrations less than 50 ppm, a negligible response was noted in microbial populations. At higher concentrations (1,000 ppm), soil actinomycetes and bacteria populations were stimulated, but fungal populations remained approximately the same.

An increase in microbial biomass was noted in a study carried out by Baeva (2000) where clethodim applied to a soybean field stimulated bacteria, actinomycetes, and fungi (particularly in surface soil). DEFRA (1993) reported that desmedipham application on a sandy loam soil and a silt loam soil produced slight variations in microbial response, but generally the results showed no impact or slightly enhanced colony numbers of soil bacteria, actinomycetes, and fungi. Hang et al. (2001) observed stimulated growth of soil micro-organisms at low concentrations of trifluralin application, while colony development was inhibited at higher doses. Similarly, clopyralid was found to stimulate development of actinomycetes and fungi (Vasic et al., 2009). No studies specifically assessing the impacts of quizalofop-p-ethyl and trisulfuron-methyl on microbial populations were located.

APHIS previously analyzed effects of glyphosate on soil micro-organisms in appendix N of the *Final Environmental Impact Statement for Glyphosate-Tolerant Alfalfa Events J101 and J163: Request for Nonregulated Status* (USDA-APHIS, 2010a). The results of that analysis, as well as additional research, are presented below under Alternative 2, because Alternative 2 would result in the greatest use of glyphosate. In summary, glyphosate application might favor development of detrimental microbial species (or harm some beneficial microbes); however, to date there is no conclusive evidence linking applications of glyphosate to changes in soil microbial communities that have adverse effects on plants grown in those soils.

In conclusion, information on the effects of herbicides on soil microbes and microbial communities is limited, and research to date appears to have focused on glyphosate. However, available information suggests that applications of non-glyphosate conventional sugar beet herbicides might adversely affect soil micro-organisms. Glyphosate, which would be used less than the other herbicides under Alternative 1, also might result in shifts in soil microbial communities, but such shifts are not expected to harm plants that grow in those soils.

(3) Impacts on Micro-organisms from Crop Management Practices

Management practices used in sugar beet production can affect soil micro-organisms by altering microbial populations and activity through modification of the soil environment. The impacts from crop management practices have the potential to be beneficial to some soil biota and detrimental to others. In addition to herbicide use (which is described immediately above), tillage can influence microbial populations and their activities (Gupta and Roget, 2010). Micro-organisms are sensitive to physical soil disturbance, and their population dynamics can serve as indicators of changes in soil quality (Kennedy et al., 2004). For example, the interactions between micro-organisms and organic matter in the soil largely determine the fertility and overall quality of the soil. See section III.E.2.e for further discussion of micro-organism contribution to soil quality.

Under Alternative 1, if farmers allow the land to become fallow for a few years in the short term and continue to plow the land seasonally to inhibit colonization by weeds, the tillage would periodically disrupt the micro-organism's soil habitat. Tilling usually disturbs at least 15–25 cm of the soil surface and replaces stratified surface soil horizons with a tilled zone that is more homogeneous with respect to physical characteristics and residue distribution. The loss of a stratified soil microhabitat causes a decrease in the density of soil micro-organisms (Altieri, 1999). If farmers do not continue to plow the fallow lands, these fallow lands would revert to more natural grasslands/shrublands and soil habitat conditions would be more stable. There might be a short-term change in the abundance and species of soil micro-organisms present, with shifts toward more natural communities found in the absence of pesticides and fertilizers. This would be short term and only last until another crop is planted. Longer term impacts would depend on subsequent land use.

If farmers immediately plant conventional sugar beets (or a rotational crop) rather than allowing the land to go fallow, periodic disruption (i.e., conventional tillage) to micro-organism habitat would occur when farmers till the fields, which can result in the impacts described in the paragraph above. Also, as mentioned in section III.B.1.d, conventional tillage associated with growing conventional sugar beets involves more tillage and less crop residue retained in the field compared with conservation tillage practices (e.g., no till, row tillage, strip tillage) commonly employed by H7-1 sugar beet growers. Not retaining crop residues during harvest can result in less microbial biomass and microbial activity compared to agricultural fields where crop residues are preserved on the soil surface (Kennedy et al., 2004). This in turn could lead to a decline in soil organic matter quality over time (see section IV.E.2 for a discussion of soil quality).

b. Alternative 2 – Full Deregulation

(1) Impacts on Micro-organisms from Exposure to the H7-1 Gene and Gene Product

Alternative 2 would result in the greatest adoption rate of H7-1 sugar beets. Thus, the potential for micro-organism exposure to the H7-1 gene and gene product would be greatest under Alternative 2.

After conducting an extensive literature search, APHIS is not aware of any data to date indicating that transfer of the intact *cp4 epsps* gene into microbes has occurred. Exposure to H7-1 DNA in soils, however, is unlikely to result in transfer of the intact *cp4 epsps* gene into microbes, because biodegradation of plant materials tilled into soils generally results in fragmentation of DNA strands into small pieces, none of which are likely to be long enough to represent an intact entire *cp4 epsps* gene (Hart et al., 2009; Lerat et al., 2007; Levy-Booth et al., 2008).

Although several mechanisms of gene transfer exist among micro-organisms, as discussed in section III.C.4, evidence of horizontal gene transfer (HGT) between higher plants and bacterial species, or between plants and their parasites, is extremely limited. As discussed in section III.C.4, plants growing in nature have numerous opportunities to interact directly with other organisms such as fungi and bacteria. Despite this frequent interaction, there are no reports to date of significant HGT between sexually incompatible or evolutionarily distant organisms (as reviewed in (Keese, 2008). Where data indicate HGT might have taken place, these events are believed to have occurred on an evolutionary time scale on the order of millions of years (Brown, 2003; Koonin et al., 2001). Furthermore, there has been no evidence of HGT occurring as a result of transgenes in crop species (Demanèche et al., 2008; Pontiroli et al., 2007). Therefore, HGT between H7-1 sugar beets and micro-organisms is not expected.

Exposure to the CP4 EPSPS protein in soils also is unlikely. The potential for intact CP4 EPSPS protein in a functional configuration to appear in soils is remote, because the protein degrades once it is released from cells decaying in soils (Australian Government, 2006) If some molecules did persist in soils, there is no reason to anticipate toxicity of the CP4 EPSPS protein to soil microbes. Microbes might be exposed to the protein if they incorporate an intact *cp4 epsps* gene from the environment which became functional within the bacterial genome. Although unlikely, if this occurred and glyphosate-resistant micro-organisms developed, populations of glyphosate-resistant microbes could expand with repeated glyphosate applications and displace non-glyphosate-resistant microbes. Because gene transfer between micro-organisms is common (Keese, 2008; McDaniel et al., 2010), if an intact *cp4 epsps* gene was incorporated into a micro-organism, the micro-organism might transfer the gene to other micro-organisms, resulting in a greater presence of the gene in the environment. The *cp4 epsps* gene was isolated from a naturally occurring bacteria nearly 20 years ago so it is possible that exchange of the *cp4 epsps* gene has been ongoing for decades. Given that gene transfer between plants and micro-organisms is thought to occur on an evolutionary time scale, there is not likely to be any incremental increase in gene transfer among micro-organisms under Alternative 2.

(2) Impacts on Micro-organisms from Herbicide Use

Under Alternative 2, potentially all of the approximately 1.1 million acres planted in sugar beets would receive applications of glyphosate. Also, Alternative 2 likely would result in the use of lower amounts of the numerous other herbicides used to control weeds in conventional sugar beet fields. As described in section III.B.1.f, much smaller quantities of the conventional herbicides would be used over much smaller areas compared with Alternative 1.

APHIS previously analyzed effects of glyphosate on soil micro-organisms in appendix N of the *Final Environmental Impact Statement for Glyphosate-Tolerant Alfalfa Events J101 and J163: Request for Nonregulated Status* (USDA-APHIS, 2010a). The results of that analysis are summarized here, and additional research is presented. Several types of micro-organisms produce aromatic amino acids through the shikimate pathway,[34] similar to plants. Because glyphosate inhibits this pathway, it could be expected that glyphosate would be toxic to micro-organisms. Contrary to expectations, older field studies show that glyphosate has little effect on soil micro-organisms, and, in some cases, field studies have shown an increase in microbial activity due to the presence of glyphosate, although the taxa of microbes responsible for increased respiration were not identified (USDA-FS, 2003).

Kremer and Means (2009) indicated shifts in soil microbial community composition that might or might not cause some adverse consequences in agricultural fields over the long term. They reported that roots of glyphosate-resistant corn and soybean treated with glyphosate were heavily colonized by *Fusarium*, a disease causing fungus, compared to non-glyphosate-resistant or glyphosate-resistant cultivars not treated with glyphosate. Similarly, Zobiole et al. (2010) reported increased root colonization by *Fusarium* spp. in response to glyphosate application to glyphosate-resistant soybeans. Kremer and Means (2009) also reported a reduction in pseudomonad spp., which are considered beneficial bacteria that produce antifungal chemicals as metabolites.

Powell and Swanton(2008) reviewed the studies that examined the effects of glyphosate on diseases associated with *Fusarium*, and cited greenhouse studies that have shown *Fusarium* growth to be stimulated by glyphosate. In their review of the literature, however, they found no direct evidence of glyphosate effects on either *Fusarium* abundance or *Fusarium*-related disease in field studies. EPA and others have concluded that based on chemical fate and toxicity, glyphosate is not expected to pose an acute or chronic risk to micro-organisms if label directions are followed (U.S. (U.S. EPA 1993c). Long-term soil studies following repeated applications of Roundup® agricultural herbicides in the field have shown no detectable adverse effects on soil microbes (Hart and Brookes, 1996; Olson and Lindwall, 1991). Investigations have shown that glyphosate is degraded by soil microbes so that even at high application rates, the soil microbial community is not affected (Haney et al., 2002) Ratcliff et al. (2006) applied glyphosate at different rates to a clay loam soil and a sandy loam forest soil in California to investigate potential changes in microbial community structure. When applied at the recommended field rate for a Ponderosa pine plantation (5 kg a.i. per hectare, or 3.65 lb a.e. per acre, which is over 3 times the rate applied to H7-1 sugar beets [1.125 lb a.e. per acre]), few changes in microbial community structure were observed. The authors concluded that the commercial formulation of glyphosate has

[34] The shikimate pathway is the biosynthetic sequence (or pathway) by which plants and micro-organisms (e.g., bacteria) generate the aromatic amino acids. The shikimate pathway is found only in micro-organisms and plants, never in animals.

a benign effect on soil microbial community structure when applied at the recommended field rate.

As described in section III.C.3.d.(1), one study of glyphosate on disease susceptibility of the Roundup Ready® sugar beet event T-120 observed mixed results in the greenhouse (Larson et al., 2006) but was not repeatable in the field (Larson, 2010). Thus the data from sugar beet are not consistent with an adverse effect of glyphosate on promoting disease susceptibility. Furthermore, sugar beet growers only use varieties that have been tested in the field for disease resistance.

In conclusion, information on the effects of herbicides on soil microbes and microbial communities is limited, and research to date appears to have focused on glyphosate. Some studies suggest that in some soils, glyphosate application might favor development of detrimental microbial species (or harm some beneficial microbes); however, to date there is no conclusive evidence linking applications of glyphosate to changes in soil microbial communities that have adverse effects on plants grown in those soils. Sugar beet growers only use varieties that are tested in the field for disease resistance so no increased incidence of disease in sugar beets is expected from glyphosate use on H7-1 sugar beets. Available information does not indicate that glyphosate would cause substantially greater adverse effects to soil micro-organisms than the other conventional sugar beet herbicides.

(3) Impacts on Micro-organisms from Crop Management Practices

As discussed in section III.B.1, H7-1 sugar beet growers generally use different conservation tillage practices (e.g., no till, row tillage, strip tillage) rather than conventional tillage, thus reducing the amount of tillage compared to Alternative 1. As mentioned in section III.B.1.d, after adopting H7-1 sugar beets (following deregulation in 2005), some growers have been using conservation tillage practices. Under conservation tillage systems, disruption or modification to the micro-organism's soil habitat from tilling would not occur as often. This reduction could lead to greater microbial activity, biomass, and diversity. Conservation tillage (e.g., no till, row tillage, strip tillage) preserves crop residue on the soil surface, which reduces erosion and promotes microbial populations (Kennedy et al., 2004). Drijber et al. (2000) reported an increase in microbial biomass in a no-till system. Also, Altieri (1999) has found that no-till systems increase the ratio of fungi to bacteria and provide for a more diverse population of soil microbes than does conventional tillage.

Sugar beet farmers that implement conservation tillage practices would minimize the potential impacts of tillage on micro-organisms. The percentage of farms that have been employing conservation tillage practices upon adopting H7-1 sugar beets varies between the sugar beet growing regions. As discussed in section III.B.1.c(2), in the Great Lakes region in 2010, nearly 25 percent of Michigan's sugar beet fields were planted into stale seedbeds (where fields are tilled in the fall and then left untouched the following spring when planting begins) as compared to less than 5 percent in 2006-2007 (Lilleboe, 2011). The introduction of H7-1 has allowed farmers the option of implementing varying methods of reduced tillage systems. In the Midwest region, ridge tillage (a type of conservation tillage practice) has been used on less than 1,000 acres, strip tillage (another conservation tillage practice) has been used on 1,800–2,500 acres in North Dakota and Minnesota combined, and no tillage is rarely used (Overstreet et al., 2011; Overstreet, 2011). Farmers in the Great Plains region generally have reported that strip tilling and H7-1 have worked well with strip tilling resulting in reduced wind erosion (Lilleboe, 2010). Similarly, in the Northwest region, some farmers have switched to strip tillage and have reported reduced wind erosion (Lilleboe, 2008). In the Imperial Valley, if H7-1 sugar beets are adopted, no conservation tillage is likely to be practiced because it would interfere with furrow irrigation as it is currently practiced.

c. Alternative 3 – Partial Deregulation

(1) Impacts on Micro-organisms from Exposure to the H7-1 Gene and Gene Product

Under Alternative 3, the potential for exposure to the H7-1 gene and gene product would not exist for micro-organisms in California and western Washington, as well as any areas where growers decide to plant conventional varieties, due to prohibitions on H7-1 sugar beet cultivation. For other locations under Alternative 3 where H7-1 sugar beets could be grown, lack of toxicity of the gene and gene product are expected as described under Alternative 2. Similarly, no HGT between H7-1 sugar beets and micro-organisms is expected.

(2) Impacts on Micro-organisms from Herbicide Use

Under Alternative 3, glyphosate would be the predominant herbicide applied in all sugar beet growing regions with the exception of the Imperial Valley. This herbicide use would result in the same potential for impacts as described for Alternative 2 for the Northwest and for Alternative 1 for the Imperial Valley.

(3) Impacts on Micro-organisms from Crop Management Practices

In those areas where H7-1 sugar beets are grown, the potential impacts on micro-organisms from tillage practices would be similar to Alternative 2.

In those areas where H7-1 sugar beets are not grown (California, western Washington, and areas where farmers choose to plant conventional sugar beets), or where farmers employ conventional tillage practices, the potential impacts on micro-organisms from tillage would be similar to Alternative 1.

3. Plants

a. Selection for Herbicide Resistance

As discussed in section III.C.3.a, herbicide-resistant weeds result from the selective effect of herbicides on plant populations. There are many practices that can delay herbicide resistance selection in weed populations. As a result, there are impacts relating to the development of herbicide resistance from growing any crop plant that requires herbicide control, whether or not that crop is a conventional breed or genetically engineered. Resistance has been selected in 197 different weed species and to 19 major categories of herbicides (Heap, 2011).

The use of H7-1 sugar beets has the potential to impact the selection of herbicide resistance in weeds due to the use of glyphosate as an herbicide, and not due to any properties of H7-1 sugar beet plants themselves.

The following sections analyze each alternative in terms of potential effects on the development of herbicide resistance in weed species as a result of growing H7-1 sugar beet seed or H7-1 sugar beet root crops. Because there are differences in herbicide usage between H7-1 sugar beet seeds and H7-1 sugar beet roots, the likelihood of developing herbicide resistance in weeds is also different. As a result, each alternative is discussed first regarding the impacts of H7-1 seed production, followed by a discussion of the impacts of H7-1 root production. The impacts of herbicide-resistant weeds in both agricultural and non-agricultural settings are discussed.

(1) Alternative 1 – No Action

H7-1 sugar beet seed production does not typically involve the use of glyphosate. As described in section IV.B.1.c, weed management in seed production fields after the adoption of H7-1 sugar beets has not appreciably changed because one of the parents in hybrid seed production lacks the H7-1 trait so it is not typically used for post-emergent weed control. Hence glyphosate use in seed production and other weed control measures such as seed bed preparation, crop rotation, hand weeding, and in-crop cultivation would remain similar amongst all the alternatives. Development of herbicide resistance from seed production is not likely to vary under each of the alternatives.

Breeder seed production would be an exception. Under Alternative 1, no changes are expected to hybrid seed production/ Glyphosate could no longer be used for post emergent weed control in breeder fields. Weed control measures such as seed bed preparation, crop rotation, hand weeding, and in-crop cultivation would remain unchanged. In contrast, with regard to impacts on development of herbicide resistance from sugar beet root production, Alternative 1 is expected to differ from the other alternatives.

The Willamette Valley in Oregon (the primary production region for H7-1 sugar beet seed) is used for seed production for many different kinds of seeds. As noted in section III.B.1c(2), a minimum of 5 years of rotation with non *Beta* crops are required for seed production fields (American Crystal Sugar Company, 2010; Loberg, 2010b) however, there are no rotation restrictions or requirements for steckling nurseries because no seed is produced and there is less concern with root diseases. Field herbicide history is also a factor taken into consideration.

Currently, no herbicide-resistant weeds have been identified as having originated in sugar beet seed production fields. This may be due to the fact that, as noted in section III. B.1.c(2), seeds are grown with a minimum rotation of 5 years. Under Alternative 1, essentially no change in herbicide is predicted for seed production compared to the other alternatives and no changes in the selection of herbicide resistant weeds in sugar beet seed production fields is expected between the alternatives

In contrast, with regard to impacts on selection of herbicide resistance from sugar beet root production, Alternative 1 is expected to differ from the other alternatives. The potential selection of weed resistance in the four impacted regions would change under Alternative 1 compared to deregulation (2005–2010).

Alternative 1 would reduce weed control options for all sugar beet growing regions in the United States. Before the introduction of H7-1 sugar beets, growers had difficulty controlling weeds in their regions due to the selection of weeds with resistance to conventional herbicides such as ALS inhibitors, ACCase inhibitors, PSII inhibitors, synthetic auxins, mitosis inhibitors and fatty acid synthesis inhibitors. As reported in table 3–9 for notable weeds of sugar beets, the planting of H7-1 sugar beets and the concurrent use of glyphosate as a preferred herbicide have vastly improved the control of many weed species, including weeds that have been identified as having conventional herbicide-resistant biotypes. (See section 3B.1.d.(4) for a description of why glyphosate controls weeds more effectively than non glyphosate herbicides.)

Growers in all regions that have adopted H7-1 sugar beets would need to resume using non-glyphosate herbicides to control weeds in sugar beet. Many weeds resistant to non-glyphosate herbicides have already been selected (see Table 3-25, table 3-26). Under Alternative 1, selection of weeds resistant to non glyphosate herbicides will continue to occur and existing resistant weeds will continue to grow, flower, and disperse. Such weeds, to name a few, include Kochia resistant to PSII inhibitors, ALS inhibitors, and synthetic auxins or Wild oat resistant to ACCase inhibitors, fatty acid synthesis inhibitors, ALS inhibitors, and mitosis inhibitors (Table 3-26). As described in section III.C.3.a, one of the major mechanisms that can act to delay the development of herbicide resistance in weed species is the use of herbicides with different mechanisms of action. Glyphosate affords growers with another herbicide mechanism of action to manage weeds that have been selected for resistance to non glyphosate herbicides (for a list, see Table 3-25). Glyphosate is seldom used in conventional sugar beets but is the predominant herbicide used on H7-1 sugar beets. Under Alternative 1, growers will have one less mechanism of action to use for weed control and consequently, selection of herbicide resistant weeds is expected to be greater under Alternative1 compared to Alternatives 2 and 3. With non-glyphosate herbicides, resistant biotypes of weeds are expected to be difficult to control (e.g., kochia).

As time goes on, weed seed banks will build up, resulting in unsustainable levels of weeds in sugar beet harvests. In certain regions such as the Northwest and Great Plains, sugar beet root production may become uneconomical and abandoned due to intense weed pressures (Sexton, 2010a). In areas where weed pressure is too high for conventional sugar beets to be economically viable, farmers could potentially lose both the use of glyphosate as a tool for combating weeds resistant to other herbicides and the use of sugar beets as a rotational crop. If the loss of sugar beet as a rotation crop results in fewer options for weed control (both mechanical and chemical) throughout the rotation, then herbicide selection for resistant biotypes could be faster than if those extra options were available.

(2) Alternative 2 – Full Deregulation

As discussed under Alternative 1, weed management in seed production fields has not substantially changed compared with methods utilized in the production of conventional sugar beet seed with the exception that glyphosate may be used for postemergent weed control in some breeder seed fields. These fields represent a small percentage of the seed production which itself only represents less than one percent of total sugar beet production. Thus under Alternative 2 sugar beet seed production is not expected to increase the potential for glyphosate-resistant weed development.

Under Alternative 2, H7-1 sugar beets could be adopted by farmers in the Imperial Valley region. Currently, no Roundup Ready® crops are reported in rotation with sugar beets in the Imperial Valley. Sugar beet rotation crops in California include alfalfa, durum wheat, sudan grass, Bermuda grass, onions for dehdration, lettuce, carrots, sweet corn, none of which have Roundup Ready® varieties except alfalfa (see table 3–6). However, in the Imperial Valley, growers have elected not to grow Roundup Ready® alfalfa there according to Forage Genetics International(International, 2011). APHIS assumes that the adoption of H7-1 sugar beets in California would result in the application of glyphosate to control weeds. As glyphosate would represent an herbicide with a different mechanism of action than is currently used, weed populations would change. Wild beet, lambsquarter, common mallow, sow thistle, canary grass, dodder, knotweed, and barnyardgrass are all problem weeds that occur in Imperial Valley sugar beet fields and that are known to be effectively controlled with glyphosate (Beet Sugar Development Foundation et al., 2011). Velvetleaf also occurs in California sugar beet fields and has some natural glyphosate tolerance and therefore may not be controlled by glyphosate applications. Imperial Valley Currently, *Conyza canadensis* and *C. bonariensis* are listed as glyphosate-resistant in California (Imperial Valley) but are not reported as sugar beet weeds (Heap, 2011). They are both listed as weeds in roadsides and orchards, which are the type of continuous environments believed to have resulted in some glyphosate-resistant weeds in other parts of the United States. These weeds can be controlled by cultivation and are therefore not expected to be problematic in California where conventional cultivation is also expected to be practiced should H7-1 sugar beets be adopted. Glyphosate resistant junglerice has been reported on two sites covering about 50 acres in CA and could potentially become a problem in H7-1 sugar beets (Heap, 2011). Glyphosate resistant johnsongrass has been reported in soybean fields in Arkansas and Louisiana (Heap, 2011) and could become a problem in H7-1 sugar beet fields should a glyphosate resistanyt biotype establish in sugar beet fields. Wild beets, *Beta macrocarpa*, are not a problem weed in any crop except sugar beets. In the United States they are principally found in the Imperial Valley. Many herbicides control wild beets in other crops and no herbicide resistance has developed in this species. Wild beet is not controlled by conventional herbicides used in sugar beets because it is so similar to sugar beet and herbicides that can kill it would also kill sugar beets. If H7-1 sugar beets are grown in California, glyphosate resistance is not expected to evolve in *B. macrocarpa* by herbicide selection but could conceivably result from gene flow of the H7-1 trait from bolting sugar beets into flowering *B. macrocarpa*. This occurrence is unlikely as described in section III.B.5 due to an almost complete lack of flower synchrony, and extremely limited compatibility between the two species. If it did occur, however, glyphosate would lose its effectiveness in controlling wild beet and there would be a return to the current control methods of hand weeding and use of alternate herbicides in crop rotation.

In the other four regions, H7-1 sugar beets have been widely adopted since initial deregulation (2005) and this has led to an increased use of glyphosate and decreased use of other herbicides. As discussed in section III.C.3, herbicide selection of resistant biotypes occurs most frequently when herbicides are used continuously without varying mechanisms of action. Specifically, resistance is expected to occur fastest (5 years or later) in cropping systems where the herbicide mechanism of action and crops are not rotated. As a result, selection of resistant biotypes have occurred in systems where a single herbicide is used across rotations, such as in orchards, vineyards, along roadsides, and in rotations between Roundup Ready® corn and Roundup Ready® soybeans.

Although no glyphosate-resistant weeds have been attributed to the production of H7-1 sugar beets and glyphosate resistant weeds are not currently a problem in sugar beets, H7-1 sugar beet production could create an environment where glyphosate-resistant weeds may establish following dispersal from other sources. This dispersal has been observed in several cases of glyphosate-resistant weeds. For example, recent reports document that glyphosate-resistant Horseweed (*C. Canadensis*), which originally occurred in the continuous cropping of Christmas trees, has recently been observed in a stale seed bed sugar beet field in the Great Lakes region (Sprague and Everman, 2011).

Furthermore, it could create a situation in certain regions such as the Midwest and Great Lakes where in a three crop rotation, all three crops would be RoundupReady®. While this situation is more likely to promote the selection and dispersal of glyphosate resistant weeds than a three crop rotation lacking a RoundupReady® crop, it is still preferable to a two crop rotation where both crops are RoundupReady® because the differences in cultivation practices and crop ecology help delay resistance. Furthermore, H7-1 allows an additional mechanism of action to be used for weed control. As discussed in section III.C.3, use of herbicides with different mechanism of action is one of the best practices that can delay the selection of resistant biotypes. If glyphosate resistant weeds were to become prevalent in sugar beets, combinations of herbicides with different mechanisms of action are expected to still provide effective control provided that the glyphosate resistant weed does not already carry resistance to multiple herbicides.

To estimate what possible weeds shifts could look like in H7-1 sugar beets in the future, APHIS conducted an analysis of known glyphosate-resistant weed species and their distributions in sugar beet production states. Initially, APHIS examined the distribution of glyphosate-resistant weed species in the states that produce sugar beet (Sprague and Everman, 2011); (table 4–20) and states that are immediately adjacent to sugar beet states. APHIS then noted if these resistant biotypes occurred in sugar beet or sugar beet rotation crops. APHIS then expanded the analysis of these glyphosate-resistant weeds by examining the distribution of additional biotypes of each species that have been noted as having biotypes that are resistant to conventional herbicides (see table 3–26) as well as the distribution of sensitive biotypes (USDA-NRCS, 2010). Finally, APHIS examined the distribution of all remaining glyphosate-resistant species that have occurred worldwide (Heap, 2011), noting if they have been identified as sensitive biotypes in any sugar beet states. Using a tiered system to qualitatively classify the different weed species identified in each of the five sugar beet production regions, APHIS identified weed species with potential to shift into H7-1 sugar beet or other glyphosate-resistant crops in rotation with H7-1.

Table 4–20 presents a distribution of resistant weeds broken down by the five root production regions that are discussed in section III.B.1.c(1) (Imperial Valley, Northwest, Great Plains, Midwest, and Great Lakes). The table also sorts the weeds into four tiers (1, 2, 3, and 4) that denote the relative risk of the weeds becoming problems under Alternative 2. This analysis is constrained by the accuracy in reporting the identification and presence of weed species by the sources available. APHIS acknowledges that it is possible that new weed species could become problems in the future. Additionally, a weed with lower ranking could achieve a higher rank over time. Tier 1 and 2 weeds have the highest risk of shifting into H7-1 sugar beets and tier 3 and 4 weeds have a lower risk of shifting into H7-1 sugar beets. Tier rankings are not exclusive; any given weed species may have different tier rankings depending on the current weed and crop situation in each State. As a result, any given weed species can have a different tier ranking in different States. All the weeds listed in table 4–20 have glyphosate-resistant biotypes.

The tiers in table 4–20 were defined as follows:

Tier 1: **Weeds that currently occur in rotation crops.** The greatest risk of a problematic weed is a weed species that has been identified as having a glyphosate-resistant biotype in a crop species that has been found in sugar beet or is found in a rotated crop with sugar beet in a sugar beet producing state. These species could reproduce in rotation crops, contribute to the seed bank, and germinate in H7-1 sugar beets. For example, a biotype of common ragweed (*Ambrosia artemisiifolia*) has been identified as a glyphosate-resistant weed in soybean production in North Dakota. If H7-1 sugar beets were rotated into that field, it is likely that the glyphosate-resistant ragweed biotype would be selected by glyphosate-treatment in that sugar beet field. To be classified as a tier 1

Table 4- 20. Qualitative Analysis of Potential Weed Shifts: Problematic Weeds in H7 1 Sugar Beets[1]

	Common Name	Species	Setting	Risk Tier	Adjacent State
Imperial Valley	Junglerice	*Echinochloa colona*	corn, orchards, roadsides	2	
	Johnsongrass	*Sorghum halepense*	Cotton, orchards	3a	
Northwest	Kochia	*Kochia scoparia*	wheat	3a	
	Common Waterhemp	*Amaranthus tubuerculatus* (syn. *rudis*)		3a	
Great Plains	Horseweed	*Conyza canadensis*	soybean	2	
			soybean, cotton	3b	OK, MO
	Kochia	*Kochia scoparia*	corn, wheat	3a	
			corn, cotton, cropland, soybean	3b	KS
	Common Waterhemp	*Amaranthus tuberculatus* (syn. *rudis*)	soybean	3b	KS, IA
	Giant Ragweed	*Ambrosia trifida*	corn, soybean	3b	IA
Midwest	Kochia	*Kochia scoparia*	cropland	1-2	
	Common Waterhemp	*Amaranthus tuberculatus* (syn. *rudis*)	soybean	1	
			corn, soybean	3b	IA
	Giant Ragweed	*Ambrosia trifida*	soybean	1	
			corn, soybean	3b	IA
	Common Ragweed	*Ambrosia artemisiifolia*	soybean	1	
Great Lakes	Horseweed	*Conyza canadensis*	nurseries, soybean, sugarbeet	1[2]	
			soybean	3b	IN, OH
	Common Waterhemp	*Amaranthus tuberculatus* (syn. *rudis*)	soybean	3a	
			soybean	3b	IN

Sources: (Heap, 2011); (Stachler et al., 2011); (Nandula et al., 2005); (Cerdeira and Duke, 2006); (Van Deynze et al., 2004)

[1] Qualitative analysis of potential weeds shifts in H7-1 sugar beet. Cells shaded grey indicate the weed biotype has resistance to glyphosate in the indicated State.

[2] Glyphosate resistant Horseweed has been identified in a sugar beet field in Michigan, but Horseweed is currently not considered a weed of sugar beet.

risk, the weed must meet all of the following criteria: the species is a weed of sugar beets, a glyphosate-resistant biotype is present in the sugar beet producing state, and this biotype occurs in a crop that is known to be in rotation with sugar beets. These weeds are listed in table 4–20.

In the Midwest region (Minnesota and North Dakota), APHIS identified four Tier 1 weeds including Common waterhemp (*Amaranthus tuberculatus*), Giant Ragweed (*Ambrosia trifida*), and Common Ragweed (*Ambrosia artemisifolia*) whose glyphosate resistant biotypes have been confirmed in these states, and Kochia (*Kochia scoparia*, whose glyphosate resistant biotype has been reported but not confirmed. All four resistant biotypes were reported in crops (corn/soybean) that are rotated with sugar beet. As a result, should these weeds ultimately end up in sugar beet fields, they would not be controlled by glyphosate and alternative methods would need to be employed. As a result of the glyphosate being used in two or more rotations, differences in the cultivation practices between crops, alternative herbicides, herbicide mixes, and mechanical removal of weeds will be important for reducing dispersal and selection of weed resistance.

In the Great Lakes region, glyphosate-resistant Horseweed (*C. canadensis*) has been identified in both a rotational crop (soybean) and a stale seed bed for sugar beet. However Horseweed has not been noted as a problem weed in sugar beet crops even though, in the Great Lakes, biotypes are present that are resistant to non glyphosate herbicides used on sugar beet (Heap, 2011). Horesweed is primarily a problem in areas where no-till is used and no-till has not yet been widely adopted in Michigan sugar beet production.

Tier 2: **Weeds that could occur following short distance dispersal**. The next greatest risk of a problematic weed is a weed species that infests sugar beet, has glyphosate-resistant biotypes in a sugar beet production state, but is currently found only in crops that are <u>not</u> in rotation with sugar beet. To be classified as a tier 2 risk, the weed must meet the following criteria: a glyphosate-resistant biotype is present in the sugar beet producing state in a crop that is not in rotation with sugar beet and the weed species is known to occur in sugar beets. APHIS is aware of two examples of a tier 2 risk. Glyphosate-resistant junglerice occurs in California in corn fields, orchards, and roadsides (Heap, 2011), none of which are rotated with sugar beets in the Imperial Valley, and junglerice is a weed in California sugar beet fields. Also, glyphosate-resistant horseweed occurs in soybean in Nebraska, but soybean is not rotated with sugar beets in that State. Horseweed could become a weed in H7-1 sugar beets that are grown with strip till.

Tier 3: This tier describes two types of situations that could potentially happen. We arbitrarily label them as 3a and 3b so as not to imply one situation is more likely than the other-that would depend on a number of factors such as the biology of the species, the distance between resistant biotypes and the sugar beet production area, and myriad farm practices.

- **Tier 3a: Weeds that could develop resistance elsewhere**. Here we assume that resistant biotypes could arise in a second locale if they have arisen in another. For example, Hairy Fleabane (*Conyza bonariensis*) biotypes have been selected for glyphosate resistance in South Africa, Spain, Brazil, Israel, Columbia, the US. Australia, and Portugal (Heap, 2011). Glyphosate resistant Hairy Fleabane is not expected to be a problem weed in sugar beets because it can be controlled by cultivation in the states where it occurs. To be classified as a tier 3a risk, the weed must meet the following criteria: demonstrated ability to develop glyphosate resistance somewhere, known weed in sugar beets, and sensitive or conventional resistance biotypes present in a sugar beet production state. These weeds are listed in table 4–20.

- **Tier 3b: Weeds that could be dispersed over long distances.** This risk of a problematic weed is determined by the presence of a biotype of a glyphosate-resistant weed species found in a neighboring state. Because some weed species are particularly adept at dispersal, rare instances of long distance dispersal or persistent movement over several years could ultimately result in the long distance dispersal of resistant biotypes across states. A weed is classified as a tier 3b risk if it is known to be a weed in sugar beet and glyphosate-resistant biotypes are present in a neighboring State. Glyphosate resistant Kochia and Waterhemp from Kansas, for example, could conceivably disperse into neighboring Nebraska.

Weeds that are naturally tolerant to glyphosate and occur as sugar beet weeds were also considered (table 3–26). As tolerance is not tracked in the same manner as resistance, information on the presence in a single crop (or rotation crop) is not available. As discussed in Alternative 1, there is evidence that many of these tolerant weed species are currently being at least partially controlled by glyphosate applications in H7-1 sugar beets. This is not a contradiction. Tolerance can be stage dependent where older plants are much less sensitive than younger plants. Perennials, which have underground reserves may be able to regrow a shoot that has been killed by the herbicide. Alternatively, tolerance may be based on plant structures, such as a waxy cuticle or dense hairs that prevent herbicides from reaching the leaf cells. High herbicide rates, early application, and herbicide additives like surfactants can sometimes overcome tolerance. Because these naturally tolerant weeds may be controlled by glyphosate, clearly some of the formulations of glyphosate can overcome natural tolerance. Examples where glyphosate does not routinely control naturally tolerant weeds in sugar beet include Velvet leaf

(*Abutilon theophrasti*), Lambsquarters (*Chenopodium album*), Nutsedge (*Cyperus* spp.), Large crabgrass (*Digitaria sanguinalis*), Filaree (*Erodium* spp.), Cheeseweed (*Malva parviflora),* Purslane (*Portulaca oleracea*), and Burning nettle (*Urtica uren*).

Alternative 2 would allow growers of H7-1 sugar beet varieties the option to control conventional herbicide-resistant weed biotypes with postemergent applications of glyphosate if they are present in sugar beet fields, and this in turn may reduce populations of these conventional herbicide-resistant biotypes in crops grown in rotation. If these biotypes were to develop resistance to glyphosate, alternative herbicides and continued monitoring and destruction of resistant weeds would be essential to preventing widespread dispersal of multi-herbicide-resistant weeds. Farmers are aware of the problems of glyphosate-resistant weeds and are proactive in the identification and removal of new weeds (see section III.C.3).

Under Alternative 2 growers would still have the currently available weed control methods (e.g., conventional herbicides and cultural practices described in section III.B.1.d) to manage any glyphosate-resistant weeds, whether they are present in sugar beets or other crop production fields.

In the Great Lakes, Midwest, Northwest, and Great Plains regions, H7-1 sugar beets could be used in rotation with other previously deregulated Roundup Ready® crops (e.g., corn and soybean) (see table 3–6). As a result, these regions contain fields where glyphosate use could occur in other rotation years. Repeated use of glyphosate could lead to the selection of glyphosate-resistant weed populations in these regions. However, crop rotations themselves can effectively delay the selection of resistant biotypes by changing planting, tillage, and other management practices. If Roundup Ready® volunteers or glyphosate-resistant weed biotypes occur in these regions, it is possible that farmers could alternate to rotational crops with other herbicide resistance such as glufosinate-resistant soybeans. Additionally, incentive programs designed to encourage use of herbicide mixtures (e.g., Roundup Ready PLUS™ program, Monsanto, 2011) may be used to delay resistance development by increasing the number of mechanisms of action selecting on weed populations.

Crop monitoring and follow up by academic and industry weed scientists in cases of suspected resistance are important parts of all herbicide stewardship programs. There is widespread information regarding combating glyphosate resistance available to sugar beet farmers from universities, crop commodity groups, and manufacturers.

In cases where weeds are not controlled with glyphosate, Monsanto/KWS SAAT AG refers questions on what products to use to the local extension expert because recommendations are region-dependent (Monsanto, 2011b).

Stachler et al. (2009c) recommend controlling glyphosate resistant common ragweed in sugar beets with a mixture of glyphosate and clopyralid (Stinger). Similarly, a mixture of Stinger and glyphosate is recommended to control glyphosate resistant giant ragweed (Stachler et al., 2009c). These herbicide combinations are expected to also control giant and common ragweed that is resistant to both glyphosate and ALS inhibitors which are known to exist in Minnesota (Stachler and Zollinger, 2009).

In farm scale experiments with sugar beets, (Heard et al., 2003a; Heard et al., 2003b) weed biomass and seed rain (seeds deposited to the soil) were lower for Roundup Ready® crops compared to conventional crops.

Changes in weed populations since the adoption of H7-1 sugar beets indicate that glyphosate has resulted in dramatic changes in the weed seed bank (Stachler et al., 2011). Because of the trends observed for weed reductions and improvement in weed control in the four regions where H7-1 sugar beets have been grown, APHIS believes that weed seed banks will diminish under Alternative 2. The possibility that glyphosate resistant weeds may appear in sugar beet fields could reverse this trend. Alternatively, the decline trend may be maintained by the use of additional herbicides with glyphosate to better manage glyphosate-resistant weeds.

In summary, APHIS has determined that adoption of Alternative 2 would result in different impacts in different regions. In the Northwest where weeds resistant to conventional herbicides are rampant and conservation tillage is practiced, Alternative 2 will provide a big benefit to weed control. In the Imperial Valley region, APHIS has determined that gene flow between H7-1 sugar beet and wild beet (*B. macrocarpa*) is unlikely due to asynchrony in flowering time and lack of cross compatibility. Adoption of H7-1 sugar beets will likely result in greater control of weed species and potentially a reduction in the weed seed bank of *B. macrocarpa* and weed species with resistance to non-glyphosate herbicides.

In the remaining four regions, improved weed control and changes in weed populations will continue. APHIS expects, due to crop rotation practices, use of sequential herbicides with different mechanisms of action, high awareness of farmers, and the contractual management practices outlined under the Monsanto TUG, that in the short term, selection for resistance as a result of H7-1 sugar beets is unlikely. Resistant weed populations will eventually need to be controlled in H7-1 sugar beet fields. Otherwise these weeds will grow to maturity and disperse to neighboring crops, non-agricultural lands, and contribute to the seed bank where they would impact future rotations.

All regions are expected to see a net decline in the development and dispersal of herbicide resistant weeds due to the introduction of an additional mechanism of action for weed management. A shift in the weed seed bank to include more glyphosate-resistant weeds is more likely under Alternative 2 compared to Alternative 1. However, management practices including the use of different herbicides with different mechanisms of action (either in mixes or sequentially), consistent crop rotation practices, and BMPs (both voluntarily adopted and contractually binding) can reduce and delay the evolution and spread of resistant weeds.

(3) Alternative 3 – Partial Deregulation

Under Alternative 3, the impacts on seed production are minimal because glyphosate is seldom used in seed production fields as described under Alternative 2.

For root production, the Great Lakes, Midwest, Great Plains, and Northwest regions would continue to experience the weed control observed over the past 5 years and described under Alternative 2. None of the permit conditions anticipated under Alternative 3 specifically impact herbicide-resistant weed management practices. In California, where H7-1 sugar beets would not be permitted, only the conventional weed management tools would be available. Impacts in those areas would be similar to those described for Alternative 1 where weed species with resistance to conventional herbicides would continue to be a problem for sugar beet farmers in the Imperial Valley.

b. Herbicide Impacts on Non-target Plants

(1) Alternative 1 – No Action

Under Alternative 1, there would be a rapid transition to greater use of the herbicides used on conventional sugar beets and much less use of glyphosate as H7-1 sugar beets are replaced with conventional sugar beets. Assuming that acreage stays constant into the future under Alternative 1, it is likely that use of glyphosate would return to preemergence use only on approximately 13 percent of the total sugar beet acreage, or 0.15 million acres (see tables 3-14 and 3-15 for expected herbicide use under Alternative 1).

Under Alternative 1, if farmers allowed the land to go fallow for a few years rather than immediately planting a conventional sugar beet variety (or a rotational crop), there would be no impacts on non-target terrestrial and aquatic plants as a result of herbicide drift, because no herbicides would be applied to the land during that time. If farmers immediately planted conventional sugar beets (or a rotational crop), there would be an increase in the use of non-glyphosate herbicides used on conventional sugar beets (or herbicides used on the rotational crop) compared with current (2010) use rates, because as of 2010, the majority of farmers (95 percent) had adopted glyphosate-resistant sugar beets. Under Alternative 1, all of the sugar beet acreage, approximately 1.18 million acres, would require treatment with conventional sugar beet herbicides at conventional rates. Thus, incidental exposure of nearby non-target terrestrial and aquatic plants to those herbicides could occur over larger areas than in 2010.

The potential impacts of Alternative 1 on specific non-target terrestrial plant species depends on the herbicides that are used on conventional sugar beets and how and when they are applied. The conventional herbicides generally target either particular groups of plants, such as broadleaf weeds (dicots) or grasses (monocots), or taxonomically related weeds within those groups. Table 3–11 in section III.B.1.d lists the general targeted weed groups or species for each of the 13 herbicides used on conventional sugar beet herbicides. Potential impacts on terrestrial and aquatic non-target plants of using those herbicides on conventional sugar beet fields under Alternative 1 are discussed below.

The toxicities of the 13 herbicides used on conventional sugar beets to non-target plants are presented in table 4–21. The U.S. EPA's OPP generally requires toxicity data for one or more representative dicots and one or more representative monocots for herbicide registration and reregistration. EPA OPP does not categorize toxicity severity levels for plants, however. The toxicity values presented in table 4–21 for dicots and monocots broadly correspond to the target plant groups for each herbicide noted in tables 3–11 and 4–7, with exceptions for the selective herbicides.

For terrestrial plants, EPA OPP evaluates two endpoints: seedling emergence and vegetative vigor (i.e., measures of plant growth). For each type of test, EPA OPP evaluates at least one monocot (e.g., a grass) and at least one dicot (i.e., broad-leaf plant). Two toxicity metrics are identified: EC_{25} and EC_{05} or no-observed effect level (NOEL. The EC_{25} is the effective concentration for inhibiting seedling emergence or plant growth by 25 percent. The EC_{25} is used to assess the potential for adverse impacts on non-listed non-target plants in the vicinity of agricultural fields. The EC_{05} is the effective concentration for inhibiting seedling emergence or plant growth by only 5 percent. If a NOEL value was not determined, the EC_{50} can be used instead. The EC_{05}/NOEL values are used to assess the potential for adverse impacts on listed plants in the vicinity of agricultural crops.

Table 3–15 shows that clopyralid, desmedipham, phenmedipham, and triflusulfuron-methyl were the herbicides most widely used (in terms of acreage treated) on conventional sugar beets in 2000. These four herbicides are applied *postemergence* an average of 2.6 to 2.8 times per season. As noted in table 4–7, desmedipham and phenmedipham were designed for and are used almost exclusively on sugar beets (98–100 percent of total amount used in the United States annually) to control broadleaf weeds. Sugar beets, which also are dicots, are less affected at the application levels used to kill target weeds, because sugar beets rapidly detoxify the parent herbicides, whereas the target dicots do not. Several groups of dicots are more sensitive to clopyralid (e.g., thistles, knapweeds) and to triflusulfuron-methyl (e.g., kochia, mustards) than are sugar beets. Thus, postemergence application of these four herbicides can be used to kill the targeted weeds in sugar beet fields.

Table 3–52 and table 3-53 list several of the characteristics of the herbicides that can influence the likelihood of drift and runoff. Two of the herbicides, EPTC and ethofumesate, have essentially no potential for drift because they are incorporated into the soil at application. Eptam® (EPTC) must be disked several inches into the soil for application owing to its high volatility. Ethofumesate also is applied to the soil. The remaining herbicides generally are applied to conventional sugar beets via bands or broadcast spray (see section III.B.1.d). These herbicides should have, therefore, similar chances of drift beyond the sugar beet fields at the time of an application. The herbicides applied more often (e.g., 2.5 to 2.8 times per season for clethodim, clopyralid, desmedipham, phenmedipham, and triflusulfuron-methyl) have more chances per season for drift to occur.

Table 4–7 indicates that the method of application for clopyralid, desmedipham, phenmedipham, and triflusulfuron-methyl is typically in bands or broadcast using a ground sprayer (e.g., boom situated near the ground). However as much as 14% of the post emergent herbicide applications are applied aerially (Stachler et al., 2011). Compared to aerial application, applying herbicides near ground level reduces the potential of herbicide drift into non-target areas. Nonetheless, some degree of herbicide drift during application is possible. The five post emergent non glyphosate herbicides applied 2-3 times per season pose the highest risk of impacts on non-target plants due to the large proportion of sugar beet fields treated with these herbicides (46%-94%) and the multiple treatments per growing season, with some risk of drift at each application. These five herbicides can impact both non-target *broadleaf* terrestrial

Table 4- 21. Herbicide Toxicity Values for Terrestrial Non-Target Plants

Active Ingredient	Seedling Emergence			Vegetative Vigor		
	NOEL or EC_{05} (lb a.i./A)[1]	**EC_{25} (lb a.i./A)[1]**	**Species (Dicot, Monocot)**	**NOEL or EC_{05} (lb a.i./A)[1]**	**EC_{25} (lb a.i./A)[1]**	**Species (Dicot, Monocot)**
Clethodim	>0.25 0.004	>0.25 0.0063	Dicot Monocot	>0.25 0.003	>0.25 0.003	Dicot Monocot
Clopyralid	ND	ND	ND	0.09 LOEL 0.09 LOEL	ND ND	Spinach Bluegrass
Cycloate[2]	ND	ND	ND	2.0 LOEL 3.0 LOEL	ND ND	Spinach Bristlegrass
Desmedipham	0.15 0.30	0.31 0.58	Tomato Onion	1.22 ND	>1.22 ND	Lettuce ND
EPTC[3]	ND 0.017	ND 0.10	ND Wild oats	0.23 NU	NU 0.22	Velvet leaf Winter wheat
Ethofumesate (43.8% a.i.)	0.031 0.16 0.08	0.40 0.17 0.15	Tomato Lettuce Wheat	0.06 0.08 0.06	0.22 1.04 0.24	Tomato Lettuce Wheat
Glyphosate TGAE	ND ND	>5 >5	Dicot Monocot	ND ND	0.074 0.16	Dicot Monocot
Phenmedipham[4]	NA	NA	NA	0.5 NOEL 0.5 LOEL	ND ND	Spinach Grasses
Pyrazon TGAI	0.008 0.022	0.035 0.117	Cabbage Rye grass	0.009 0.057	0.033 0.141	Cucumber Rye grass
Quizalofop-p-ethyl[5]	ND	ND	ND	ND	ND	ND
Sethoxydim TGAI	ND ND	ND ND	ND ND	ND 0.025	>0.47 0.029	Dicot Ryegrass

Table 4–21. (continued)

	Seedling Emergence			Vegetative Vigor		
Active Ingredient	NOEL or EC_{05} (lb a.i./A)	EC_{25} (lb a.i./A)	Species (Dicot, Monocot)	NOEL or EC_{05} (lb a.i./A)	EC_{25} (lb a.i./A)	Species (Dicot, Monocot)
Trifluralin	2 0.13	4 0.33	Cabbage Onion	0.25 0.125	0.80 1.1	Cucumber Corn
Triflusulfuron-methyl[5,6]	>0.0001 ND ND	ND 0.0096 0.0165	Sorghum Turnip Onion	0.000030	0.00052 0.00063 0.00035	Sorghum Pea Broomcorn

Sources: EPA OPP RED documents and EPA OPP Ecological Fate and Effects Division (EFED) ecological risk assessment documents available from the herbicide dockets unless noted otherwise. The lowest value from among the different dicot or monocot species tested was used to represent dicot and monocots for this table, respectively.

[1] Unless otherwise noted in row header as acid equivalent (AE or a.e.) instead of active ingredient (AI or a.i.).

[2] Data from EPA ECOTOX as NOEL/LOEL data only; no testing specifically for EPA's Office of Pesticide Programs.

[3] EPTC – Users must obtain information to identify any endangered or threatened plant species of concern that might be found in areas adjacent to crops treated with EPTC.

[4] EPA's ECOTOX database.

[5] No data for terrestrial plants available for quizalofop-p-ethyl; studies submitted to EPA were considered unacceptable and new data have been requested from the registrant.

[6] NOEL values from Health Canada (1999) and EC_{25} values from EPA's ECOTOX, with exception of sorghum, for which EC_{25} for vegetative vigor is from Health Canada (1999).

Abbreviations: A = acre; ND = no data available; NA = data might exist but are not available from EPA online; archived to disks; TGAE = technical grade acid equivalent; TGAI = technical grade active ingredient; NU = not used by EPA OPP in risk assessment because plant yielding the lowest EC_{25} did not yield the lowest EC_{05}; EC_{25} = effective concentration for 25% inhibition of seedling emergence or plant growth; EC_{05} = effective concentration for 5% inhibition of seedling emergence or plant growth; NOEL = no-observed-effect level, generally bounded by a LOEL; however, LOEL values not listed in RED or ecological risk documents.

plants and grasses adjacent to sugar beet fields. Of these five herbicides, triflusulfuron-methyl is the most toxic to terrestrial plants. Under Alternative 1, the chance of herbicide drift is greater than under Alternative 2 because more frequent herbicide applications are made and the percentage of applications made aerially is greater.

Because conventional sugar beet plants also are sensitive to the effects of glyphosate, the herbicide is used only preplant or preemergence for conventional sugar beets, primarily to eliminate weeds present at that time (see table 4–7). Thus, under Alternative 1, the opportunity for glyphosate drift affecting nearby terrestrial plants would be limited to the beginning of the growing season as well as limited geographically to approximately 13 percent of total sugar beet acreage.

Table 4–22 below compares the potential of the different herbicides used on conventional sugar beets to impact non-target dicots and monocots in the vicinity of a sugar beet field if drift occurs at the time of application.

The basis of the exposure comparison is the maximum single application rate allowed on sugar beets at some point in the season (e.g., preemergence for glyphosate, postemergence for clethodim). For ease of comparison, the application rates are normalized to the glyphosate maximum allowed single application rate preplant on conventional sugar beets, which is estimated to be 4.5 lb a.i. per acre. This estimate is based on the maximum total glyphosate allowed preemergence for H7-1 sugar beets, which is 3.7 a.e. per acre total preemergence or approximately 4.5 lb a.i. per acre depending on the exact salt used in the formulation (see table 3–13). The annual limit of 7.32 lb a.i. per acre for H7-1 sugar beets does not apply to Alternative 1, because glyphosate is not applied postemergence on conventional sugar beet fields.

The bases for the toxicity comparison among herbicides are the EC_{25} values listed in table 4–21. The lowest EC_{25} values listed in table 4–21 for the herbicide for a dicot and for a monocot are included in table 4–22, whether for seedling emergence or vegetative vigor. No observed effect levels (NOELs) or EC_{05} values (effective concentration for a 5 percent change in the endpoint relative to controls) are not used to compare toxicity of the herbicides because estimation of NOEL values depends on spacing of the exposure levels and because a 5 percent effect level is a more uncertain value (near the lower limit of observed data) than a 25 percent effect level, which generally falls within the observed exposure-response data for the toxicity tests. Relative risk (RR) is estimated in table 4–22 as the product of an herbicide's maximum relative single application rate and its relative toxicity.

Table 4- 22. Relative Risk to Non-target Terrestrial Plants of Herbicides Used on Conventional Sugar Beets Relative to Glyphosate Under Alternative 1[1]

Herbicide	**Max[2] Single App. Rate (lb a.i./acre)**	**(A) Max [3] Single App. Rate Relative to Glyphosate**	**Lowest EC_{25} Value[4] (lb a.i./acre)**		**(B) Toxicity Relative to Glyphosate[5]**		**Relative Risk[6] RR = (A) x (B)**	
			Dicot	**Monocot**	**Dicot**	**Monocot**	**Dicot**	**Monocot**
Clethodim	0.25	0.056	0.25	0.0030	0.36	65.07	0.020	**3.6**
Clopyralid	0.67	0.148	0.09	0.09	1.00	2.17	0.149	0.32
Cycloate	4.00	0.889	2	3	0.05	0.07	0.040	0.058
Desmedipham	1.26	0.280	0.31	0.58	0.29	0.34	0.082	0.094
EPTC	4.60	no drift[7]	ND	0.1	ND	1.95	0[7]	0[7]
Ethofumesate	3.75	no drift[7]	0.17	0.15	0.53	1.30	0[7]	0[7]
Glyphosate[8]	4.50	1.000	0.090	0.195	1.00	1.00	1.00	1.00
Phenmedipham	1.01	0.224	0.5	0.5	0.18	0.39	0.041	0.088
Pyrazon	7.30	1.622	0.033	0.12	2.7	1.67	**4.4**	**2.7**
Quizalofop-p-ethyl	0.08	0.018	ND	ND	ND	ND	ND	ND
Sethoxydim	0.47	0.104	ND	0.029	ND	6.73	ND	0.70
Trifluralin	0.75	0.167	0.80	0.33	0.11	0.59	0.019	0.10
Triflusulfuron-methyl	0.03	0.007	0.00052	0.00035	174	557.71	**1.2**	**4.0**

Sources: Listed by column header endnote.

1 Unshaded rows for herbicides used preemergence on conventional sugar beets; shaded rows for postemergence use herbicides.

2 Maximum single broadcast (near ground-level) application rate allowed from table 4–7.

3 Application rates relative to glyphosate = maximum single application for herbicide (pre- or postemergence) divided by maximum single application for glyphosate when used post emergence.

4 Lowest EC_{25} value in table 4–21 for the chemical and type of plant (i.e., some toxicity values are for seedling emergence, while others are for vegetative vigor).

5 Estimated as ($1/EC_{25}$) for the herbicide divided by ($1/EC_{25}$) for glyphosate.

6 Because glyphosate is the herbicide used to normalize application rates and toxicity, its relative risk value = 1.00. Values in bold indicate herbicides that pose higher risks of impacts on non-target plants adjacent to sugar beet fields than does glyphosate assuming the same application method and assuming that the chemical characteristics that might influence drift are the same among the herbicides for this comparison. Bolded values for herbicides with preemergence RR greater than glyphosate.

7 Herbicide soil-incorporated at application; assume no drift.

8 Glyphosate toxicity values based on lb a.e./acre in table 4–21 have been converted to the equivalent toxicity values in lb a.i./acre assuming that the mass of the a.i. is on average (i.e., across the types of salts used) 1.22 times higher than the mass of the a.e. (Hartzler et al., 2006).

Abbreviations: Max = Maximum. App = Application. lb a.i. = pounds of active ingredient. ND = no data. RR = relative risk.

As indicated in table 4–22, if drift occurs, a single maximum application of pyrazon has an RR value 4.4 times higher than glyphosate for adverse effects on non-target dicots that have already emerged or are growing at that time. Triflusulfuron-methyl has an RR value 1.2 times higher than glyphosate for non-target dicots. The remaining herbicides, if applied preemergence at the maximum allowed rate for a single application, have similar or lower RR values than the RR for glyphosate for dicots. Also as indicated in table 4–22, of the herbicides used preemergence, a single maximum application of pyrazon has an RR value 2.7 times higher than glyphosate for adverse effects on non-target monocots that have already emerged or are growing at that time. Triflusulfuron-methyl and clethodim have RR values of 4.0 and 3.6 times higher than glyphosate, respectively for non-target monocots. The remaining herbicides used preemergence have RR values for monocots similar to or lower than the RR value for glyphosate. Of the herbicides that have higher RR values than glyphosate, trisulfuron methyl was used on 83% of sugar beet acres in 2000, pyrazon was used on 6%, and clethodim was used on 43%. Therefore at least two of these herbicides are expected to be widely used on sugar beet under Alternative 2.

Under FIFRA, EPA carefully regulates pesticides to ensure that they do not pose unreasonable risks to human health, the environment, or non-target species when used as specified on the product label. The RR values are based on the assumption that the method of application (e.g., broadcast equipment, droplet size, and height above ground) and any chemical characteristics that might influence drift are the same across the herbicides, with the exceptions of EPTC and ethofumesate, both of which are assumed not to drift during application because they are incorporated into the soil.

Under Alternative 1, sugar beet fields also generally require conventional tillage to ensure weed control. Conventional sugar beet tillage (which can be performed in fall and spring) improves soil structure for seedling emergence and growth, eliminates early weeds, and reduces erosion risk from compacted soils (see section III.E.2.a). Conventional fall tillage is the primary tillage event (using moldboard plows or heavy disks) followed by one or more secondary tillage(s). To minimize overwinter erosion, farmers must try to retain adequate residues on the soil surface to prevent erosion or must try to use compatible cover crops for erosion control. In the spring, some tillage generally is required for early weed control, incorporating pesticides into the soils, and to improve soil texture for planting seeds (see section III.B.1). In the spring, farmers need to keep tillage to a minimum to maintain residues on top of the soil to reduce erosion and the chances of wind damage to fragile sugar beet seedlings as they emerge (Cattanach et al., 1991). Conventional tillage results in 100 percent soil disturbance (USDA-NRCS, 2008). Downgradient erosion of top soils can introduce agricultural chemicals into nearby non-target environments with various effects on terrestrial plants (e.g., excessive nutrients, exposure to fungicides, insecticides, herbicides). It is not possible to quantify such effects nationwide as each location would differ in one or more attributes that would influence the likelihood or severity of impacts on non-target terrestrial plants adjacent to conventional sugar beet fields.

The potential impacts of Alternative 1 on aquatic plant species (all are non-target) depends on the type of herbicide and on the type of aquatic plant. Table 4-23 below presents toxicity values for aquatic plants for the herbicides used on conventional sugar beets. Possible routes of aquatic plant exposure to herbicides are spray drift over nearby surface waters, inadvertent direct overspray, wind transport of soil particles loaded with adsorbed herbicide, runoff of surface waters containing the herbicide, or leaching of the herbicide into drainage systems (Borggaard and Gimsing, 2008; U.S. EPA 2006a). Each of the herbicides exhibit somewhat different chemical and physical characteristics that affect their potential mobility in the environment, as discussed in section III.E.4.d (e.g., water solubility, half-life, adsorption coefficient). For herbicides that are particularly toxic to aquatic organisms, EPA imposes specific label use restrictions, such as “Avoid direct application to any body of water.” Federal law requires herbicides to be used in accordance with the label.

Table 4–23 below also compares the potential of the different herbicides used on conventional sugar beets to impact aquatic plants in the vicinity of a sugar beet field if drift and runoff occur. Estimated environmental concentrations of the herbicides were based on the assumption that a 1-acre pond, 6 feet deep receives 5 percent drift from a 1-acre field and 5 percent runoff from a 10-acre field ollowing application at the maximum rate allowed for a single application (Monsanto/KWS, 2010).

The toxicity of the herbicides to the most sensitive and least sensitive aquatic plant tested (one or more of five algal species and duckweed, a small floating dicot), is expressed as a water concentration of the herbicide active ingredient. Specifically, EPA OPP uses the effective concentration at which algal or duckweed growth is inhibited by 50 percent compared with controls (EC_{50}) as the endpoint by which to evaluate aquatic plant toxicity for non-listed species. Those data are presented in table 4–23, too.

Toxicity data for the end-use formulated products generally are not readily available, thus this analysis is a comparison based solely on the active ingredients. Any label warnings and other available hazard and/or risk descriptions for non-target aquatic species are also included. A risk quotient (RQ) was determined for each active ingredient by dividing the EEC by the toxicity (EC_{50}) value. If the RQ value exceeds 1.0, the EPA considers the potential risk to pose risks of concern for non-listed aquatic plants.[35] The RQs for glyphosate are among the lower of the RQs for aquatic plants. The RQ exceeded 1.0 for desmedipham, pyrazon, and trifluralin, and those values are highlighted in bold in the table. Under Alternative 1, applications of each of these herbicides could pose risks to aquatic plants nearby sugar beet fields.

The USDA–NRCS maintains an online Pesticide Active Ingredient Rating Report (PAIRR) in which it ranks pesticide active ingredients by several characteristics, including the potential for runoff from agricultural fields either in solution or adsorbed to fine soil particles. Those rankings, and values for water solubility and K_{oc}, which are chemical-physical properties that influence environmental fate and transport, are listed in table 3–53). Cycloate, ethofumesate, and glyphosate are ranked as having a high potential for runoff in solution. Glyphosate, quizalofop-p-ethyl, and trifluralin are ranked as having a high potential for runoff adsorbed to particles. Therefore, glyphosate is ranked as having a high potential for runoff both in solution and adsorbed to soil particles. Many other factors also influence the likelihood of significant runoff events including rain and storm frequency and intensity in a geographic region, gradient (slope), soil texture, soil cover, stage of planting, and others. On the other hand, glyphosate dissipates more rapidly in surface water than most other herbicides. (For more information on herbicide transport to surface waters, see section III.E.)

An additional impact of Alternative 1 to aquatic plants and organisms in general is use of conventional tillage, which disturbs 100 percent of the soil and generally results in more soil erosion than conservation tillage practices. Runoff of herbicides, fertilizers, other chemicals, and soil particles to nearby surface waters is higher, sometimes much higher, under conventional tillage practices than under conservation tillage practices (see section III.E.4.c). Fertilizer runoff can cause substantial algal blooms followed by death of algae and other organisms, resulting in depletion of water oxygen as the bacteria process dead tissues. Algal blooms can be followed by fish kills due to the water anoxia that follows the bloom die-off. Runoff of soil particles into surface waters generally increases water turbidity and reduces water clarity, which can alter aquatic plant community structure, sometimes substantially. It is not possible to

[35] http://www.epa.gov/oppefed1/ecorisk_ders/toera_risk.htm#Deterministic

Table 4- 23. Comparison of Potential Effects of Glyphosate and Sugar Beet Herbicides on Aquatic Plants (Algae and Duckweed).

Herbicide Active Ingredient	Max Single App Rate (lb a.i./acre)	EEC[1] (ppm)	Aquatic Plant[2] EC_{50} (mg a.i./L) (low/high)	Aquatic Plant Risk Quotient (RQ)[3] (worst/best)	Classification / Label Warnings
Clethodim	0.25	0.003	1.34; >11.4	0.0023; <0.0003	May pose a hazard to federally designated endangered species of Solano Grass and Wild Rice
Clopyralid	0.67	0.008	6.9; ND	0.001; ND	
Cycloate	4.0	0.135	ND; ND	ND; ND	
Desmedipham	1.26	0.040	0.044; >0.33;	0.909; 0.123	
Glyphosate Pre **Glyphosate Post**	3.0 1.37	0.10 0.038	14.5; 14.8 0.8; 38.6	0.007; 0.007 0.047; 0.001	
EPTC	4.6	0.141	1.36; 41	0.104; 0.003	
Ethofumesate	3.75	0.121	>2.76; >39	<0.003; <0.044	
Phenmedipham	1.01	0.020	0.19; >0.32;	0.106; <0.064	Toxic to fish and aquatic organisms
Pyrazon	7.3	0.246	0.17; >4.6;	**1.441;** <0.053	
Quizalofop-p-ethyl	0.0825	0.006	>0.082; >1.77	<0.069; <0.004	Toxic to fish and aquatic organisms
Sethoxydim	0.47	0.016	>0.27: >5.6	0.059; <0.003	Toxic to aquatic organisms
Trifluralin	0.75	0.024	0.015; 5.0	0.005; **1.6**	Extremely toxic to freshwater, marine, and estuarine fish and aquatic invertebrates, including shrimp and oyster
Triflusulfuron-methyl[4]	0.03	0.0027	0.0028; 0.123	0.96; 0.022	

Sources: Identified by endnote for column header.

[1] EEC values as reported by Monsanto 2010, table 4-3. Assumes that a 1-acre pond, 6 feet deep receives 5 percent drift from a 1-acre field and 5 percent runoff from a 10-acre field.

[2] Aquatic EC50 values obtained from the 2010 EPA Ecotoxicology One-Line Database except for the values of phenmedipham which are from the Reregistration Eligibility Decision (RED) for phenmedipham (U.S. EPA 2005g).

[3] Risk Quotient (RQ) = EEC/EC_{50}; RQ **bolded** if >1.0 = Level of Concern for non-listed aquatic plants for EPA's Office of Pesticide Programs (http://www.epa.gov/oppefed1/ecorisk_ders/toera_risk.htm#Deterministic).

[4] Toxicity values are from the Regulatory Note REG99-03 from the Pest Management Regulatory Agency of Canada

Abbreviations: EEC = Estimated Environmental Concentration; ND = no data; EC_{50} = concentration resulting in 50% growth inhibition as measured by cell count for algae and dry biomass or fronds for duckweed.

quantify such effects nationwide, because each location would differ in one or more attributes that would influence the likelihood or severity of impacts on nearby non-target aquatic plants.

In summary, under Alternative 1, there would be a rapid transition to greater use of the non glyphosate herbicides used on conventional sugar beets and much less use of glyphosate. There are several reasons to expect the potential risk to non target plants to be greater under Alternative 1 compared to Alternative 2. First, non glyphosate herbicides are expected to be sprayed more frequently than is glyphosate under Alternative 2. Second, aerial applications are expected to be more frequent under Alternative 1 than under Alternative 2. The increased frequency of spraying and the greater use of aerial spraying is expected to increase the likelihood of drift thereby increasing exposure of non-target plants to herbicide. Third, under Alternative 1, tillage is expected to be greater than under Alternative 2. Tillage is expected to increase runoff and erosion of soil that also can increase the exposure of herbicides into nearby non-target environments. Fourth, at least three of the post emergent herbicides used under Alternative 1, clethodim, trisulfuron-methyl, and pyrazon, are expected to pose greater risk to non target terrestrial plants than is glyphosate. For aquatic plants, desmedipham, pyrzaon, and trifluralin are expected to pose greater risk to aquatic plants than is glyphosate. Desmedipham, clethodim, and trisulfuron-methyl are expected to be widely used in all sugar beet fields under Alternative 1. Therefore the risk to non target plants is expected to be greater under Alternative 1 because both the hazard and the exposure are greater than under Alternative 2.

(2) Alternative 2 – Full Deregulation

Alternative 2 would result in the use and application of glyphosate-based herbicide formulations on 95 percent of total sugar beet acreage (approximately 1.1 million acres) in the short term and approach 100 percent of sugar beet acreage in the long term (approximately 1.2 million acres). Expected herbicide use under Alternatives 2-3 is shown in table 3-18 which based on data from year 2010 where 95% of sugar beets grown in the U.S. were H7-1. Use of non glyphosate herbicides would still occur, but at about 10% of the amounts used under Alternative 1. Table 4-3 in section IV.B.1.e shows that, as a result of deregulating H7-1 sugar beets in 2005, use of the non glyphosate herbicides on sugar beets has declined substantially, while use of glyphosate has increased from 86,000 lb per yr in 2000 to over 2.5 million lb per yr in 2010. Under Alternative 2, glyphosate is expected to be applied on average 2.5 times per year, with 1.4 applications on postemergence sugar beet plants. In comparison, under Alternative 1, post emergent applications are usually made 2-3 times. Note, however, that the maximum application rate of glyphosate postemergence on H7-1 sugar beets is more than three fold less than pre emergence or 1.37 lb a.i. per acre (1.125 a.e. per acre) compared to 4.5 lb.

a.i.per acre for pre emergent applications. This change in application rate will change the relative risk of the herbicides normalized to glyphosate. Values are recalculated in table 4-24. The result is qualitatively similar to that reported in table 4-22, but the differences between glyphosate and the herbicides that pose greater potential risk to non target plants are greater because glyphosate is being used at a lower relative concentration. Pyrazon (14.6) and trisulfuron-methyl (4.1) are expected to pose greater risk to dicots than is glyphosate. Clethodim (12), pyrazon (8.9), and trisulfuron-methyl (13) are expected to pose greater risks to monocots. One additional herbicide, sethoxydim (2.3), is expected to pose greater risks to monocots. Under Alternative 2, the use of these non glyphosate herbicides are expected to be reduced about 90%. Thus fewer impacts from the non glyphosate herbicides are expected under Alternative 2 compared to Alternative 1.

The RR values are based on the assumption that the method of application (e.g., broadcast equipment, droplet size, and height above ground) and any chemical characteristics that might influence drift are the same across the herbicides. (For the preemergence herbicides EPTC and ethofumesate, the potential for drift is considered negligible because they are soil-incorporated at application.) Under FIFRA, EPA carefully regulates pesticides to ensure that they do not pose unreasonable risks to non-target plants when used as specified on the product label.

A survey of sugar beet growers in Minnesota, North Dakota, and Montana in 2009 showed that glyphosate applied to glyphosate-tolerant sugar beets is almost always broadcast with a ground sprayer (Stachler et al., 2011), b). Stachler et al. (Stachler et al., 2011) reported that, for those sugar beet acres represented in their survey, glyphosate was broadcast-applied by air on only 3 percent of the acreage in Minnesota and eastern North Dakota. The potential for spray to drift outside of the boundaries of the sugar beet field is lower when applying glyphosate with a ground sprayer (e.g., 1 percent) than by air (e.g., 5 percent, possibly higher). Non-target plants immediately adjacent to sugar beet fields would have the greatest risk of receiving spray drift. To mitigate potential adverse effects due to glyphosate drift during applications, EPA has imposed specific label use restrictions for its use, including “the product should only be applied when the potential for drift to adjacent sensitive areas (e.g., residential areas, bodies of water, known habitat for threatened or endangered species, non-target crops) is minimal (e.g., when wind is blowing away from the sensitive areas).”

Under Alternative 2, any surface waters in the vicinity of H7-1 sugar beet fields might on occasion receive glyphosate from drift during application or surface runoff during rain or storm events. Table 3-53 above indicates that USDA–NRCS rates glyphosate as having a high potential for runoff

Table 4- 24. Relative Risk to Non-target Terrestrial Plants of Herbicides Used on H7-1 Sugar Beets During Growing Season (i.e., postemergence) Under Alternative 2[1]

Herbicide	Max[2] Single App. (lb a.i./acre)	(A) Max [3] Single App. Relative to Glyphosate	Lowest EC_{25}[4] Value (lb a.i./Aacre)		(B) Toxicity Relative to Glyphosate[5]		Relative Risk[6] RR = (A) x (B)	
			Dicot	Monocot	Dicot	Monocot	Dicot	Monocot
Clethodim	0.25	0.182	0.250	0.003	0.36	65.07	0.066	**12**
Clopyralid	0.67	0.487	0.090	0.090	1.00	2.17	0.49	**1.1**
Cycloate	4.00	2.92	2.0	3.0	0.05	0.07	0.13	0.19
Desmedipham	1.26	0.92	0.31	0.58	0.29	0.34	0.27	0.31
EPTC	4.60	no drift[7]	ND	0.10	ND	1.95	0[7]	0[7]
Ethofumesate	3.75	no drift[7]	0.17	0.15	0.53	1.30	0[7]	0[7]
Glyphosate post	1.37	1.00	0.090	0.195	1.00	1.00	1.00	1.00
Phenmedipham	1.01	0.737	0.50	0.500	0.18	0.39	0.13	0.29
Pyrazon	7.3	5.33	0.033	0.117	2.7	1.67	**14.6**	**8.9**
Quizalofop-p- ethyl	0.08	0.060	ND	ND	ND	ND	ND	ND
Sethoxydim	0.47	0.343	ND	0.029	ND	6.7	ND	**2.3**
Trifluralin	0.75	0.547	0.80	0.330	0.11	0.59	0.062	0.32
Triflusulfuron-methyl	0.03	0.023	0.00052	0.000035	174	557	**4.1**	**13**

Sources: As in table 4–23 with the exception noted above under endnote c.

1 Shaded rows are for herbicides applied after sugar beet emergence (postemergence); unshaded rows are for preemergence herbicide application.

2 Maximum single broadcast (near ground-level) application rate allowed for glyphosate, the maximum allowed per post emergent application to H7-1 sugar beets

3 Application rates relative to glyphosate = maximum single application for herbicide (pre- or postemergence) divided by maximum single application for glyphosate when used postemergence.

4 Lowest EC_{25} value whether for seedling emergence or vegetative vigor.

5 Estimated as ($1/EC_{25}$) for the herbicide divided by ($1/EC_{25}$) for glyphosate.

6 Because glyphosate is used to normalize the application rates and toxicity, its relative risk value = 1.00. Values in bold indicate herbicides that pose higher risks of impacts to on non-target plants adjacent to sugar beet fields than does glyphosate assuming the same application method and that the chemical characteristics that might influence drift are the same among the herbicides for this comparison.

7 Herbicide soil-incorporated at application – preemergence only; assume no drift occurs.

Acronyms: A = acre. Max = Maximum. App. = Application. lb a.i. = pounds of active ingredient. ND = no data.

in solution and adsorbed to soil particles, and it is the only herbicide of the 13 with high rating for both types of runoff. Because glyphosate binds strongly to soil particles, however, conservation tillage practices (e.g., no-till, row tillage) that can be practiced in many locations under Alternative 2 have the potential to reduce runoff compared with conventional tillage practices generally required for conventional sugar beets. As discussed previously, adoption of H7-1 sugar beets has reduced the amount of tillage needed to produce a sugar beet crop. However, glyphosate still may reach aquatic environments in runoff and by erosion of soils during storm events. Borggaard and Gimsing (2008) reviewed the state of knowledge on sorption, degradation, and leachability of glyphosate in soils. The results of their review showed that sorption, degradation, and leaching of glyphosate vary from soil to soil ((Borggaard and Gimsing, 2008) citing Gimsing et al., 2004, Landry et al., 2005, Mamy et al., 2005). This variability and uncertainty make it difficult to predict glyphosate's fate in the soil. Borggaard and Gimsing (2008) concluded that although sorption and degradation are affected by many factors (e.g., the physical and chemical properties of the soil) which might affect the mobility of glyphosate in the soil, leaching of glyphosate is mainly determined by soil structure and rainfall. Limited leaching has been reported in non-structured sandy soils, as well as structured soils, but only when large amounts of rainfall followed glyphosate application (Borggaard and Gimsing, 2008). The potential for glyphosate transport from terrestrial to aquatic environments can be mitigated by conservation tillage practices, and glyphosate is not expected to reach groundwater or to travel downgradient in aquifers that recharge surface waters due to sorption and degradation in the soil (Borggaard and Gimsing, 2008). The extent to which use of conservation tillage would mitigate glyphosate runoff to surface waters cannot be estimated nationally given available data and would depend on local conditions.

Use of conservation tillage practices under Alternative 2 can benefit aquatic plants and animals by reducing runoff of fertilizers, other chemicals, and soil particles to nearby surface waters compared with conventional tillage (see section III.E.4.d). Potential impacts from agricultural runoff to surface waters were discussed under Alternative 1. Use of conservation tillage can potentially reduce the frequency and magnitude of algal blooms, anoxic waters, fish kills, and sedimentation. It is not possible to quantify such effects nationwide at this time.

Aminomethyl phosphonic acid (AMPA), the primary degradation product of glyphosate, seems to be equally or less toxic than glyphosate (USDA-FS, 2003). Also, EPA determined that, based on toxicological considerations, AMPA need not be regulated (U.S. EPA 2006c); (U.S. EPA 1993c). Therefore, AMPA is believed to pose less risk than glyphosate itself.

In summary, Alternative 2 would result in the application of glyphosate-based herbicide formulations on 95 percent of total sugar beet acreage in the short term and approach (and potentially reach) 100 percent of sugar beet acreage in the long term. Use of non glyphosate herbicides would still occur, but in much lower annual pounds. Under Alternative 2, there would be less frequent spraying of post emergent herbicides, less aerial spraying, and more conservation tillage which all would reduce the exposure of non target plants to herbicides. Under Alternative 2, the amount of glyphosate used relative to clethodim, pyrazon, trisulfuron-methyl , sethoxydim, and desmedipham, would increase relative to Alternative 1. As all these non glyphosate herbicides pose greater risk to non target plants than does glyphosate, the risk to non target plants is expected to be less under Alternative 2 than Alternative 1.

(3) Alternative 3 – Partial Deregulation

Under Alternative 3, the risk to non-target plants in the northern sugar beet regions would be the same as under Alternative 2 and the risk to non-target plants in California wouls be the same as under Alternative 1.

c. Sugar Beet Weediness Potential

This section describes impacts of H7-1 sugar beets on weeds in nonagricultural settings. Weed abundance and weed seed banks and the impacts of H7-1 sugar beet plants and gene product on weeds (such as sugar beet volunteers) in agricultural settings are discussed in section IV.B.1.c.

(1) Alternative 1- No Action

Under Alternative 1, glyphosate could be used to control sugar beet volunteers in seed production fields. As sugar beets have never established feral populations in the United States, it is unlikely that glyphosate would be needed to control sugar beets in non-agricultural settings.

(2) Alternative 2 – Full Deregulation

APHIS considered whether the new phenotype imparted to H7-1 sugar beets might allow the plant to be grown or employed in new habitats and especially if it could naturalize in the environment. In performing the plant pest risk assessment (PPRA), APHIS assessed whether H7-1 sugar beets are any more likely to become a weed than the non-transgenic recipient sugar beet line or other currently cultivated sugar beets. Weediness potentially could affect plant species if H7-1 sugar beets were to become naturalized in the environment. The PPRA considers the basic biology of sugar beets and an evaluation of unique characteristics of H7-1 sugar beets. The parent plant, *Beta vulgaris* L. spp. *vulgaris*, is not listed as a weed by the Weed Science Society of America (2010) nor is it listed as a noxious weed species by the U.S. Federal government (7 CFR part 360). The characteristics of plants that are notable of successful weeds are not possessed by sugar beets (Baker, 1965; Keeler, 1989). In trials conducted in the United States under permits issued by APHIS, no differences were observed between H7-1lines and conventional lines with respect to the plants ability to persist or compete as a weed (Schneider and Strittmatter, 2003). APHIS considered data relating to plant vigor, bolting, seedling emergence, seed germination, seed dormancy, and other characteristics that might relate to increased weediness. No unusual characteristics were noted that would suggest increased weediness of H7-1 sugar beet plants. Additionally, results were variable over different trial locations and indicated that there were no consistent characteristics relating to disease or insect resistance that might affect weediness. H7-1 sugar beets are still susceptible to the typical insect and disease pests of conventional sugar beets.

APHIS considered the potential for H7-1 sugar beets to extend the range of sugar beets into new nonagricultural areas. The genetic transformation does not impart any phenotypic characteristic that would allow for the establishment of H7-1 sugar beets in areas unsuitable to other sugar beet varieties. Nonagricultural sugar beet growth patterns and distributions would be the same for H7-1 sugar beets as for other sugar beet varieties. Sugar beet plants do not have naturalized or feral populations except in California, as discussed in section III.B.5.

Under Alternative 2, H7-1 sugar beets will likely be grown in California. California is currently the only state where escaped *B. vulgaris* occurs and these populations have persisted for many years, indicating that conditions for *B. vulgaris* to act as a weed exist in California. The origin of these populations is unclear but researchers have suggested that they represent escaped varieties of Swiss chard and not sugar beets (see section III.B.5). Wild *B. vulgaris* is unlikely to be growing in the Imperial Valley where all the sugar beet production is located. At one time sugar beets were produced in the Central Valley but these operations have been abandoned and all five sugar beet processing plants have closed in this area indicating sugar beet production will not resume in the Central valley. The only wild beet species found in the Imperial Valley is *Beta macrocarpa* and it only occurs in sugar beet fields. As no feral populations of sugar beets or wild beets exist in the current sugar beet growing area, and none of the feral populations of wild beet in California were derived from sugar beets despite the fact that they have been grown for nearly 100 years in California, it is not reasonably foreseeable that feral populations of sugar beets will establish in California.

(3) Alternative 3 – Partial Deregulation

Under Alternative 3 the weediness potential of H7-1 sugar beet is negligible as it is under Alternatives 1 and 2.

D. Socioeconomic Impacts

This section assesses potential socioeconomic impacts under each of the three alternatives analyzed in this EIS. There are three ways in which the choice of alternative might have socioeconomic impacts. First, because costs of producing H7-1 sugar beets differ from those of conventional (non-GE) sugar beets and because yields may differ between H7-1 varieties and conventional varieties, this section assesses the economic implications of the alternatives analyzed for sugar beet producers, processors, and consumers. Second, because over 95 percent of sugar beet seed produced in recent years is estimated to be of H7-1 varieties (Colacicco, 2010b), conventional seed and some herbicides might no longer be available at the scale needed to supply the entire sugar beet root market with conventional seed and associated herbicides. Because sugar beet seed production has a multiyear cycle, where seed production fields are planted 2 years before planting root production fields, and because increases in herbicide production might require considerable advanced planning, this section discusses the implications for sugar beet root and seed growers and for the sugar market, under two scenarios: a) one in which conventional sugar beet seed and associated herbicides are available to supply the entire U.S. sugar beet root market in 2013; and b) one in which conventional sugar beet seed and/orassociated herbicides are not available to supply the entire U.S. sugar beet root market in 2013. Third, to the extent that there is gene transmission from H7-1 sugar beet root or seed production to conventional or organic sugar beet root or seed fields or to vegetable beets, this section addresses whether adverse socioeconomic impacts could occur to producers or consumers of conventional or organic sugar beets and sugar and to producers and consumers of vegetable beets. The implications of these three potential sources of impacts for producers, processors, and consumers of sugar, sugar beets, vegetable beets, and beet seed, under each of the three alternatives are assessed below. In addition, in compliance with Executive Order (EO) 12898 (*Federal Actions To Address Environmental Justice in Minority Populations and Low-Income Populations*, February 11, 1994), this section discusses whether any impacts were identified in this EIS that could have disproportionally high and adverse human health or environmental effects on minority or low-income populations.

This section is organized as follows. Section IV.D.1 addresses impacts on the U.S. sugar and sugar beet markets derived from differences in costs and returns to H7-1. Two different scenarios are discussed. In IV.D.1.a APHIS assumes conventional sugar beet seed and associated herbicides are available to supply the entire U.S. sugar beet root market in 2013. In IV.D.1.b, APHIS assumes conventional sugar beet seed and/or associated herbicides are not available to supply the entire U.S. sugar beet root market in 2013. Section IV.D.2 analyzes impacts of each of the three alternatives to sugar beet seed markets. Here too, impacts under each of the two scenarios are discussed. Section IV.D.3 addresses impacts of each alternative on organic and conventional sugar beet root and seed markets. Section IV.D.4 addresses impacts on vegetable beet root and seed markets. Finally, section IV.D.5 discusses environmental justice impacts in minority and low-income populations.

1. The U.S. Sugar and Sugar Beet Markets

a. Impacts Assuming No Shortages of Conventional Seed and/or Herbicide

(1) Alternative 1 – No Action

Under Alternative 1, H7-1 sugar beets would be fully regulated and the entire root crop from 2013 onward would need to be planted with conventional seed. Under Alternative 1, the current trend of a decline in the number of farms producing sugar beets and of the number of processing plants could continue. As discussed in sections III.D.1.b and III.D.1.c, declines in the number of farms and of processing plants in the past two decades were part of a consolidation process in sugar beet industry. This consolidation process avoided declines in beet sugar production by increasing yields in the field and efficiency in the plants. Between 1992 and 2007, the number of farms growing sugar beets decreased from 8,810 to 4,022 (USDA-NASS, Various Years), and 13 sugar beet processing plants have shut down since 1996 (ASA, 2011). Under Alternative 1, this process could continue, resulting in further decreases in the number of sugar beet farmers and number of plants. In a survey of sugar beet processing plant chief executive officers (CEOs) conducted in 2010, one processor stated that it would no longer be profitable to operate with conventional seed and would likely cease operations if only conventional sugar beet seed were available (Sexton, 2010a). Sugar beet growers could incur losses related to the purchase of equipment for production of H7-1 sugar beet (e.g. for strip tillage).

(2) Alternative 2 – Full Deregulation

Under Alternative 2, over 95 percent of the 2013 root crop would be expected to be of H7-1 sugar beet varieties, similar to the adoption rate of H7-1 in the 2009 sugar beet crop. As H7-1 varieties adapted to conditions in California are developed, it is expected that the share of root crop production that is of H7-1 varieties would approach 100 percent. Section III.D.1.d reviewed the existing evidence on differences in costs and returns between H7-1 and conventional varieties of sugar beets. There is evidence that production of H7-1 sugar beets has the potential to reduce production costs with labor, fuel, fertilizer, and water. There is also evidence of potential reductions in herbicide costs and increased yields, although costs with herbicides might increase over time due to weed resistance and weed shifts. On the other hand, H-71 sugar beet root growers would have to pay the technology fee for H7-1 seed. Section III.D.1 shows that the existing studies indicate an increase in the overall economic returns to sugar beet root production with H7-1 adoption, although with considerable regional differences. In particular, root growers in the largest production area, the Midwest, might not benefit from H7-1 adoption as much as those of other areas.

Under Alternative 2, because of the cost savings and potential for increased yields associated with H7-1 sugar beet root varieties when compared to conventional sugar beet varieties, sugar beet grower incomes would be expected to be higher than if only conventional sugar beet varieties were available. As discussed in section III.D.1.d, Kniss (Kniss, 2010b) estimated the net economic benefit to farmers of H7-1 sugar beet adoption to be 233 U.S. dollars (USD) per acre (and a 15 percent increase in yields) in Wyoming in 2007. Sexton (2010a) estimated the average expected gross profits for growing H7-1 sugar beets to be 276 USD per acre more than the average expected gross profits for conventional sugar beet seed, among a sample of sugar beet farmers, and Sexton (2010b), based on a processor survey, weighted by the acreage planted in each region, estimated that the total reduction in grower profits from planting conventional as opposed to H7-1 sugar beets amounted to approximately 120 USD per acre.

In addition to increased profitability per acre, growers obtain benefits from the convenience and flexibility of using H7-1 sugar beets. As described in section III.B.1. weed control is much easier to manage with glyphosate because fewer herbicides are needed and the application timing is less critical. Weed control is more effective than using nonglyphosate herbicides so fewer tractor trips across the field are made and less hand labor is needed for weeding. Glyphosate is less toxic to the applicator than many of the non-glyphosate herbicides. By simplifying the management of growing sugar beets and saving the grower time, these factors improve the quality of life for the grower.

Increased incomes would mean that sugar beet growers would be less likely to leave sugar beet production in favor of production of other crops, particularly in regions where returns to sugar beet production compete closely with returns to other crops.[36] Because processing costs tend to decrease with volume of production, maintenance of sugar beet production volumes is important to maintain the feasibility of processing plants and sugar beet plants would be less likely to close. As there is indication that

[36] For example, see Patterson (2009) for a discussion of relative returns of sugar beets and other crops in Idaho.

H7-1 varieties are at least currently more suitable to some producing areas than others, not all producing areas would benefit equally. Sugar beet growers in the Midwest seem to not benefit as much as other sugar beet producing areas from the adoption of H7-1 sugar beet varieties. The Midwest, however, was already the region with the lowest operating and total economic costs in 2000, according to Ali (2004) (table 3–36). None of the 13 plants that closed since 1996 was in the Midwest (section III.D.1.b).

Despite the increased income that adoption of H7-1 sugar beets has likely provided sugar beet growers and processors, seasonal agricultural workers might find less opportunities for work in hand weeding of H7-1 sugar beet fields, compared to those of conventional sugar beet fields.

(3) Alternative 3 – Partial Deregulation

Under Alternative 3, H7-1 sugar beet seed would be produced under permits and sugar beet roots under compliance agreements. The permits and compliance agreements would allow APHIS to control individual seed field locations and enforce stewardship practices. Sugar beet growers adopting H7-1 varieties would continue to experience potential savings in labor, fuel, fertilizer, water and possibly herbicide costs, and potential increased yields and incomes. However, Alternative 3 would impose mandatory conditions on production, processing and transport of sugar beets that would constitute a regulatory burden on sugar beet growers, even if minor, similar to that experienced during the partial deregulation conditions currently in place.

Many measures generally required of H7-1 sugar beet seed growers during production would be similar to those measures taken through industry stewardship agreement adhered to by H7-1 sugar beet seed growers under the full deregulation (Alternative 2). However, stewardship controlled by APHIS has the potential to improve compliance through additional oversight and enforcement mechanisms. In addition, Alternative 3 does impose some added requirements such as the need to obtain a permit for seed production activities and compliance agreements for root production activities.. In addition, the location of H7-1 sugar beet seed production would be restricted to areas outside California and western Washington, although these areas do not currently produce H7-1 sugar beet seed. To the extent that improved compliance, added requirements and geographical restrictions add costs to H7-1 sugar beet seed growers through greater regulatory burdens, these added costs would likely be at least partially transferred to sugar beet root producers in the form of increased sugar beet seed prices. Because APHIS was unable to identify an estimate for the price elasticity of demand for sugar beet seed, the extent to which increased seed production costs would be transferred to sugar beet root producers cannot be estimated. However, increased seed costs would impact no more than 7 percent to 14 percent of total sugar beet production costs (table 3–37).

Sugar beet root growers of H7-1 would be impacted by the mandatory conditions of Alternative 3. In addition to any increase in sugar beet seed prices, H7-1 sugar beet root growers would need to enter into compliance agreements with APHIS establishing specific mandatory conditions for root growth. Compliance agreements would typically be signed by sugar beet cooperatives or processors on behalf of their members/farmers and much of the financial and time burden of Alternative 3 would be absorbed by such cooperatives/processors. These include the financial and time costs of applying for and obtaining a compliance agreement with APHIS, collecting information on acreage and global positioning system (GPS) coordinates of growers, arranging and paying for third-party inspectors and third-party audits, record generation and maintenance and training of crop growers and field personnel.[37] An indicator of the burden imposed by these financial and time costs on growers can be obtained by dividing estimated costs by the acreage of H7-1 produced to obtain an indicator per acre. The largest of these costs is likely to be the third-party inspectors and audits. Based on APHIS' current experience, one field inspection costs about 500 USD, including travel. Enough H7-1 sugar beet fields would have to be visited to guarantee compliance at a 95 percent level of confidence. Based on APHIS' experience, if over 95 percent of sugar beet producers adopted H7-1 sugar beet varieties, some 3,000 inspections could be required. At 500 USD each, this would amount to a total of 1.5 million USD for one round of inspections. If these costs are divided by all farmers based on their sugar beet acreage, and assuming a total sugar beet acreage of roughly 1,000,000, the cost per acre of one inspection would be 1,500,000 USD /1,000,000 acres = 1.5 USD per acre. If more than one field could be visited on a single trip, this cost would be less. In addition to inspections, sugar beet growers would be requested to pay for audits. Based on APHIS experience, 100 audits could be conducted. At a cost of 1,000 USD per audit, this would amount to another 100,000 USD, or 0.10 USD per acre. If miscellaneous other regulatory costs are added (say, hiring personnel or recordkeeping), an additional 400,000 USD of costs would be needed for the total regulatory burden on H7-1 sugar beet grower cooperative/processors to reach 2 USD per acre.

In addition to financial and time costs for sugar beet root grower cooperative/processors, Alternative 3 also requires that individual growers incur added financial and time costs directly from production management operations. These costs related to surveying fields for bolters every 3 to 4 weeks, accompanying inspectors and auditors on field visits, generating and maintaining records, monitoring for volunteers, and any losses

[37] Additional inspections, training, and recordkeeping would be required from APHIS.

incurred by the restrictions imposed on crop rotation and use of equipment for Swiss chard/table beet. Some of these costs may not be new to growers. For example, rotation crops are often visually distinct from sugar beets, producers might not commercially grow Swiss chard or table beet and some degree of field monitoring and recordkeeping is likely already done by most growers. In addition, some of these costs, such as those with recordkeeping and time spent with inspectors and in training, would be diluted by the average size of sugar beet fields (300 acres per farm, according to the 2007 Agricultural Census).

Based on the above discussion, the overall burden of Alternative 3 on sugar beet root growers is likely to be no more than a few dollars per acre. The burden is likely not enough to discourage the adoption of H7-1 sugar beet varieties by growers. As discussed in section III.D.1.d, H7-1 sugar beet production often offers returns of over 100-200 USD per acre above the returns for conventional sugar beets. To the extent that the mandatory conditions of Alternative 3 do discourage some growers from planting H7-1 in favor of conventional varieties, this impact would be expected to affect growers in the Midwest region, where differential returns of H7-1 appear to be less than in other growing regions.

Alternative 3 does not allow production of H7-1 sugar beet roots in California and western Washington. Although H7-1 sugar beet roots are currently not produced in these areas, conventional sugar beet root production does occur in California and amounts to approximately 2.2 and 3.1 percent of total U.S. sugar beet acreage and production, respectively (table 3–34). Sugar beet producers in California would not be able to adopt H7-1 in the future and would not realize any potential increased income derived from adoption of H7-1 sugar beet varieties. California growers would be expected to benefit considerably from the use of glyphosate to manage wild beets because they are very costly to manage in conventional sugar beets for three reasons. First, because selective herbicides are not available, wild beets require extensive hand labor. Second, wild beets physically interfere with the harvest increasing the labor needed for the harvest and decreasing the grower's return per acre. Third, fields with heavy infestations of wild beets must be kept out of sugar beet production for as much as ten years to reduce the wild beet seed bank. As sugar beets are the most lucrative crop in the rotation, the wild beet infestation represents a significant lost opportunity cost (2011). There is currently one remaining sugar beet plant in California, in Imperial County. Of the 13 sugar beet plants that closed since 1996, 5 were in California.

b. Impacts Assuming Shortages of Conventional Seed and/or Herbicide

(1) Alternative 1 – No Action

Under Alternative 1, H7-1 is fully regulated and the entire root crop from 2013 onwards would need to be planted with conventional seed.

Information regarding the availability of domestically produced conventional seed is not publicly available, given that sugar beet seed companies treat this information as business confidential. In 2010, upon request from the Intervenor-Defendants (representatives of sugar beet growers and processors) in the litigation *Center for Food Safety, et al., v. Tom Vilsack, et al.*, Civil Action No. 3:08-cv-00484, Dr. Susan H. Manning, a private consultant, obtained information from four sugar beet seed providers and eight beet sugar processing companies and estimated the availability of conventional seed for the 2011 crop by matching existing supply with demand from each growing region, taking into consideration the suitability in terms of disease and pest resistance and any possible deterioration due to age (Manning, 2010). Although the exact numbers are not publicly available, a declaration to the court stating the identification of a shortfall in the availability of conventional seed for the 2011 crop production is available. This declaration stated that: (1) seed breeders had not engaged in conventional variety seed development since 2006/2007; (2) the estimated shortfall in conventional seed availability for the 2011 crop production would not be the same for each producing region but would be substantial even under highly conservative assumptions; and (3) basic seed stock for production of seed for the 2012 crop production was not available for all varieties, so availability of conventional seed for sugar beet growers in 2012 would depend on the varieties demanded (Manning, 2010). Based on contacts with manufacturers of herbicides, Manning also stated that production of two herbicides used with conventional sugar beet production (BetaMix® and BetaNex®) was discontinued, and the production of two others (Nortron® and Upbeat®) was severely reduced with the adoption of H7-1 varieties. To restart or ramp up production of these herbicides, manufacturers indicated they would need a lead time of approximately one year and decisions would depend on demand expectations.

Manning's estimates were made for the 2011 crop, before the current partial deregulation of H7-1 was in place. The current regulatory uncertainty regarding the possibility of growing H7-1 sugar beet root in 2013 and beyond could have led seed providers to produce seed of conventional varieties, starting in 2011 for use in 2013, in the event that H7-1 sugar beets could no longer be commercialized from 2013 onwards. APHIS currently has no information on the extent to which this has occurred. Given the potential losses to the industry of disruptions to sugar beet production (see discussion further below), APHIS expects that any shortages of conventional seed or herbicide for conventional production would be less severe than those predicted for 2011 in Manning (2010).

To the extent that a shortage of domestic conventional seed did occur under Alternative 1, it would likely not be fully addressed through increased seed imports. European sugar beet seed varieties would be relatively unadapted and expected to yield less than varieties developed for the U.S. market. Due to the possibility of importing Europe's weed beet problem along with the seed, this option could potentially have long-term adverse consequences on the U.S. beet sugar industry. Canada is a net importer of beet seed (United Nations, 2011). Chile, although historically a net exporter, exported less than 4,000 kg of sugar beet seed in 2009, when it was actually a net importer as well (United Nations, 2011). It is unlikely that either of these countries or others would be able to meet a U.S. demand that was estimated in 2010 to have been between 575 tons and 5,750 tons of sugar beet seed (section III.D.2.a).

Figure 4–4 below shows that the sugar beet seed production cycle started in 2011 would have concluded and the sugar beet seed production cycle to be started in 2012 would not yet have started, if Alternative 1 were chosen in May of 2012. However, H7-1 seed production from the 2011 production cycle would not be allowed to be sold in the domestic market and would need to be channeled to export markets. The main sugar beet seed importer that has currently approved H7-1 sugar beet seed for planting is Canada. Canada's imports of sugar beet seed from the United States typically amount to less than 700 tons per year (table 3–40), far less than U.S. seed production of about 3,500 tons in 2007, and would not be able to absorb all U.S. H7-1 seed. Sugar beet seed producers would likely lose most of the H7-1 sugar beet seed production from the 2011/2012 cycle.

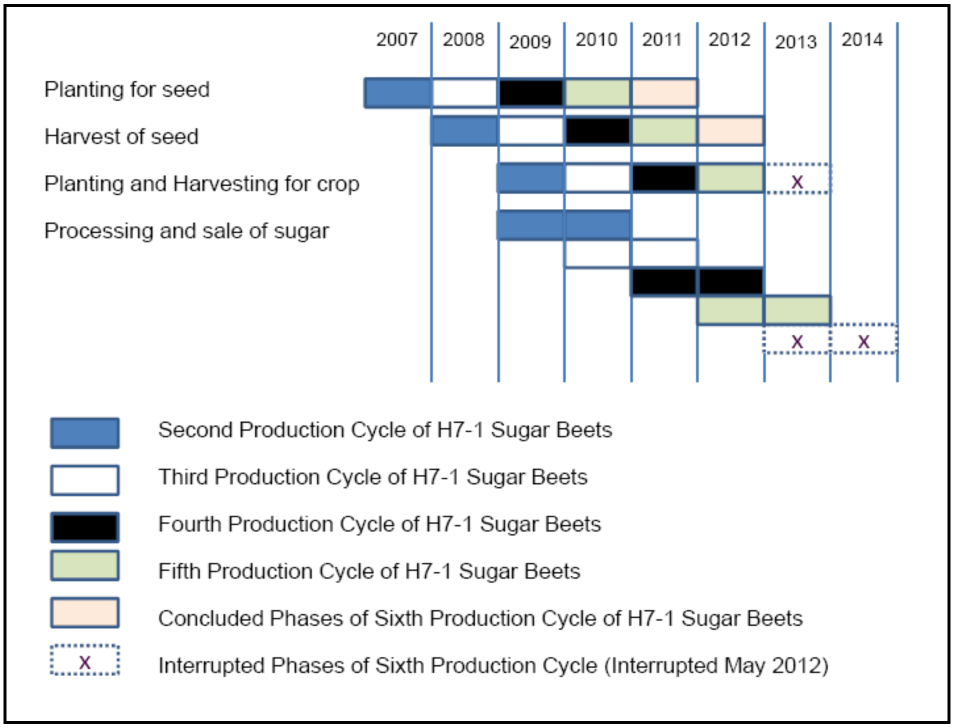

Figure 4- 4. Interrupted production cycles of sugar from H7-1 sugar beets under Alternative 1

Figure 4–4 assumes the 2012 root crop would be allowed to be harvested and commercialized. Sugar beet root production during 2013 and sugar production during 2013 and 2014 would be affected by a shortage of seed. A shortage of conventional seed would imply reduced sugar beet acreage and reduced domestic production with potential consequences for sugar beet grower income and for sugar prices, but the potential consequences would depend on the extent of the seed shortage.

In the event that a shortage of seed of the magnitude estimated for 2011 by Manning did occur, some estimates of the consequences provide a reference for understanding their severity. Based on Manning's study, for example, the Director of the Dairy and Sweetener Analysis Group (DSA) at USDA's Farm Service Agency estimated that availability of conventional seed in 2011, would have allowed sugar beet production in only 63 percent of the total acreage, and would have led to a reduction in beet sugar production by an estimated 1.6 million tons, an increase in the price of refined sugar from 33 cents per pound to 41 cents per pound, an additional 1.6 billion USD paid by consumers for sugar and a loss of 700 USD million to growers and processors (Colacicco, 2010b). Based on the same estimates, Dr. Richard Sexton, a professor of agricultural economics at the University of California, Davis, estimated that a limitation in the availability of seed in production years 2011 and 2012 would have led to reduced income for sugar beet growers and salaried employees between 300 million and 400 million USD in both 2011 and 2012.

Both Colacicco's (2010b) (USDA's sugar expert) and Sexton's (2010b) (an economist hired by the Intervenor-Defendents) estimates were done in support of the Intervenor-Defendants (representatives of sugar beet growers and processors) in the litigation *Center for Food Safety, et al., v. Tom Vilsack, et al.*, Civil Action No. 3:08-cv-00484.

As previously discussed, APHIS considers unlikely that any shortages of seed in 2013, under Alternative 1, would be as severe as those estimated for 2011 because seed and herbidice providers have had more time to build up supplies of conventional seeds and the associated herbicides. A severe shortage, even if only during one or two planting seasons, could have long term consequences for the sugar beet industry. Sexton (Sexton, 2010b), for example, predicted that the unavailability of H7-1 seed for 2 years, 2011 and 2012, would lead to the permanent closure of eight beet processing plants: six in the West region and two in the East region.[38] Plant closures would have immediate impacts on local communities, with loss of permanent and seasonal jobs and loss of income for sugar beet growers, and would impact the communities around the sugar beet plants as a whole, through their economic interactions with sugar beet growers and processing plants.[39] If the shortage is less severe, some or all of these plant closures would be less likely to follow, however, as would the labor and income impacts for the grower and processing plant communities.

To the extent that a shortage of conventional sugar beet seed or of herbicide for conventional sugar beet production would occur, sugar beet growers and processors would be adversely impacted. However, the possibility of deterring these adverse impacts from also occurring in the sugar market would depend on the extent to which cane sugar is available to replenish the market. Increased use of cane sugar to supply the domestic sugar market faces two obstacles: (1) U.S. sugar cane refining capacity, and (2) world supply of refined sugar. Domestic sugar shortages are typically alleviated by USDA through increases in the raw sugar tariff rate quota. This solution depends on the domestic capacity to refine imported raw cane sugar, recently estimated to be operating at nearly full capacity (Colacicco, 2010b). The U.S. sugar policy does not allow reassignment of the U.S. sugar marketing allotments between domestic cane and beet sugar processors, but program actions could be taken to increase imports. However, use of domestically produced sugar from cane would also face the limitations in the domestic capacity to refine sugar.

[38] Producer regions have been combined for this discussion into two regions due to disclosure issues. The West Region includes the Northwest and Great Plains regions. The East Region includes the Upper Midwest and Great Lakes regions. The Imperial Valley is excluded from this section on economic impacts because only conventional seed is used there; hence, the unavailability of H7-1 beet seed would have no impact.

[39] Producers in Ontario, Canada, producing for the Michigan Sugar Company would also be affected. These include over 90 producers and almost 10,000 acres of sugar beets (Better Farming, 2010; Better Farming, 2011).

The possibility of importing refined sugar instead depends on the availability of refined sugar in world markets to address U.S. increased imports. This would be challenging due to the limited world sugar processing capacity and the uncertain capability of foreign producers to supply refined sugar of the quality and packaging needed by U.S. sugar users. It would also tax the current refined sugar distribution system (Colacicco, 2010b). If sugar could be attained from the world market, the temporary loss of cane refineries in 2005 and 2008[40] showed that many U.S. food manufacturers have difficulty using imported refined sugar due to the difference in product quality or packaging (Colacicco, 2010b). This suggests a domestic shortage of sugar and increases in the domestic sugar price would likely follow any potential shortages in conventional sugar beet seed.

(2) Alternative 2 – Full Deregulation

Under Alternative 2, no shortage of seed for production of sugar beets would be expected and current trends for sugar beet and sugar production would be expected to continue without interruption. Figure 4–5 shows the production cycles of sugar from H7-1 sugar beets under Alternative 2.

Because there would be no shortage of sugar beet seed under this alternative, the potential losses in grower income and processor jobs discussed under Alternative 1 for 2011 and 2012 would not occur. Nor would processing plants be forced to close because of limited availability of sugar beets. There would be no reason to expect a spike in domestic sugar prices or for consumers to pay higher prices due to domestic sugar production shortages.

(3) Alternative 3 – Partial Deregulation

Under Alternative 3, H7-1 sugar beet seed would be produced under permits and sugar beet roots under compliance agreements. The permits and compliance agreements would allow APHIS to control individual plot locations and enforce stewardship practices. Alternative 3 would also not allow seed or root production of H7-1 sugar beet varieties in California or western Washington. Conditions would be similar to those currently in place. Based on the discussion in IV.D.1.a (3) of the regulatory burden of this alternative, APHIS does not expect production of H7-1 sugar beet seed to suffer interruptions under this alternative and no shortage of sugar beet seed would be expected. There would be no losses in grower income

[40] The refined sugar market was disrupted in 2005 by the closing of two New Orleans sugar refineries after Hurricane Katrina, and the failure of the early sugar beet product in the Red River Valley, North Dakota, and Minnesota, which resulted in a loss of 160,000 to 210,000 tons of refined sugar. The market was disrupted again in 2008 by an explosion at an Imperial Sugar plant in Savannah, Georgia which reduced U.S. refining capacity by 900,000 tons (Colacicco, 2010b).

and processor salaries, plant closures or increased sugar prices due to an acute domestic sugar shortage.

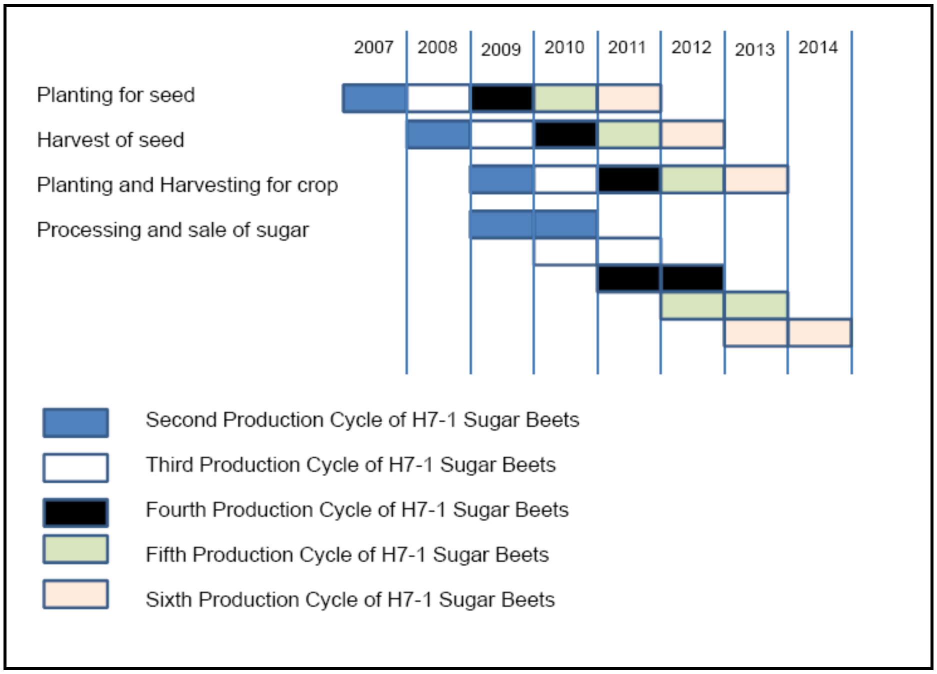

Figure 4- 5. Production cycles of sugar from H7-1 sugar beets under Alternative 2.

2. The Sugar Beet Seed Market

a. Alternative 1 – No Action

Under Alternative 1, H7-1 sugar beets would be fully regulated and the entire root crop from 2013 onward would need to be planted with conventional seed. Sugar beet seed production from 2012 onward would consist only of conventional sugar beet seed varieties, with the exception of research and development activities in small plots, allowed under permit or notification. These research and development activities would be expected to dwindle with time.

Because sugar beet seed production has a multi-year cycle, H7-1 seed grown in 2011 for the 2013 crop production would need to be mostly discarded, as discussed in IV.D.1.b. Sugar beet seed companies would lose past investments in the development of H7-1 varieties and any past investments in stewardship programs incorporating H7-1 varieties. As the biotechnology developers, Monsanto and KWS SAAT AG would lose investments in research and development and in regulatory approvals abroad, to the extent that returns on those investments depend on production in the U.S. To the extent that there is a shortage of domestic conventional seed in 2013, sugar beet seed providers would temporarily experience decreased seed sales. These sales would be expected to gradually recover. Because U.S. sugar beet seed exports are destined mostly to Canada, where H7-1 varieties are approved, it is possible that U.S. sugar beet seed exports to that country would temporarily decrease.

The main impact of Alternative 1 for the sugar beet seed industry would be the large financial losses resulting from research and development costs for the production of varieties that could not be used, lost time to develop new varieties, and lost inventory from seed that would need to be discarded. APHIS does not know the financial impact for the lost R and D costs that result from not being able to use hundreds of lines that took from 5-10 years to develop. Just the seed inventory for the 2013 planting year that would need to be discarded represents a loss in excess of $110 million U.S.D. (Enright, 2010); (Fritz, 2010); (Meier, 2010). Potentially, there might be the disincentive to future investments in genetically engineered varieties of sugar beets, if the expected likelihood of obtaining regulatory approval is diminished.

b. Alternative 2 – Full Deregulation

Under Alternative 2, over 95 percent of the 2013 root crop would be expected to be of H7-1 sugar beet varieties, similar to the adoption rate of H7-1 in the 2009 sugar beet crop. As H7-1 varieties adapted to conditions in California are developed, it is possible that the H7-1 share of root crop production would approach 100 percent. In addition, no shortage of seeds for sugar beet production would be expected.

There is no publicly available information on differences in costs and returns for production of sugar beet seed of H7-1 varieties compared to conventional varieties. The difference in returns to individual seed growers of producing H7-1 or conventional sugar beet seed varieties would depend not only on production costs, but on the contractual arrangements made with each sugar beet seed company. As described in section III.D.2.b, U.S. sugar beet seed production is concentrated in few farms and seed companies. In 2007 there were 93 farms producing sugar beet for seed and in 2002 there were 130, occupying less than 4,500 acres (USDA-NASS, 2009c). These farms produce under contract for five sugar beet seed companies who develop and market sugar beet seed varieties, both conventional and containing the H7-1 trait.

The main impact on sugar beet seed producers of differential costs and returns of sugar beet production under Alternative 2 is the resulting demand for specific varieties of seed. This resulting demand has implications on past and future research and development of sugar beet seed varieties. Under Alternative 2, conventional seed produced in case H7-1 is no longer being allowed for planting in 2013 would likely be discarded, although some might be exported to Canada, depending on the varieties. Any recent investments in development of those conventional seed varieties would also likely be lost. Past investments in varieties with the H7-1 trait and in research and development leading to H7-1 sugar beets would be preserved. Incentives for future development of GE sugar beet varieites for the United States would be maintained as would current trends in seed exports.

c. Alternative 3 – Partial Deregulation

Under Alternative 3, H7-1 sugar beet seed would be produced under permits and sugar beet roots under compliance agreements. The permits and compliance agreements would allow APHIS to control individual field locations and enforce stewardship practices. Conditions would be similar to those currently in place. Based on the discussion of the regulatory burden of this alternative, H7-1 adoption rates would be expected to be over 95 percent, although not 100 percent, given that sugar beet root producers would not be allowed to produce H7-1 sugar beet varieties in California or western Washington. Producers in California would continue to demand conventional sugar beet seed. Under this alternative, past investments in H7-1 sugar beet seed varieties and in conventional sugar beet seed varieties suited to California would be preserved, while any current investment in development of H7-1 sugar beet seed varieties for California would be lost. Incentives for future development of GE sugar beets the United States would be maintained.

Sugar beet seed growers of H7-1 varieties would be bound to comply with measures imposed to limit gene flow from H7-1 sugar beet seed fields. Many measures required from H7-1 sugar beet seed growers during production under permit would be similar to those H7-1 sugar beet seed growers would be required to adopt under full deregulation (Alternative 2) by industry stewardship agreements. However, co-existence stewardship controlled by APHIS has the potential to improve compliance. In addition, Alternative 3 imposes the added requirements needing to obtain a permit and packaging specifications for the transport of seed. Improved compliance, added requirements, and geographical restrictions could add costs to H7-1 sugar beet seed production. However, because of the extent to which co-existence stewardship practices already prevail in the seed industry, these costs would not be expected to substantially influence the supply or price of seed.

3. Organic and Conventional Sugar Beets and Sugar Markets

As discussed in section III.D.3, the demand for organic sugar has been steadily increasing though it still remains just 1 percent of the sugar market. Organic sugar is primarily imported and derived from cane. There currently is a small amount of organic cane sugar production in the U.S. but no commercial organic beet sugar production. At least a segment of the domestic and export sugar market is likely sensitive to the presence of GE material. The impacts of each of the alternatives on these markets are discussed below.

a. Organic and Conventional Sugar Beet Root and Sugar Markets
For each alternative, the sections below summarize the information obtained on the likelihood of gene flow to organic and non-GE sugar beet root fields and the potential socioeconomic impacts on growers and consumers if gene flow does occur.

(1) Alternative 1 – No Action

Under Alternative 1, H7-1 is fully regulated and the entire root crop from 2013 onward would need to be planted with conventional seed. No H7-1 sugar beets could be planted other than for research and development. No sugar derived from these beets would be available.

Under Alternative 1, all sugar sold in the domestic market would be conventional or organic (approximately 1 percent). Sales of organic sugar would be expected to increase to keep pace with the expanding organic market, with the main source of supply being imported organic sugar from cane.Domestic organic sugar production, while currently insubstantial, could develop if the domestic demand for organic sugar grows, domestic production can effectively compete with imported organic cane sugar, and a solution is devised to economically process organic sugar from either cane or sugar beets. .

Consumers would have the option of choosing between conventional and organic sugar. Sugar beet growers and processors would not have the option of growing and processing H7-1 varieties of sugar beets.

(2) Alternative 2 – Full Deregulation

Under Alternative 2, adoption of H7-1 sugar beet varieties by root growers would be expected to remain above 95 percent of the root crop, increasing to 100 percent as H7-1 varieties become available in California. Even with such widespread adoption of H7-1 varieties, no adverse socioeconomic impact due to gene flow is expected to conventional and organic sugar beet producers.

LLP in conventional sugar beet is not expected to lead to any economic losses for several reasons. First, by mutual agreement among growers, cooperatives, processors, and marketers, H7-1 sugar beets and conventional sugar beets are currently harvested, transported, stockpiled, processed, and marketed without distinction in all producing regions with the exception of California, where H7-1 sugar beets ve not been grown to date. This indicates that current domestic demand for conventional sugar beets is not sensitive to the presence of GE material. Second, Canada and Mexico, the main importers of U.S. sugar, allow the import of GE sugar beet products without restriction, as does Japan, the main importer of sugar beet pulp from the United States (section III.D.1.b). This suggests that the main foreign buyers of U.S. sugar would not impose restrictions to conventional sugar exports from the United States for fear of presence of GE material. In addition, refined sugar from sugar cane or from sugar beets is typically 99.95 percent sucrose, and sucrose is identical irrespective of its cane or beet origin (The Sugar Association, undated). During the processing of sugar beets into refined sugar, the DNA and protein is removed so molecular tests cannot distinguish between H7-1 and conventional beet sugar.

Currently there is no organic beet sugar market to be impacted by H7-1. If an organic beet sugar market were to develop, it would require segregation from the rest of the beet sugar produced from H7-1 and would be sensitive to LLP, Seed lacking LLP could be obtained from a number of sources. It could be produced in areas outside of eastern Washington and the Willamette Valley where no H7-1 sugar beet seed is produced. It could be produced in Eastern Washington and the Willamette Valley taking care to observe isolation distances and testing the seed for LLP[41]. It could be obtained from Europe where some organic sugar beets are produced.

The organic sugar beet root crop can be produced in proximity to H7-1 sugar beet root crop without concern of LLP because no gene flow is possible from one root crop to the next. Thus, if seed is verified to lack LLP, the root crop produced from that seed will also lack LLP. Testing of the sugar beet root crop would be very cumbersome given the size of the root (several pounds) and the labor intensiveness to collect a representative sample from thousands of roots for analysis. Testing the refined sugar would be pointless because measureable quantities of protein and DNA are absent (see section III.F.1.a.(5)).

Because beet seed production already is established with isolation distances that minimize cross pollination between various beta seed crops and the organic and H7-1 root crops can be produced in proximity without adverse impacts to the organic crop, APHIS does not believe that widescale adoption of H7-1 will interfere with the emergence of an organic beet sugar industry. The greatest challenges for establishing an organic beet sugar industry will come from the costs of establishing and maintaining dedicated storage and processing facilities for organically grown sugar beets, the high cost of growing sugar beets without chemical weed control, and competition from imported organic sugar which can be produced at lower cost due to lower labor costs needed for weed control.

[41] Conventional lines lacking LLP are still successfully produced in the Willamette Valley as are vegetable beets. Conventional sugar beet seed is routinely tested for the H7-1 trait (Anfinrud, 2010)

Manufacturers of sugar containing products destined for GE sensitive markets, currently have the option of using conventional or organic cane sugar. For example, European markets require labeling of ingredients obtained from GE crops and exporters of sugar containing products destined to Europe would need to opt for cane sugar or other sweeteners if the label were not desired. Because sugar from sugarcane is processed and can be marketed separately from sugar from sugar beets, manufacturers and consumers wishing to avoid sugar from GE sugar beets would be able to do so.

Sugar beet processing generates pulp and molasses as co-products that is mainly used as feed for livestock. Sugar beet tops may also be fed to livestock. To the extent that livestock farmers are sensitive to the presence of GE material in feed, Alternative 2 would make sugar beet co-products unavailable to those livestock farmers. Sensitivity to GE material in feed is likely restricted to a small share of livestock farmers, if any. As an example, Putnam (2005) notes that GEcrops such as corn and soybeans have been used as animal feed for years with no perceptible impact on the marketing of beef. Also, sugar beet products represent a very small share of the feed products available to farmers. As an example, if all the sugar beet co-products from 2010 (approximately 32 million tons) were sold as pulp pellets for livestock feed, the amount sold would be approximately 1.76 million tons of pellets (at 110 lb of pellets per 1 ton of sugar beet (Western Sugar Cooperative, 2006). This would correspond to just over 1 percent of the 140 to 180 million tons of four major feed grains (corn, sorghum, barley and oats) consumed for feed each year (USDA-ERS, 2011b). In addition, livestock is often highly dependent on forage. As an example, only 16 million out of 96 million cattle were on feed as of December 2007 (USDA-NASS, 2007). Organic livestock farms would typically not be affected because 100 percent organic feed is required by the National Organic Program (see 7 CFR § 205.37(a)) and there are currently no commercialized organic sugar beets.

Under Alternative 2, consumers of sugar would still have the option of obtaining conventional or organic sugar. Sugar beet growers and processors would have the option of producing and processing conventional or H7-1 varieties of sugar beetsWidescale H7-1 sugar beet production under Alternative 2 would prevent little incremental barrier for the development of an organic beet sugar industry.

(3) Alternative 3 – Partial Deregulation

Under Alternative 3, H7-1 sugar beet seed would be produced under permits and sugar beet roots under compliance agreements. The permits and compliance agreements would allow APHIS to control individual field locations and enforce stewardship practices. Conditions would be similar to those currently in place. Based on the discussion of the regulatory burden of this alternative, H7-1 adoption rates would be expected to be over 95 percent, although not 100 percent, given that sugar beet root producers would not be allowed to grow H7-1 sugar beet varieties in California or western Washington. As explained in section IV.D.3.a (2), even under full deregulation (Alternative 2), no economic losses to conventional sugar beet root growers would be expected, even under the unlikely presence of GE material in their fields. Nor would APHIS expect impacts on sugar containing products sold in GE sensitive markets l, because of the availability of conventional and organic cane sugar, as well as other sweeteners. The controls imposed by Alternative 3 on sugar beet production and transport would reduce further the likelihood of gene flow.

Under Alternative 3, consumers of sugar would still have the option of obtaining conventional or organic sugar. Sugar beet growers and processors would have the option of producing and processing conventional or H7-1 varieties of sugar beets.

b. Organic and Conventional Sugar Beet Seed Markets

For each alternative, the sections below summarize the information obtained on the likelihood of gene flow to organic and non-GE sugar beet seed fields and the potential socioeconomic impacts on growers if gene flow does occur.

(1) Alternative 1 – No Action

Under Alternative 1, H7-1 is fully regulated and the entire sugar beet root crop from 2013 onward would be planted with conventional seed. Sugar beet seed production from 2012 onward would consist only of conventional varieties, with the exception of research and development activities in small plots, allowed under permit or notification. These research and development activities would be expected to dwindle with time.

Under Alternative 1, all sugar beet seed available in the domestic market would likely be conventional. Because the demand for seed is a derived demand from the demand for sugar beet roots and no organic sugar beet roots are expected to be grown, no demand for organic sugar beet seed is expected to develop. Although there may be some demand for organic sugar beet seed in Europe, this market would likely be supplied by locally produced varieties of seed (see III.D.2.a for a discussion).

(2) Alternative 2 – Full Deregulation

Under Alternative 2, adoption of H7-1 sugar beet varieties by root growers would be expected to remain above 95 percent of the root crop, increasing to 100 percent as H7-1 varieties become available in California. This means that the domestic market for sugar beet seed would increasingly demand H7-1 sugar beet varieties. However, conventional sugar beet seed could still be produced in the short run or for foreign markets that do not plant GE sugar beet seed.

As noted in section III.D.2.b, almost all domestic sugar beet seed is produced by five seed companies. Because production of sugar beet seed is concentrated in these companies, and because gene flow can be minimized by isolation distances and other production management practices, availability of conventional sugar beet seed to satisfy any existing demand would depend largely on a business decision made by these seed companies. Section III.B.1 reviews the sugar beet seed industry current stewardship practices. These include mapping of seed fields, tracking systems, isolation distances, and seed processing procedures that minimize gene flow between sugar beet seed fields of different varieties. In addition testing can be done for GE sensitive seed markets (export markets) with cost estimates varying from a few dollars to 300 dollars per test (see section IV.D.3.b for more details).

Based on the existing data on sugar beet seed production and international trade before and after the authorization for planting of H7-1 varieties of sugar beet seed in 2005, no impacts on total sales or U.S. international trade of sugar beet seed can be detected from the availability of H7-1 varieties in the U.S. market. Exports have fluctuated around 700 tons since 2000 with 65 to 86 percent of exports destined to Canada (table 3–40).

(3) Alternative 3 – Partial Deregulation

Under Alternative 3, H7-1 sugar beet seed would be produced under permits and sugar beet roots under compliance agreements. The permits and compliance agreements would allow APHIS to control individual field locations and enforce stewardship practices. Conditions would be similar to those currently in place. Based on the discussion of the regulatory burden of this alternative, H7-1 adoption rates would be expected to be over 95 percent, although not 100 percent, given that sugar beet root producers would not be allowed to produce H7-1 sugar beet varieties in California or western Washington. As explained in section IV.D.3.b (2), even under full deregulation (Alternative 2), no economic losses to conventional sugar beet seed growers would be expected. The controls imposed by Alternative 3 on sugar beet seed production would reduce further the likelihood of gene flow. No impacts on sugar beet seed markets would be expected.

4. Vegetable Beet Markets

a. Vegetable Beet Markets (Leaf and Root)

For each alternative, the sections below summarize the information obtained on the likelihood of gene flow to chard and table beet vegetable fields and the potential socioeconomic impacts on growers and consumers if gene flow does occur.

(1) Alternative 1 – No Action

Under Alternative 1, H7-1 is fully regulated and the entire sugar beet root crop from 2013 onward would be planted with conventional seed. No H7-1 seed could be planted other than for research and development. Under Alternative 1, U.S. production and consumption of vegetable beets would likely continue to be between 100,000 tons and 150,000 tons a year, with a tendency to decline. Acreage might also decline, although the number of farms might not, given the recent declining trend in vegetable beet acres per farm. Exports would likely remain few and mostly destined to Canada (section III.D.4.a).

(2) Alternative 2 – Full Deregulation

Under Alternative 2, adoption of H7-1 sugar beet varieties by root growers would be expected to remain above 95 percent of the root crop, increasing to 100 percent as H7-1 varieties adapted to sugar beet production in California become available. As described in section III.D.4.a, vegetable beet root production for processing is highly concentrated in New York and Wisconsin, two states that do not produce sugar beets for root or seed. Vegetable beet root production for the fresh market is more dispersed and includes States such as Michigan – a producer of sugar beet root crop, and Oregon – a producer of sugar beet seed.

Section III.B.5.c describes the potential for gene flow from H7-1 sugar beet varieties to conventional and organic vegetable beets. Because commercial vegetable beets are harvested before flowering, no pollen-mediated gene flow would occur. If any bolting occurred, the bolting inflorescence would be removed, given that the flowering stock is undesirable to vegetable beet crop farmers, precluding any possibility of gene flow. No impacts would be expected to vegetable beet root growers or consumers.

(3) Alternative 3 – Partial Deregulation

Under Alternative 3, H7-1 sugar beet seed would be produced under permits and sugar beet roots under compliance agreements. The permits and compliance agreements would allow APHIS to control individual field locations and enforce stewardship practices. Conditions would be similar to those currently in place. Based on the discussion of the regulatory burden of this alternative, H7-1 adoption rates would be expected to be over 95 percent, although not 100 percent, given that sugar beet root producers would not be allowed to produce H7-1 sugar beet varieties in California or western Washington. As explained in section IV.D.4.a (2), even under full deregulation (Alternative 2), no economic losses to conventional sugar beet root growers would be expected. The controls imposed by Alternative 3 on sugar beet root production and transport would reduce further the likelihood of gene flow. No impacts would be expected to vegetable beet root growers or consumers.

b. Vegetable Beet Seed Markets

For each alternative, the sections below summarize the information obtained on the likelihood of gene flow to vegetable beet seed fields and the potential socioeconomic impacts on growers if gene flow does occur.

(1) Alternative 1 – No Action

Under Alternative 1, H7-1 is fully regulated and the entire root crop from 2013 onward would be planted with conventional seed. Sugar beet seed production from 2012 onward would consist only of conventional sugar beet seed varieties, with the exception of research and development activities in small plots, allowed under permit or notification. These research and development activities would be expected to dwindle with time.

Under Alternative 1, because demand for vegetable beet seed is derived from the demand for vegetable beet roots and leafy greens, domestic demand for vegetable beet seed would tend to decline. Foreign demand might remain stable at around 700 to 800 tons a year (table 3–46). Vegetable beet seed production would likely continue to be concentrated in the western States of Washington, Oregon and California, with a strong concentration in western Washington (section III.D.4.b).

(2) Alternative 2 – Full Deregulation

Under Alternative 2, adoption of H7-1 sugar beet varieties by sugar beet root growers would be expected to remain above 95 percent of the root crop, increasing to 100 percent as H7-1 varieties become available in California.

Under Alternative 2, gene flow to vegetable seed production from sugar beet seed fields would be possible. Current industry practices, including mapping of seed fields, tracking systems, isolation distances and seed processing procedures would tend to minimize gene flow, but would not eliminate the possibility (see section III.B.1 for a review of sugar beet seed industry current stewardship practices).

Seed could need to be tested, if required by the market,[42] or to avoid the unintentional sale of seed with adventitious presence of genetically engineered material. Seed could be tested by protein or DNA based tests (see Section III.B.1.b.19). According to Morton (2010), testing costs for DNA by Polymerase Chain Reaction (PCR) would cost 300 USD per seed lot. Protein based testing using Lateral Flow Strips cost about $2-4/test, do not require special equipment, but are about ten fold less sensitive and are not quantitative. If LLP were to be found, it could result in lower value of the seed crop for the seed grower if he caters to a GE sensitive market. If the market for the vegetable seed is not GE sensitive, such as the beet canning industry, there is not likely to be any new impacts. Nor would there necessarily be impacts to the organic producer. The National Organic Program excludes the use of genetically engineered products but is process based (as opposed to product based) and LLP would not automatically imply the loss of organic certification. APHIS is not aware of any organic grower who has lost organic certification due to LLP. However, individual customers and foreign markets might still have zero tolerance for LLP even though the product has an organic certification.

For the grower of vegetable beet seed for a GE sensitive market who discovers LLP in his seed, it is possible that the intended purchaser of the seed may reject the lot (for example, many foreign markets forbid the planting of GE seed) and the grower will need to find an alternative buyer who would likely pay less for the seed. Seed tested and found to lack LLP might still contain LLP at a frequency below the limit of detection for the assay. Assuming the limit of detection is 1 seed in 10,000 seed for a DNA based test, a vegetable beet grower who purchased such seed might expect to find 5-10 off-type vegetables/acre. As discussed in section III.B.5.e(1), the GE trait will be limited to either sugar beet plants or hybrid off-types and such plants usually are visibly distinct from vegetable beets and can be rogued. When identified they could be removed and not reach the consumer but could represent a minor loss to the vegetable producer. The loss from roguing the hybrid, is no different whether the hybrid off-types result from any combination of vegetable beet and sugar beet including conventional. If the vegetable beet seed is being used to grow microgreens or sprouts, off-types would not be detectable and could reach the consumer at a very low frequency.

Vegetable beet seed growers have expressed concern that the reputation of seed growing regions in western Oregon, such as the Willamette Valley or the Rogue River Valley, will be harmed, in the view of organic and GE sensitive markets, by the potential for LLP (Morton (Morton, 2008, 2010, 2011; Tipping, 2010). If the market has zero tolerance for any level of

[42] Morton (2010)claims that he must test his seed if GE varieties of his contracted species are being grown within 10 miles of his seed but his tests have so far been done willingly (not in response to a request from a client).

LLP, vegetable beet producers who cater to this market may insist in purchasing their seeds from regions outside of Oregon.

If permanent harm to seed grower's reputations, including loss of clients, were in fact inflicted by the detection of LLP in conventional or organic seed, or by the perception that the geographic origin of the seed alone poses the risk of presence of LLP in vegetable beet seed, the potential impact in the Willamette Valley could affect an estimated 300 acres of chard and table beet seed with an annual gross value of 1.75–2.25 million USD produced by a "dozen family seed farms," according to the Director of Advocacy of the Organic Seed Alliance (Dillon, 2010). Some vegetable beet seed growers could cease production of vegetable beet seed and contracts with seed companies to produce this seed may shift elsewhere.

The extent of the impact of Alternative 2 on U.S. vegetable beet seed production as a whole would depend on the extent to which the market for U.S. vegetable beet seed is sensitive to the perceived risk of presence of LLP in vegetable beet seed, even if no LLP is present in testing or has ever been detected. Several literature reviews suggest that there is a portion of food markets that is sensitive to GE food ingredients . Fernandez-Cornejo (2006), for example, notes that consumers often do have concerns with food containing GE ingredients. Many contingent valuation studies exist for Europe, United States, Japan, and Australia reporting that consumers are typically willing to pay a higher price for GE-free foods, and various articles review this literature (Lusk et al., 2004; Rigby et al., 2004). However, studies suggest consumer sensitivity is usually only a portion of the market and often has less impact on sales than expected. Hallman et al. (2003) report that only one quarter of the U.S. residents they surveyed approved of use of genetic engineering in animal farming, but one half approved of plant-based engineering, suggesting consumer sensitivity levels also depend on the kind of product being sold. Noussair et al. (2004) found that the level of content of GE material seems to influence consumer preference. In their survey, 89 percent of consumers were willing to purchase a product with up to 1 percent GE content and 96 percent with up to 0.1 percent GE content. But Fernandez-Cornejo (Fernandez-Cornejo and Caswell, 2006) also points out that most surveys and consumer studies indicate consumer concerns have not had a large impact on the market for these foods. As previously noted Putnam (2005) argues that GE crops such as corn and soybeans have been used as animal feed for years with no perceptible impact on the marketing of beef. Based on the literature cited above, it is unlikely that all the U.S. vegetable beet market is sensitive to GE material, even though a portion of it likely is.

Under Alternative 2, at least a share of vegetable beet consumers would continue to demand GE free vegetable beetsand there would continue to be a derived demand for GE-free vegetable beet seed. Consumers would still have the choice to consume conventional or organic vegetable beet. Sugar beet growers and processors would have the option of producing and processing conventional or H7-1 varieties of sugar beets.

(3) Alternative 3 – Partial Deregulation

Under Alternative 3, H7-1 sugar beet seed would be produced under permits and sugar beet roots under compliance agreements. The permits and compliance agreements would allow APHIS to control individual field locations and enforce stewardship practices. Conditions would be similar to those currently in place. Based on the discussion of the regulatory burden of this alternative, H7-1 adoption rates would be expected to be over 95 percent, although not 100 percent, given that sugar beet root producers would not be allowed to produce H7-1 sugar beet varieties in California or western Washington. Under Alternative 3, the enforcement of stewardship practices and the added conditions imposed on sugar beet seed production of H7-1 varieties would reduce the likelihood of LLP in vegetable beet seed fields, even further than under full deregulation (Alternative 2). To the extent that seed producers still engage in testing of vegetable beet seed lots for LLP, whether required by the market or not, Alternative 3 would result in added costs to vegetable seed producers.

As in the case of Alternative 2, however, under Alternative 3, at least a share of vegetable beet consumers would continue to demand GE-freevegetable beet root and there would continue to be a derived demand for GE-free vegetable beet seed. Consumers would still have the choice to consume conventional or organic vegetable beet. Sugar beet growers and processors would have the option of producing and processing conventional or H7-1 varieties of sugar beets.

The existence of disproportionally high and adverse human health and environmental effects on minorities and low-income populations depends on the co-existence in the affected area of minority or low-income populations and significant impacts of a proposed alternative.

To identify and address disproportionally high and adverse human health or environmental effects on minority or low income populations the following analytical process was adopted.

(1) The affected area was identified as counties where sugar beets are grown for root or seed;

(2) The affected area was then characterized regarding the presence of minority and low income populations. In doing so:

  (a) Areas were identified where: (a) minority or low-income presence exceeds 50 percent, or (b) minority or low-income presence is meaningfully greater than the percentage presence in the general population or other appropriate unit of geographic analysis;

(b) Transient communities sharing common conditions of environmental exposures were also considered as potential minority or low-income communities: in this case, agricultural workers.

(3) Potentially high and adverse human health or environmental effects described by other sections of this EIS were assessed;

(4) If significant impacts were found in step 3, existence of disproportionate high and adverse impacts on minority and/or low-income populations would then be determined.

Steps 1 and 2 of the analytical process were conducted in section III.D.5. Minority and low-income presence in the counties where sugar beets are grown for root or seed was described and two environmental justice populations were identified: a) sugar beet growing counties in California, where the presence of minorities is meaningfully greater than in other areas of reference; and b) agricultural workers, among which both minority and low-income presence was likely meaningfully greater than other groups of reference.

Step 3 requires assessing potentially high and adverse human health or environmental effects described by other sections in this EIS. Although adverse impacts to resources were identified among the alternatives, none were identified to be high and adverse human health or environmental effects. Because no high and adverse human health or environmental effects were identified, APHIS did not proceed to step 4. There would be no disproportionate impacts to minority or low-income populations.

E. Physical Environment

The potential environmental impacts of implementing the three alternatives on the physical environment are discussed in sections IV.E.1 through IV.E.4. The discussion of land use addresses potential impacts on the acreage and location of land used for sugar beet production. The discussion of soil quality addresses potential impacts on the structure and physical make-up of soil due to sugar beet production. The discussion of air quality and climate change addresses potential impacts on air and global climate change due to sugar beet production. The discussion of water quality addresses potential impacts on surface water and groundwater quality due to sugar beet production.

In this section, the assessment of potential impacts on land use, soil quality, air quality and climate change, and surface water and groundwater quality is based on the following assumptions:

- H7-1 sugar beet production results in increased conservation tillage practices.
- H7-1 sugar beets have the same fertilizer requirements as conventional sugar beets because the genetic alteration does not affect the nutrient needs of the plant.
- H7-1 sugar beets have the same water requirements and efficiency levels as conventional sugar beets because the genetic alteration does not affect the water needs and efficiency of the plant.
- H7-1 sugar beets have the same processing requirements as conventional sugar beets.

1. Land

Genetically engineered crops are largely replacing conventional crops rather than becoming an additional market or causing the conventional crop to become a separate market (USDA-ERS, 2009a) . The average yearly acreage of principal crops from 1983 to 1995, was 328 million (USDA-NASS, 2010b) and after the introduction of biotechnology-derived crops in 1996, including several principal crops such as soybeans, corn, and cotton, in 2009, 319 million acres of principal crops were planted, which is less than a 3-percent change (USDA-NASS, 2010b). Sugar beet acreage has remained relatively constant over the last 50 years with 1.13 million acres planted in 1961 increased by about 5 percent to 1.18 million acres in 2010. Considering the agricultural use of the land for sugar beet production has remained relatively consistent over the last five decades, and the alternatives under consideration analyze continued conventional sugar beet or H7-1 sugar beet crop production, it is generally expected that the agricultural use of land currently under sugar beet production would not substantially change under any of the alternatives.

a. Alternative 1 – No Action

In spring 2011, H7-1 sugar beet was planted subject to partial deregulation, and assuming that H7-1 sugar beet would again be planted under partial deregulation in 2012, Alternative 1, if implemented, would first apply to the root crop that would be planted in the spring of 2013 and the seed crop planted in the fall of 2013. Thus in 2013, no H7-1 sugar beet root crop or seed crop would be produced. In addition, on those agricultural lands that would no longer be allowed to grow H7-1 sugar beets, growers could allow the land to go fallow, or could plant other Roundup Ready® crops, other agricultural crops, or use the land for other purposes. That most growers would choose to do something with the land other than grow sugar beets is not expected because of the contractual relationship between sugar beet growers and sugar beet processing facilities (for a detailed discussion of the U.S. sugar market and its regulatory framework, see section III.D.1.a; see section III.D.1.b for a discussion of the demand for sugar beets). There may be some growers who would not go back to planting conventional sugar beets if H7-1 sugar beets are no longer available. However, considering the high value of sugar beets and the potential penalties for not producing a grower's allotment of sugar beets, it is possible though that most growers would continue to produce conventional sugar beets if H7-1 sugar beets are not available.

Growers may choose to grow other Roundup Ready® crops like Roundup Ready® corn or Roundup Ready® soybean if they cannot grow H7-1 sugar beets. However, the decision to do this could be influenced by several factors including, availability of desirable varieties, availability and cost of any specialty cultivating equipment (e.g., for conservation or reduced tillage methods), value of these glyphosate-resistant crops compared to other alternative crops, and the potential penalty or lost ownership shares in the cooperative for not growing conventional sugar beets. Similar factors would also influence the potential decision to plant other agricultural crops.

Alternative 1 could result in a decrease in sugar beet production over the short term due to a potential shortage of conventional sugar beet seed as discussed in section IV.D. If there is a shortage of conventional sugar beet seed in the short term, it would reduce sugar beet acreage and harvest, reduce domestic production, and increase the cost of sugar.

Another possible scenario to consider under Alternative 1 could be that conventional sugar beet seed would be available, and growers choose to plant conventional sugar beets instead of other glyphosate-resistant crops and acreage would be expected to be similar to 2010 sugar beet planted acreage at 1,171,400 acres. As discussed in section IV.D.1.b, the current regulatory uncertainty regarding the possibility of growing H7-1 sugar beet roots in 2013 and beyond, could have led seed producers to develop conventional varieties, starting in 2011 and for use in 2013, in the event that H7-1 sugar beets could no longer be commercialized starting in 2013. In this case, several factors could influence the decision to begin growing conventional sugar beets, including availability of herbicides, availability and cost of specialty cultivating equipment, availability of desirable varieties of sugar beets, the cost of hand labor for weeding under conventional production, and the value of sugar beets compared to alternative crops.

b. Alternative 2 – Full Deregulation

Under Alternative 2, H7-1 sugar beets and progeny derived from them would no longer be regulated articles under the regulations at 7 CFR part

340, would not require permits or notifications for the introduction of H7-1 into the environment, and growers would be able to freely move H7-1 sugar beet seed, stecklings, and any harvested seeds and roots without any APHIS oversight. Given growers' established preference for H7-1 sugar beets made evident by the 95 percent adoption rate of H7-1 sugar beets in 2009–2010 (USDA-ERS, 2009a) , H7-1 sugar beets would be expected to almost entirely replace conventional varieties with adoption continuing at 95 percent in the short term and expected to reach 100 percent in the long term, including planting of H7-1 sugar beet crops in California when suitable varieties of H7-1 sugar beets become available. Thus, Alternative 2 is expected to result in an increase in the prevalence of H7-1 sugar beets. Even after wide-scale planting of H7-1 sugar beet varieties occurred in 2008, the total U.S. sugar beet acreage after 2005 remained similar to the total sugar beet acreage of 1961 and successive years (USDA-NASS, 2010b). Therefore, implementation of Alternative 2 is not expected to change current land use patterns and no impact on land use compared to current conditions is expected.

Under Alternative 2, it is possible that Swiss chard and table beet seed production could relocate from the Willamette Valley to California, western Washington, and Arizona to counter market perceptions of potential LLP of the H7-1 trait (see section IV.D.4 for a detailed discussion of potential impacts on vegetable beet markets). As a result, the land used to grow approximately 300 acres of Swiss chard and table beet seed in the Willamette Valley may be used to produce a non-*Beta* seed crop.

As discussed in section III.D.1, existing studies indicate a potential increase in the overall economic returns to sugar beet root production with H7-1 adoption, although with considerable regional differences. Considering the potential for increased economic returns, it is possible that sugar beet growers may increase sugar beet acreage in some regions, however, increased returns are unlikely to lead to increased acreage of sugar beet root production as a whole. As discussed in section III.D.1.a, the domestic sugar market is closely managed by USDA's Sugar Program and maximum amounts of sugar allowed to be sold domestically are set each year for sugar beet processors (see section III.D.1.a for a detailed discussion of the U.S. Sugar Market's regulatory framework). Further, sugar beet processing plants have a certain processing capacity and no new plants are expected to open (see section III.D.1.b for a discussion of sugar beet processing plants). Thus, sugar beet growers might be unable to increase acreage in response to H7-1 sugar beets increased returns because of the limit to the amount of sugar that can be domestically sold and the limited processing capacity of the existing plants with no new processing plants being expected to open.

Section III.D.1.d, discusses a study (Kniss, 2010a) that compared 22 sugar beet fields (11 H7-1 and 11 conventional) in Wyoming in 2007 and reported that yields of H7-1 sugar beets were 15 percent higher than those of conventional varieties. Thus, there could even be an incentive for sugar beet growers to decrease acreage, if the increased yields obtained with H7-1 sugar beet production allow the production of the maximum amounts of sugar with less acreage. However it is important to consider that there are notable differences in growing conditions across sugar beet production regions in the United States and the results from this study in Wyoming do not provide sufficient data to generalize yield potential with H7-1 sugar beet adoption in all sugar beet growing regions across the country. The potential for decreased acreage across sugar beet growing regions cannot be substantiated at this time.

c. Alternative 3 – Partial Deregulation

Under Alternative 3, partial deregulation would allow planting of sugar beet root and seed crops and in any state within the United States except in California or western Washington. The acreage of H7-1 sugar beets would not be as widespread under Alternative 3 compared to Alternative 2 due to the mandatory exclusion of California, which produces about 3 percent of the root crop on about 2 percent of the acreage, from potential H7-1 sugar beet crop plantings. Adoption of H7-1 sugar beets would be expected to range from 95 to 97 percent in the long term. It should also be noted that APHIS may deny individual field locations, which could also affect adoption rates.

As discussed under Alternative 2, the overall acreage under sugar beet production would not be expected to change notably with the adoption of H7-1 sugar beets even though the potential for increased returns with H7-1 sugar beets is realized. This stasis is expected because U.S. sugar market is regulated and beet processing capacity is limited.

As discussed in section IV.D.1.a(3), with the implementation of Alternative 3, H7-1 sugar beet root growers could be impacted by the regulatory burden of Alternative 3 which is expected to be a few dollars per acre (see section IV.D.1.a(3) for a detailed discussion). This modest burden is generally not expected to diminish overall H7-1 sugar beet adoption behavior across sugar beet growing regions in the United States considering the variable costs involved in sugar beet production in different regions. As stated in section IV.D.1.a(3), to the extent that the regulatory burden of Alternative 3 does discourage some growers from planting H7-1 in favor of conventional varieties, this impact would be expected to affect growers in the Midwest region, where differential returns of H7-1 might be less than in other growing regions.

2. Soil Quality

Different production systems used to grow sugar beets (root crops and seed crops) cause different impacts on soil quality. Cultivated soils are prone to degradation because certain farming practices, such as tilling, disturb and expose the top layer of the soil surface. Soil tillage may result in degradation of soil quality because of the varying impacts of erosion on soil nutrient composition and in the loss of top soil which, once lost, could take centuries to replace (Cerdeira and Duke, 2006; Lal and Bruce, 1999). Such erosion out of the fields would result in more chemical nutrient support being required for continued plantings on land. Tillage could also cause soil carbon stores to release into the atmosphere, contributing to global climate change (Lal and Bruce, 1999).

a. Soil Quality and Tillage

The different types of tillage methods used in sugar beet production, conventional tillage, conservation tillage, reduced tillage, and strip tillage have been described in section III.E.2.a(2). Implementation of any of the three alternatives is expected to result in changes to the extent to which these tillage methods would be applied to sugar beet production in the future. Potential impacts from these tillage methods on soil are briefly summarized below.

Conventional tillage would result in 100 percent soil disturbance (USDA-NRCS, 2008), and leave less than 15 percent crop residue on the soil (Anderson and Magleby, 1997). Conventional tillage tends to enhance the breakup of soil organic matter by aerating the soil and releasing organic matter locked up in soil aggregates (Cheesman, 2004) citing Bakker, 1999 and Haynes and Hamilton, 1999). Erosion risk presented by compacted soils may be reduced by conventional tillage but conventional tillage can in itself exacerbate erosion problems and can also result in increased moisture loss from the soil as compared to no till or strip tillage (Cheesman, 2004); (Nowatzki et al., 2008). Thus, increased use of conventional tillage could present increased erosion problems compared to reduced or conservation tillage methods. With full soil disturbance and no crop residue left on the soil surface, the soil surface remains unprotected from wind for a prolonged period, and after emergence, abrasion by wind-blown soil particles can damage seedlings (Häkansson et al., 2006). In sugar beet production regions that have a high concentration of excessive wind erosion croplands like the Great Lakes and the Midwest (see figure 3–22) which include some of the highest sugar beet producing states (Minnesota, North Dakota, and Michigan), the impacts from increased wind erosion on conventionally tilled cropland could be particularly pronounced compared to other sugar beet production regions that do not experience as much wind erosion. Conventional tillage also requires working the soil multiple times, and thus leads to multiple passes on the field, and it is expected to result in greater soil compaction during the crop production cycle compared to conservation or reduced till systems (Anderson and Magleby, 1997).

Conservation tillage and reduced tillage involve the ground being worked fewer times during a crop cycle than with conventional tillage, leaving more residue on the surface (30 percent with conservation tillage, and 15 to 30 percent with reduced tillage) (Anderson and Magleby, 1997). Either conservation or reduced tillage has the potential to improve soil structure (Cerdeira and Duke, 2006), maintain long-term productivity, and improve soil quality (Anderson and Magleby, 1997). Increased crop residue on the soil surface could protect the soil from both wind and water erosion (Häkansson et al., 2006) thereby helping conserve soil nutrients. Higher soil moisture, reduced surface crust formation, and enhanced infiltration may also be seen with the adoption of conservation tillage. Conservation and reduced tillage can also contribute to reductions in soil compaction (Cerdeira and Duke, 2006 citing Holland, 2004) and no till can help to minimize soil compaction through fewer trips over the field and reduced weight and horsepower requirements (Anderson and Magleby, 1997 citing CTIC, 1996). As stated in section III.E.2.a(2), additional conservation tillage benefits can include slowing the breakdown of soil organic matter into carbon dioxide, thereby reducing emissions, and potentially improved air quality as a result of crop residues left on the soil surface by reducing wind erosion and the generation of dust that contributes to air pollution. It is likely that decreased soil erosion as a result of an increased use of conservation or reduced tillage methods could be observed more prominently in sugar beet growing regions like the Midwest and the Great Lakes that have a high concentration of excessive wind and water erosion areas (see figure 3–22). Also, in general, decreasing the intensity of tillage and/or reducing the number of field operations would be expected to result in lower machinery, fuel, and labor costs, as well as time requirements for the farm operator (Sandretto, 2001). However, cost savings of conservation or reduced tillage may be offset somewhat by increases in chemical costs for controlling weeds and insects and in starter fertilizer costs to attain optimal yields (Sandretto, 2001).

Because weed control in conservation tillage is primarily accomplished with herbicides (Anderson and Magleby, 1997) an increase in the use of conservation tillage could lead to an increase in the use of herbicides. Impacts from an increased use of herbicides to soil are discussed in sections IV.C.2 and IV.E.4.

Strip tillage combines the benefits of no till and conventional tillage, confining tillage to 6- to 8-inch strips (Nowatzki et al., 2008). Advantages of strip till are similar to that of conservation and reduced tillage and include: reduced wind erosion, less release of carbon into the air, maintenance of higher levels of soil organic matter, conservation of soil moisture and shedding of excess water, and maintenance of larger soil pores as compared to conventional tillage, yields equal to those of conventional tillage (Franzen et al., 2008; Overstreet and Cattanach, 2008), reduced fuel expenditures and expenses by elimination of some primary and secondary tillage; less labor, time, and machinery use; and the potential for conservation payments through Federal agencies, such as the Natural Resources Conservation Service if certain criteria are met (Overstreet and Cattanach, 2008).

In general there has been an increased use of reduced or no-till systems since the introduction of glyphosate-resistant crops (Cerdeira and Duke, 2006) and according to the Conservation Technology Information Center, there is a correlation of the introduction of transgenic crops and conservation or reduced tillage (Hirnyck, 2007).

Research has shown that land management techniques involving tillage, crop type, or a pest management regime have notably greater effects on the biology of the soil than the type of crop grown (Griffiths et al., 2007). Specifically, the changes in soil micro-organisms associated with growing currently deregulated GE crops are relatively variable and transient compared to the effects from crop rotation, tillage, herbicide usage, and irrigation (Pontiroli et al., 2007). For more information on micro-organisms in soil and sugar beet production, see section III.E.2.e.

Greater seed bed tilth (soil structure suitable for seeding) is needed for seed production and thus requires more cultivation than seeding operations for root production.

(1) Alternative 1 – No Action

Alternative 1 could potentially result in a decrease in sugar beet production over the short term due to a potential shortage in the availability of domestic conventional sugar beet seed as discussed in section IV.D. If there is a shortage of conventional sugar beet seed in the short term, it would imply reduced sugar beet acreage and harvest, and reduced domestic production. Farmers may allow the field to go fallow or replace the sugar beet crop with another Roundup Ready® crop.

If the land is tilled and allowed to go fallow, the amount of organic matter within the soil would be expected to decrease (USDA-ARS, 2005) resulting in the loss of potentially good bacteria and los of soil fertility (USDA-NRCS, 2011b). Further, leaving the field fallow would also increase the likelihood of erosion.

If farmers plant other Roundup Ready® crops, such as Roundup Ready® corn or Roundup Ready® soybean, it is expected that soil management practices would be similar to those employed for H7-1 sugar beets. H7-1 sugar beets have been planted using conventional tillage and conservation tillage systems such as no till, and strip till, however, there has been an observed decrease in the use of conventional tillage in sugar beets since the widespread adoption of H7-1 sugar beets in 2008, largely due to improved weed control through the use of glyphosate applications (NRC (National Research Council), 2010) (Duke and Cerdeira, 2007; Wilson Jr, 2009). Thus it is expected that more conservation or reduced tillage would be used in the event that Roundup Ready® corn and Roundup Ready® soybean are planted in place of H7-1 sugar beets. However, the extent of increase in the use of conservation or reduced tillage and the consequent impacts as described in section IV.E.2.a as a result of planting Roundup Ready® crops under Alternative 1 would vary and depend on the individual crop's (corn or soybean for example) needs for optimal yield, (for example, specific fertilizer, herbicide, pesticide, irrigation, and plowing needs) and the regional soil characteristics, topography, and climate such as timing and quantity of rainfall (Cheesman, 2004).

Another scenario to consider would be if conventional sugar beet seed is available for planting and growers choose to plant conventional sugar beets instead of other Roundup Ready® crops. As discussed in section IV.D.1.b, the current regulatory uncertainty regarding the possibility of growing H7-1 sugar beet roots in 2013 and beyond, could have led seed producers to develop conventional varieties, starting in 2011 and for use in 2013, in the event that H7-1 sugar beets could no longer be commercialized starting in 2013. In that case with the availability of domestic conventional sugar beet seed, farmers would plant conventional sugar beets in the place of H7-1 and thus would likely employ more intensive tillage practices such as conventional/traditional tillage for soil management compared to H7-1 sugar beets or other GE crops. Thus a related decrease in the use of conservation and reduced tillage may be observed. There are conventional sugar beet growers in the United States who used conservation or reduced tillage practices prior to the release of H7-1 sugar beet, and they may continue to do so under Alternative 1 provided they continue to get adequate weed control with non-glyphosate herbicides (see section III.E.2.a). The growers who adopted conservation tillage as a result of the weed control they obtained with glyphosate on H7-1 sugar beets are likely to return to conventional tillage. Adoption of conventional tillage with the planting of conventional sugar beet crops would be expected to result in greater erosion risks, loss of organic matter, and soil compaction, and reduced moisture holding capacity as discussed in section IV.E.2.a as compared to conservation or reduced tillage methods (see section IV.E.2.a for details on how conventional tillage can impact soil).

(2) Alternative 2 – Full Deregulation

Under Alternative 2, growers who have been producing H7-1 sugar beet seed and root would be expected to continue those plantings, and H7-1 seed and root production could expand to areas that currently produce conventional sugar beet seed and root since it has been observed that GE crops are largely replacing conventional crops rather than becoming an additional market or causing the conventional crop to become a separate market (USDA-ERS, 2009a).

With the anticipated high level of adoption of H7-1 sugar beets across the country, it is expected that the use of less intensive tillage methods such as conservation tillage, reduced tillage, and strip tillage would be greater relative to Alternative 1 (see section IV.E.2.a for more details). Increased adoption of less intensive tillage methods would vary between the production regions and is expected to result in varying impacts on soils in sugar beet production regions depending on the site specific soil characteristics, topography, climate, and related factors. For example, conventional tillage would continue in California because it is needed for furrow irrigation that is practiced there (2011).

Per a national survey in 2000, some sugar beet root production regions already employed conservation or reduced tillage to some degree, for example, 28 percent of sugar beet farms in Michigan (Great Lakes region) used reduced or mulch tillage and in 2006–2007, sugar beet fields being planted into stale seedbed increased to 25 percent (Ali, 2004); (Lilleboe, 2011), and in the Midwest, 36 percent of conventional sugar beet farms used reduced or mulch tillage (see section III.E.2.a for a detailed discussion). H7-1 sugar beets have largely replaced conventional sugar beet varieties in all regions except the Imperial Valley, and conservation, reduced, and strip tillage use in all these regions increased, and positively impacted the soil quality and structure as discussed in section IV.E.2a.

Some benefits of conservation, reduced, and strip tillage methods include reduced water and wind erosion, improved soil structure and increased organic matter, enhanced infiltration, increased soil moisture, reduced soil compaction, reduced carbon emissions into the air, and lower machinery, fuel, and labor costs. See section IV.E.2.a for a detailed discussion of soil impacts from conservation, reduced, and strip tillage. As stated earlier, the type of less intensive tillage method adopted (i.e., conservation, reduced, or strip tillage) would be dependent on the region's soil type, topography, climate and related factors and these factors would be expected to impact the overall degree to which these impacts may be observed.

It is expected that the adoption of H7-1 sugar beets and the associated increase in less intensive tillage methods such as conservation, reduced, and strip tillage has resulted and will continue to result in beneficial impacts on soil quality and structure in sugar beet producing regions as discussed above. It is generally expected that if H7-1 sugar beets are adopted in California where only conventional varieties were grown in the past, conservation tillage would not be adopted because it is not compatible with furrow irrigation. Therefore this region would not experience the benefits from the increased use of conservation or reduced tillage methods.

(3) Alternative 3 – Partial Deregulation

To the extent that H7-1 sugar beet root crop production is adopted in sugar beet producing states, (except in California), an associated increase in less intensive tillage methods would be generally expected. Soil impacts from the increased use of conservation, reduced, and strip tillage methods similar to those described under Alternative 2 would be likely but with a potentially lower adoption rate under Alternative 3 because of the mandatory conditions for production of H7-1 sugar beets. As stated in section IV.E.2.a, these impacts, to a lesser geographic extent than under Alternative 2, could include reduced water and wind erosion, improved soil structure and increased organic matter, enhanced infiltration, increased soil moisture, and reduced soil compaction.

Tillage in California is expected to be conventional under Alternative 3 as it was under Alternatives 1 and 2. Conventional tillage practices would continue to be used and thus more soil disturbance, a higher potential for wind and water erosion, loss of organic matter, increased soil compaction, and reduced moisture holding capacity is expected to occur compared to conservation or reduced tillage (see section IV.E.2a for details on how conventional tillage can impact soil).

b. Micro-organism Contribution to Soil Quality

As described in section III.E.2.e. interactions between micro-organisms and organic matter in the soil largely determine the fertility and overall quality of the soil. Agricultural management practices used in crop production affect soil micro-organisms either through direct effects on populations and activity or indirectly through the modification of the soil environment (Kennedy et al., 2004). Both can be either beneficial or detrimental to the soil biota. Agricultural practices that favor build-up of soil organic matter can lead to higher micro-organism diversity, whereas practices that involve high disturbance and reliance on chemical additives can result in limited micro-organism diversity or elimination of some biological groups (Kennedy et al., 2004). Severe disturbances, such as those caused by heavy tillage, can reduce plant diversity and growth, which leads to decreased micro-organism growth and functioning (Kennedy et. al., 2004 citing Christensen, 1989 and Zak, 1992). Impacts of herbicides on micro-organism activity is discussed in section IV.C.2.a.(2).

(1) Alternative 1 – No Action

Under the No Action Alternative sugar beet growers likely would (in some combination): 1) increase conventional tilling (relative to use of conservation tillage), and 2) revert to the use of herbicides used prior to nonregulated status of H7-1 sugar beets. This might result in a return to more conventional tillage practices which could reduce organic matter build-up, increase tillage activities, and increase soil disturbances. This might lead to a limited micro-organism diversity or elimination of some micro-organisms, which could alter soil quality. Under Alternative 1, shifting to non-glyphosate herbicides could lead to applying herbicides that are more toxic to micro-organisms in soil, which could limit micro-organism diversity or eliminate some micro-organisms, which might alter soil quality.

(2) Alternative 2 – Full Deregulation

Alternative 2 would be expected to result in more conservation tillage practices relative to Alternative 1 which could increase organic matter build-up, reduce tillage activities, and reduce soil disturbances. These agricultural practices favor higher micro-organism diversity (Kennedy et al., 2004). Alternative 2 could result in higher amounts of glyphosate-based herbicide used on sugar beets and a decrease in conventional herbicides. Under Alternative 2, the reduction in non-glyphosate herbicides that may be more toxic to micro-organisms may, at a minimum, not alter micro-organisms, or may increase micro-organism diversity with the use of more glyphosate (in the short term).

(3) Alternative 3 – Partial Deregulation

Micro-organism impacts from the increased use of conservation, reduced, and strip-tillage methods would be similar to those described under Alternative 2 but would not occur in as many sugar beet growing locations (owing to H7-1 exclusion from California and western Washington and a potentially lower adoption rate under Alternative 3 because of the mandatory conditions for production of H7-1 sugar beets).

c. Manganese in Soil

The potential effects of the alternatives on manganese in soil would be expected to arise from usage of herbicides and from impacts on soil. There is uncertainty associated with these potential impacts as discussed below. Manganese solubility is strongly influenced by soil pH, which can be affected by micro-organisms, other nutrients, organic matter, water availability, and herbicides. The availability of manganese in soils would depend on many of these factors and on site-specific conditions.

A shift from glyphosate-based herbicide use to a wider array of herbicides may or may not affect the availability of manganese depending on site-specific conditions. There are reports that glyphosate-resistant soybean varieties require supplemental manganese to reach their yield potential compared to conventional varieties (Gordon, 2007) and that by extension, other glyphosate-resistant crops would suffer micronutrient deficiencies. Huber (2007) found that glyphosate-resistant crops required the application of almost 50 percent more manganese to meet their physiological sufficiency than conventional soybean varieties. Zobiole et al., (2010) reported that glyphosate applications decreased manganese and other nutrient concentrations in glyphosate-resistant soybean varieties. They also reported significant reductions in shoot and root biomass due to glyphosate applications which, according to Hartzler, is not normally observed on glyphosate treated soybeans. Hartzler suggested that the differences seen in Zobiole et al., (2010) were due to other genetic differences because the effect was not confirmed in subsequent investigations (Hartzler, 2010) Finding similar inconsistencies from applying manganese to glyphosate-tolerant soybean, Diedrick et al., (2010) cautioned against any presumption of possible manganese deficits, since unnecessary application can cause yield losses. Manganese deficiency can occur in sugar beets, but the condition is related to soils with high organic matter, pHs of 6.5 and higher, and planting in old lake beds (Warncke, 2008). Growers would be able to supplement manganese-deficient soils with foliar applications of manganese to their sugar beet crops should the need arise.

No known studies have evaluated the effect of glyphosate, or the glyphosate-resistance gene, on manganese deficiency in sugar beets. Differences in manganese absorption, accumulation, and availability between glyphosate-resistant and non-treated glyphosate-resistant soybean have been observed in only a limited number of conditions (Bott et al., 2008) or not at all (Nelson, 2009; Rosolem et al., 2009). Monsanto/KWS SAAT AG conducted studies in 2008 and 2009 that tested manganese-glyphosate effects on soybean (Murdock, 2010). The research was carried out with 3 soybean varieties planted at 17 locations in multiple states. The studies had various treatment regimes (including timing and application rates) of glyphosate and manganese foliar treatments and untreated controls. The findings of those studies showed that no significant differences occurred in post-application leaf concentration of manganese for glyphosate applications within a manganese foliar treatment regime for either variety; that yield did not differ significantly among varieties, manganese treatment rates or glyphosate applications; and that the manganese concentration in seed likewise exhibited no significant difference in manganese concentrations for glyphosate applications within a manganese foliar treatment regime (Murdock, 2010). Diedrick et al., (2010) found that manganese-glyphosate interactions did not result in yield losses due to the glyphosate application on glyphosate-tolerant soybeans compared to the same variety with no glyphosate application. Thus the evidence in support of a negative interaction effect between manganese and glyphosate or the glyphosate-resistance gene is weak and conflicting for soybean and absent for sugar beet

(1) Alternative 1 – No Action

Under Alternative 1, increased tillage and use of non-glyphosate and/or glyphosate herbicides might alter the micro-organism profile and managanese solubility in the soil. If manganese became limiting for sugar beet production, growers could ensure that the correct amount of manganese would be available for growth through foliar manganese applications.

(2) Alternative 2 – Full Deregulation

Under Alternative 2, decreased tillage and use of glyphosate herbicides might alter the micro-organism profile and managanese solubility in the soil. If manganese became limiting for sugar beet production, growers could ensure that the correct amount of manganese would be available for growth through foliar manganese applications.

(3) Alternative 3 – Partial Deregulation

Under Alternative 3, the impacts are expected to be the same as under Alternative 2. If manganese became limiting for sugar beet production, growers could ensure that the correct amount of manganese would be available for growth through foliar manganese applications.

d. Nitrogen Availability in Soil

Possible impacts to soil nitrogen or its availability may be related to exposure to glyphosate, and in the case of soybean, rhizobacteria involved in nodulation and nitrifying activity demonstrate sensitivity to glyphosate with reduced nodulation (Zablotowicz and Reddy, 2004). However, unlike soybean, rhizobacteria do not colonize sugar beets. Other effects of glyphosate exposure to soil can be demonstrated on specific soil populations, such as decreases in fluorescent pseudomonads, and IAA-producing rhizobacteria (Zobiole et al., 2010). Direct exposure of soil bacteria to glyphosate or the exudation of glyphosate from roots into the soil may be the pathway for impacts on rhizobacteria (Kremer and Means, 2009). However, other herbicides may also impact soil bacteria with nitrogen cycle functions. Bromoxynil causes reductions in populations of nitrifying species, such as proteobacteria and Acidobacteria, but 84 days following treatment, most populations had returned to values typical of control values (Baxter and Cummings, 2008). Similarly in corn, both glyphosate and a mixture of acetochlor and terbuthylazine impact rhizobacterial species active in nitrifying activities, with "glyphosate being less aggressive than [the herbicide mixture] under the experimental conditions used" (Barriuso et al., 2010). Other potential effects following herbicide application have been noted by Damin et al. (Damin et al., 2010b), and these results suggest that applied herbicides can affect the content and availability of nitrogen in soil. However, these studies reflect the use of herbicides on cover crops (*Brachiaria decumbens and Pennicetum glaucum*) chosen to control erosion (from wind or water), and these grasses when dessicated may possibly release nitrogen into atmosphere, or into soil. The grassy crops studied may have quite different physiological responses to herbicide compared to the predominantly broadleaf weeds controlled in sugar beet fields by glyphosate. Cover crops for sugar beet in Minnesota or North Dakota Red River Valley may include barley and rye (Sporcic and Kuenstler, 2007). Notable also is that additional herbicides (glufosinate) can impact the plant nitrogen disposition of herbicide-killed plants just as does glyphosate (Damin et al., 2010a). Removal of cover crops by herbicide treatment can leave soil nitrogen with higher levels than by mechanical harvest (Jewett and Thelen, 2007). .

Nitrogen is the most limiting nutrient in sugar beet production, and proper nitrogen management is critical (Davis and Westfall, 2009). Growers necessarily determine the needed soil nitrogen to ensure maximum yield and sucrose content of beets. However, consequences of the type and amount of herbicides selected and used are not usually a matter of concern, since the likely impacts are not precisely known. More likely to preserve soil nitrogen are maintenance of conservation tillage practices encouraged by glyphosate (Locke et al., 2008) with H7-1 production, or by use of cover crops to reduce erosion and leaching of soil nitrogen along with H7-1 crops.

(1) Alternative 1 – No Action

Under Alternative 1, partial deregulation of H7-1 sugar beets would be phased out over time. Growers who are now growing H7-1 sugar beets, and who most likely would choose to grow conventional sugar beets, would increase the use of non-glyphosate herbicides and tillage, for weed management, which could affect nitrogen in soil. Under Alternative 1 over the long term, more nitrogen could be lost with the increased use of a wider array of non-glyphosate herbicides and the resulting increase of conventional tillage than with the more likely use of the H7-1 variety, glyphosate and subsequent conservation tillage.

It is likely that if conventional sugar beets were not planted, other crops would be planted if H7-1 were unavailable, thus limiting these potential short-term impacts of conventional sugar beet production. Growers who do not choose to continue growing sugar beets alternatively may allow land to go fallow for a year and would not likely apply any herbicide unless weeds became an issue on the fallow land and the grower had intentions of planting a crop in the near future. Herbicide impacts on nitrogen availability could be reduced under this scenario.

(2) Alternative 2 – Full Deregulation

Implementation of Alternative 2 would result in higher amounts of glyphosate-based herbicide used on sugar beets because of the increased adoption of H7-1 sugar beets. Under Alternative 2 over the long term, nitrogen loss due to herbicide use might decrease as growers substitute glyphosate-based herbicides for a wider array of non-glyphosate herbicides.

(3) Alternative 3 – Partial Deregulation

Nitrogen availability in the soil from the increased use of glyphosate would be similar to that described under Alternative 2, but would not occur in as many sugar beet growing locations due to the potentially lower adoption rate under Alternative 3 because of the mandatory conditions for production of H7-1 sugar beets. In those areas where H7-1 sugar beets are prohibited and in other areas where farmers choose to plant conventional sugar beets, the potential impacts on nitrogen availability from herbicide use and conventional tillage would be expected to be similar to those under Alternative 1, which could lead to lower availability of nitrogen in soil. However, because nitrogen is a critical limiting nutrient for sugar beet production, growers would be expected to ensure that the correct amount of nitrogen would be available in the soil through fertilization.

3. Air Quality and Climate Change

As discussed in section III.E.3, there is evidence of changes in tillage practices and equipment usage accompanying H7-1 sugar beet farming as compared to conventional sugar beet farming. The primary differences of relevance to air quality and climate are that H7-1 sugar beets may require less tillage and fewer herbicide applications compared to conventional sugar beets, which would indicate that fewer passes across the field are necessary by fossil-fuel burning machinery. A study has suggested that H7-1 sugar beets require fewer cultivation passes (which may result in less tillage, less soil compaction, and less erosion) and fewer herbicide applications with a less toxic herbicide (glyphosate) than conventional sugar beet varieties (Hirnyck, 2007). The result of less machinery usage would be decreased emissions of air pollutants and greenhouse gas emissions (GHGs). Emissions related to climate change, ozone depletion, summer smog, and carcinogenicity were found to be lower in glyphosate-tolerant crop systems compared to conventional crop systems (Bennett et al., 2004).

To the extent that (1) reductions in tillage and machinery usage have occurred with planting of H7-1 sugar beets, and (2) reduced tillage does in fact reduce fugitive particulate emissions from soil erosion and GHGs from soil (see section 3.E.3.c.), then reductions in emissions of criteria pollutants and GHGs from sugar beet farming might have resulted under 2009–2010 conditions with widespread adoption of H7-1 sugar beets, compared to pre-2005 conditions without H7-1 sugar beets. However, the available evidence is insufficient to demonstrate that such emission reductions occurred.

With adoption of H7-1 sugar beets, weed control practices could include substitution of glyphosate for herbicides that are more volatile than glyphosate and more likely to be applied aerially, as discussed in section III.B.1. As a result of these decreases in the volatility of herbicides applied and the method of application, there might be reductions in the amount of herbicide drift onto adjacent lands, and reductions in the amount of herbicide that volatilizes to the atmosphere and is dispersed, as discussed further in section III.E.3.

a. Alternative 1 – No Action

If growers choose to plant crops other than sugar beet or leave the land fallow, then the effects on air quality and climate could vary depending on the specific land use. Growers may allow land to go fallow for a growing season and may not till or apply any herbicide unless weeds became an issue on the fallow land or the grower had intentions of planting a crop in the near future. Equipment emissions, soil disturbance, fugitive particulate emissions from soil erosion, and herbicide drift would be reduced under this scenario. It is expected that plowed lands would eventually be planted with conventional sugar beets or other crops, limiting these potential short-term impacts. If farmers do not plow the fallow lands or choose not to plant any crop, the fallow lands could revert to more natural grasslands/shrublands, which would result in no machinery usage or herbicide applications. If growers choose to plant other crops, then the differences in the amount of machinery used and herbicide applied would depend on the specific crop chosen. Similarly, if growers' choice of crops involves changes to crop rotation schedules, then the resulting differences in the amount of machinery used and herbicide applied also would depend on the specific crops chosen and whether they have the glyphosate-resistant trait.

In the long term, under Alternative 1, partial deregulation of H7-1 sugar beets would be phased out over time and the presence of H7-1 sugar beets would eventually return to the pre-deregulation levels of nearly no H7-1 sugar beets (i.e., pre-2005 conditions). Under this alternative, growers who grew H7-1 sugar beets in 2009–2010, and who most likely would choose to grow conventional sugar beets, would need to use other practices for weed management. These sugar beet growers would be expected to (in some combination): 1) increase conventional tilling (relative to use of conservation tillage), and 2) revert to the use of herbicides used prior to 2005 conditions, which would increase tillage activities and machinery usage, and increase soil disturbances. Returning to non-glyphosate herbicides could lead to applying larger quantities of herbicides that are more volatile than glyphosate, which could increase machinery usage and the potential for herbicide drift. The consequences of Alternative 1 on air quality and climate for seed production are the same as for root production, because H7-1 sugar beet seed and root production acreage would be expected to eventually decline to zero.

Therefore, Alternative 1 might be expected to result in higher emissions of criteria pollutants, GHGs, and airborne herbicides, with associated potential impacts on air quality and climate, compared to Alternative 2. The likelihood of these air quality and climate impacts is uncertain, because the available evidence is insufficient to demonstrate that such emission reductions occurred.

b. Alternative 2 – Full Deregulation

Under Alternative 2, the increase in acreage devoted to H7-1 sugar beets is expected to lead to increased use of conservation tillage practices and decreased soil disturbance, as well as increased use of glyphosate herbicide, compared to Alternative 1, as discussed in section III.E.2.

Alternative 2 would result in more conservation tillage practices which would decrease machinery usage and reduce soil disturbances. Alternative 2 would result in higher amounts of glyphosate-based herbicide used on sugar beets and a reduction in the use of non-glyphosate herbicides. Sugar beet tillage practices, soil disturbance levels, machinery usage, herbicides used, and levels of herbicide application associated with H7-1 sugar beet farming would also be expected to be similar to 2009–2010 conditions. Therefore, Alternative 2 might be expected to have lower emissions of criteria pollutants, GHGs, and airborne herbicides, with associated reductions in potential impacts on air quality and climate, compared to Alternative 1. As discussed above, the likelihood of these air quality and climate impacts is uncertain.

The proportion of this impact attributable to H7-1 seed production would be less than for root production because, in contrast to H7-1 sugar beet root production, glyphosate is not used as a postemergent herbicide in hybrid seed production fields, and because the amount of acreage planted to seed and stecklings is comparatively inconsequential. For further discussion of steckling, seed, and root production methods see section III.B.1.

c. Alternative 3 – Partial Deregulation

Under Alternative 3, the impacts of tillage and herbicide use are expected to have the same beneficial impacts to air quality as described under Alternative 2. In California, there are not expected to be any differences in tillage under Alternatives 2 and 3. Herbicide use is expected to differ under Alternative 3 because in some areas producers would not use glyphosate and consequently decreases in air quality may be anticipated. Therefore, Alternative 3 might be expected to exhibit levels of emissions of criteria pollutants, GHGs, and airborne herbicides, with associated potential impacts on air quality and climate, that are similar to or slightly higher than under Alternative 2.

4. Surface Water and Groundwater Quality

As with other agricultural crops, the effects of sugar beets on surface water and groundwater (e.g., lakes, streams, aquifers) depend on multiple factors or activities related to crop production, which can include soil preparation, planting and harvesting; tillage practices; tractor and other equipment use; the use of herbicides and fertilizers; and the frequency of irrigation necessary to produce a viable crop. Table 4–25 lists some common activities that are part of crop production and how they might affect water quality.

Table 4- 25. Common Crop Production Activities and their Potential Effect on Water Quality

Crop Production Activities	Potential Effect on Water Quality
Soil Preparation Planting Harvesting	Soil disturbance from tillage practices and soil compaction from heavy equipment use could leave soils susceptible to increased wind and water erosion, leading to potential sedimentation and turbidity impacts in surface waters from increased runoff.
Nutrient Management	Use of fertilizers could lead to leaching of nitrates into groundwater and movement of nitrates and phosphorous into surface waters, potentially causing eutrophication.
Pest Management	Leaching of herbicides into groundwater and movement of herbicides to surface waters through soil erosion or runoff, spray drift, or inadvertent direct overspray.
Irrigation	Irrigation induced runoff could potentially increase movement of nutrients and herbicides into groundwater and surface waters

a. Tillage and Water Infiltration and Runoff

(1) Alternative 1 – No Action

Under Alternative 1, growers who are now growing H7-1 sugar beets, and who most likely would choose to grow conventional sugar beets, might need to use other practices for weed management, which could affect water quality. For weed control, under the No Action Alternative, sugar beet growers (in some combination) could: 1) increase conventional tilling (while reducing conservation tillage), and 2) revert to herbicide practices used for sugar beet production prior to 2005.

Growers might allow land to go fallow for a year and then continue to plow the land, which could increase the erosion of topsoil via wind or rainfall. It is likely that plowed lands would eventually be planted with conventional sugar beets or other crops, limiting these potential short-term impacts. If farmers do not plow the fallow lands or choose to not plant any crop, the fallow lands could revert to more natural grasslands/shrublands, which could result in more vegetative cover and more root stabilization in the soil, which could lead to less soil erosion and less potential sedimentation impacts on surface waters when compared to land that is planted with sugar beets or is fallow and then plowed.

Few H7-1 sugar beets would be planted; all would be under permit or notification and would likely be quickly phased out over time and be replaced by conventional sugar beets. This could result in a return to conventional tillage practices which would increase soil disturbance and expose more soil to the erosive forces of wind and water when compared to the conservation tillage practices used for H7-1 sugar beets in 2009–2010. An increase in soil disturbance could lead to increased soil erosion potential, and an increase in potential sedimentation and turbidity in nearby surface waters during rain and irrigation events ((Sandretto and Payne, 2006)citing Edwards, 1995 and USDA, 1997). In 2009, based on states' water quality reports, the EPA identified sedimentation and turbidity as 2 of the top 10 causes of impairment to surface water in 44 states, 2 territories, and the District of Columbia, with the exception of coastal waters (U.S. EPA 2009d); in 2007, the EPA had identified sedimentation as the leading cause of impairment to rivers and streams in reporting jurisdictions. Regionally, the greatest potential for soil erosion would be expected to occur in the Upper Midwest sugar beet production area as illustrated in figure 3–22.

(2) Alternative 2 – Full Deregulation

Under Alternative 2, the increase in acreage devoted to H7-1 sugar beets is expected to lead to increased use of conservation tillage practices, as well as increased use of glyphosate herbicide compared to Alternative 1.

Growers could continue to implement conservation tillage practices which would continue to decrease the erosion potential of topsoil via wind or rainfall, compared to typical tillage practices for conventional sugar beets (e.g., pre-2005 conditions). A decrease in soil disturbance could lead to decreased soil erosion potential, and a subsequent decrease in potential sedimentation and turbidity in nearby surface waters. The role of conservation tillage (including no till, ridge till, and mulch till) in controlling soil erosion and soil degradation is well documented (Sandretto and Payne, 2006). By leaving substantial residues of plant and organic matter on the soil surface, conservation tillage (1) reduces soil erosion by wind; (2) reduces soil erosion by water; (3) increases water infiltration and moisture retention; (4) reduces surface sediment and water runoff; and (5) reduces chemical runoff (Sandretto and Payne, 2006)citing

Edwards, 1995 and USDA, 1997). In addition, the filtering action of increased organic matter in the top layer of soil could result in cleaner runoff (by reducing contaminants such as sediment and adsorbed or dissolved herbicide chemicals), and thus also benefit water quality in surface waters (Anderson and Magleby, 1997) citing Onstad and Voorhees, 1987 and CTIC, 1996). The EPA has projected conservation tillage to be "the major soil protection method and candidate best management practice for improving surface water quality" (U.S. EPA 2002b) though a comprehensive data set has not yet been developed to verify EPA's projection. The EPA identifies conservation tillage as the first of its core agricultural management practices for water quality protection (U.S. EPA 2008a)

Regionally, the greatest potential for soil erosion occurs in the Midwest sugar beet production area (see figure 3–22) which means this area may benefit the most in reduced erosion, sedimentation, and potential water quality impacts that result from use of conservation tillage practices on H7-1 sugar beets. Other sugar beet regions have potential for soil erosion, but not to the same extent as the Midwest sugar beet region.

It should be noted that conventional tillage would continue in California because it is needed for furrow irrigation that is practiced there. In this area, constituting approximately 2 percent of the sugar beet growing area, there would be the same amounts of soil erosion and runoff as found under Alternative 1.

(3) Alternative 3 – Partial Deregulation

Under Alternative 3, the adoption rate of H7-1 sugar beets may be lower compared to Alternative 2 because of the mandatory condictions for production of H7-1 sugar beets under Alternative 3. The beneficial impacts associated with an increase in less intensive tillage methods would be generally expected compared to pre-2005 conditions. Soil impacts from the increased use of conservation, reduced, and strip tillage methods would be similar to those described under Alternative 2 but would not occur in as many sugar beet growing locations..

b. Herbicides and Water Infiltration and Runoff

(1) Alternative 1 – No Action

Under Alternative 1, growers may allow land to go fallow for a year and would not likely apply any herbicide unless weeds became an issue on the fallow land and the grower had intentions of planting a crop in the near future. Herbicide impacts on surface and groundwater would be reduced under this scenario. It is likely that plowed lands would eventually be planted with conventional sugar beets (similar to pre-2005 conditions) or other crops, limiting these potential short-term impacts. If farmers do not continue to plow the fallow lands or choose to not plant any crop, the fallow lands would revert to more natural grasslands/shrublands, which would result in no herbicide applications and no impacts on water resources.

Over the long term, H7-1 sugar beets would be phased out over time and would eventually be replaced by conventional sugar beets. This could result in a shift from glyphosate dominated herbicide use to a combination of herbicides used prior to de-regulation (pre-2005). Prior to adoption of H7-1 sugar beets, growers regularly used multiple chemical herbicides to control weeds (Cole, 2010); (Kniss, 2010b; Wilson, 2010) The use of glyphosate on sugar beet crops would likely return to the level of use similar to that which existed prior to the deregulation of H7-1 sugar beets (used on approximately 13 percent of sugar beet acres based on 2000 data) (USDA-NASS, 2008). Growers would likely resume the use of a larger array of other herbicides, consisting of the thirteen common sugar beet herbicides listed in table 3–11. The types and amounts of herbicide would depend on weed pressures, weed management, and production practices of a particular sugar beet production region, as well as site-specific farm conditions. See tables G1 through G11 discussed in section IV.B.1.e and provided in appendix G, which list the types and amounts of herbicides used on conventional sugar beets in 2000 for each sugar beet production region.

As described in section III.E.4.d, each herbicide's fate and transport in the environment depends on several factors, such as the physical characteristics of the herbicide, the characteristics of the soil that the herbicide is sprayed on, tillage practices, the slope of the land, rain, and irrigation volumes. In the absence of information on site specific sugar beet field conditions, an herbicide's adsorption, water solubility, and persistence characteristics can allow for comparisons between various herbicide products. Under Alternative 1, there would be an increase in conventional tillage and soil disturbance compared to 2009–2010 conditions (but similar to pre-2005 conditions), which would increase the potential for herbicides to move with soil to surface waters during erosion events. Under Alternative 1, a shift from a glyphosate dominated herbicide use to a wider array of other herbicides would increase the risk of chemical leaching into groundwater because all other sugar beet herbicides have higher potentials to leach based on their lower adsorptive properties (K_{oc}) when compared to glyphosate (which has the highest K_{oc} compared to the other herbicides) (see table 3–53). The use of non-glyphosate herbicides that would increase under Alternative 1 do not bind as tightly to soil particles as glyphosate, which would increase their potential downward mobility in soil. During erosion events, most non-glyphosate herbicides would have a lower potential than glyphosate to move in surface water runoff in solution and when attached to soil particles (see table 3–53), which could lead to a reduced potential for herbicides reaching surface waters when compared to glyphosate. Only four other non-glyphosate sugar beet herbicides have the same high potential as glyphosate to move in solution runoff (cycloate and ethofumesate) and adsorbed runoff (quizalofop-p-ethyl and trifluralin) (see table 3–53). All remaining herbicides have a lower potential than glyphosate to move in surface water runoff in solution or attached to soil particles during an erosion event (see table 3–53). Once an herbicide reaches surface water, the water quality effects of the herbicide on the environment would depend on the ecology of the aquatic system. These impacts are discussed further in section IV.C Biological Resources. However, in general, and as supported by the EPA designation of reduced risk for application of glyphosate to H7-1 sugar beets, glyphosate is a more environmentally preferred herbicide compared to other herbicides currently used in sugar beet production since glyphosate is generally less toxic and has more favorable degradation properties.

Once in surface water, glyphosate dissipates more rapidly than most other herbicides, and various studies have shown that glyphosate appears in surface water less than several alternative herbicides (Cerdeira and Duke, 2006) and (Carpenter et al., 2002). (See section IV.C for a more thorough discussion of the effects of herbicides on the aquatic biological environment.) In summary, under Alternative 1, there would be a greater potential for leaching herbicide chemicals into groundwater, but a decreased potential for herbicides to move in surface runoff and reach surface waters during erosion events. However, non-glyphosate herbicides are considered more toxic and have less favorable degradation properties than glyphosate (see section IV.C Biological Resources).

Regional herbicide use data (from 2000) presented in section III.B.1.e indicate that the Northwest sugar beet production region applied the most pounds of herbicide per acre planted (1.55 lb). The remaining four regions have relatively similar pounds of herbicide application per acre: Great Lakes (0.73 lb per acre), Midwest (0.66 lb per acre), Great Plains (0.60 lb per acre), and Imperial Valley (0.67 lb per acre). Based on this information and assuming the herbicide use would return to H7-1 sugar beet levels, the Northwest region would have the greatest potential for herbicides reaching surface water.

(2) Alternative 2 – Full Deregulation

Under Alternative 2, herbicide impacts on surface and groundwater are expected to be be similar to those that prevailed in 2009–2010, and impacts could be less intense than those occurring before introduction of H7-1 sugar beets.

As described in section III.E.4.d, each herbicide’s fate and transport in the environment depends on several factors, such as the physical characteristics of the herbicide, the characteristics of the soil that the herbicide is applied to, tillage practices, the slope of the land, rain, and irrigation volumes. Under Alternative 2, there could be a continued increase in conservation tillage, resulting in a reduction in soil disturbance compared to 2009–2010 conditions. This could decrease the potential for herbicides to move with soil to surface waters during erosion events. Under Alternative 2, an increase in use of glyphosate herbicide could decrease the risk of chemical leaching into groundwater because the other twelve sugar beet herbicides have higher potentials to leach based on their lower adsorptive properties (K_{oc} coefficient) when compared to glyphosate (which has the lowest adsorptive coefficient (K_{oc})) (see table 3–53). Glyphosate has rarely been reported in groundwater (Borggaard and Gimsing, 2008) but can be present especially after rains that immediately follow after application (Coupe et al., 2011).

Once absorbed to soil particles glyphosate has a high potential to move into surface water from runoff when erosion conditions lead to the surface transport of soil particles (see table 3–53). However, H7-1 sugar beets would lead to an increase in conservation tillage systems compared to pre 2005 conditions, which would result in less mechanical disturbance of the soil during sugar beet cultivation, decreasing the loss of surface soil. Because of this, and the fact that glyphosate binds strongly to soil particles (see table 3–53) conservation tillage of H7-1 sugar beet fields is expected to reduce the presence of glyphosate in surface water runoff. In addition, the filtering action of increased organic matter in the top layer of soil from conservation tillage could result in cleaner runoff (by reducing contaminants such as adsorbed or dissolved herbicide chemicals), and thus also benefit water quality in surface waters ((Anderson and Magleby, 1997) citing Onstad and Voorhees, 1987 and Conservation Technology Information Center or CTIC, 1996). This could lead to a reduction in the potential for all herbicides (glyphosate and non-glyphosate) used on H7-1 sugar beets to move in surface runoff. Once in surface water, glyphosate dissipates more rapidly than most other herbicides, and various studies have shown that glyphosate appears in surface water less frequently than several alternative herbicides (Cerdeira and Duke, 2006) and (Carpenter et al., 2002). (See section IV.C for a more thorough discussion of the effects of herbicides on the aquatic biological environment.). In summary, under Alternative 2, there would be a lesser potential for leaching of herbicide chemicals into groundwater, a lesser potential for all herbicides to move in surface runoff and reach surface waters during erosion events due to conservation tillage, decreased use of non-glyphosate herbicides, and an increase in the amount of glyphosate used on sugar beets. As previously mentioned in section IV.C., each of the twelve non-glyphosate herbicides used on sugar beets is considered more toxic and has less favorable degradation properties than glyphosate.

Under Alternative 2, it is expected that total applied glyphosate would increase while non-glyphosate herbicides would decrease compared to Alternative 1. The greatest potential for soil erosion (and subsequent herbicide movement) occurs in the Upper Midwest sugar beet production area (see figure 3–22), which means this area may benefit the most from the reduced erosion, sedimentation, and herbicide movement that could result from conservation tillage practices used with H7-1 sugar beet. In addition, California growers would produce H7-1 sugar beet for the first time, which would mean higher amounts of glyphosate would be expected to be introduced into the environment.

(3) Alternative 3 – Partial Deregulation

To the extent that H7-1 sugar beet root crop production is adopted in sugar beet producing states, except in California, an associated increase in glyphosate use and decrease in non-glyphosate herbicides would be generally expected, compared to pre-2005 conditions. The effect of herbicides on surface and groundwater related to the increased use of glyphosate (and reduced use of non-glyphosate herbicides) and increase of conservation, reduced, and strip-tillage methods could be less than or similar to those described under Alternative 2 but might not be chosen in as many sugar beet growing locations (owing to H7-1 exclusion from California and a potentially lower adoption rate under Alternative 3 because of the mandatory conditions for production of H7-1 sugar beets). As stated in section IV.E.4.b(1) these impacts, to a lesser geographic extent than under Alternative 2, could include reduced groundwater leaching of chemicals, reduced herbicide movement to surface waters, and reduced use of herbicides that are more toxic than glyphosate. In those areas where H7-1 sugar beets are prohibited (California) and in other areas where farmers choose to plant conventional sugar beets, the potential impacts on surface and groundwater from tillage practices could be similar to those under Alternative 1 (i.e., pre-2005 conditions), which could lead to higher potential for groundwater leaching of chemicals, higher potential for herbicide movement to surface waters, and greater use of herbicides that are more toxic than glyphosate than if H7-1 sugar beets were not prohibited.

F. Human Health and Safety

This section assesses the human health and safety impacts of the three alternative APHIS actions regarding H7-1 sugar beets. This section parallels that of section III.F by first discussing public health and safety and then worker health and safety. Impacts from sugar beets and related products and impacts from pesticides used during production are each addressed within these sections for the three alternatives.

1. Public Health and Safety

As discussed in section III.F.1, sugar beets are used for food, feed, and various other products to which people are exposed. Areas of potential environmental consequences related to public health and safety include the direct human exposure to sugar beet pollen on or near farms, the consumption of products derived from sugar beets, and exposure to pesticides used on sugar beets.

a. Sugar Beets and Related Products

Human health and safety impacts of Alternatives 1 through 3 are addressed below within the context of the public's exposure to sugar beets and related products. As discussed in detail in section III.F.1.a, people are exposed to a variety of these products. The average American consumes the equivalent of about four to five teaspoons of beet sugar daily. Trace impurities in the sugar, such as inorganics, plant proteins and other sugars (besides sucrose, the primary sugar), are a natural consequence of sugar production (Lew, 1972; Potter et al., 1990; Potter and Mansell, 1992). Other sugar beet products available on the market, including food and livestock feed additives, baker's yeast, and pharmaceuticals, also may contain impurities such as these. While some of these other products make their way into human foods only indirectly (e.g., the use of molasses as a growth medium for baker's yeast and other fermentation products, other products are ingested directly (e.g., betaine) or added directly to the human diet (e.g., fiber from beet pulp).

Another potential route of exposure to sugar beet constituents is by inhalation of pollen. This exposure is limited primarily to the less than 5,000 seed production acres in Oregon, Washington, Idaho, and Colorado because generally only sugar beets for seed production reach the stage of pollen release (see section III.B.1.b for additional detail on seed production). Another potential exposure route is gene flow from sugar beets to the other *Beta* species of Swiss chard, table beets, and fodder beets, with subsequent direct or indirect consumption of these other crops or associated products. These related plants are discussed further in section III.B.2 through III.B.4, and the potential for gene flow in *Beta* species is discussed in section IV.B.5. The amount of consumption of hybrids between sugar beet and vegetable beet is expected to be negligible because isolation distances used in seed production usually keep the hybrid frequency to below 1 in 10,000 and hybrids usually look different and can be rogued.

APHIS assessed these potential human exposures for the three alternatives by first examining the compositional nature of sugar beets and related products. APHIS then assessed whether any of these compositional factors could result in any direct adverse health effects, including adverse effects caused by the toxicity and allergenicity of sugar beet pollen and the CP4 EPSPS protein. APHIS also examined whether these factors represent other unintended consequences resulting from the action, such as a change in the nutritional makeup of the product resulting from the incorporation of the *cp4 epsps* gene in H7-1 sugar beets. Finally, APHIS examined the human health consequences from gene flow from sugar beets to related crops, such as Swiss chard, table beets, and fodder beets.

(1) Alternative 1 – No Action

Under Alternative 1, sugar, pulp, and other products derived from sugar beets would be from conventional sugar beets.

No direct consumption of or exposure to the H7-1 gene or gene product during public use is expected to occur under this alternative. The amounts of conventional sugar beet products consumed under this alternative would likely be similar to the period prior to the 2005-2006 growing season. Sugar from sugar beets would continue to be produced at roughly the same amount per capita. Sugar beet pulp would be used for direct food consumption via nonsugar food items such as fiber. Sugar beet molasses would continue to be used for the production of betaine (a nutritional supplement), citric acid, monosodium glutamate (MSG), baker's yeast, and other products, chemicals, and pharmaceuticals. Humans would continue to consume meat and dairy from livestock that consume feed derived from sugar beet molasses, sugar beet pulp, or sugar beet leaves and petioles..

Both the benefits and adverse effects associated with the consumption of products derived from sugar beets would continue under this alternative. Beet sugar would continue to contribute benefits as a readily available high energy carbohydrate, but would also continue to contribute to adverse health effects such as premature death from obesity and diabetes and other adverse effects such as hyperactivity and dental carries. The effects of other products derived from sugar beets, such as the use of betaine to treat hypochlorhydria, also would continue.

One area of potential differences between the current situation (2010-2011 growing season) and this alternative would be the shift from products almost exclusively derived from H7-1 sugar beets to those exclusively from conventional sugar beets. As discussed in section III.F.1.a(4), no meaningful differences in characteristics were found between H7-1 and conventional sugar beets. In particular, analyses included basic qualities (crude ash, crude fiber, crude fat, crude protein, and dry matter), carbohydrates, quality parameters (sucrose, invert sugar, sodium, potassium, alpha-amino nitrogen), saponins (naturally-occurring "anti-nutrients"), and 18 amino acids (see section III.F.1.a(4) for additional detail and literature citations). In summary, as part of its consultation regarding H7-1 sugar beets FDA concluded that the Agency had no questions about the developer's determination that H7-1 sugar beets are not materially different in composition, safety, or other relevant parameters from conventional sugar beets (U.S. FDA, 2004).

Similar to the public's exposure to sugar beet products, a small number of people near sugar beet seed farms could be exposed to sugar beet pollen almost exclusively from conventional sugar beets instead of H7-1 sugar beets under Alternative 1. As noted above, this exposure would be limited primarily to the less than about 5,000 seed production acres (less than 0.4 percent of total sugar beet acres), which are in Oregon, Washington, Idaho, and Colorado. Under this alternative, APHIS expects that existing adverse health effects related to allergenicity to sugar beet pollen from conventional sugar beets will continue. APHIS is not aware of any reports of differences between the allergenicity of pollen from conventional versus H7-1 sugar beets so these effects would be the same under all the alternatives.

The amount of tillage used to grow sugar beets under Alternative 1 is expected to be substantially more than is used in the recent growing seasons (e.g., 2010-2011), as described in section IV.E.3. Thus, engine exhaust emissions and fugitive soil particulates from tractor use during cultivation would be greater under this alternative compared to the recent growing seasons. These emissions and particulates, which are an expected consequence of farming in general, can result in adverse human health effects. Soil particulates can be associated with adsorbed pesticides and other chemicals, which people then inhale. See section IV.F.1.b for more on pesticide effects on human health.

In summary, APHIS concludes that the compositional characteristics of the predominantly conventional sugar beets and productsunder Alternative 1 pose no greater risks to human health than from H7-1 sugar beets currently used. In either case, there are equivalent health risks associated from over-consumption of sugar and the potential allergies from pollen inhalation under all the alternatives. Under Alternative 1, there is a greater potential for adverse health effects from inhalation of engine exhaust and soil particulates resulting from the greater amount of cultivation compared to recent tillage practices with H7-1 sugar beet.

(2) Alternative 2 – Full Deregulation

FDA concluded that the Agency had no questions about the developer's determination that H7-1 sugar beets are not materially different in composition, safety, or other relevant parameters from conventional sugar beets (U.S. FDA, 2004). As such, Alternative 2 is not likely to cause any unique adverse health effects compared to those effects caused by conventional sugar beets.

The potential for allergenicity and toxicity of the CP4 EPSPS protein in H7-1 sugar beet CP4 EPSPS protein has been evaluated and it has been concluded that CP4 EPSPS is unlikely to pose allergenicity or toxicity concerns. This finding is based on research described in section III.F.1.a(5). For example, no treatment-related adverse effects were observed in an acute toxicity test in which mice were gavaged (orally dosed) with up to 572 mg of CP4 EPSPS per kg of body weight (designed to reflect a 1,000-fold factor of safety on the highest possible human exposure to CP4 EPSPS, assuming multiple sources in the diet). The CP4 EPSPS protein also does not have biologically relevant structural similarities to protein toxins known to cause adverse health effects in humans or animals (based on a comparison of the amino acid sequence to protein sequences in the ALLPEPTIDES database). Additionally, CP4 EPSPS does not share immunologically relevant amino acid sequence homology with known allergens, as determined by comparison of the amino acid sequence of the CP4 EPSPS to sequences in the ALLERGEN3 database. Furthermore, many variants of the *epsps* gene and EPSPS protein are ubiquitous in nature, are normally present in food and feeds derived from these plant and microbial sources, and when used to impart tolerance to glyphosate in corn, cotton, and soybean plants, have not resulted in any known adverse human health effects despite being grown on hundreds of millions of acres across the United States over the past decade.

Based on these and other research findings described in section III.F, APHIS concludes that the compositional characteristics of H7-1 sugar beets grown under Alternative 2 pose no risks to human health.

In terms of gene flow, section IV.B.5 concludes that the potential for gene flow to Swiss chard and related products is too low for any meaningful transfer of traits. Furthermore, if transfer were to occur, the resulting seeds would consist of hybrid off-types that had undesirable and intermediate characteristics that would deter harvest and consumption by humans (see section 3.B.5.e). Moreover, the research cited and summarized in section III.F.1.a(4) finds that even if such traits were to transfer, no harmful changes in characteristics would occur. For these reasons, APHIS believes that gene flow from H7-1 sugar beets to vegetable beets under Alternative 2 would not pose any health risks beyond those of Alternative 1.

The amount of tillage used to grow sugar beets under Alternative 2 is expected to be similar to what is used in the recent growing seasons (e.g., 2010-2011), which declined from prior (2005-2006) seasons due to the use of H7-1 sugar beets. With this decline are possible reductions in adverse human health effects otherwise associated with the inhalation of engine exhaust emissions and fugitive soil particulates, including from pesticides adsorbed to the soil. See section IV.F.1.b for more on pesticide effects on human health.

In summary, the health effects associated with Alternative 2 are expected to be similar to Alternative 1..

(3) Alternative 3 – Partial Deregulation

Alternative 3 is expected to result in human consumption of H7-1 sugar beet products, similar to, though lower in magnitude than, the consumption described above for Alternative 2 (Full Deregulation). Human health impacts for Alternative 3 are expected to be similar to those presented above for Alternative 2..

b. Pesticides

A variety of pesticides – insecticides, herbicides, and fungicides – are used in growing sugar beets. As discussed in detail in section III.F.1.b, pesticides are composed of both active and "inert" ingredients. People can be directly exposed to pesticides via inhalation, oral, and dermal routes if they live on or near farms that use them. The broader public can be exposed to pesticides as residues on the products from crops that are sprayed directly. People also can be exposed indirectly, such as through ingestion of livestock products (e.g., milk) derived from livestock fed the sprayed crops. Consumption of adjacent crops affected by spray drift is also a possible route of exposure, as is inhalation and dermal exposure from spray drift to residents near those spraying operations. Movement of pesticides to surface water or groundwater used for drinking water also is a potential pathway for exposure. Various interacting factors affect exposure, including a pesticide's chemical characteristics (e.g., volatility, solubility, organic-carbon partitioning), a farm's environmental characteristics (e.g., soil, climate, weediness), a farm's pesticide management practices, a pesticide's use profile (e.g., conservative use, overuse, mixing with other pesticides), and the surrounding population's characteristics (e.g., proximity, behavior, physiology).

By their nature, pesticides are bioactive and may convey some risk to human health. Pesticides are carefully evaluated by EPA prior to registration to ensure that they can be used with a reasonable certainty of no harm (U.S. EPA 2011a). The risks associated with the application of these herbicides are controlled by a number of factors, including the use restrictions established by EPA and states and specified on the product labels. However, that does not mean that the correct application of these herbicides is without risk or that the risks of each herbicide are equivalent. Some herbicides pose greater risks because they are more toxic than others. Some herbicides pose greater risks because they are applied at higher concentrations and or more frequently thereby increasing the risk due to exposure.

APHIS focused on the health consequences of herbicides for this assessment and did not address insecticides and fungicides in any detail because the latter are used similarly across alternatives in terms of type, quantity, and hence would have the same potential environmental impact. Herbicides, however, are expected to be used differently among the alternatives, especially between Alternative 1 versus Alternatives 2 and 3. Alternative 3 is expected to have herbicide usage very similar to Alternative 2 and hence the only comparison for herbicide use is made between Alternatives 1 and 2. Also, while there are differences in herbicide use between seed production and root production, the amounts of herbicides used in seed production are relatively minor compared to the amounts used in root production (less than 0.4 percent of total sugar beet use, based on acreage planted). Therefore, seed production is not analyzed in detail in this assessment.

A number of tools are available to compare the relative risks of the herbicides used to produce the sugar beet root crop. These include:

Chronic Oral Reference Dose (RfD). The RfD is EPA's maximum acceptable oral dose of a toxic substance. The RfD is a value established by EPA that is based on toxicity studies in laboratory animals and adjusted for a number of factors, including human toxicity data, population variability, and inadequacies in the studies. The Oral RfD is an "…estimate, with uncertainty spanning perhaps an order of magnitude, of a daily oral exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime" (U.S. EPA 1993b).

- **Dietary Risk Assessment for Food**. Dietary risk assessment incorporates both exposure and toxicity of a given pesticide. (U.S. EPA 2004) The risk is expressed as a percentage of a maximum acceptable dose (i.e., the dose which will result in no unreasonable adverse health effects) (U.S. EPA 2004). This dose is referred to as the Population Adjusted Dose (PAD). Dietary risk is characterized in terms of the PAD, which reflects the Reference Dose (RfD), either acute (aPAD) or chronic (cPAD), that has been adjusted to account for the Food Quality Protection Act (FQPA) Safety Factor. A risk estimate that is less than 100% of the PAD is not of concern to the Agency. The values of the cPAD for all 13 herbicides do not pose risks of concern (table 4-26).

- **Aggregate Risk**. The aggregate risk integrates the assessments conducted for food, water, and residential uses when appropriate. All uses of the herbicide are considered, not just uses for sugar beet. Some herbicides (cycloate, desmedipham, ethofumesate, phenmedipham, pyrazon and triflusulfuron-methyl), are used almost exclusively on sugar beets. For the remainder, use on sugar beet is often a small fraction of the total use. All of the thirteen herbicides do not pose risks of concern indicating that no unreasonable adverse effects on human health by the herbicides are expected regardless of the registered use of the herbicide.

- **APHIS Relative Risk Score (RRS).** The APHIS RRS is a metric used by APHIS to provide an estimate of the risk of various herbicides, relative to a given herbicide (in this case glyphosate). For public health, the RRS is based on the maximum application rates per season (a surrogate for exposure), divided by the chronic oral RfD (a surrogate for toxicity). For this analysis, APHIS indexed the RRS on glyphosate, given the importance of this herbicide to this determination. Thus, the ratios for exposure (a given herbicide's maximum application rate divided by glyphosate's maximum application rate) and toxicity (a given herbicide's RfD divided by glyphosate's RfD) are divided, producing the RRS. This indexing allows a comparison of the inherent risks of the herbicides to glyphosate. Thus, the overall risk score for glyphosate is 1. This approach is similar to risk-based scoring approaches that USDA has conducted for other actions (see WIN-PST).

- **Windows Pesticide Screening Tool (WIN-PST) Exposure Adjusted Toxicity Category.** WIN-PST was developed by the USDA–NRCS as a risk screening tool for pesticides. WIN-PST is used to evaluate the potential for pesticides to move with water and eroded soil/organic matter and affect nontarget organisms. WIN-PST considers the impact of soil characteristics, irrigation/rainfall probability, and pesticide application area, method, and rate on the potential for pesticides to move off-site following application (UC-Davis, 2008). For assessing human health impacts in this EIS, APHIS used only the exposure adjusted toxicity rating from WIN-PST, which represents the soluble pesticide long-term toxicity level for humans. This metric is used to determine relative risk and is based on the drinking water maximum contaminant level (MCL, determined by EPA), health advisory (HA, determined by EPA), or chronic human carcinogen level (CHCL, calculated using an EPA algorithm) for the given pesticide. The exposure adjusted toxicity categories are "Very Low," "Low," "Intermediate," "High," and "Extra High."

- **Consumer Environmental Impact Quotient (EIQ)**. The EIQ, developed by Kovach et al. ((1992)and updated annually integrates information on different types of environmental and human health impacts of individual pesticides into a single indicator value of impact. The EIQ is a method of determining the environmental impact of different pesticides and pest management programs (Cornell University, 2011). The EIQ is an average of the impact values for three components: farm workers, consumers, and ecosystems. APHIS used the consumer component of the EIQ for this analysis. It is the sum of consumer exposure potential and potential groundwater effects. Consumer exposure is calculated as chronic toxicity multiplied by the average residue potential in soil and plant surfaces multiplied by the systemic potential rating of the pesticide (the pesticide's ability to be absorbed by plants). Generally, a lower EIQ indicates that an herbicide poses less risk.

Each of these metrics has underlying assumptions and limitations, which are addressed in detail in the indicated references. One of these metrics, the RfD, is toxicity-based only and thus must be considered along with some measure of exposure, such as application rate, to obtain a reasonably complete understanding of health risks. This is the basis for the APHIS RRS. The other metrics used here are relative risk-based approaches that do incorporate some measures of individual exposure. When used either alone or together for purposes such as comparing pesticides for regulatory actions, as with H7-1 sugar beets, these metrics provide a reasonable understanding of the relative health risks that were used to form impact conclusions for each alternative.

One approach used by EPA for protection of human health, but not otherwise addressed in this analysis, is the tolerance (maximum residue). As described in section III.F.1.b and shown in table 3–54, tolerances exist for the 13 most common herbicides applied to sugar beets (or, in the case of trifluralin, to other root crops or to sugar cane). Tolerances are enforceable maximum residue limits for pesticides on food products and are based on the requirement for a "reasonable certainty" that no harm will result from exposure to active ingredients at levels below the tolerance. Tolerances are derived assuming application of the pesticide is according to label directions; therefore, unless tolerances are exceeded due to mixing or application errors, APHIS anticipates that there will be no unreasonable human health impacts of herbicides from public exposure. Table 3-54 ilustrates that refined sugar, the principle sugar beet product to which the population is exposed, generally does not have a tolerance level for any herbicide, except for ethofumesate, because pesticide residues are simply not detected in the product.

Note that the metrics considered in this analysis address the active ingredient of these herbicides only, and not the inert ingredients. While these inert ingredients are known to contribute their own risks or modify the risks of the active ingredients, in most cases they are confidential and so cannot be individually analyzed. Furthermore, they may be similar across the herbicides and thus would not affect the relative risk. Food-use inerts such as those used on sugar beets also must be approved by EPA, as noted in section III.F.1.b.

(1) Alternative 1 – No Action

Under Alternative 1, APHIS expects that the herbicide use profiles described in section IV.B.1.e for Alternative 1 and shown in table 4–1 would apply. Herbicide use would consist mainly of the 13 herbicides shown in this table and would be similar in proportion to the use in 2000, which is when NASS collected the data shown in table 4–26 (as described in section IV.B.1.e). Under Alternative 1, and compared to the recent (2010-11) growing seasons, the use of conventional sugar beets would lead to an increase in exposure to all of the listed herbicides with the exception of glphosate. Exposure could occur during application of the herbicide, transportation and processing of harvested crops, and in the consumption of livestock that have been fed sugar beet pulp and beet molasses. However, most of the population is not expected to have contact with sugar beet fields or the unprocessed beets. Most of the population will be exposed to beet sugar which has no detectable herbicide residue except in the case of ethofumesate.

For that subset of the population that might be exposed to beet products other than refined sugar, table 4-26 compares various risk metrics for each of the thirteen herbicides. These include APHIS relative risk score, windows pesticide screening tool, consumer environmental impact quotient, and chronic oral reference dose.

The following observations can be made about the risk-based metrics shown in table 4–26:

- The **APHIS RRS** is lowest for clopyralid (0.5), triflusulfuron-methyl (0.8), and glyphosate (1.0). Clopyralid and trisulfuron-methyl are two of the most widely used herbicides on sugar beet. The remaining 10 herbicides rank higher than glyphosate in terms of this RRS and could pose greater risks to human health. The highest RRS score is for cycloate (192) followed by EPTC (59). These two herbicides are not expected to be that widely used in sugar beet production. In 2000 they were used on about 5% of sugar beet acres (table 3-15). However clethodim, desmedipham, and phenmedipham are all expected to be widely used on sugar beet under Alternative 1 (table 3-15) and all have higher RSS values than glyphosate.

- The range of values for the **WIN-PST** exposure adjusted toxicity category is from Very Low to Intermediate for the 13 herbicides evaluated. Glyphosate is in the category of very low risk as is most of the herbicides used on sugar beet. Three of the herbicides in this analysis – cycloate, trifluralin, and triflusulfuron-methyl – had rankings of Intermediate risk. Of these herbicides, triflusulfuron-methyl is expected to be heavily used under Alternative 1 (table 3-15). Clethodim and quizalofop-p-ethyl had rankings of Low risk and clethodim is expected to be widely used under Alternative 1. Thus the WIN-PST ratings indicate that at least 5 herbicides expected to be used on sugar beets have higher toxicity ratings than glyphosate and two of those herbicides are expected to be widely used on conventional sugar beets.

- The **Consumer EIQ** values available for the herbicides in this analysis ranged from 2.55 to 8.00. Desmedipham had the lowest rating (2.55) followed by glyphosate at 3.00. All other herbicides had higher ratings

Table 4- 26. Selected Hazard Metrics for Public Exposures[1]

Herbicide	APHIS Relative Risk Score	WIN-PST Exposure Adjusted Toxicity Category	Consumer Environmental Impact Quotient (EIQ)	Chronic Oral Reference Dose (RfD)	Chronic dietary risk assessment for food [2]	Aggregate Risk: Food, Water, Residential
Clethodim	**12**	**Low**	**8**	**0.01**	**27/73**	<LOC
Clopyralid	0.5	Very Low	**8**	**0.15**	**9/23**	<LOC
Cycloate	**192**	**Intermediate**	**7**	**0.005**	**2.4/5.5**	<LOC
Desmedipham	**11**	Very Low	2.55	**0.04**	ND	<LOC
EPTC	**59**	Very Low	**4**	**0.025**	**9.6/17.4**	<LOC
Ethofumesate	**3**	Very Low	**6**	**0.3**	<1/<1	<LOC
Glyphosate	1	Very Low	3	1.75	2/7	<LOC
Phenmedipham	**3**	Very Low	4.55	**0.24**	<1/<1	<LOC
Pyrazon	**10**	Very Low	**7**	**0.18**	<0.1/<0.1	<LOC
Quizalofop-p-ethyl	**5**	**Low**	**3.33**	**0.009**	**/29**	<LOC
Sethoxydim	**2**	Very Low	**4.55**	**0.14**	2.7/7.5	<LOC
Trifluralin	**8**	**Intermediate**	**5.5**	**0.024**		<LOC
Triflusulfuron-methyl	0.8	**Intermediate**	–	**0.024**	<1/<1	<LOC

[1] See the introduction to section IV.F.2.b for the derivation of each of these metrics

[2]Percent of RfD or cPAD. The first value is for the general public; the second is for the highest exposed subgroup

Abbreviations: WIN-PST = Windows pesticide screening tool, LOC= Level of concern; ND –not determined indicating that the potential risk to human health is greater for these herbicides than for glyphosate.

- The **Chronic Oral RfD** for the herbicides analyzed ranges from 0.005 to 1.75, or nearly three orders of magnitude. In general, the lower the RfD value, the higher the toxicity (or the greater the uncertainty); alternatively, the lower the RfD, the higher the risk given the same dose or exposure. By this measure, glyphosate is considered to pose the least potential risk to human health with an RfD of 1.75. Considering the chronic RfD of the six herbicides expected to be used on greater than 33% of all sugar beet acres under Alternative 1, clethodim (0.01), clopyralid (0.15), desmedipham (0.04), ethofumesate (0.3), phenmedipham (0.24), triflusulfuron-methyl (0.02), the potential hazard posed by these herbicides to Human health and public safety range from 175 to nearly 6 fold greater than for glyphosate.

- Aggregate Risk. The chronic dietary risk assessment values as percent of the chronic public adjusted dose is shown in table 4-26. The first value is for the general population and the second is for the most sensitive subgroup, usually infants or small children. Values range from less than 0.1 for pyrazon to 73 for clethodim. Though there are differences in the degree of potential risk with clethodim the highest and pyrazon the lowest, values for all thirteen herbicides are below 100, and therefore none of these herbicides pose risks of concern when used according to the label. In cases where herbicide is detected in ground or surface water, a dietary risk assessment for drinking water will be conducted. In cases where there is residential use of the herbicide, an additional assessment is conducted for residential use. The dietary food, dietary water, and residential risk assessments are integrated into the aggregate risk assessment. EPA has found that for all thirteen herbicides the aggregate risk does not pose risks of concern.

Application method also can have an effect on risk and was not considered in the metrics described above. Aerial broadcast leads to higher herbicide exposures to the public compared to non-aerial methods because of the drift that occurs. As indicted by data in section III.B.1.d(4), Alternative 1 would likely result in about 9 percent of herbicides being applied to sugar beet using aerial broadcast methods compared to 3 percent under Alternative 2. The greater use of aerial spraying under Alternative 1 is another reason to expect the the risk to Human Health and public safety is greater under Alternative 1 compared to Alternative 2.

(2) Alternative 2 – Full Deregulation

Glyphosate use would be many fold greater under Alternative 2 than Alternative 1, but, the use of most other herbicides would decrease on the order of 90%, as shown in table 4-3. As described under Alternative 1, this change in herbicide use is expected to reduce the overall risk to the general public because generally glyphosate is less toxic than other herbicides and is less likely to be aerially applied. This conclusion does not mean that herbicide use under Alternative 1 is expected to be unsafe, in both cases the herbicide use is based on a standard of reasonable certainty of no harm. As shown in table 4-26, for all the herbicides used on sugar beet, risks of concern are not expected when the herbicide is used as directed according to the label. For many of the herbicides which are used on other crops, the risk assessment takes into account these additional uses.

Under Alternative 2, the addition of H7-1 sugar beets is not expected to lead to an increase in the exposure to glyphosate in the diet of the general public because any residue left on H7-1 sugar beets would be removed during refining. The EPA's current aggregate dietary risk assessment concludes there is no concern for any subpopulation regarding exposure to glyphosate, including the use on many fruits and vegetables and H7-1 sugar beets (71 FR 76180, 2006). EPA's current dietary risk estimates are based on a theoretical maximum residue contribution (TMRC), which assumes that residues at the tolerance level are present on all crops that might be treated with glyphosate. Glyphosate is registered for use as a direct application to weeds in several conventionally produced fruits and vegetables, and tolerances are established in the consumable commodities of these crops. The increase in glyphosate use at the national level associated with Alternative 2 would not alter these EPA risk conclusions, which are based on glyphosate use restrictions for any particular application, not based on total quantities used nationally.

(3) Alternative 3 – Partial Deregulation

The potential human health impacts for Alternative 3 would be similar to those presented above for Alternative 2 except that slightly less glyphosate and slightly more conventional herbicides are expected to be used.

2. Worker Health and Safety

This section analyzes potential worker health and safety impacts of the four APHIS action alternatives that are the subject of this EIS. Areas of potential environmental consequences related to worker health and safety include those related to sugar beets and derived products (direct exposure to allergens, risks from farm equipment) and those related to pesticides used on sugar beets.

a. Sugar Beets and Related Products

No meaningful occupational risks are expected to sugar beet farm and processing workers from direct exposure to the sugar beet root crop based on the absence of reported cases and the lack of evidence of any meaningful differences in characteristics between conventional and H7-1 sugar beets. In the limited area where seed is produced, up to 5,000 acres primarily in Oregon and Washington, workers could be exposed to allergens in sugar beet pollen but no differences are expected among the alternatives. Workers also experience risks of injuries and fatalities from the use of equipment involved with sugar beet farming and product manufacturing, as discussed in section III.F.2.a. The use of farm equipment is expected to vary for the four action alternatives and this area is further discussed below.

(1) Alternative 1 – No Action

Equipment Use. The risks of injuries and fatalities from equipment use under Alternative 1 are expected to be similar to the risks prior to the 2005-2006 growing season, when cultivation equipment use was higher and more workers were in the fields (e.g., weeding by hand). Data specific to sugar beets during that timeframe are available only for fatalities. As discussed in detail in section III.F.2.a, these data indicate that about 0.7 fatal injury occurred per year (or a fatality about every 1.4 years). APHIS developed an estimate of worker injuries from sugar beet farming using data on injuries associated with the use of tractors, rotary hoes and harrows, weed pullers, and other equipment in agriculture in general. As injury data specific to sugar beet farming are not available, APHIS assumed the proportion of injuries specific to sugar beet farming was the same proportion of agricultural land specifically used to farm sugar beets or approximately 4.1 percent of the total injuries due to use of agricultural equipment (section 3.F.2.a.). The resulting estimate is that an average of about 95 non-fatal injuriesand 0.7 fatal injury are expected each year to workers under Alternative 1.

The higher amount of equipment use expected under Alternative 1 compared to the expected use under Alternative 2 should result in higher engine exhaust emissions and fugitive soil particulates from tractor use, as described in section IV.E.3. These emissions and particulates, which are an expected consequence of farming in general, can result in adverse worker health effects. Soil particulates are associated with adsorbed pesticides and other chemicals, which workers then inhale (see section IV.F.2.b for more on pesticide effects on worker health). The larger expected number of field workers under Alternative 1 also means more workers are exposed to emissions and particulates.

(2) Alternative 2 – Full Deregulation

The potential for allergenicity and toxicity of the CP4 EPSPS protein in H7-1 sugar beet CP4 EPSPS protein has been evaluated and it has been concluded that CP4 EPSPS is unlikely to pose allergenicity or toxicity concerns (U.S. FDA, 2004). Thus workers exposed to CP4 EPSPS protein are unlikely to face allergenicity or toxicity concerns. This finding is based on research described above for public health exposure (section IV.F.1.a). APHIS notes that many variations of the EPSPS protein are ubiquitous in nature, and when used to impart tolerance to glyphosate in corn, cotton, and soybean plants, have not resulted in any known adverse worker health effects despite being grown on hundreds of millions of acres across the United States over the past decade. Based on these research findings, APHIS concludes that the compositional characteristics of any H7-1 sugar beets grown under the short term under Alternative 1 would pose no risks to worker health.

Equipment Use. The risks of injuries and fatalities from equipment use under Alternative 2 are expected to be similar to the risks during the recent (2010-2011) growing season, when cultivation equipment use was lower compared to earlier (pre-2005-2006) seasons and fewer workers were in the fields (e.g., weeding by hand). Data specific to sugar beets for this time period were not available. Therefore APHIS conducted an analysis using the pre-2005-2006 estimates and recent equipment use reduction data. This analysis, described in section III.F.2.a, estimated that conventional sugar beet production resulted in average rates of about 95 non-fatal injuries and 0.7 fatal injury each year to workers. The subsequent adoption of H7-1 sugar beets resulted in a reduction of approximately 30 percent fuel use which should translate into at least a 30% reduction in tractor, cultivation, and other equipment use (see section III.F.2). APHIS used the reduction in equipment use under H7-1 sugar beet adoption to estimate a proportional reduction in injuries and fatalities. Therefore, APHIS estimates that Alternative 2 would be associated with a worker fatality rate of approximately 0.5 per year (or approximately 1 fatality every 2 years) and a non-fatal injury rate of about 66 per year.

The lower amount of equipment use under Alternative 2 compared to prior (2005-2006) seasons would likely result in lower engine emission and soil particulate exposures to workers. Fewer workers in the fields also means fewer workers exposed, including to pesticides adsorbed to the soil (see section IV.F.2.b for more on pesticide effects on worker health). Thus under Alternative 2, injuries from equipment operation and exposure to engine emissions and soil particulates are expected to be less than under Alternative 1.

(3) Alternative 3 – Partial Deregulation

Alternative 3 would result in worker exposures to the H7-1 sugar beet and its products and equipment uses that are similar to, though slightly less than, those described above for Alternative 2. Under Alternative 3, APHIS expects that the risks of injuries and fatalities would be similar to the risks described above for Alternative 2. Alternative 3, however, likely would not result in the same reductions in equipment use as expected under Alternative 2 due to lower adoption of H7-1 sugar beets (and thus farming practices) under Alternative 3 compared to Alternative 2. Thus, APHIS expects Alternative 3 to result in only marginally higher injury rates than the approximately 0.5 fatal injury per year (about 1 fatality every 2 years) and 66 non-fatal injuries per year estimated under Alternative 2. Also, similar to Alternative 2, the lower amount of equipment use under Alternative 3 compared to prior (2005-2006) seasons would likely result in lower engine emission and soil particulate exposures to workers. In addition, fewer workers in the fields means fewer workers exposed, including to pesticides adsorbed to the soil (see section IV.F.2.b for more on pesticide effects on worker health).

b. Pesticides

This analysis of environmental consequences to workers from pesticides used on sugar beets was conducted using an approach similar to that used for analyzing public health consequences from pesticides (section IV.F.1.b). That is, while the action alternatives assessed here involve the use of pesticides and create the potential for worker exposures, when the pesticides are used according to the label there should be no unreasonable adverse health effects.

In addition, insecticides and fungicide useage is not expected to differ across the alternatives but herbicide usage is expected to vary between Alternatives 1 and 2 - 3. Therefore, consistent with public health risks (section IV.F.1.b), this section focuses on herbicide use.

For both Alternatives 1 and 2, and similar to what was done for public exposure in section IV.F.1.b, APHIS compiled tables that characterize and compare a series of selected risk-based metrics for worker exposures to the 13 most common herbicides used in sugar beet root production. Unlike public exposure which is primarily assumed to occur through an oral route, worker exposure is thought to occur primarily through dermal and inhalation routes and the risk metrics differ from that used to analyze public exposure effects.

Below is a more detailed description of the various risk metrics considered and their relevance to human health risk.

- **Label Signal Word.** Label signal words are advisories that appear on pesticide product labels. Pesticides signal words are Caution, Warning, and Danger, with Caution representing low relative toxicity, Warning representing moderate relative toxicity, and Danger representing high relative toxicity. Signal words are based on acute toxicity testing of the concentrated product by oral, inhalation, dermal, skin sensitization, and eye exposures. Test results showing the highest toxicity are used to determine the pesticide label signal word. Section III.F.2.b provides additional detail about the label signal word and its use on sugar beet herbicides. As shown in Table 4-27, The **Label Signal Word** indicates that quizalofop-p-ethyl has the highest acute toxicity (Danger), which reflects concern that this herbicide causes irreversible eye damage. Two herbicides, phenmedipham and sethoxydim, have moderate levels of concern (Warning). The remaining nine herbicides, including glyphosate, have the lowest toxicity (Caution).

- **Farm Worker Environmental Impact Quotient (EIQ)**. The EIQ, developed by Kovach et al. (1992)and updated annually) integrates information on different types of environmental and human health impacts of individual pesticides into a single indicator value of impact. The EIQ is a method of determining the environmental impact of different pesticides and pest management programs (Cornell University, 2011). The EIQ is an average of the impact values for three components: farm workers, consumers, and ecosystems. The farm worker component of the EIQ is the sum of applicator exposure potential and picker exposure potential multiplied by the pesticide's chronic toxicity. Chronic toxicity is identified through various long-term laboratory studies conducted on small mammals to detect potential reproductive, teratogenic, mutagenic, and oncogenic effects. Applicator exposure potential is calculated by multiplying the dermal toxicity rating to small laboratory mammals and by a coefficient of 5 to account for the increased risk associated with handling concentrated pesticides. Picker exposure potential is calculated as dermal toxicity multiplied by the rating for plant surface residue half-life potential. Generally, a lower EIQ indicates that a pesticide is less hazardous. Data are lacking for trisulfuron-methyl. The **Farm Worker EIQ** values available for the herbicides in this analysis ranged from 6.00 to 12.00. Four herbicides, clethodim, cycloate, quizalofop-p-ethyl, and trifluralin, are in the highest third; three herbicides, clopyralid, ethofumesate, and glyphosate, are in the middle third; and the remaining five are in the lowest third.

- **Acute Toxicity LD_{50} Values, Dermal Exposure**. Lethal doses from laboratory testing are often used as indicators of acute toxicity for risk assessment purposes. Dermal (skin) LD_{50} values are presented in the matrices, as those are the exposure routes most relevant to human health for this analysis. Generally, the higher the LD_{50} value, the lower the overall toxicity of the substance in question. EPA has classified toxicity values such as LD_{50}s into four toxicity categories: Severely irritating (up to 200 mg/kg); Moderately irritating (200-2000 mg/kg); Slightly irritating (2000 thru 20,000 mg/kg; not an irritant (> 20,000 mg/kg). As shown in Table 4-27, the **Acute Dermal LD_{50}** values for the herbicides compared in the tables ranged from 2,000 mg per kg per day to greater than 20,050 mg per kg per day. This range of values includes EPA Toxicity III (Slightly irritating) and

IV (non-irritating) (undated). All the herbicides are in the slightly irritating category with the exception of pyrazon which is not considered to be an irritant.

Note that the metrics considered in this analysis address the active ingredients of these herbicides only, and not the inert ingredients. Although these inert ingredients are known to contribute their own risks or modify the risks of the active ingredients, toxicity data for these inert ingredients and whole pesticide formulations are presently not available. For a more complete understanding of the actual or "absolute" risks of these herbicides and inert ingredients in the environment, see the herbicide-specific risk assessment and pesticide registration documents noted in section III.F.1.b.

Table 4- 27. Selected Hazard Metrics for Occupational Exposures

Herbicide	Label Signal Word	Farm Worker Environmental Impact Quotient (EIQ)	Acute Dermal Toxicity, LD_{50} (mg/kg)
Clethodim	Caution	**12**	>5,000
Clopyralid	Caution	8	>5,000
Cycloate	Caution	**12**	>5,000
Desmedipham	Caution	7.1	>4,000
EPTC	Caution	6	>2,000
Ethofumesate	Caution	8	> 20,050
Glyphosate	Caution	8	>2,000
Phenmedipham	**Warning**	7.1	>4,000
Pyrazon	Caution	6	>2,000
Quizalofop-p-ethyl	**Danger**	**10.65**	>2,000
Sethoxydim	**Warning**	7.1	>5,000
Trifluralin	Caution	**9**	>2,000
Triflusulfuron-methyl	Caution	–	>2,000

[1] See the introduction to section IV.F.2.b for the derivation of each of these metrics.

(1) Alternative 1 – No Action

Table 4-27 compares various hazard metrics for occupational exposures. Most of the herbicides including glyphosate are labeled with caution, the least hazardous signal word. Two herbicides, phenmedipham and sethoxydim are labeled with warning. Quizalofop-p-ethyl is labeled with danger. Considering the Farm Worker EIQ, clethodim, cycloate, quizalofop-p-ethyl, and trifluralin had EIQ values higher than the value for glyphosate. Desmedipham, EPTC, phenmedipham, pyrazon, and sethoxydim all had lower Farm Worker EIQ values than glyphosate. All of the herbicides had relatively low acute dermal toxicity. As listed in table 3-56, desmedipham, EPTC, phenmedipham, sethoxydim, trifluralin, and triflusulfuron-methyl all are in category III for acute dermal while glyphosate and the other herbicides are in the less toxic category IV. For inhalation, three of the herbicides, EPTC, ethofumesate, and triflusulfuron-methyl are in the relatively toxic category II. Clethodim, Sethoxydim, and trifluralin are in category III. Glyphosate and the other herbicides are in category IV. For skin irritation, clethodim is in the very toxic category I. Cycloate is in category III and the other herbicides are in category IV. For eye irritation, clopyralid is in the very toxic category I, desmedipham is in category II, glyphosate and six other herbicides are in category III. Several of the herbicides, cycloate, sethoxydim, and trifluralin can cause skin sensitization. Overall, glyphosate is in the lowest hazard category for each worker category (oral, dermal, inhalation, skin irritation, and skin sensitization) except eye irritation where it is in the second lowest category. Considering the six herbicides expected to be used on greater than 33% of sugar beet acres under Alternative 1, clethodim is very toxic from the standpoint of causing skin irritation (category I vs category IV for glyphosate), clopyralid is much more toxic from the standpoint of causing eye irritation (category I vs category III for glyphosate), desmedipham is more toxic from the standpoint of causing eye irritation (category II vs category III for glyphosate), ethofumesate is more toxic from the standpoint of inhalation (category II vs category IV for glyphosate), and triflusulfuron-methyl is much more toxic from the standpoint of inhalation (category II vs category IV for glyphosate). Based on the comparison of these hazard metrics, APHIS expects that the herbicides used under Alternative 1 have a higher potential risk compared to the predominant use of glyphosate expected under Alternative 2.

Alternative 1 would likely result in more workers in the field, for cultivation and hand-weeding purposes. A greater number of workers would be exposed to herbicide residues in the field from either aerial or ground applications. Furthermore, more frequent herbicide applications are expected to be made under Alternative 1 compared to Alternative 2, further increasing the risk of exposure.

In summary, APHIS concludes that while the potential for adverse worker health impacts associated with herbicide use under Alternative 1 would not pose unreasonable risks, the potential risks for five of the six most widely used herbicides exceed that of glyphosate in one or more toxicity categories. Clethodim causes severe skin irritation. Clopyralid causes severe eye irritation. EPTC, ethofumesate, and triflusulfuron-methyl are relatively toxic by the inhalation route. The risks to workers associated with the application of these pesticides would be controlled by adherence to the use restrictions established by EPA and specified on the product labels. If the pesticides are applied according to these restrictions, the resulting worker exposures and health risks should not be unreasonable, according to available toxicity information and government approvals. It is expected that worker exposure to herbicides will be greater under Alternative 1 compared to Alternative 2 because more field workers will be needed for cultivation and handweeding and herbicide applications will be more frequent.

(2) Alternative 2 – Full Deregulation

Under Alternative 2, workers in sugar beet fields will be exposed to more glyphosate and less non glyphosate herbicides. Overall worker exposure to pesticides is expected to decrease compared to Alternative 1 due to the decreased number of field workers needed for weed control and the more frequent herbicide applications. According to EPA (U.S. EPA 1993c), glyphosate exposure to workers and other applicators generally is not expected to pose undue risks, due to glyphosate's low acute toxicity. However, splashes during mixing and loading of some products can cause injury, primarily eye and skin irritation. EPA is continuing to recommend personal protection equipment, including protective eye wear, for workers using end-use products that are in Toxicity Categories I or II for eye and skin irritation. To mitigate potential risks associated with reentering treated agricultural areas, workers are not permitted to enter fields for 12 hours after spraying. As discussed in detail in section III.F.2.b and this section under Alternative I, glyphosate poses a relatively low individual worker risk compared to the other herbicides used for sugar beets.

Herbicide quantity is an indication of how many workers are potentially exposed to the herbicide rather than an indication of how much herbicide any given individual worker is exposed to. Under Alternative 2, most workers will be exposed to glyphosate and will have very little exposure to other herbicides. One factor affecting the potential number of workers exposed to herbicides under this alternative is that as growers have adopted H7-1 sugar beets in recent years, the use of manual labor has declined substantially, as noted in section IV.F.2.a. APHIS would expect that these reductions in field workers would result in fewer workers being exposed to herbicides. In addition, while no change in insecticide and fungicide use would be expected between the alternatives, the expected reduction of workers in the field would mean a reduction in exposure to these other pesticides too.

In summary, APHIS concludes that the potential for adverse worker health impacts associated with herbicide use under Alternative 2 would be less than under Alternative I because there are less human health hazards associated with glyphosate relative to the other herbicides used on sugar beet, there are expected to be less field workers needed to produce sugar beets under Alternative 2, and there are expected to be fewer applications of herbicide. As a result of the reduced need for field workers, workers will be exposed to less insecticides and fungicides. Applications of all herbicides under this alternative – including glyphosate – would be subject to use restrictions specified by EPA that have been established to ensure that resulting worker health risks are not unreasonable.

(3) Alternative 3 – Partial Deregulation

Alternative 3 would result in worker exposure to H7-1 sugar beet production practices similar to, though lower in magnitude than, the exposure described above for Alternative 2. Thus, conclusions on potential worker health impacts for Alternative 3 would be similar to those presented above for Alternative 2.

G. Other Impacts and Mitigation Measures

This section describes other potential impacts associated with the implementation of the alternatives, including unavoidable impacts; short-term versus long-term productivity of the environment; and irreversible/irretrievable commitment of resources. This section also describes potential impact mitigation measures, as applicable, beyond what is already built into the alternatives.

1. Unavoidable Impacts

Unavoidable impacts are any adverse environmental effects which cannot be avoided should the proposal be implemented (40 CFR § 1502.16).

a. Production Management

Sugar beet production practices require herbicide usage in order to be economically feasible. As a result, herbicide application is unavoidable for all of the alternatives. Likewise, even though the adoption of H7-1 increases the use of conservation tillage (including strip-till) methods, some degree of tillage and its resulting disturbance of soil is also unavoidable.

A low level of gene flow between sugar beets and other fertile *Beta* species is unavoidable in sugar beet seed production practices. However, with proper mitigation measures in place, unwanted gene flow can be reduced to negligible levels.

b. Biological Resources

While there are many mechanisms that can delay the occurrence of herbicide resistance in weed populations, the selection of herbicide-resistant weeds is unavoidable under all three alternatives. Selection of herbicide-resistant weeds is greatly influenced by farmer choices such as weed control strategies. The selection of herbicide-resistant weeds can be mitigated to the extent that farmer behaviors can be influenced.

Under Alternative 1, a shift to non-glyphosate herbicides is expected with the return to growing of conventional sugar beets. Potential toxic effects from these herbicides on animals include impaired growth, development, reproduction, and long-term survival. Pyrazon might pose a substantial risk of sublethal or chronic effects to individual mammals. There could be a risk of sublethal or chronic effects on birds (and possibly reptiles) from the application of sethoxydim postemergence, and to a lesser extent, trifluralin applied preemergence (or early postemergence). None of the herbicides are expected to pose risks of population-level effects when used within label limits. Although unlikely, there could be a short-term loss of groundcover for those species using sugar beet fields if farmers allow the land to go fallow for a few years. Potential impacts on aquatic species from conventional tillage include impaired habitat conditions from soil erosion, which can result in harm to individual species, including individual mortality.

Under all three alternatives, potential adverse impacts on soil microbial communities might occur from herbicide use, depending on the herbicides used. Under Alternative 1, the return to conventional tillage practices associated with conventional sugar beet production and removal of crop residues could result in decreased microbial biomass and activity.

Application of herbicides according to EPA label requirements should pose a reasonable certainty of no harm to terrestrial plants at the population level in the vicinity of treated crops, but drift, runoff, or groundwater seepage into unintended areas on some occasions and at some locations is possible under all the alternatives. Under Alternative 1, the increased use of non-glyphosate herbicides could result in impaired plant growth or death, with non-target broadleaf terrestrial plants adjacent to sugar beet fields being at greatest risk. Glyphosate use under Alternatives 2 and 3 could have similar adverse effects to a wide variety of plants adjacent to treated sugar beet fields.

Under Alternative 1, threatened and endangered aquatic species might be adversely affected by impaired habitat conditions resulting from a return to conventional tillage practices and the subsequent induced soil erosion that may occur.

c. Socioeconomic Impacts

Under Alternative 1, sugar beet seed growers would need to discard H7-1 seed grown in 2011 for the 2013 crop production cycle. Returns to past investments in the development of H7-1 varieties that depend on production in the United States would no longer be realized. Also, sugar beet growers and processors would not be able to benefit from any increased returns provided by H7-1 as compared to conventional sugar beets. To the extent that there is a shortage of domestic conventional seed in 2013, sugar beet seed growers would temporarily experience decreased sales of seed.

Under Alternatives 2 and 3, sugar beet seed producers would stop growing any conventional seed that they specifically started growing in anticipation of H7-1 not being approved for planting in 2013, and any costs incurred would not be recovered.

Under Alternative 3, due to imposed planting restrictions, California sugar beet producers and processors would not be able to benefit from any increased returns provided by H71 sugar beets.

d. Physical Environment

Under Alternative 2, for land use impacts it is possible that some Swiss chard and table beet seed producers may decide to use other growing regions due to concern about gene flow, market perceptions of increased risk of gene flow, the cost of testing for the H7-1 gene and lack of available production area in Willamette Valley. As a result, in the long term, Swiss chard and table beet seed production may increase in other areas within the U.S., or overseas and decrease in the Willamette Valley.

Under Alternative 1, use of more intensive tillage practices (conventional/traditional tillage) for soil management by growers planting conventional sugar beets in place of H7-1 would likely increase compared to practices used in planting of H7-1 sugar beets. Adoption of conventional tillage with the planting of conventional sugar beet crops would be expected to result in greater soil erosion, loss of organic matter, soil compaction, and reduced moisture holding capacity, as compared to conservation or reduced tillage methods. This would lead to an increase in potential sedimentation and turbidity in nearby surface waters during rain and irrigation events. A return to more conventional tillage methods would also lead to more limited micro-organism diversity and possible elimination of some micro-organisms. In addition, under Alternative 1 sugar beet growers would shift to more non-glyphosate herbicides which could lead to applying herbicides that are more toxic to micro-organisms in soil. This could limit micro-organism diversity or to possible elimination of some micro-organisms.

e. Human Health

Under Alternative 1, use of cultivation and other equipment would increase compared to recent H7-1 practices, which could increase adverse health effects from exposure to engine exhaust and fugitive soil particulates. Also under Alternative 1, adverse human health impacts from herbicides could be higher compared to the recent H7-1 practices due to higher toxicity of conventional herbicides and the higher potential for use of aerial spraying of these herbicides. While use restrictions would be in place, accidents or misuse may still occur and could have greater impact due to higher toxicities.

Workers would likely be exposed to a higher rate of potential equipment accidents due to the production practices associated with growing conventional sugar beets under Alternative 1, and they would be likely exposed to higher rates and amounts of engine emissions and soil particulates, as compared to practices used in growing H7-1 sugar beets. Also under Alternative 1, the number of workers in the field would likely increase given the different production practices for conventional sugar beets, which could increase the numbers exposed to equipment emissions, soil particulates, and pesticides.

2. Short-term Use vs. Long-term Productivity of the Environment

Short-term uses and long-term productivity of the environment are linked, and opportunities that are acted upon have corollary opportunity costs in terms of foregone options and productivity could have continuing effects well into the future.

One substantial issue of concern for long-term productivity is the extent to which glyphosate-resistant and tolerant weeds are increased by the practices related to each alternative. The stewardship practices are designed to minimize this effect, but it is less clear how effective these will be in concert with rotations with other crops.

Conflicts regarding short-term use versus long-term productivity of the environment were identified with respect to socioeconomic impacts. Under Alternative 1, the choice to plant H7-1 sugar beet seeds for production purposes would no longer be available to farmers. It is possible that for some producer regions, H7-1 varieties have allowed for benefits in production costs or yields. The possibility of exploring potential cost and yield benefits of biotechnology for the production of sugar beets could be hindered by the selection of this alternative.

Under Alternatives 2 and 3, conventional or organic sugar beet seeds might not be available or only available in small quantities to conventional or organic sugar beet producers from the four main domestic sources of sugar beet seeds. This would likely have little to no long-term economic impact, however, given that the commercial market for conventional or organic sugar beets is small or non-existent.

Irreversible resource commitments represent a loss of future options. It applies primarily to the use of nonrenewable resources and to factors that are renewable only over long time spans, or to adverse impacts that cannot be reversed once they are set in motion. An irretrievable commitment of resources represents opportunities that are foregone for the period of the proposed action. It also includes the use of renewable resources, such as timber or human effort, as well as other utilization opportunities that are foregone in favor of the proposed action.

Based on available data, irreversible or irretrievable loss of any resources related to this proposed action are limited to certain effects to biological resources, socioeconomic resources, and human health. No irreversible or irretrievable commitments of resources were identified with respect to production and management of sugar beet seed and root crops and physical environment resources for any alternative. It is expected that much of the land that would be used for H7-1 sugar beet production under Alternatives 2 and 3 is already in use for sugar beet production or for other agricultural production. Land currently used for sugar beet production could be allowed to go fallow or could be used for crops other than sugar beets. Acreage used for sugar beet seed and root production does not represent an irreversible or irretrievable commitment of resources because the land can be easily converted to serve other purposes such as growing other crops or for commercial or residential use. Soil used for sugar beet seed and root production does not represent an irreversible or irretrievable commitment of resources because the soil composition can be amended through changes in production management (e.g., tillage practices, chemical application) or converted to serve other purposes such as growing other crops or going fallow. Surface water and groundwater used for irrigation purposes would be replenished through the natural water cycle as long as sustainable use of water resources is practiced.

For biological resources, under Alternative 1, the increased use of non-glyphosate herbicides could result in impaired growth or death to non-target plants adjacent to treated fields, which would represent an irreversible loss of those resources. Alternatives 2 and 3 could have similar adverse effects on nontarget plants related to glyphosate spray drift.

For socioeconomic impacts, under Alternative 1, the research and development costs that industry has spent to date would represent an irreversible expenditure of resources. The investments that cooperatives and growers have made in developing H7-1 stewardship programs, efficient production techniques, and marketing strategies would also represent an irreversible cost under Alternative 1. In addition, specialized equipment that growers may have purchased that is unique to growing H7-1 sugar beets would also represent an irreversible cost, unless they are able to sell the equipment, which could result in a loss from the original purchase price. Also under Alternative 1, if processing plants were to close, the investment in those resources and the employment and other economic activity associated with them would represent an irreversible or irretrievable commitment of resources. Under Alternative 1, the loss of ability for sugar beet growers and processors to benefit from any increased returns provided by H7-1 sugar beets represents an irretrievable impact. Under Alternatives 3, the restriction on planting of H7-1 in California would result in a similar irretrievable impact of the lost benefit for growers and processors in that state to benefit from any increased returns provided by H7-1.

For human health resources, under Alternative 1 the shift in production practices and the subsequent higher potential for worker injuries and fatalities from equipment accidents, and the potential increased exposure to engine exhaust and fugitive soil particulates, represent potentially irreversible impacts. Also under Alternative 1, use of cultivation and other equipment would increase compared to recent H7-1 practices, which could increase adverse health effects from exposure to engine exhaust and fugitive soil particulates. Also under Alternative 1, human health risks from herbicides could be higher compared to the recent H7-1 practices due to the higher toxicity of herbicides used in conventional production and the higher potential for use of aerial spraying of these herbicides. While use restrictions would be in place, accidents or misuse may still occur and could have greater impact due to higher toxicities. Workers would be exposed to a higher rate of potential equipment accidents due to the production practices associated with growing conventional sugar beets under Alternative 1, and they would be likely exposed to higher rates and amounts of engine emissions and soil particulates. Also under Alternative 1, the number of workers in the field would likely increase, which could increase the numbers exposed to equipment emissions, soil particulates, and pesticides.

As defined in the CEQ regulations for implementing NEPA (40 CFR § 1508.20) mitigation includes:

- avoiding the impact altogether by not taking a certain action or parts of an action;
- minimizing impacts by limiting the degree or magnitude of the action and its implementation;
- rectifying the impact by repairing, rehabilitating, or restoring the affected environment;
- reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action; and
- compensating for the impact by replacing or providing substitute resources or environments.

See sections IV.B through IV.F for a discussion of specific impacts resulting from the three alternatives. The only mitigation measures described below are those that are not built into the alternatives (see the descriptions of the alternatives in chapter II). For example, in Alternatives

3, a variety of conditions restricting planting locations would be implemented either by APHIS or another entity. In addition, key measures described in chapter II that apply to many of the adverse impacts described in chapter IV are the MTSA that requires growers to follow the TUG and the Roundup Ready PLUS™ program, which is a voluntary program for reducing the development of herbicide-resistant weeds. The MSTA/TUG measures apply to the impacts described under Alternatives 2 and 3, since under Alternative 1, H7-1 sugar beets would only be allowed to be grown for research and development conditions under the strict conditions of APHIS-imposed Notification or Permit Conditions. In the long term once patents expire, APHIS assumes that there would be no binding enforcement mechanism to ensure that farmers follow the TUG. In addition, without MTSAs in place, Monsanto/KWS SAAT AG would have less ability to track technology users. However, before and after patent expiration, the Grower Cooperatives would likely continue to necessitate certain similar stewardship requirements because all commercial sugar beets are produced under contracts with the grower owned cooperatives. Industry has best practice protocols in place to mitigate LLP, such as Industry Provisions to Prevent Inadvertent Mechanical Mixing in Seed Production and West Coast Beet Seed Company Protocol for Genetically Modified (GM) Seed Production. In addition, Biotechnology Industry Organization and American Seed Trade Association have initiated efforts to develop principles and processes to manage the regulatory, stewardship, and liability issues posed following the expiration of patents on commercial biotech events. These efforts build on the already established stewardship principles articulated in the Excellence Through Stewardship program that provides detailed guidance on how to develop and implement stewardship programs and quality-management systems that will assist product developers in maintaining plant product integrity.

a. Production Management

(1) Measures to Mitigate Herbicide Impacts

Mitigation measures to oversee the proper usage of herbicides are determined by EPA and are disseminated to the herbicide users through EPA approved labels. Under Alternative 1, non-glyphosate herbicides would be used on sugar beets presumably at similar levels as prior to deregulation. Under Alternatives 2 and 3, more glyphosate, but less non-glyphosate herbicides would be used than under Alternative 1. Adhering to herbicide label requirements, including application rates and techniques and following industry glyphosate stewardship programs, will largely minimize improper herbicide usage.

(2) Measures to Mitigate Gene Flow between Beta crops

Under Alternative 1, there would be no further commercial release of H7-1 and existing H7-1 plants would eventually be harvested. Research and development permits would not be affected by this alternative. Therefore, research and development plantings under APHIS permit could still occur. Those plantings would be subject to the permit conditions, which have gene flow mitigation stipulations.

Under Alternative 2, H7-1 sugar beets could be grown by farmers across the country. Mitigation measures to reduce the potential impact of H7-1 gene flow include the currently utilized geographic separation of seed production regions. Additionally, standard isolation distances currently employed by farmers of *Beta* species to reduce unintended presence of sugar beets in vegetable beet crops, and vice versa, would likely continue to be employed. These isolation distances can reduce the likelihood of successful long distance gene flow to levels established for current crop purity standards. For example, in the Willamette Valley in Oregon (the primary seed production region in the nation), all commercial seed producers and growers of *Beta* crops utilize a pinning map and established isolation distances between sexually compatible species, in accordance with guidelines for isolation and minimum separation distances between fields provided by WVSSA. These include 1 mile between open pollinated fields, or between hybrid pollinated fields of the same color and group; 2 miles between hybrid and open pollinated fields of the same color and group and between stock-seed and hybrid; 3 miles between different colors within a group, between stock seed and open pollination, or between GMOs and any other *Beta* species; and 4 miles between hybrid and open pollination of different groups. In addition, the potential for gene flow between commercial seed fields is also greatly limited by the use of the CMS hybrid method in H7-1 seed production (see section III.B.1.b(8)).

Producers of H7-1 sugar beet seed also implement both voluntary and mandated management practices designed to prevent admixture of seeds during harvest, seed cleaning, storage, and shipping of H7-1 seeds (see section III.B.1.b(18)). These methods include watering fields after seed harvest to germinate shattered seeds in seed production fields followed by tillage or herbicide treatment to reduce the H7-1 sugar beet seed bank. Additionally, field inspections of past sugar beet fields are conducted to monitor and destroy volunteers. Multi-year crop rotations are used in both sugar beet seed and root production to facilitate the detection and elimination of sugar beet volunteers. If unintended mixing of H7-1 seeds with vegetable crop seeds or conventional sugar beet seeds occurs, the use of protein or DNA assays could be used as an additional measure to test for and limit LLP of hybrid H7-1 seeds in conventional seed. Bolting H7-1 sugar beets could be a potential source of gene flow as they would produce H7-1 pollen. However, farmers typically remove bolters as bolting depletes the root of sugars and the woody roots that result from bolters can damage harvesting and processing equipment (Ellstrand, 2003). Additionally under the Monsanto TUG, farmers are required to remove bolters in H7-1 sugar beet fields (Monsanto, 2011a). While such management practices may not always be followed by all growers or may not be 100 percent effective, they help reduce the likelihood of gene flow.

Under Alternative 3, APHIS or another Federal agency, would impose restrictions as described in chapter II which will serve to mitigate nearly all potential for gene flow. Because of the limitations on areas available for cultivating H7-1 sugar beet seeds under these alternatives (banned from western Washington and California), the potential for long distance gene flow is extremely low. The only recognized areas where sugar beet seeds and vegetable beet seeds occur is in the Willamette Valley of Oregon and a single county in southern Oregon. Sugar beet seed production overlaps with Swiss chard seed production in seven counties (Polk, Washington, Clackamas, Benton, Linn, Marion and Jackson) and overlaps with 2.2 percent of table beet seed production in one county (Polk). Use of CMS production in sugar beets with 85% of H7-1 carried on male sterile female plants in 2011, reduces the chance of gene flow between most seed fields. For areas of overlap between H7-1 and conventional sugar beet or vegetable beet seed production, isolation distances that are commonly employed and standard farmer practices can reduce the potential for unintended successful gene flow below detection limits and within levels established for current crop purity standards.

(3) Measures to Mitigate Gene flow to Wild Beet Populations

There are very few situations where gene flow is possible between H7-1 sugar beet and wild beet populations with the exception of sugar beet root crop production in the Imperial Valley. Even in the Imperial Valley the likelihood of gene flow is low because the wild beets are a different species and not likely to cross with sugar beets. Methods to mitigate gene flow into wild populations include using H7-1 sugar beet varieties that require long vernalization times to flower, monitoring fields for bolting plants, and removing flowering plants during the time when wild beets are also flowering.

b. Biological Resources

(1) Measures to Minimize Impacts on Animals and Non-target Plants

Mitigation measures to minimize the potential impacts on animals, micro-organisms, and non-target plants under all of the alternatives include measures that already are a part of standard production practices for sugar beets. Complying with herbicide label instructions as required by EPA should minimize potential toxic effects from all alternatives. In addition, crop rotation and use of herbicides with different mechanisms of action over time not only help to minimize development of resistant weeds, but also minimize the potential for cumulative impacts from repeated use of the same set of herbicides in one location.

Under Alternatives 2 and 3, to mitigate potential adverse effects due to glyphosate drift during applications, EPA has imposed specific label use restrictions for its use, including "the product should only be applied when the potential for drift to adjacent sensitive areas (e.g., residential areas, bodies of water, known habitat for threatened or endangered species, non-target crops) is minimal (e.g., when wind is blowing away from the sensitive areas)" and "avoid application over water." Additionally, ground-based application of herbicides minimizes the potential for spray drift to occur. For Alternatives 2 and 3, conservation tillage practices associated with H7-1 sugar beet production maximize retention of crop residues and minimize soil disturbance erosion, thereby minimizing potential adverse effects on micro-organisms from soil disturbance and crop residue removal, and minimizing potential adverse effects on aquatic plants and animals from sedimentation, turbidity, and chemical inputs from runoff.

(2) Measures to Mitigate the Development of Resistant Weeds

No glyphosate-resistant weeds have been attributed to the production of H7-1 sugar beets to date. Glyphosate-resistant weeds have developed in continuous cropping systems and two crop back-to-back Roundup Ready® rotations. If sugar beets continue to be grown in at least a three crop rotation and the other rotations are not all Roundup Ready® crops, it is less likely that glyphosate-resistant weeds will be selected by glyphosate treatment in H7-1 sugar beets. In addition to crop rotations, the deployment of several other practices by growers, including the use of herbicides with different mechanisms of action and BMPs (as discussed in section III.C.3.a) also will help delay selection of herbicide resistant weeds.

In growing sugar beets, if recommended herbicides are not effective, hand weeding and mechanical cultivation may be the best options for herbicide-resistant weed control. Stachler and Zollinger (2009) also provide recommendations for managing herbicide-resistant weeds in sugar beets in Minnesota and North Dakota based on the mechanism of action of the resistant herbicide. Once resistant weeds are observed, mechanisms that can help mitigate weed persistence include field scouting and other management practices that can identify weeds that appear to have resisted the herbicide, and the use of high label rates of postemergent herbicides can help assure that weed plants that have low levels of resistance do not survive to hybridize with other partially resistant plants. Among growers there is increasing awareness of herbicide stewardship needs. Industry is providing more tools to help growers adopt the farming practices that will both delay the development of herbicide resistance and help control the spread of herbicide-resistant weeds from field to field. One of these programs is Monsanto's Roundup Ready PLUS™ program.

c. Socioeconomic Impacts

To the extent that a shortage of conventional sugar beet seed or of herbicides to be used in conventional sugar beet production would occur under Alternative 1, sugar beet producers and processors would be adversely impacted. However, the possibility of deterring these adverse impacts from also occurring in the sugar market would depend on the extent to which cane sugar is available to replenish the market. The U.S. sugar policy does not allow re-allotment of the U.S. sugar market between domestic cane sugar and beet sugar productions, but program actions could be taken to increase imports. Increased use of imported sugar to supply the domestic sugar market faces two obstacles: (1) U.S. sugar refining capacity, and (2) the quality of imported sugar. U.S. sugar refining seems to have been operating near capacity in the recent past and imported refined sugar seems to differ in quality from domestic refined sugar hampering its utilization (see section IV.D.1.b for a discussion).

d. Physical Environment

In general, impacts on the physical environment from sugar beet farming, as with any crop, are minimized through implementation of proper management practices for each agricultural activity, such as tillage, erosion control, and pesticide application.

As described in section IV.E.1, increases in the acreage of H7-1 sugar beets are expected under Alternatives 2 through 4. Land use-related impacts such as potential for gene flow can be minimized by adherence to the management practices, isolation distances, and geographic restrictions, that are established by the regulatory authority or compliance agreements, as applicable.

Impacts on soil quality are an expected consequence of farming in general. As described in section IV.E.2, soil impacts can vary with the tillage practices in use, and can be reduced through increased use of conservation and reduced tillage techniques. Adoption of H7-1 sugar beet facilitates increased use of conservation and reduced tillage and thus can lead to reduced adverse impacts on soil quality.

As described in section III.E.3, the use of tractors and other equipment to cultivate the soil and conduct other activities involved with growing sugar beets can result in engine emissions and fugitive soil particulates being carried by the wind to the neighboring public. These emissions and particulates are an expected consequence of farming in general, but they can be reduced by changes in farming practices. Under Alternatives 2 and 3, there is evidence that the increased use of conservation and reduced tillage associated with adoption of H7-1 sugar beets can decrease usage of fossil fuel-burning equipment, decrease soil erosion by wind, and decrease pesticide usage. However, evidence that these effects reduce emissions of air pollutants, fugitive particulates, and GHGs is uncertain.

As with other agricultural crops, the effects of sugar beet farming on surface water and groundwater (e.g., lakes, streams, aquifers) depend on multiple factors or activities related to crop production, which can include soil preparation, planting and harvesting; tillage practices; tractor and other equipment use; the use of herbicides and fertilizers; and the frequency of irrigation necessary to produce a viable crop. Under Alternatives 2 and 3 and as discussed in section III.E.4, adoption of H7-1 sugar beet facilitates increased use of conservation and reduced tillage practices which, compared to typical tillage practices for conventional sugar beets, decreases soil erosion, reduces water runoff, and reduces contaminant levels in runoff, all of which lead to improved surface water and groundwater quality.

e. Human Health

For the potential adverse effects to human health from the use of pesticides that may occur under all of the alternatives, mitigation measures include the handling and use requirements and precautionary statements on pesticide labels required by EPA. Pesticide labels convey the necessary information developed by EPA on how to handle, store, apply, and dispose of pesticides with a reasonable certainty of no harm to human health. Using a pesticide in a manner that is inconsistent with these directions on the label is a violation of FIFRA and can result in enforcement actions to correct the violations. This does not mean that the correct application of these pesticides will not cause any adverse health effects to some individuals, only that the risk of such adverse effects is minimized by following the label instructions. For the potential higher equipment use under Alternative 1 with the return to conventional sugar beet growing practices, safety labels and equipment already are used and no additional mitigation measures could be identified.

V. Cumulative effects

Cumulative impacts, as defined by CEQ (40 CFR 1508.7), are impacts to the environment that result from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions, regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts may result from individually minor, but collectively significant, actions taking place over time.

This section discusses the cumulative impacts that are associated with the alternatives, when combined with other recent past, present, and reasonably foreseeable future actions within the affected environment. Because sugar beet production only occurs in certain regions and is localized around processing plants APHIS looked at regional, and local effects in addition to national effects. APHIS only identified potential effects at the local level. Furthermore, these effects at the local level are not expected to result in cumulative effects at the regional or national level.

A. Class of Actions to be Analyzed

This analysis addresses large local, regional, and national-scale trends that have impacts that may accumulate with those of the proposed alternatives.

1. Geographic and Temporal Boundaries for the Analysis

As described in the Affected Environment, over the past 10 years, the number of acres planted annually in sugar beets in the US has ranged from 1 to 1.4 million acres(USDA-NASS, 2011e). H7-1 sugar beets are produced in five major regions in the US (see Figure 3-6).

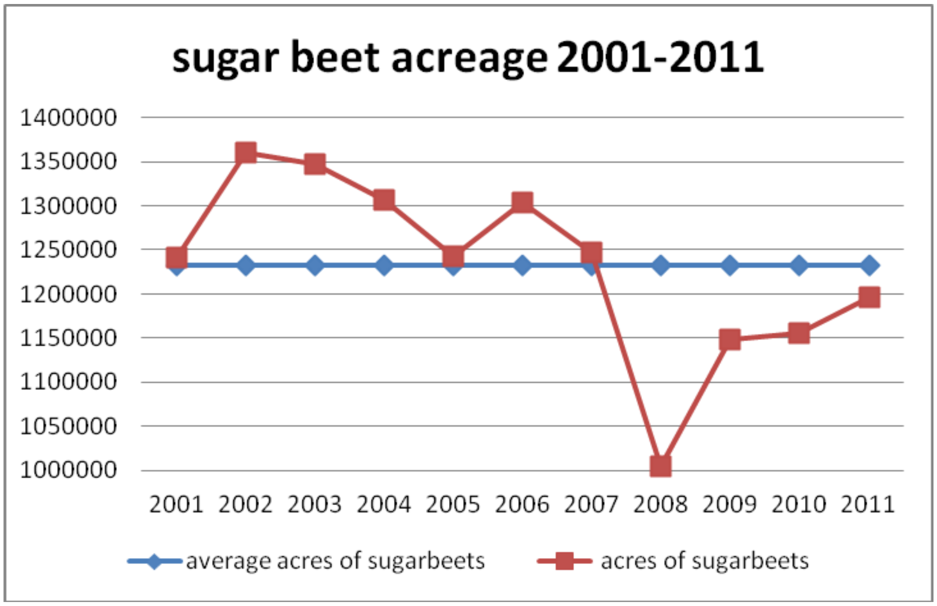

FIGURE 5- 1: SUGAR BEET ACREAGE 2001-2011: **Sugar beet acreage ranged from a high of 1,360,700 acres in 2002 to 1,004,500 in 2008. Throughout this period the average number of acres was 1,232,290 acres.**

Regarding the geographic boundaries of this analysis, APHIS will consider the cumulative effects of growing H7-1 sugar beets at the national, regional, and local levels. Agricultural production practices vary with the type of crop planted. Many factors are considered by growers when choosing crop rotation and management practices.

Regarding the temporal boundaries of this analysis, APHIS considers reasonably foreseeable actions as those future actions for which there is a reasonable expectation that the action could occur, a project that has already started, or a future action that has obligated funding. It also includes other actions such as crop rotations and associated weed and land management practices that overlap in space and time with areas that are likely to grow H7-1 derived sugar beet varieties. This analysis focuses more on geographic interaction of projects than timing of interactions because the actual timeframes for many of the reasonably foreseeable future actions are not definitively known.

APHIS has identified activities relevant to the cumulative impacts analysis from reviews of information available from government agencies, such as environmental impact statements, land-use and natural resource management plans, and from private organizations. Not all actions identified in this analysis would have cumulative impacts on all resource areas.

B. Resources Analyzed

This cumulative impacts analysis addresses the potential impacts of the alternatives on harvested cropland on a national, regional, and local-scale and on the biological resources. This section analyzes the cumulative impacts related to changes in tillage practices and herbicide usage, including potential increased glyphosate usage with the cultivation of glyphosate tolerant crops.

1. Magnitude of Effects on Resources

The potential extent of the impacts of the preferred alternative combined with other actions, and the duration of those impacts, are considered in determining the magnitude of the cumulative effects that impact each resource. When possible, the assessment of the effects on a resource is based on a quantitative analysis, however, many effects are difficult to quantify. In these cases, a qualitative assessment of cumulative effects is made. Incomplete or unavailable information is documented in accordance with 40 CFR § 1502.22 .

In the following analysis, cumulative effects are considered additive unless designated as otherwise. In the case of most resources that may experience cumulative effects, the preferred alternative is only responsible for a contribution of an incremental portion of the total impact on the resource. The past, present, and reasonably foreseeable connected actions typically contribute to the majority of impacts experienced by the resource, and would continue to have impacts on the resource even if the no action alternative were implemented.

Assumptions and Methodology

In the analysis throughout chapter four, APHIS concludes that all of the effects on biological resources and the physical environment are indirect effects of changes in agricultural practices associated with the adoption of H7-1. This conclusion is based on the evidence that H7-1 sugar beet closely resembles conventional sugar beet and by itself does not directly affect the environment. Rather, the adoption of H7-1 sugar beets allows for the adoption of changes in certain production practices which have the potential to impact biological resources and the physical environment. The principal changes that APHIS has identified are changes in pesticide use and changes in tillage practices. As described in section IIIB, APHIS found that other practices used for growing sugar beet are unlikely to differ between H7-1 and conventional and assumes other production practices are likely to remain unchanged.

With the adoption of H7-1 there is a shift in herbicide use toward glyphosate. With this shift comes a decrease in other herbicide use (See section III.B.1.f.). Changes in herbicide use have the potential to impact biological resources and the physical environment. APHIS concludes that the changes in pesticide use are not likely to affect human health (see discussion in section IV.F.).The shift toward post emergent glyphosate use in sugar beets when combined with the use of glyphosate in other agricultural activities also has the potential to contribute to selection for glyphosate resistant weeds. This is discussed extensively in section (IV.C.3.). Decreases in the use of non glyphosate herbicides can reduce selection for weeds resistant to the modes of action of non glyphosate herbicides. Use of non glyphosate herbicides may increase if glyphosate resistant weeds become more prevalent or by incentives to decrease the potential selection of glyphosate resistant weeds.

The adoption of H7-1 results in an increase in conservation tillage (See section III.B.1.C.(2)) and a reduction of tillage during the growing season. The change in tillage practice follows from the switch to glyphosate use because glyphosate usually increases the effectiveness of chemical weed control compared to non glyphosate herbicides so additional mechanical tillage is not needed. Increased conservation tillage can reduce run-off of pesticides and decrease soil erosion (needs cite back to text). If glyphosate resistant weeds become prevalent, the expected reduction in tillage associated with adoption of H7-1 sugar beets may lessen.

To analyze the potential for the changes in production practices associated with the adoption of H7-1 sugar beets to contribute to the effects associated with pesticide use and tillage in agriculture, APHIS first determined the overall contribution of sugar beet production to harvested cropland. Harvested cropland is all land used for agriculture excluding land used for pasture, orchards, livestock, and fallow. While all of these lands are important to agriculture, these lands are not used to cultivate sugar beets or the crops rotated with sugar beets. One of the potential cumulative effects is the likelihood that glyphosate use on crops rotated to sugar beet, particularly other Roundup Ready® crops, could increase the selection of more glyphosate resistant weeds. As sugar beets, sugar beet rotation crops, and all Roundup Ready® crops are only grown on the land characterized as harvested cropland, APHIS chose harvested cropland for the analysis. By excluding these other farm areas, the ratio of sugar beet acres relative to land area considered is maximized and so the potential cumulative effect attributable to the adoption of H7-1 sugar beet is also maximized.

APHIS simplified the analysis by assuming that cumulative effects would primarily arise from glyphosate use on other herbicide resistant crops which account for over 75% of glyphosate use. An additional 15% of glyphosate is used in agriculture for applications not involving herbicide resistant crops but which includes a wide assortment of crops. Some of these crops, for example wheat, are rotated to sugar beets. Although glyphosate is widely used in wheat production as a preplant burndown, the amount used represents a small fraction of national glyphosate use[43]. Nevertheless as a result of this simplification, there may be slightly higher background use of glyphosate than indicated in the analysis described below. As a consequence, the number of counties that exceed the threshold described below might be overestimated.

APHIS used data from the 2007 Census of agriculture to identify the acres of sugar beets planted at the county level and the amount of harvested cropland in each county. In one instance, NASS did not report harvested cropland for one county in this study in 2007 but did so in 2002. For that one county, APHIS used the 2002 data which may result in an imprecise estimate of the sugar beet acreage for that county relative to the other counties in 2007. APHIS also used 2007 census data to derive the amount of corn, soy, canola, cotton and alfalfa, other crops that have been engineered to be glyphosate resistant, grown in each county. Where NASS did not report data for these crops because there were too few growers to maintain anonymity, APHIS assumed the acreage was zero for those counties. While this may cause an underestimate in those cases, this is a reasonable assumption because the acreage represents a small percentage of sugar beet acres planted and an even smaller percentage of herbicide resistant crops planted. Adoption rates of herbicide resistant crops by state were derived from ERS (USDA-ERS, 2011a). APHIS used 2007 adoption rates for herbicide resistant corn, cotton, and soy. APHIS assumed that both sugar beets and canola had adoption rates of 100% for the purposes of this analysis. APHIS used the 10 year adoption rate by region for alfalfa predicted by industry market research (USDA-APHIS, 2010a).

To distinguish cumulative effects due to H7-1 sugar beet production from baseline effects due to other glyphosate use and tillage in harvested cropland, APHIS set a threshold of a 10% change from the baseline due to H7-1 adoption. APHIS set the threshold at 10% because changes in production practices, such as shifts in pesticide use and tillage, also occur with crop rotation, fluctuations in acreage planted to a particular crop, variations in weather that result in changes in pest load, and economic influences such as price of the commodity and cost of inputs. In regions where sugar beet production accounts for less than 10% of the total harvest cropland, the effects from changes in tillage patterns or herbicide use are likely to be smaller than the changes associated with normal variation in the crop production cycles and yearly adaptations to environmental conditions. APHIS assumed that all the sugar beet acreage would be used to produce H7-1 sugar beet and analyzed the extent to which this additional acreage of herbicide resistant crops increased the

[43] In 2006, about 1.4 million pounds of glyphosate were applied to wheat representing less than 1% of glyphosate use (http://www.pestmanagement.info/nass/app_statcs3_crop.cfm)

amount of herbicide resistant crops in the area. APHIS also assumed that potential cumulative effects due to H7-1 sugar beet production would occur in areas where sugar beet production increased the herbicide resistant crops in the area by at least 10%.

C. Contribution of sugar beet production to total harvested cropland

APHIS has identified changes in tillage practices and herbicide use as the principle causes of effects associated with the use of H7-1 sugar beets. These changes in production practices indirectly affect physical and biological resources. The impacts caused by the changes in tillage and herbicide use are observed with the cultivation of other Roundup Ready® crops and are not unique to H7-1 sugar beet production. Several types of cumulative effects are possible. Adoption of H7-1 sugar beets would lead to increased glyphosate use and depending on management practices, might promote the selection of glyphosate resistant weeds. Additional adoption of H7-1 sugar beets would improve weed control in sugar beet fields and could reduce the spread of weeds into neighboring fields. Adoption of H7-1 sugar beets is expected to increase the use of conservation tillage that could have beneficial effects on water and air quality and the organisms that rely on these resources. In this section, we examine the contribution of sugar beet production on a national, regional, and local level, and its contribution to to tillage and herbicide use.

1. National level

APHIS has concluded that there are no measurable cumulative impacts associated with the adoption of H7-1 sugar beets at the national level.

Glyphosate use would increase on H7-1 sugar beets by about 45-fold compared to the glyphosate use on conventional sugar beets (table 4-3). APHIS evaluated this increase in glyphosate usage in the context of all glyphosate usage (see table 5-1). Glyphosate is widely used on corn and soybean crops which are, respectively, over 70 and 90%, Roundup Ready®. As indicated in table 5-1, glyphosate use on sugar beets with the adoption of H7-1 sugar beets is less than 1% of the total glyphosate use. Therefore, the increase in glyphosate use as a result of the adoption of H7-1 is minor compared to other uses on a national scale.

Table 5- 1

Glyphosate usage on a National Scale						
RR crops	lbs/acre[1]	RR adoption[2]	total acres x 1 million[3]	RR acres x 1 million	lbs x 1000	% of total
Corn	0.95	0.7	87.9	61.5	58454	25.1
Cotton	1.89	0.78	10.9	8.5	16069	6.9
Soybean	1.36	0.93	79	73.5	99919	42.9
Canola	1.125	1	1.5	1.5	1688	0.7
Sugar beet	1.89	1	1.1	1.1	2079	0.9
Estimated glyphosate use on "other" applications[4]						
1997	agricultural uses (non RR ready)				36000	15.4
1999	home and garden				6500	2.8
1999	industry commercial government				12500	5.4
Total all uses					233209	

[1]corn, cotton, soybean glyphosate rates from Benbrook (2009), canola rate from Berglund (2007)
[2]http://www.ers.usda.gov/Data/BiotechCrops/;
[3]2010 acres from NASS (http://www.nass.usda.gov, accessed Sept 8, 2010)
[4]from Kiely et al. (2004)

The sugar beet root crop is produced on less that 0.4% of the acres of harvested cropland in the US (USDA-NASS, 2009a). This production is conducted on approximately 0.3% of the farms that include harvested cropland in the US (USDA-NASS, 2009a). The increased use of glyphosate from H7-1 adoption and associated changes in tillage will have little influence on the overall glyphosate use and tillage practices within the US because the acreage is so small.

The variation in the amount of corn, soy, or wheat that is planted from year to year is greater than the total amount of sugar beet acres planted in each year. Over the past ten years, the average variation in these crops has been 5 million acres for corn and 2 million acres for soy and wheat.[44] In the same period, sugar beet production has ranged from 1 million to 1.4 million acres (USDA-NASS, 2011d). Therefore, variability in the glyphosate use and tillage associated with major crops such as corn, soy, and wheat will exceed the total change in glyphosate use and tillage expected from H7-1 sugar beet adoption. Relative to the uses on these major crops, the national scale changes in sugar beet production practices will not exceed changes to the baseline variation that typically occur from year to year in the planting of other crops. Consequently on a national scale, H7-1 sugar beet production is not expected to contribute to cumulative impacts on physical or biological resources that result from agricultural production in the US.

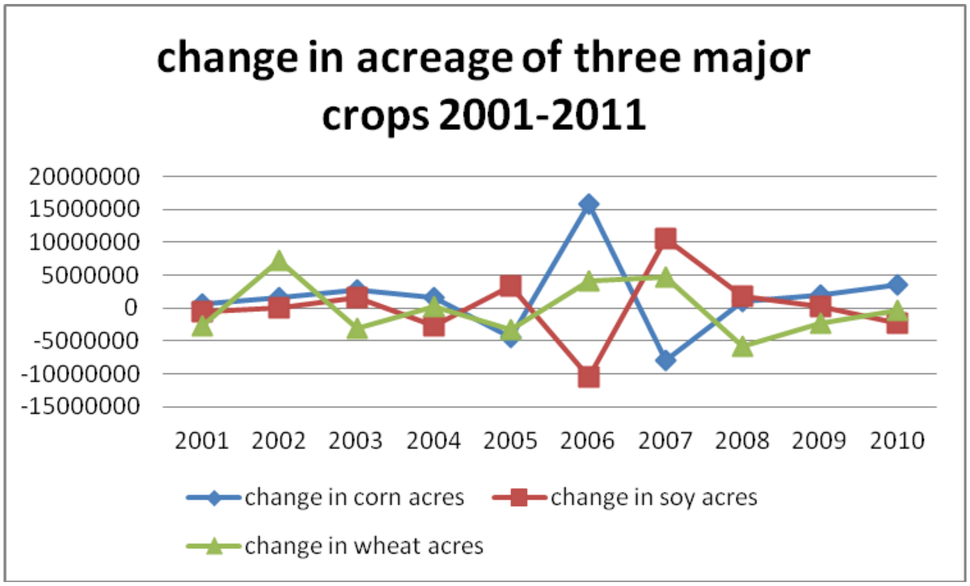

FIGURE 5- 2: CHANGE IN ACREAGE OF THREE MAJOR CROPS 2001-2011: Variation in acres planted in corn soy and wheat within the US varies from year to year. Corn typically varies by about 5 million acres each year, while soy and wheat vary by about 2 million acres each year. (USDA-NASS, 2011d)

2. Regional Level.

Because sugar beet production is not distributed evenly across the US, APHIS considered whether changes in sugar beet production may contribute to the impacts associated with agricultural practices in the regions where sugar beets are grown. APHIS also considered the overall contribution of H7-1 sugar beets to the adoption of herbicide resistant cropping systems at a regional level. APHIS found changes in production practices associated with the adoption of H7-1 sugar beets will not contribute incrementally to the impacts of agricultural production practices

[44] Total crop acres planted in corn over the past ten years ranged from 75 million to 93 million acres. Total crop acres for soy over this period ranged from 65 million to 77 million acres. Total crop acres for wheat over this period ranged from 53 million to 63 million acres (NASS survey data 2001-2011.

at the regional level because sugar beet production represents a relatively small fraction of agriculture at the regional level.

Herbicide resistant crops facilitate farmer's use of conservation tillage practices and reduce the number of herbicides they apply to their crops. APHIS examined the past and present impacts of agricultural systems on resources within these areas, the influence of herbicide resistant crops on these resources, and how the inclusion of H7-1 sugar beets in these agricultural systems cumulatively contributes to these impacts.

Herbicide resistant crops such as corn, soy, canola, sugar beets and, more recently, alfalfa, have been adopted across the US. The level of adoption of herbicide resistant crops, however, has not been uniform across or within regions primarily because herbicide resistant varieties have not been developed for the principal crops grown in certain regions, particularly the Western States. As a result, in certain regions, H7-1 sugar beet may be the only herbicide resistant crop grown in the area while in others; H7-1 sugar beet will represent a very small percentage of the herbicide resistant crops grown in the area.
APHIS modeled the potential herbicide resistant acres in each county that grows sugar beets within the sugar beet growing regions defined in the affected environment. Sugar beets are grown in five regions, described in Chapter IIIB.1c.1)
These regions include:

- Great Lakes – Michigan and Ontario;
- Midwest– Minnesota and Eastern North Dakota;
- Great Plains – Montana, Wyoming, Colorado, Nebraska, and western North Dakota;
- Northwest – Idaho, Oregon, and Washington; and
- Imperial Valley – California.

To estimate the percent of harvested cropland in a county that will be potentially planted in herbicide resistant crops, APHIS used county level crop data from the 2007 Census of Agriculture. APHIS used state level adoption rates of herbicide crops (USDA-ERS, 2011a) for corn, cotton, and soy based on USDA surveys. Alfalfa adoption rates were obtained from USDA-APHIS (USDA-APHIS, 2010a) based on industry predictions from market research. APHIS used the industry projected 10 year region adoption rates to define potential alfalfa adoption. In the short term this could overestimate the amount of herbicide resistant alfalfa acreage planted. However, it provides a longer-term view of the potential herbicide resistant acreage within a county. APHIS assumed that the adoption rate for both canola and sugar beets is 100%. APHIS chose this rate for canola because press accounts [45]imply it is widely adopted (http://www.nytimes.com/2010/08/10/science/10canola.html, accessed 9.8.10). APHIS chose 100% for sugar beets because H7-1 sugar beet adoption has approached 100% in all growing regions except California. APHIS chose to use harvested cropland because this is the type of cropland defined in the NASS survey that includes row crops and hay crops. It excludes pastureland and fallow land(USDA-NASS, 2009a).

APHIS examined the contribution of sugar beets to land used for harvested cropland in each region. APHIS considered only the acreage in counties that reported sugar beet production in the 2007 Census of Agriculture. APHIS did not consider total harvested cropland acreage in each state within a region because sugar beet root production is clustered within the state around processing plants. NASS reports data by county, so finer scale divisions are not possible based on the available data.

a. Great Lakes Region

Within the Great Lakes Region, Michigan is the only sugar beet producing state in the United States; data was not analyzed for Ontario, Canada. In Michigan, there are nineteen (19) counties that reported sugar beet production in the 2007 Census. Of those, NASS did not report specific acreage on five (5) counties because there were too few farms in these counties that raise the crop to maintain anonymity of the growers if the data were disclosed. These counties do not contribute much acreage to the total and APHIS excluded those counties from the regional analysis. In those areas where sugar beets are cultivated and data is reported, sugar beet production accounts for approximately 5.7% of the harvested cropland. Within these same counties, soybeans, corn, and alfalfa account for about 71% of the harvested cropland. Glyphosate resistant varieties of each of these crops are commercially available. Based on published adoption rates, APHIS estimates that approximately 41% of the harvest cropland in this region has the potential to be planted in glyphosate resistant crops(other than sugar beet) under Alternative 1 and 46.7% of the harvested cropland acreage has the potential to be planted in glyphosate resistant crops (including sugar beet) under the remaining 2 alternatives.

b. Midwest Region

Within the Midwestern Region, seven (7) counties in North Dakota report sugar beet production in the 2007 Census of Agriculture. Of these, NASS reports specific acreage on six (6) counties. In Minnesota there are thirty-one (31) counties that report sugar beet production; of these NASS provides specific acreage data for twenty-four (24) counties. In this region there is almost 12.5 million acres of harvested cropland (2007 Census of Ag). Of those acres, 715,000 are planted in sugar beets. This represents

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[45] The majority of this acreage is corn and soybeans (63%).

5.7% of the total harvested cropland. In this same region, corn, canola, soybeans, and alfalfa are grown on about 65% of the harvested cropland acres. APHIS calculated the percent of the harvested acres that are likely to be planted in glyphosate resistant crops using published adoption rates. Under Alternative 1 (without sugar beets) there is the potential for 48% of the acres to be planted in glyphosate resistant crops. This increases to 53.7% under Alternatives 2 and 3.

c. Great Plains

Within the Great Plains region, North Dakota reports two counties with sugar beet production. However, only one county has specific acreage reported in the 2007 Census of agriculture. Montana reports eleven counties with sugar beet production, nine have specific acreages reported. Nebraska reports 14 counties that grow sugar beet, eleven have specific acreage reported. Colorado reports twelve counties that produce sugar beets, with nine counties having specific acreage data. In this region there is approximately 6.7 million acres of harvested cropland. Approximately 2.4% of the harvested cropland is planted in sugar beets. Approximately 44% of the harvested cropland is planted in canola, corn, alfalfa, and soybeans nearly all of which is corn and alfalfa[46]. . When considering adoption rates for herbicide resistant crops, approximately 21% of the acreage has the potential to be planted in glyphosate resistant crops under Alternative 1 if H7-1 is not used in sugar beet production. This increases to about 23.4% if H7-1 is used exclusively in sugar beet production under Alternatives 2 and 3.

d. Northwest

Within the Northwest, Washington reports one county that grows sugar beets for sugar[47]. Oregon reports two counties and Idaho reports fifteen (15) counties of which thirteen (13) report specific acreage. In this region there are approximately 2.4 million acres of harvested cropland. Production of sugar beets grown for sugar accounts for 7.3% of the harvested cropland acreage in this region. Within this region corn, alfalfa, soybean, and canola are reported. However, the acreage of soybean and canola are minor and specific acreage is not reported for most counties. Approximately 40% of the harvested cropland in this region is devoted to crops that have herbicide resistant varieties on the market. Using published adoption rates 23% of the harvested crop acreage has the potential to be planted in glyphosate resistant crops under Alternative 1. This increases to 31% under the remaining two alternatives. The assumption is that the majority of this acreage would be planted to

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[46] Soybeans and canola make up less than 0.3% of the total acreage in this region

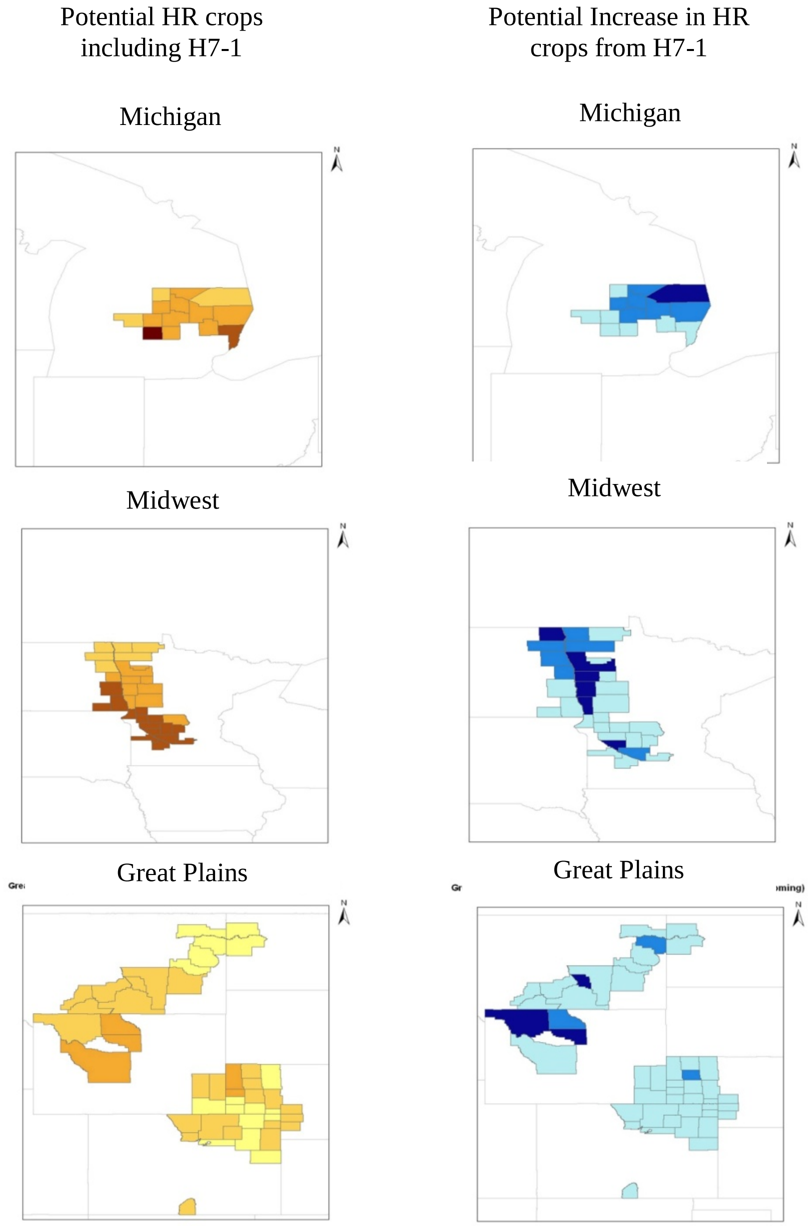
[47] Seed crops are not included because the acreage is minimal and glyphosate use and tillage practices are typically not different for H7-1 and conventional sugar beet seed production because glyphosate is seldom used for post emergent weed control in seed fields.

herbicide resistant alfalfa (17%) based on industry predicted adoption rates.

e. Imperial Valley CA

The Imperial Valley in California is the only area in California that still produces sugar beets. At the time of the 2007 census there was still some sugar beets planted in the Central Valley. We have not included that acreage in this assessment because the sugar processing plant in that area has closed and sugar beets are no longer grown in that part of the state. (Ben Goodwin, personal communication). Imperial County has 376,000 acres of harvested cropland. Within that area, 6.8% of the land is planted in sugar beets. Some canola, cotton, and corn are grown in the county. Together they account for about 2% of the harvested cropland in the county. Alfalfa is also grown within the county. It accounts for about one third of the harvested cropland in the county. APHIS has been provided with information to indicate that the alfalfa growers in the Imperial Valley are not adopting glyphosate resistant varieties of alfalfa. If they do not adopt these varieties, then the introduction of H7-1 sugar beets would increase the potential acreage planted to glyphosate resistant crops from less than 1% to about 7.8%. If glyphosate resistant varieties of alfalfa are adopted, then the alfalfa alone could account for one quarter of the harvested cropland in the county. The addition of H7-1 to this scenario could result in about one third of the harvested cropland being planted to glyphosate resistant crops under Alternative 2. Under Alternative 3, H7-1 sugar beets would not be grown in California.

Sugar beet production does not exceed 10% of the harvested cropland in any of the regions where sugar beets are grown. Therefore APHIS has concluded that the potential for cumulative impacts resulting from changes in tillage or pesticide use on biological or physical resources at a regional level are smaller than the variations associated with agricultural production. Therefore, changes in production practices associated with the adoption of H7-1 sugar beets are not expected to contribute incrementally to the impacts of agricultural production practices at the regional level.


Potential HR crops including H7-1
Potential Increase in HR crops from H7-1
Michigan
Michigan
Midwest
Midwest
Great Plains
Great Plains
N

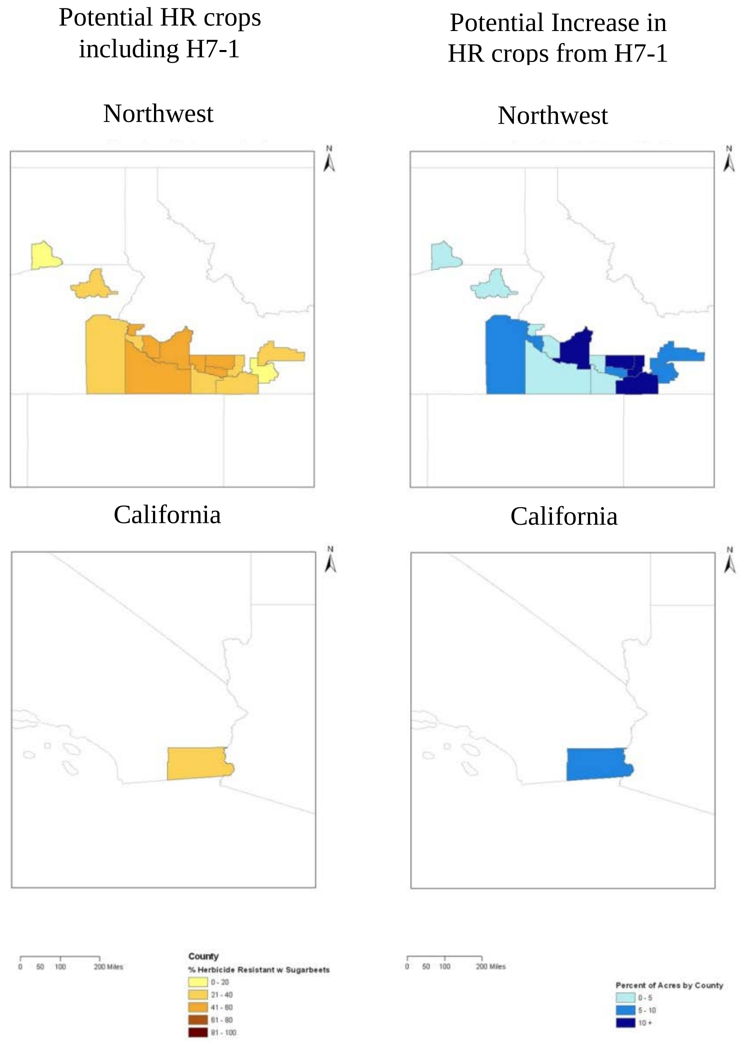


FIGURE 5- 3 PERCENT OF HARVESTED CROPLAND PLANTED TO HERBICIDE RESISTANT CROPS: The percent of harvested cropland planted to herbicide resistant crops was calculated for counties which grow sugar beets. Estimates include herbicide resistant corn, cotton, soybeans, canola, alfalfa, and sugar beets. The panels on the left show the estimated percent of herbicide resistant acres planted by county. The right panels show the potential incremental increase in herbicide resistant crops from the adoption of H7-1 sugar beets. The panels for California include an estimate for herbicide resistant alfalfa based on APHIS (USDA-APHIS, 2010a). APHIS has been informed that, at this time, herbicide resistant alfalfa has not been adopted in Imperial County.

3. Local Level

For the purposes of this analysis APHIS is using county level divisions to define the local area. County level data is the smallest subset available from NASS. Again using 10% as a threshold and data from the 2007 Census of Agriculture, APHIS examined the counties that produce sugar beets for sugar in the US. Sixteen counties have 10% or more of the harvested cropland planted in sugar beets (Table 5-2). In 14 of these counties (All the counties in Table 5-2 except Big Horn and Kittson), the adoption of H7-1 sugar beets could lead to a 10% increase in the use of glyphosate resistant crops. Adoption of H7-1 sugar beets could contribute to overall use of glyphosate resistant crops and the increased use of glyphosate above the background variation in agricultural production in these 14 counties.

Table 5- 2. Counties with ten percent of harvested cropland in sugar beet production

State	County	Percent harvested acres in sugar beet production
Idaho	Cassia	11 %
	Minidoka	23%
	Elmore	11%
	Power	10%
Michigan	Huron	14%
Minnesota	Clay	12%
	Kittson	10%
	Norman	12%
	Polk	13%
	Chippewa	12%
	Wilkin	13%
Montana	Treasure	14%
North Dakota	Pembina	14%
Wyoming	Big Horn	10%
	Park	12%
	Washakie	16%

In addition to identifying the counties with greater than 10% sugar beet production, APHIS also looked at the sugar beet growing counties with respect to glyphosate resistant crop adoption. Figure 5-3 illustrates the potential acres planted to herbicide crops.

D. Land Use

1. Great Lakes Region

The county in Michigan with the greatest change in potential herbicide resistant acres from the adoption of H7-1 sugar beet is Huron County. Huron County's five major crops are corn, dry beans, wheat, sugar beets, and soy. The adoption of H7-1 sugar beets has the potential to increase the proportion of harvested cropland in herbicide resistant crops from 1/4 to about 1/3 of the available acres. Increases in acres planted to herbicide resistant crops are likely to be associated with the increased use of certain herbicides and production practices. Glyphosate tolerant crops are expected to account for a large proportion of the herbicide resistant crop acres, because glyphosate resistant varieties are available for these crops and commonly used. H7-1 is likely to incrementally contribute to an increase in glyphosate use in counties where sugar beets are a major crop, like Huron County. However, counties which previously had high adoption rates of herbicide resistant crops, and/or where sugar beets are a minor crop, are unlikely to have measurable increases in glyphosate use with the adoption of H7-1 sugar beets. Clinton and St. Clair are examples of counties where the adoption of H7-1 sugar beets are unlikely to influence overall glyphosate use in the county. In these counties, glyphosate resistant crops already account for 89 and 60 percent and H7-1 would only increase the amount by 2 and 1%, respectively. Counties, such as Arenac, Bay, Midland, Saginaw, Tuscola, Lapeer and Sanilac have intermediate adoption of herbicide resistant crops; in these counties, between 5 and 10% of the harvested cropland is devoted to sugar beet production. In these areas, the adoption of H7-1 sugar beets may incrementally increase the amount of glyphosate used within these counties on harvested cropland. However, whether the changes exceed the normal fluctuations in glyphosate use will depend on other uses of glyphosate, such as its use as a pre-emergent herbicide.

2. Midwest

In the Midwest, six counties use greater than 10% of the harvested cropland for sugar beet and will experience at least a 10% increase in the use of herbicide resistant crops from the adoption of H7-1. These counties include, Pembina, Polk, Norman, Clay, and Wilkin in the North and Chippewa in the South. In the South, herbicide resistant crops are more prevalent (see figure 5-3) because corn and soybeans are grown on a greater acreage than in the other counties. As a result, the impact of H7-1 sugar beets on the baseline level of adoption of herbicide resistant crops is less in the southern Midwest than in the northern Midwest.

In the Great Plains region, the proportion of harvested cropland acres potentially planted to herbicide resistant crops is lower than in the Great lakes region and the Midwest region. In the majority of the counties less than 40% of the harvested cropland is planted with herbicide resistant crops. In these areas corn and soybean are not widely planted but alfalfa is[48]. Three counties, Park and Washakie, Wyoming and Treasure, Montana, have more than 10% of the harvested cropland planted to sugar beet and the potential for more than a 10% increase in the acreage planted to herbicide resistant crops as the result of the adoption of H7-1 sugar

[48] Although most alfalfa in the Great Plains is not herbicide resistant, industry projections suggest herbicide resistant alfalfa may be widely adopted here. If so, alfalfa would be the predominant herbicide resistant crop. In contrast, in the Midwest and Great lakes region, the predominant crops are corn and soybeans.

beets. Of these one, Washakie has the potential to have more than 40% of the harvested cropland planted with herbicide resistant crops. These increases in glyphosate resistant crops and glyphosate use are expected under Alternatives 2 and 3. However, it should be noted that while sugar beet acreage may be the predominant herbicide resistant crop in these counties in the short term, most of the potential herbicide resistant crop acreage is likely to come from alfalfa under all three alternatives.

3. Northwest

In the Northwest, the proportion of potential acres planted to herbicide resistant crops is similar to those in the Great Plains region[49]. In these counties, the adoption of H7-1 sugar beets may result in an incremental increase in the percent of land planted to herbicide resistant crops and an increased use of glyphosate within this region under Alternatives 2 and 3.

4. Imperial Valley

In the Imperial Valley there are very few herbicide resistant crops planted. Under the current partial deregulation, H7-1 sugar beets are not permitted in California. In addition, alfalfa growers in the Imperial Valley have not adopted herbicide resistant alfalfa. Because corn, soy, and cotton are grown on limited acres, the potential herbicide resistant acres are currently about 1% of the total cropland. The adoption of H7-1 sugar beets could increase the acreage to approximately 8% under Alternative 2. If herbicide resistant alfalfa varieties are grown in the future, alfalfa varieties could account for about 26% of the total harvested cropland in the Imperial Valley under all three alternatives.

Based on this analysis, 14 counties in the US were identified where planting of H7-1 sugar beets will increase the amount of herbicide resistant crops more than 10%. These are shown in dark blue in figure 5-3. Adoption of H7-1 sugar beets could contribute to overall use of glyphosate resistant crops and the increased use of glyphosate in these 14 counties. As such, there may be cumulative impacts at the local level in these counties. However, it is uncertain how this may incrementally affect biological and physical environment in these counties. While there may be increased selection for glyphosate resistant weeds as glyphosate use increases, selection of glyphosate resistant weed populations is dependent on more than glyphosate use. Management practices such as tillage, crop rotations, and use of multiple herbicides all reduce the selection pressure.

Another reason it is difficult to ascertain whether the local increase in glyphosate use will incrementally affect the biological and physical

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[49] Alfalfa would be the predominant herbicide resistant crop, if market predictions are correct, under all three alternatives. Corn is also planted widely and is likely to be the second most prevalent herbicide resistant crop under all three alternatives. In 4 counties in Idaho, Lincoln, Minodaka, Elmore, and Cassia, sugar beets represent at least 10% of the harvested crop land and adoption of H7-1 sugar beet would increase the acreage planted to herbicide resistant crops by at least 10%.

environment is because it is unknown what the impacts from incremental glyphosate use is relative to impacts from varying background levels of glyphosate use. As shown in table 5-2, the biggest county increases in herbicide resistant crops due to the adoption of H7-1 are typically in the 10-15% range. The cumulative effects of a 10-15% increase in glyphosate resistant crops may be different when the background adoption rate is 0-20% versus 80-100% or somewhere in between. In areas where glyphosate use is low, such as the Imperial Valley of California, essentially no cumulative effects are expected from H7-1 adoption. As the background adoption rate increases, the cumulative impacts may increase nonlinearly because the potential selection pressure may increase nonlinearly and at some point may reach a saturation level. For example, in areas such as the Great Lakes region and Southern Midwest, where a three herbicide-resistant-crop rotation may be used to grow sugar beets, the selection pressure is expected to be greater than in areas where one of the crops in the rotation is not herbicide-resistant. However, farms in Michigan also may be raising only corn and or soybeans in a one or two crop rotation of herbicide resistant crops which would have greater selection pressure than the three crop rotation mentioned above. Consequently, the incremental effect from H7-1 adoption at the county level is uncertain.

The percent of acres potentially planted with herbicide resistant crops in the west are lower than in the Great Lakes Region and the Midwest, as relatively little corn and soybean are planted in these regions. The potential for planting herbicide resistant crops in the Northwest, the Great Plains, and the Imperial Valley, will be driven primarily by the adoption of glyphosate resistant alfalfa, as alfalfa accounts for a large amount of the acreage in the three western regions. Adoption of sugar beet in these regions is likely to contribute to a shift toward the use of herbicide resistant crops. However, like the east, regional patterns of herbicide resistant crops are not defined by areas of greater sugar beet production because it is a relatively minor crop.

E. Tillage practices and pesticide use

In the 16 counties where sugar beet production exceeds 10% of the harvested cropland (see Table 5-2), APHIS examined the contribution of changing production practices in sugar beets to impacts associated with agricultural practices. Throughout this section APHIS will compare the use of H7-1 sugar beets (Alternatives 2-3) to the use of conventional varieties of beets (Alternative 1). The discussions are divided by county or groups of counties where appropriate. Changes in tillage practices have the potential to indirectly affect soil erosion, which in turn can affect air and water quality (See section III.E.2.a. of the affected environment and IV.E.2.a. of the environmental consequences sections). In addition to tillage, pesticide uses can also affect air and water quality. Changes in water quality can affect aquatic organisms. Runoff of chemicals used in agriculture can also affect water resources. In section (IV.E.2. and IV.E.4), APHIS analyzed the direct and indirect effects of the use of H7-1 sugar beets on soil and water resources. In this section we extend the analysis to consider the potential for cumulative impacts on these resources. Herbicide resistant corn, soybeans, cotton, alfalfa, and canola are commercially available. In areas with greater than 10% of the harvested farmland in sugar beets, cotton is not grown. Adopters of herbicide resistant soybeans are also adopters of conservation tillage. However, that correlation is not as strong for corn (NRC (National Research Council), 2010). Throughout this section we examine the impacts of agricultural practices on the resources in particular areas and the contribution of sugar beet production practices to those impacts. We examine the contribution to those impacts of both conventional sugar beet and H7-1 sugar beets.

1. Idaho

Within Idaho, four counties, Cassia, Minidoka, Elmore, and Power use more than 10% of the harvested cropland for sugar beet production. Sugar beets in this area are grown in the Snake River Valley.
According to the "Envirowater mapper" website (http://watersgeo.epa.gov) of the EPA, many of the streams in this area have issues with sedimentation. One of the primary causes of sedimentation is runoff, to which agriculture can contribute. According to the USGS, "Almost half of the stream segments in the study unit assessed for water-quality conditions by the Idaho Department of Health and Welfare were affected by nonpoint-source activities. The primary nonpoint-source activities are irrigated and nonirrigated agriculture, grazing, stream flow regulation from dams and diversions, and recreation. Primary point-source activities are agricultural-related industry, municipal wastewater-treatment facilities, mining related industry, and aquaculture. Water quality of lakes and reservoirs in the study unit is affected primarily by agricultural and aquacultural-related activities."
http://id.water.usgs.gov/nawqa/factsheets/LOW.165.html
The same report identifies the following specific water-quality issues:

- Elevated concentrations of sediments and nutrients, and the occurrence of low dissolved oxygen and elevated water temperature in surface water associated with agriculture, grazing, and aquaculture; the result is degraded water quality and impairment of beneficial uses of water in some tributary basins and along the Snake River.
- Potential ground-water contamination by nutrients and pesticides associated with agricultural activities in intensively irrigated areas; and
- Potential surface- and ground-water contamination by nutrients from recreational activities in the upper part of the study unit.

As was discussed in the affected environment section, adoption of conservation tillage within this region could be beneficial, but growers have not adopted it in sugar beets on a large scale. Adoption of conservation tillage would be more likely under Alternatives 2 and 3 compared to Alternative 1. In this regard, the potential for beneficial cumulative effects on water and air quality are greater under Alternatives 2 and 3 than under Alternative 1.

Idaho growers used a variety of pesticides prior to the adoption of H7-1. They used triflusulfuron-methyl, phenmedipham , ethofumesate, and desmedipham on 80% or more of the sugar beet acres. Ethofumesate is used on *Beta* species, carrots, and turf (U.S. EPA Undated-a)and is expected to continue to be used on these crops under all three alternatives whereas the other three herbicides are used almost exclusively on sugar beets (U.S. EPA 1996b), (U.S. EPA (United States Environmental Protection Agency), 2005) , (U.S. EPA 2002a). According to the 2007 Census of Agriculture, carrots and turf are not major crops in these four counties. Therefore, almost all of the environmental exposure to these herbicides is from sugar beet production. Under Alternatives 2 and 3, herbicide use of Triflusulfuron-methyl, phenmedipham, ethofumesate, and desmedipham would decrease by about 90% in these four Idaho counties compared to Alternative 1 and glyphosate use would increase. APHIS does not have data on existing glyphosate use per county and cannot predict the percentage increase expected.

To the extent that adoption of H7-1 has allowed the transition to conservation tillage practices and the reduction of certain pesticide use, it may have a positive effect on water quality in this area. If the continued use of H7-1 sugar beets under Alternatives 2 or 3 allows for the transition of more acres into conservation tillage these practices may contribute incrementally to improved surface water quality in the Snake River Valley. Under the no action alternative, growers will no longer be able to use H7-1 sugar beets. Any use of conservation tillage that may have occurred as a result of adoption of H7-1 sugar beets would be lost. However, given that current adoption rates for conservation tillage are low, there is not likely to be differences between the alternatives with respect to sedimentation. There may be a difference in pesticide runoff as glyphosate replaces other herbicides under Alternatives 2 and 3.

2. Huron County, Michigan

Huron County is the only county in the Great Lakes Region that uses more than 10% of its harvested cropland for sugar beet production. It is surrounded on three sides by water. Agriculture is a major industry in Huron County. Because of its location, the impacts of agricultural practices on water quality and soil conservation are important considerations when choosing tillage methods. In Huron County the top five crops are corn, dry beans, wheat, sugar beets, and soybeans. All of these crops can be grown in rotation using conservation tillage even without incorporating H7-1 sugar beets (Sanchez et al., 2001).

As discussed in section IV.C.3.c, 25% of the sugar beet acreage in MI was planted using stale seedbeds in 2010. These are beds that are cultivated in the fall but are not cultivated again in the spring at planting time. This is up from less than 5% three or four years earlier (Lilleboe, 2011). This transition is attributed to the use of H7-1 sugar beets. However, the extent to which no-till or other conservation tillage methods are employed are not well documented because such information is not typically collected in Michigan. If the use of H7-1 sugar beets increases the use of conservation tillage in crop rotations in this area, H7-1 sugar beets can contribute incrementally to improvements in the water quality of Lake Huron and Saginaw Bay. Saginaw Bay is part of the Michigan State Conservation Reserve Enhancement Program (http://www.michigan.gov/mdard/0,1607,7-125-1567_1599_1603---,00.html). One of the goals of this program is to decrease agricultural runoff into Saginaw Bay. The adoption of Alternative 1, the no action alternative, would likely increase the amount of tillage in Huron County when compared to those alternatives that allow for the adoption of H7-1 sugar beets. This is because H7-1 sugar beets are now grown in Huron county and would no longer be grown there under Alternative 1. To the extent that growers would revert to conventional tillage practices, the benefits to this watershed from using conservation tillage would be lost.

Growers apply Triflusulfuron-methyl, phenmedipham , and desmedipham to more than 80% of the acres in MI (see Appendix G). Clopyralid is applied to about 78% of the acreage. Clopyralid is also used on corn. Based on the NASS statistics, in Michigan about twice as much clopyralid is applied to corn as to sugar beets. Therefore, there could be a reduction of 25% of the clopyralid used in Michigan under alternatives 2 and 3 compared to alternative 1 and 90% of the triflusulfuron-methyl, phenmedipham , and desmedipham used. Glyphosate use would increase. APHIS does not have data on existing glyphosate use per county and cannot predict the percentage increase expected.

3. Minnesota/North Dakota (Red River of the North Basin)

In Minnesota, six counties, Clay, Kittson, Norman, Polk, Chippewa, and Wilkin produce sugar beets on more than 10% of the harvest cropland. In North Dakota there is only one, Pembina. All of these counties fall within the Red River of the North basin (http://www.pca.state.mn.us/index.php/view-document.html?gid=14171 and http://savethesheyenne.org/watershedmapusgs.htm). Two thirds of the land in the MN portion of the Red River Basin is in cropland (http://www.pca.state.mn.us/index.php/view-document.html?gid=6039). More than forty percent of the phosphorous and thirty percent of the nitrogen that eventually flows to Lake Winnipeg comes from the Red River, even though it only accounts for eleven percent of the flow. These nutrients contribute to algal blooms in the lake. http://www.pca.state.mn.us/index.php/view-document.html?gid=6039 . Cultivation practices can lead to sedimentation and runoff in this river basin. (http://mn.water.usgs.gov/nawqa/redn/env.html.) Available data on pesticides in surface water in the Red River of the North Basin predate the introduction of H7-1 sugar beets. (See http://mn.water.usgs.gov/nawqa/redn/biblio.html) In these studies pesticides were below EPA allowable levels.

Because nutrient runoff and sedimentation are problematic in the Red River of the North Basin, the potential for the adoption of conservation tillage with H7-1 sugar beets under Alternatives 2 and 3 could contribute incrementally to a decrease in agricultural runoff in this Basin. However, as described in section III.B.1.c.(2), conservation tillage has not been widely adopted in the Red River Valley, even with the adoption of H7-1 sugar beets. Ultimately, the potential benefits to water quality in this region would only be realized if H7-1 adopters convert to conservation tillage methods. Research is being conducted on applying methods of conservation tillage to sugar beet production in this region (Overstreet, 2011). However, unless growers adopt the practices on a large extent of the sugar beet acres in this region, there will be no measurable incremental difference with respect to sedimentation and water quality between the alternatives.

Clethodim, clopyralid, desmedipham and triflusulfuron-methyl are applied to more than 80% of the sugar beet acres in this region. Clopyralid is used on corn, oats, sugar beets, and wheat in this area. Adopting Alternatives 2 or 3 would result in a 20% reduction on clopyralid use when compared to Alternative 1. Clethodim is used on sugar beets and soybeans in this region. Adoption of Alternatives 2 or 3 would result in a 50% reduction in use when compared to Alternative 1. Desmedipham and trisulfuron-methyl use would decrease by about 90%. Glyphosate use would increase. APHIS does not have data on existing glyphosate use per county and cannot predict the percentage increase expected.

4. Montana and Wyoming (Yellowstone River Basin)

About 14% of the harvested cropland in Treasure County Montana is planted to sugar beets. It is the only county in Montana that has above 10% of its harvested cropland planted in sugar beets. Treasure County overlaps four watersheds, although most of the county is in the Lower

Yellowstone-Sunday watershed and part of the Yellowstone basin. Big Horn, Park, and Washakie counties in Wyoming also are in the Yellowstone River Basin. According to a 1999 USGS report on the Yellowstone River Basin (http://pubs.usgs.gov/wri/wri984269/wri984269.pdf) agriculture, including sugar beets, contribute to water quality issues. Within this region, however, grazing, mining, and other natural resource extraction also contribute to overall water quality impacts. Changes in tillage practices associated with H7-1 sugar beet production may offer some incremental improvement in areas where agricultural runoff is impacting the local watershed. However, impacts from other anthropomorphic activities are negatively impacting the surface water, so the changes may not offer a significant improvement. Under the no action alternative, any potential improvement in water quality due to an increase in conservation tillage associated with H7-1 would be lost.

Phenmedipham, desmedipham, and triflusulfuron-methyl which are used almost exclusively on sugar beets are used on more than 80% of the acres in this area. Clopyralid is also used on more than 80% of the acres in this area. According to NASS it is used on barley and sugar beets in this area. Adopting Alternatives 2 or 3 could result in a 60% reduction in the amount of clopyralid used in this area when compared with alternative 1. Phenmedipham, desmedipham, and triflusulfuron-methyl use would decrease about 90% while glyphosate use would increase. APHIS does not have data on existing glyphosate use per county and cannot predict the percentage increase expected.

F. Biological effects

As discussed above clopyralid, clethodim, phenmedipham , desmedipham and triflusulfuron-methyl use are likely to decrease substantially under Alternatives 2 and 3 as compared to Alternative 1 because these herbicides are used almost exclusively on sugar beets. In addition with the adoption of H7-1 sugar beets it is possible that more growers will adopt conservation tillage. However, in the areas with the greatest proportion of acres dedicated to sugar beet production, conservation tillage does not appear to be used widely.

1. Mammals

According to section IVC, none of these herbicides have acute or chronic toxicity effects on mammals at typical labeled rates.Therefore there is no difference between the alternatives with respect to mammals from changes in the use of the herbicides under the three alternatives.

2. Birds and reptiles

According to section IVC, none of these herbicides have acute or chronic toxicity to birds or reptiles. Laboratory studies suggest that desmedipham could be associated with eggshell cracking(U.S. EPA 1996b). Therefore reduction in desmedipham use under Alternatives 2 or 3 could reduce the likelihood that birds are exposed to doses that affect eggshells as compared to Alternative 1.

3. Fish and amphibians

According to section IVC, none of the herbicides discussed above have acute or chronic toxicity effects on fish and amphibians at application rates used in sugar beets. Therefore there is no difference between the alternatives with respect to fish and amphibians from changes in the use of theses herbicides under the three alternatives. If conservation tillage is adopted under alternative 2 or 3, reductions in soil erosion and runoff could contribute to improved water quality which in turn could reduce stress on fish and amphibian populations in impacted waterways.

4. Invertebrates

According to section IV.C none of the herbicides discussed above have acute or chronic toxicity effects on invertebrates. Therefore there is no difference between the alternatives with respect to invertebrates from changes in the use of theses herbicides under the three alternatives. If conservation tillage is adopted under alternative 2 or 3, reductions in soil erosion and runoff could contribute to improved water quality which in turn could reduce stress on aquatic invertebrate populations in impacted waterways.

5. Plants

Plants which grow in and around agricultural settings are affected by agricultural processes. Undesirable plants that grow within agricultural fields are considered weeds. Weeds are often the target of control. The wide adoption of glyphosate resistant cropping systems has resulted in improved control of weeds within agricultural fields. However, with the reliance on this type of cropping system has also come the increase in glyphosate resistant or tolerant weeds within these cropping systems. The potential contributions of H7-1 sugar beets to the selection for glyphosate resistant or tolerant weeds are discussed extensively in section IV.C.3.

In conventional fields especially in the Western growing regions, there is often poor weed control in sugar beet fields that result in weeds blowing into neighboring farms. Most of the principal weeds of sugar beet, described in section III.B.1d, also are problematic weeds in other crops growing in the area. Thus the spread of weed seeds from a field that has poor weed control has the potential to impact neighboring fields of unrelated crops. An expected cumulative impact from the adoption of herbicide resistant crops is the reduction of weed pressure in fields that do not adopt herbicide resistant crops.

Before the introduction of H7-1 sugar beets, growers had difficulty controlling weeds in their regions due to the selection of weeds with resistance to conventional herbicides such as ALS inhibitors, ACCase inhibitors, PSII inhibitors, synthetic auxins, mitosis inhibitors and fatty acid synthesis inhibitors. As evident in table 3–9, glyphosate is much more effective than alternative herbicides in the control of the major sugar beet weeds and the concurrent use of glyphosate as a preferred herbicide have vastly improved the control of many weed species, including weeds that have been identified as having non-glyphosate herbicide-resistant biotypes. (See section 3B.1.d.(4) for a description of why glyphosate controls weeds more effectively than non glyphosate herbicides). The control of weeds resistant to other herbicides within sugar beet fields, decreases the likelihood that weed seed from these fields will spread to other agriculture production fields and reduce the resources needed for weed control in the neighboring fields.

In farm scale experiments with sugar beets, (Heard et al., 2003a; Heard et al., 2003b) weed biomass and seed rain (seeds deposited to the soil) were lower for Roundup Ready® crops compared to conventional crops. As adoption of H7-1 sugar beet has resulted in a decrease in weeds, the adoption of H7-1 sugar beets in Alternative 2 and 3 is likely to incrementally contribute to a decrease in the seed banks for weeds resistant to several common herbicides. These effects will be most apparent in areas where the adoption of other herbicide resistant crops is low, herbicide resistant weeds are problematic, and sugar beets are planted on a large scale. This beneficial effect is expected in regions of low adoption rates because where herbicide resistant crops are widely adopted, weed seeds resistant to non glyphosate herbicides are expected to be effectively controlled by glyphosate. The decrease in weed seed from difficult to manage weeds in conventional sugar beets is likely to only have an effect on the local agricultural system in areas where sugar beet production is a major crop and weed control has been a problem in the past.

In areas where glyphosate resistant crops are used extensively, there is a concern that glyphosate resistant weeds will develop within these cropping systems. Section IV.C.3 discusses the likelihood of development of glyphosate resistant weeds in sugar beet production fields and the likelihood of dispersal of glyphosate resistant weeds from other crops to sugar beets. Given the analysis in that section, H7-1 could contribute to the selection of glyphosate resistant weeds in agricultural systems in the Midwest and Great lakes regions, where glyphosate resistant weeds have been identified in rotation crops. Cultural management (tillage) of sugar beet fields combined with application of non-glyphosate herbicides may control these weeds, so they may not persist as well in sugar beet fields as other rotation crops. However, if conservation tillage is adopted, alternative measures may be needed to control glyphosate resistant weeds in H7-1 sugar beets and the rotation crops in which they are currently found. Under Alternative 1, H7-1 would not contribute incrementally to the persistence of glyphosate resistant weeds in the seed bank (see section III.C.3.a.(4)), but as discussed above the use of conventional sugar beets has contributed to selection for weeds resistant to other herbicides and the selection of those weeds in the seed bank.

Socioeconomic Impacts
Indirect effects of H7-1 sugar beets on socioeconomic issues such as the US sugar and sugar beet markets, the sugar beet seed market, the organic and conventional sugar beet and sugar markets, and vegetable beet markets are described in section IVD. Outside of these indirect effects, APHIS was unable to identify any cumulative effects related to the three alternatives proposed.

Climate Change
Indirect effects of H7-1 sugar beets on climate change are discussed in section IV.E.3. Outside of these indirect effects, APHIS was unable to identify any cumulative effects related to the three alternatives proposed.

Human Health and Safety Impacts.
Indirect effects of H7-1 sugar beets on human health are described in section IVF. Outside of these indirect effects, APHIS was unable to identify any cumulative effects related to the three alternatives proposed.

G. Summary

In summary, no cumulative effects are expected from adoption of H7-1 sugar beets on a national and regional scale because sugar beet production represents a very small percentage of the glyphosate resistant crops planted on a national and regional level. APHIS identified 14 counties in the United States (table 5-2 excluding Big Horn and Kittson counties) where sugar beet production represents at least 10% of the harvested cropland and adoption of H7-1 sugar beet would represent a 10% increase in the herbicide resistant crops planted in the county. In these counties, adoption of H7-1 sugar beet could result in cumulative effects on the biological and physical environment. These effects include the potential for an increase in the selection of glyphosate resistant weeds depending on management practices adopted, a decrease in the selection of weeds for non glyphosate herbicides, a decrease in the spread of weeds from sugar beet fields into neighboring crops, and a potential improvement in air and water quality depending on the adoption of conservation tillage.

VI. Index

VII. Acronyms and Glossary

A

a.e. Acid equivalent is the portion of a formulation that theoretically could be converted back to the corresponding parent acid. It's weight includes just the acid portion of the active ingredient and not the salt or other part of the derivative..

a.i. Active ingredient. The active ingredient of a pesticide formulation is the component responsible for its toxicity. Its weight includes the derivative used in the formulation (ester, salt, amine, etc.).

Abiotic Describing non-living, environmental factors such as cold, heat, drought, flooding, salinity, toxic substances, and ultraviolet light.

ACCase Acetyl CoA carboxylase.

Actinomycetes A type of rod-shaped bacteria found in soil.

Acute exposure Single or short-term exposure to a substance.

Acute toxicity studies Those that study the effects of a single or short-term exposure to a substance.

Adjuvant Something that is added to a spray solution to increase the effectiveness of the active ingredient. For example, a substance added to an herbicide to improve the adherence of an herbicide to a crop.

Agrobacterium tumefaciens A bacterium that causes crown gall disease in some plants and canincorporate a piece of its own DNA into the host plant genome. When this DNA-transfer mechanism is commonly used in the genetic engineering of plants, the *Agrobacterium* is modified so crown gall disease does not occur

***Agrobacterium*-mediated transformation** The process of DNA transfer from *Agrobacterium tumefaciens* to plants, which occurs naturally during crown gall disease and can be used as a method to introduce foreign DNA into plant cells.

Agronomics A branch of agriculture that deals with field-crop production and soil management.

Alleles One of two or more forms of a gene occupying the same locus on paired chromosomes and controlling the same inherited characteristic.

Allelochemical A chemical produced by a plant of one species that has an effect on another species.

Allelopathy The inhibition of growth in one species of plants by chemicals produced by another species

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Allergen Any substance that causes an allergic reaction.

ALS Acetolactate synthase

AMPA Aminomethyl phosphonic acid; degradation byproduct of glyphosate

Anoxia Absence of oxygen usually resulting in cellular damage.

Anti-nutrient A natural or synthetic compound that interferes with the utilization of one or more nutrients by affecting intake, absorption, metabolism, or all three processes.

APHIS Animal and Plant Health Inspection Service

ARMS Agricultural Resources Management Survey

ATP Adenosine triphosphate

Autotoxicity A form of allelopathy in which a species inhibits growth or reproduction of members of that same species through the production of chemicals that are released into the environment.

B

BCF Bioconcentration factor

BCTV Beet curly top virus

Beet molasses A product of beets that contains about 50 percent sugar and is used for yeast, chemical, and pharmaceutical production and in mixed cattle feeds.

***Beta* crops** Cultivated crops form the genus, *Beta* which includes sugar beet, table beet, swiss chard, and fodder beet.

Betaine A nutritional supplement commonly marketed as a pro-vitamin in the food, animal feed, and pharmaceutical industries.

Biennial A type of plant species that typically requires 2 years of growth in order to produce flowers and complete the plant life cycle.

BIO Biotechnology Industry Organization

Bioaccumulate To increase the concentration of a chemical in biological systems above the concentration in the environment.

Biota All the living organisms of a region.

Biotechnology The practice of making specific modifications to the genome of an organism using techniques based on molecular biology, such as genetic engineering, gene transfer, DNA typing, and cloning of plants and animals.

Biotype A group of plants or animals within a species that possess certain traits or characteristics not common to the entire population.

BLS Bureau of Labor Statistics

BMP Best management practice

Bolting The growth of an elongated stalk with flowers grown from within the main stem of a plant.

Breeder's seeds The initial seeds collected from selected plant varieties prior to distribution for commercial planting.

Breeding The process of changing the genetics of plants or animals in order to produce desired characteristics.

Burndown An herbicide application used to kill all vegetation in a field prior to planting..

C

Calendar year The period of 365 or 366 days from January 1 to December 31.

CAS See Chemical Abstracts Service

Cation A positively charged ion.

CDMS Crop data management system

CEO Chief executive officer

CEQ Council on Environmental Quality

Certified seed Seed of a known variety produced to specific standards to assure purity and absence of weed seeds and seedborne pathogens. Certified seed is typically purchased by growers forfor commercial production of the crop and is usually not used for producing more certified seed.

CFIA Canadian Food Inspection Agency

CFR Code of Federal Regulations (U.S.)

CFS Center for Food Safety

Chard A beet crop primarily used as a fresh market leafy vegetable.

CHCL Chronic human carcinogen level

Chemical Abstracts Service CAS numbers are unique numerical identifiers for chemical elements, compounds, polymers, biological sequences, mixtures, and alloys.

Chlorination A water purification and disinfection process that uses chlorine.

Chlorotic The state or condition resulting in yellowing of the plant tissue from low chlorophyll as a result of a plant stress..

Chronic exposure Repeated, continuous exposure to a substance over an extended period.

Chronic toxicity studies Studies to examine the toxicity of a substance from repeated continuous exposure over an extended period.

Citric acid	A common food additive used as a preservative and flavor enhancer, commercially produced during the fermentation of sugar beet molasses.
CMS	See Cytoplasmic male sterility
Companion crop	A crop distinct from the primary crop for harvest grown in close physical proximity to the primary crop, on the theory that they assist each other in weed control, nutrient uptake, pest control, pollination, and other factors necessary to increase crop productivity.
Conservation tillage	A broad range of soil tillage systems that leave crop residue on the soil surface, substantially reducing the effects of soil erosion from wind and water.
Conventional tillage	Full-width tillage that is performed prior to and/or during planting, and generally involves plowing with a moldboard plow and/or other intensive tillage equipment.
CP4	Strain of *Agrobacterium* carrying the *cp4 epsps* gene which confers resistance to glyphosate.
cPAD	Chronic population adjusted dose
CRM	Crop residue management
Crop rotation	Practice of growing a crop in a cycle with other crops in an effort to reduce weed and other pest pressures.
Crop year	The time period from one harvest to the next, varying according to the commodity; crop year does not include fallow times when no crop is planted.
Cross-pollination	Process that occurs when pollen is delivered to the female structures of the flower from a different plant and results in the formation of a seed.
CRP	USDA's Conservation Reserve Program
CSA	Community supported agriculture
Curly top	A disease of beets caused by the beet curly top virus (BCTV).

The young leaves of beets infected by BCTV roll inward, pucker, and thicken; typically, affected young plants die rapidly.

Cytoplasmic male sterility (CMS) A recessive form of genetic male sterility in which plants fail to produce viable pollen but can produce viable seeds. When used in hybrid seed production, CMS plants are the female parent or seed producer..

D

Damping-off Rot of seedlings caused by soilborne pathogens that attack seed or seedlings before, during, or after germination.

DEFRA Department for Environment, Food, and Rural Affairs (UK)

DEIS Draft environmental impact statement

Deoxyribonucleic acid (DNA) A nucleic acid that carries the genetic information of a cell. The structure of DNA is two long chains, consisting of chemical building blocks (nucleotides), twisted into a double helix. The order of nucleotides determines hereditary characteristics.

Devernalize Reversing or losing vernalization due to exposure of seeds to high temperature, resulting in failure to flower.

Dicot A flowering plant with two cotyledons usually having broad leaves and a network of leaf veins.

Direct field method In hybrid seed production, the practice of directly seeding the male and female parents in blocks in the same field as opposed to transplanting nursery plants.

Disked Cultivated using a tool (such as a harrow or plow) to turn and loosen the soil with a series of discs.

DNA See deoxyribonucleic acid

DRES Dietary risk evaluation system

DSA Dairy and Sweetener Analysis Group

E

EA Environmental assessment

EEC Expected environmental concentration

EFSA European Food Safety Authority

EIQ Environmental impact quotient

EIS Environmental impact statement

Environmental justice The fair treatment and meaningful involvement of all people regardless of race, color, sex, national origin, or income with respect to the development, implementation and enforcement of environmental laws, regulations, and policies.

EO Executive order

EPA U.S. Environmental Protection Agency

EPSPS An enzyme; 5-enolpyruvylshikimate-3-phosphate synthase

EPTC Eptam® (herbicide)

ESA Endangered Species Act

EU European Union

Event See transformation event

Expression The means by which a gene's information stored in DNA (or RNA in some viruses) is turned into biochemical information such as RNA or protein.

F

Fallow During a crop rotation period the land is rested (no crops are grown) at varying intervals. The traditional fallow is for a period of one year. During the inter-crop fallow, the land is rested in the fall and winter season.

FARE Foods analysis and residue evaluation

FDA	Food and Drug Administration
Feral	An animal or plant that has escaped from domestication and returned, partly or wholly, to a wild state.
FFDCA	Federal Food, Drug, and Cosmetic Act
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
Fiscal year	A 12-month period at the end of which all accounts are completed to provide a statement of a company's, organization's, or government's financial condition, or for tax purposes.
Fodder beets	Relative of the sugar beet; typically grown for use as livestock feed. Although less common, fodder beet leaves can be consumed by humans.
FONSI	Finding of no significant impact
Forage	Plant material consumed by livestock or other grazing animal species.
Foundation seed	Seed of a particular plant variety that is produced from breeder seed and is then planted to produce certified seed (See also breeder seed and certified seed)
FQPA	Food Quality Protection Act of 1996
FR	Federal register
Furrow irrigation	A method of surface irrigation where farmers flow water down trenches running through their crops.
FY	Fiscal year

G

GE	See genetically engineered
Gene	The basic unit of heredity transmitted from generation to generation during sexual or asexual reproduction; an ordered sequence of nucleotide bases comprising a segment of DNA. A gene contains the sequence of DNA that encodes an individual RNA or protein.

Gene flow	The transfer of genes from one population to another by the movement and establishment of individuals, pollen, seeds, or spores.
Gene insertion	The incorporation of one or more copies of a gene into a chromosome.
Gene product	An RNA or a protein (e.g., an enzyme), the production of which is directed by the corresponding gene.
GENEEC	Generic estimated exposure concentration
Genetic engineering	Process by which one or more genes and other genetic elements from one or more organism(s) are inserted into the genetic material of a second organism using recombinant DNA techniques.
Genetically engineered (GE)	Modified in genotype and, hence, phenotype, using recombinant DNA techniques.
Genome	All of the genetic material in a cell, including DNA present in the cell nucleus and in other locations such as plant chloroplasts and mitochondria.
Genotype	A description, usually regarding specific genes or alleles, of the genetic makeup of an individual, dependent on DNA composition.
GHG	Greenhouse gases
GM	Genetically modified
GMO	Genetically modified organism
GPS	Global positioning system
GR	Glyphosate-resistant
Gramnivorous	Feeding primarily on grasses and seeds.
GRAS	Generally recognized as safe
Groundkeepers	Small roots left behind in sugar beet fields after harvest that produce plants the next growing season.
GT	Glyphosate-tolerant

H

H7-1 sugar beet varieties	Sugar beets that are genetically engineered to be resistant to the herbicide glyphosate bred from the transformation event designated H7-1.
HA	Health advisory
Half-life	With regard to an herbicide's persistence; the time (in days) it takes for an herbicide to degrade in soils to 50 percent of its original amount.
Henry's Law Constant	The equilibrium level that is reached when the amount of gas dissolved in a liquid is equal to the pressure of the gas over the liquid.
Herbicide	A chemical that kills plants.
Herbicide resistance	The ability of a plant to remain relatively unaffected by the application of what would otherwise be a highly damaging dose of an herbicide.
Herbicide drift	Inadvertent direct overspray, or transport (via wind or water flow from rainfall) of soil particles loaded with adsorbed herbicide that contacts non-target terrestrial and aquatic plants (including non-target crops and non-agricultural plants).
Herbivory	The consumption of plants by insects and other animals.
HGT	See horizontal gene transfer
HHS	U.S. Department of Health and Human Services
HIARC	Hazard Identification Assessment Review Committee
Horizontal gene transfer (HGT)	The movement of genetic material between non-sexually compatible, unrelated organisms.
HTS	Harmonized tariff schedule
Human environment	According to the Council on Environmental Quality, the term human environment "shall be interpreted comprehensively to include the natural and physical environment and the relationship of people with that environment" (40 CFR § 1508.14).

Hybrid The offspring resulting from breeding between two genetically dissimilar organisms.

Hybrid "off-types" In plant breeding,when offspring possess visually identifiable traits that indicate they were the result of an unintended cross. .

Hybridization The process by which two individuals interbreed to form hybrid offspring.

Hydrolysis The process of chemical decomposition by water.

Hydrophilic Describing or characterizing a substance that bonds with and dissolves in water.

I

IDS Incident data system

Indirect steckling method In hybrid beet seed production,the practice of growing young transplants in nurseries and subsequently transplanting them into seed production fields.

Interfertile Describing two plants or groups of plants capable of breeding and producing offspring.

Interseed Seeding a crop after a crop has already been established.

Interspecific Arising or occurring between individuals of different species.

Intraspecific Arising or occurring between individuals within the same species.

Introgression The introduction and stabilization of genes from one species or population into the gene pool of another via sexual crossing. The process begins with hybridization between the two individuals, followed by repeated sexual crossing (backcrossing) to one of the parent species.

IPA Isopropylamine

IPCC Intergovernmental Panel on Climate Change

ISHRW International Survey of Herbicide Resistant Weeds

Isopropylamine An organic amine. Used in glyphosate herbicides.

L

Lb. a.e. A unit of measure for pounds acid equivalent, which is the common notation used for measurement of glyphosate herbicide formulations.

LLP Low-level presence

LOAEC Lowest-observed-adverse effect concentrations

M

MCL Maximum contaminant level

Meristem A tissue in plants consisting of undifferentiated cells (meristematic cells) and found in zones of the plant where growth can take place - the roots and shoots.

Micro-organism An organism that is microscopic (too small to be seen by the human eye without the use of instruments that significantly magnify the image of the organism).

Microrate application Common practice of conventional sugar beet growers to frequently apply postemergent herbicides at low levels to minimize damage to the sugar beet plant.

MOE Margins of exposure

Monocot Plants characterized by a single cotyledon, narrow leaves, and parallel veins. Grasses are monocots..

MSG Monosodium glutamate

MTSA Monsanto Technology/Stewardship Agreement

Mutagenic Inducing or increasing the likelihood of mutations.

N

NAAQS National Ambient Air Quality Standards

NDSU North Dakota State University

NEPA National Environmental Policy Act of 1969 and subsequent amendments

NHANES National Health and Nutrition Examination Survey

NIOSH National Institute of Occupational Safety and Health

NMFS National Marine Fisheries Service

No till A tillage method that leaves previous crop residue undisturbed from harvest to planting except for nutrient injection or narrow strips, and planting or drilling is accomplished in a narrow seedbed or slot.

NOA Notice of availability

NOAEC No-observed-adverse-effect concentration

NOAEL No observable adverse effect level

NOEL No-observed-effect level

NOI Notice of intent

Nontarget organism Organisms that are not the target of a pesticide.

NOP National Organic Program

Notification As defined by USDA, an administratively-streamlined alternative to a permit. The GE plant must meet specified eligibility criteria, and the introduction must meet certain pre-defined performance standards.

NPCS National Poison Center System

NPDES National Pollutant Discharge Elimination System

NPKS Nitrogen, phosphorus, potassium, and sulfur.

NSC National Safety Council

O

OAQ Overall allotment quantity

OECD Organization for Economic Cooperation and Development

Oncogenic Causing the formation of tumors.

OSCS Oregon Seed Certification Service

OSHA Occupational Safety and Health Administration

OSH Act Occupational Safety and Health Act

OSTP Office of Science and Technology Policy

O-type restorer A plant line that is genetically identical to a line characterized by cytoplasmic male sterility except that it can produce pollen.

Outcrossing A term used to describe the movement of plant genes from one plant to another genetically distinct plant via successful pollen movement

Ozonation A water purification and disinfection process that uses ozone.

P

Packing A method of planting seeds. Soil packing benefits crop emergence, crop uniformity, soil moisture retention and overall yields in farming conditions where soil structure and moisture are not ideal for plant growth

PAIRR Pesticide Active Ingredient Rating Report

PCR Polymerase chain reaction

Perennial Plant species that live more than two years. The above ground portion of the plant dies or becomes dormant in the winter, but grows back from root-stock the following spring.

Pesticide A chemical that kills pests. Pesticides include herbicides, insecticides, and rodenticides.

Petioles The small stalk that attaches a leaf to the stem of a plant.

PHED Pesticide Handler Exposure Database

Phenotypic The observed characteristics produced by the interaction of the genotype and the organism's surrounding environment.

Photolysis The process of chemical decomposition by light.

Piling Accumulation and storage of harvested sugar beet root crop for subsequent sugar processing.

Pinning maps Maps that enable growers to see where sexually compatible crops are being grown so that they can take steps to ensure that required seed isolation distances are met.

Plant pest Any living stage of any of the following that can directly or indirectly injure, cause damage to, or cause disease in any plant or plant product: protozoan, nonhuman animal, parasitic plant, bacterium, fungus, virus or viroid, infectious agent or other pathogen, or any article similar to or allied with any of the articles specified in the preceding subparagraphs. (7 U.S.C. 7702(14))

PLTP Plant lipid transfer proteins

PNT Plant with a novel trait

POEA Polyethoxylated tallowamine; a surfactant that can be added to herbicide formulations to increase leaf penetration.

Pollen cloud A dense airborne accumulation of pollen.

Postemergent For herbicide applications, this term refers to applications made onto the plant after the seedling emerges from the soil.

PPA Plant Protection Act

PPE Personal protective equipment

PPI Preplant incorporated

PPRA Plant Pest Risk Assessment

Preemergent Used or occurring before seedling emergence above the ground.

Pre-pile A period where the processing facility begins to manufacture sugarprior to the full harvest .

Pre-piling Harvesting a small fraction of sugar beet root crop for initial sugar processing, typically done prior to the full harvest period.

Preplant Occurring or used before planting a crop.

Protandrous When anthers release their pollen before the stigma of the same flower is receptive.

R

Recombinant DNA DNA, including DNA from different organisms, that has been cut apart and recombined using enzymes.

RED Reregistration eligibility decision

Reduced tillage A full-width tillage method that usually involves one or more tillage passes over the field prior to and/or during planting, and leaves 15- to 30-percent residue cover after planting.

Regulated article Subject to APHIS regulation under 7 CFR part 340.

RfD Reference dose

Risk assessment A scientifically based process consisting of the following steps: (i) hazard identification; (ii) hazard characterization; (iii) exposure assessment; and (iv) risk characterization.

Rosette Describing a circular arrangement of leaves at the same height, usually at ground level.

Rotary hoe A motorized cultivator with revolving blades used for in-row weed control.

Rotation In crop production, the cycle of crops grown in successive years in the same field.

RPHC Relative public health concern

RQ Risk quotient

RR Relative risk

RRS Relative risk score

RRSB Roundup Ready® sugar beets

RR-WTQIs Relative-risk weighted total quantity indicators

Ruderal A plant that colonizes and grows in disturbed habitats.

S

Saponins A class of chemical compounds, one of many secondary metabolites found in natural sources. They have a bitter taste and can act as a deterrent to foraging.

Secondary seedling Seedlings that are not planted directly by the farmer but rather sprout unintentionally.

Self-pollinate The process of pollination and seed production that results from movement of pollen among flowers on the same plant. The tendency of a plant species to produce offspring that result from a flower pollinating itself. (Also see outcrossing.)

Shattering An event when the sugar beet seeds break open and release/disperse seeds prior to or during harvest.

Shikimate pathway Biochemical pathway in plants that produces aromatic amino acids.

Soil compaction A form of soil degradation typically caused by heavy machinery and livestock trampling.

Soil tilth A measure of the health of soil. Good tilth refers to soil that has the proper structure and nutrients to grow healthy crops.

SOP Standard Operating procedures

SP Standards of practice

Steckling Sugar beet roots that are grown from seed for less than a full season. Stecklings are typically grown for hybrid seed production in nurseries where they are subsequently transplanted into a different location for seed production.

Strip tillage A field tillage system that combines no till and full tillage to produce row crops.

STRV Short tons, raw value

Subchronic toxicity studies Studies of the toxicity effects of a substance on a small percentage of a subject's life span.

Sugar beet pulp A high-quality feed produced from sugar beets that has high energy and high fiber content that is fed to cattle and sheep. Dried beet fiber residue left over from sugar extraction used in plain dried, molasses dried (containing 25 percent molasses), and pelleted forms.

Sugar beet tops The leaves and petioles of the sugar beet; often used as both fertilizer and animal feed.

Surfactants Surface-action agents that are soluble in organic solvents and water.

T

Table beets A beet crop consumed as a vegetable for both the root and leafy greens.

TDN Total digestible nutrients

TEP Typical end-use products

Teratogenic Causing malformation and/or birth defects.

TGAE Technical grade acid equivalent

TGAI Technical grade active ingredient

Tilth A soil structure suitable for seeding.

TMRC Theoretical maximum residue contribution

Trait A characteristic of an organism that manifests itself in the phenotype. Traits can be the result of a single gene or can be polygenic, resulting from the simultaneous expression of more than one gene.

Transformation event An organism produced by the uptake and integration of DNA in a cell's genome.

Transgene A foreign gene that is inserted into the genome of a cell via recombinant DNA techniques.

TRQ Tariff-rate quotas

TSCA Toxic Substances Control Act

TUG Monsanto Technology Use Guide

U

U.S. EPA–HED U.S. Environmental Protection Agency–Health Effects Division

U.S. EPA OPP U.S. Environmental Protection Agency–Office of Pesticide Programs

U.S.C. United States code

USD U. S. dollar

USDA U.S. Department of Agriculture

USDA–APHIS See APHIS

USDA–ARS U.S. Department of Agriculture–Agriculture Research Service

USDA–BRS U.S. Department of Agriculture–Biotechnology Regulatory Services

USDA–ERS U.S. Department of Agriculture–Economic Research Service

USDA–FAS U.S. Department of Agriculture–Foreign Agricultural Service

USDA–FSA U.S. Department of Agriculture–Farm Service Agency

USDA–FSIS U.S. Department of Agriculture–Food Safety and Inspection Service

USDA–NASS U.S. Department of Agriculture–National Agricultural Statistics Service

USDA–NRCS U.S. Department of Agriculture–Natural Resources Conservation Service

USFWS U.S. Fish and Wildlife Service

USGS U.S. Geological Survey

USSEC U.S. Soybean Export Council

V

Vector The agent, such as a plasmid, used by researchers to carry new genes into cells.

Vegetable beets Beet crops such as table beets, and Swiss chard which are consumed as vegetables as opposed to sugar beets and fodder beets which are used for sugar production and feed, respectively.

Vernalization The process by which low temperatures induce flowering..

Vigor A qualitative term used to measure overall health of a plant and its rapidness of growth.

VOC Volatile organic carbons

Volunteer Plants resulting from crop seed that escapes harvest and remains in the field until subsequent seasons, where it germinates along with the succeeding crop.

W

Weed shifts These occur when the local population of weeds changes due to the selective pressures of differing management strategies.

Weediness The ability of a plant to colonize a disturbed habitat and compete with cultivated species.

WIN-PST Windows pesticide screening tool: A pesticide environmental risk screening tool to evaluate the potential of pesticides to move with water and eroded soil/organic matter and potential to affect non-targeted organisms

WPS Worker protection standard

WSSA Weed Science Society of America

WSU Washington State University

WTO World Trade Organization

WVSSA Willamette Valley Specialty Seed Association

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Appendix G. Herbicide Applications in Conventional Sugar Beets

Tables G–1 through G–11 present herbicide use by State, in conventional sugar beets, for 2000. These herbicide use data were gathered from the USDA Agricultural Chemical Use Database (USDA, 2008). The data for acres planted were obtained from the USDA 2000 Crop Production Survey (USDA, 2001). Data are presented for the 11 sugar beet production States in 5 regions: Imperial Valley (California); Great Lakes (Michigan); Great Plains (Colorado, Montana, Nebraska, Wyoming); Midwest (Minnesota and North Dakota); and Northwest (Idaho, Oregon, Washington). These data provide a regional perspective on sugar beet herbicide use and represent the most current regional herbicide use data in sugar beets for the entire United States. Further discussion of herbicide use by region, including a regional summary table is presented in section III.B.1.d.

Table G- 1. Herbicide Applications to Conventional Sugar Beet Acres in California (Imperial Valley Region), 2000

Agricultural Chemical (Herbicide)	Trade Name (typical)	WSSA Mechanism of Action Group No.[1]	Acreage Treated (%)	No. of Applications per Year	Rate per Application (lb/app./acre)	Rate per Acre (lb/acre)	Total Applied per Year (lb)
Clethodim	Select®	1	7%	1	0.09	0.08	ND[2]
Desmedipham	Betanex®	1	69%	1.5	0.17	0.11	11,000
Ethofumesate	Nortron®	8	6%	1.2	0.53	0.44	3,000
Glyphosate	(Several)	9	15%	1	0.6	0.6	9,000
Phenmedipham	Betamix®	5	69%	1.5	0.17	0.11	11,000
Sethoxydim	Poast®	1	51%	1.5	0.51	0.33	25,000
Trifluralin	Treflan® HFP	3	9%	1	0.72	0.72	7,000
Triflusulfuron-methyl	Upbeet®	2	26%	1.1	0.01	0.01	ND

Pesticide Usage Source: National Agriculture Statistics Service, Agricultural Chemical Use Database (http://www.pestmanagement.info/nass/app_usage.cfm).
[1] Source: Heap, 2011; WSSA, 2007.
[2] ND = No data were reported for total herbicide applied per year (lb), although the available data indicated that the herbicide was applied in California (Imperial Valley Region).

Table G- 2. Herbicide Applications to Conventional Sugar Beet Acres in Michigan (Great Lakes Region), 2000

Agricultural Chemical (Herbicide)	Trade Name (typical)	WSSA Mechanism of Action Group No.[1]	Acreage Treated (%)	No. of Applications per Year	Rate per Application (lb/app./acre)	Rate per Acre (lb/acre)	Total Applied per Year (lb)
Clopyralid	Stinger®	4	78%	2.5	0.07	0.03	10,000
Cycloate	Ro-Neet™	8	3%	1	3.03	3.03	16,000
Desmedipham	Betanex®	5	92%	2	0.12	0.06	21,000
Ethofumesate	Nortron®	8	14%	1.5	0.13	0.08	3,000
Phenmedipham	Betamix®	5	90%	2	0.11	0.06	19,000
Pyrazon	Pyramin®	5	35%	1	0.99	0.97	66,000
Quizalofop-p-ethyl	Assure® II	1	12%	1.3	0.07	0.05	2,000
Triflusulfuron-methyl	Upbeet®	2	87%	2	0.01	0.01	2,000

Pesticide Usage Source: National Agriculture Statistics Service, Agricultural Chemical Use Database (http://www.pestmanagement.info/nass/app_usage.cfm).
[1] Source: Heap, 2011; WSSA, 2007.

Table G- 3. Herbicide Applications to Conventional Sugar Beet Acres in Colorado (Great Plains Region), 2000

Agricultural Chemical (Herbicide)	Trade Name (typical)	WSSA Mechanism of Action Group No.[1]	Acreage Treated (%)	No. of Applications per Year	Rate per Application (lb/app./acre)	Rate per Acre (lb/acre)	Total Applied per Year (lb)
Clethodim	Select®	1	36%	1	0.02	0.02	1,000
Clopyralid	Stinger®	4	46%	1.2	0.07	0.05	2,000
Cycloate	Ro-Neet™	8	8%	1	1.31	1.31	7,000
Desmedipham	Betanex®	5	83%	1.2	0.06	0.05	3,000
Ethofumesate	Nortron®	8	65%	1	0.14	0.13	7,000
Phenmedipham	Betamix®	5	83%	1.2	0.06	0.05	3,000
Quizalofop-p-ethyl	Assure® II	1	12%	1	0.05	0.05	ND[2]
Triflusulfuron-methyl	Upbeet®	2	80%	1.2	0.01	0.009	ND

Pesticide Usage Source: National Agriculture Statistics Service, Agricultural Chemical Use Database (http://www.pestmanagement.info/nass/app_usage.cfm).

1 Source: Heap, 2011; WSSA, 2007.

2 ND = No data were reported for total herbicide applied per year (lb), although the available data indicated that the herbicide was applied in Colorado (Great Plains Region).

Table G- 4. Herbicide Applications to Conventional Sugar Beet Acres in Montana (Great Plains Region), 2000

Agricultural Chemical (Herbicide)	Trade Name (typical)	WSSA Mechanism of Action Group No.[1]	Acreage Treated (%)	No. of Applications per Year	Rate per Application (lb/app./acre)	Rate per Acre (lb/acre)	Total Applied per Year (lb)
Clethodim	Select®	1	65%	2.6	0.12	0.04	5,000
Clopyralid	Stinger®	4	92%	2.5	0.08	0.03	5,000
Desmedipham	Betanex®	8	99%	2.7	0.15	0.05	9,000
Ethofumesate	Nortron®	5	41%	2.3	0.17	0.07	4,000
Glyphosate	(Several)	8	67%	1	0.42	0.42	17,000
Phenmedipham	Betamix®	5	97%	2.7	0.13	0.05	8,000
Quizalofop-p-ethyl	Assure® II	1	5%	2	0.04	0.02	ND[2]
Triflusulfuron-methyl	Upbeet®	2	91%	2.6	0.03	0.01	2,000

Pesticide Usage Source: National Agriculture Statistics Service, Agricultural Chemical Use Database (http://www.pestmanagement.info/nass/app_usage.cfm).

1 Source: Heap, 2011; WSSA, 2007.

2 ND = No data were reported for total herbicide applied per year (lb), although the available data indicated that the herbicide was applied in Montana (Great Plains).

Table G- 5. Herbicide Applications to Conventional Sugar Beet Acres in Nebraska (Great Plains Region), 2000

Agricultural Chemical (Herbicide)	Trade Name (typical)	WSSA Mechanism of Action Group No.[1]	Acreage Treated (%)	No. of Applications per Year	Rate per Application (lb/app./acre)	Rate per Acre (lb/acre)	Total Applied per Year (lb)
Clethodim	Select®	1	41%	1	0.09	0.09	3,000
Clopyralid	Stinger®	4	66%	1.8	0.08	0.04	4,000
Cycloate	Ro-Neet™	8	17%	1	1.72	1.72	23,000
Desmedipham	Betanex®	5	90%	2	0.15	0.08	11,000
Ethofumesate	Nortron®	8	70%	1.2	0.22	0.18	12,000
Phenmedipham	Betamix®	5	86%	2	0.15	0.07	10,000
Sethoxydim	Poast® II	1	3%	1	0.16	0.16	ND[2]
Triflusulfuron-methyl	Upbeet®	2	70%	2	0.02	0.01	1,000

Pesticide Usage Source: National Agriculture Statistics Service, Agricultural Chemical Use Database (http://www.pestmanagement.info/nass/app_usage.cfm).

[1] Source: Heap, 2011; WSSA, 2007.

[2] ND = No data were reported for total herbicide applied per year (lb), although the available data indicated that the herbicide was applied in Nebraska (Great Plains Region).

Table G- 6. Herbicide Applications to Conventional Sugar Beet Acres in Wyoming (Great Plains Region), 2000

Agricultural Chemical (Herbicide)	Trade Name (typical)	WSSA Mechanism of Action Group No.[1]	Acreage Treated (%)	No. of Applications per Year	Rate per Application (lb/app./acre)	Rate per Acre (lb/acre)	Total Applied per Year (lb)
Clethodim	Select®	1	35%	1.7	0.11	0.06	2,000
Clopyralid	Stinger®	4	71%	2.1	0.07	0.03	3,000
Cycloate	Ro-Neet™	8	15%	1	0.79	0.78	7,000
Desmedipham	Betanex®	5	86%	2.1	0.1	0.05	5,000
EPTC	Eptam®	8	12%	1	2.15	2.15	15,000
Ethofumesate	Nortron®	8	37%	1.1	0.17	0.15	4,000
Phenmedipham	Betamix®	5	78%	2.2	0.09	0.04	4,000
Triflusulfuron-methyl	Upbeet®	2	79%	2.1	0.02	0.009	1,000

Pesticide Usage Source: National Agriculture Statistics Service, Agricultural Chemical Use Database (http://www.pestmanagement.info/nass/app_usage.cfm).

[1] Source: Heap, 2011; WSSA, 2007.

Table G- 7. Herbicide Applications to Conventional Sugar Beet Acres in North Dakota1 (Midwest Region), 2000

Agricultural Chemical (Herbicide)	Trade Name (typical)	WSSA Mechanism of Action Group No.[2]	Acreage Treated (%)	No. of Applications per Year	Rate per Application (lb/app./acre)	Rate per Acre (lb/acre)	Total Applied per Year (lb)
Clethodim	Select®	1	83%	2.9	0.11	0.04	24,000
Clopyralid	Stinger®	4	85%	3.1	0.1	0.03	22,000
Desmedipham	Betanex®	5	98%	3.3	0.21	0.06	54,000
Ethofumesate	Nortron®	8	32%	2.5	0.12	0.05	10,000
Glyphosate	(Several)	9	9%	1	0.67	0.64	16,000
Phenmedipham	Betamix®	5	75%	3	0.14	0.05	28,000
Quizalofop-p-ethyl	Assure® II	1	8%	1.4	0.06	0.04	1,000
Sethoxydim	Poast®	1	4%	3.4	0.21	0.06	2,000
Triflusulfuron-methyl	Upbeet®	2	87%	3.2	0.02	0.006	4,000

Pesticide Usage Source: National Agriculture Statistics Service, Agricultural Chemical Use Database (http://www.pestmanagement.info/nass/app_usage.cfm).

[1] For North Dakota in 2000, 242,400 acres of sugar beets were planted in eastern North Dakota and 15,600 acres were planted in the two western counties (Williams and McKenzie). The NASS herbicide usage database does not break out by county, so North Dakota data were grouped with the Midwest region.

[2] Source: www.weedscience.org; www.hracglobalcom.

Table G- 8. Herbicide Applications to Conventional Sugar Beet Acres in Minnesota (Midwest Region), 2000

Agricultural Chemical (Herbicide)	Trade Name (typical)	WSSA Mechanism of Action Group No.[1]	Acreage Treated (%)	No. of Applications per Year	Rate per Application (lb/app./acre)	Rate per Acre (lb/acre)	Total Applied per Year (lb)
Clethodim	Select®	1	75%	2.6	0.04	0.1	38,000
Clopyralid	Stinger®	4	95%	3.2	0.03	0.1	46,000
Desmedipham	Betanex®	5	100%	3.3	0.07	0.25	121,000
Ethofumesate	Nortron®	8	20%	2.1	0.04	0.08	8,000
Glyphosate	(Several)	9	4%	1	0.5	0.5	10,000
Phenmedipham	Betamix®	5	70%	3	0.05	0.15	52,000
Quizalofop-p-ethyl	Assure® II	1	9%	1.4	0.04	0.06	3,000
Sethoxydim	Poast®	1	16%	1.7	0.16	0.28	21,000
Trifluralin	Treflan® HFP	3	6%	1	0.84	0.84	23,000
Triflusulfuron-methyl	Upbeet®	2	94%	3.3	0.007	0.02	10,000

Pesticide Usage Source: National Agriculture Statistics Service, Agricultural Chemical Use Database (http://www.pestmanagement.info/nass/app_usage.cfm).

[1] Source: www.weedscience.org; www.hracglobalcom.

Table G- 9. Herbicide Applications to Conventional Sugar Beet Acres in Idaho (Northwest Region), 2000

Agricultural Chemical (Herbicide)	Trade Name (typical)	WSSA Mechanism of Action Group No.[1]	Acreage Treated (%)	No. of Applications per Year	Rate per Application (lb/app./acre)	Rate per Acre (lb/acre)	Total Applied per Year (lb)
Clopyralid	Stinger®	4	62%	2.2	0.07	0.03	9,000
Cycloate	Ro-Neet™	8	13%	1	2.39	2.39	65,000
Desmedipham	Betanex®	5	100%	2.9	0.13	0.04	28,000
EPTC	Eptam®	8	20%	1	2.93	2.93	125,000
Ethofumesate	Nortron®	8	94%	2.7	0.12	0.05	25,000
Glyphosate	(Several)	9	24%	1	0.4	0.39	20,000
Phenmedipham	Betamix®	5	100%	2.9	0.13	0.04	28,000
Quizalofop-p-ethyl	Assure® II	1	23%	2	0.07	0.03	3,000
Sethoxydim	Poast®	1	13%	1	0.26	0.24	7,000
Trifluralin	Treflan® HFP	3	9%	1	0.5	0.5	10,000
Triflusulfuron-methyl	Upbeet®	2	84%	2.6	0.04	0.02	7,000

Pesticide Usage Source: National Agriculture Statistics Service, Agricultural Chemical Use Database (http://www.pestmanagement.info/nass/app_usage.cfm).
[1] Source: www.weedscience.org; www.hracglobalcom.

Table G- 10. Herbicide Applications to Conventional Sugar Beet Acres in Oregon (Northwest Region), 2000

Agricultural Chemical (Herbicide)	Trade Name (typical)	WSSA Mechanism of Action Group No.[1]	Acreage Treated (%)	No. of Applications per Year	Rate per Application (lb/app./acre)	Rate per Acre (lb/acre)	Total Applied per Year (lb)
Clopyralid	Stinger®	4	58%	2.6	0.09	0.03	1,000
Desmedipham	Betanex®	5	89%	2.8	0.15	0.05	2,000
EPTC	Eptam®	8	15%	1.3	3.79	2.75	9,000
Ethofumesate	Nortron®	8	31%	2.9	0.2	0.07	1,000
Glyphosate	(Several)	9	39%	1	0.45	0.45	3,000
Phenmedipham	Betamix®	5	89%	2.8	0.15	0.05	2,000
Quizalofop-p-ethyl	Assure® II	1	10%	1	0.07	0.07	ND[2]
Trifluralin	Treflan® HFP	3	27%	1	0.55	0.55	2,000
Triflusulfuron-methyl	Upbeet®	2	88%	2.6	0.03	0.01	ND

Pesticide Usage Source: National Agriculture Statistics Service, Agricultural Chemical Use Database (http://www.pestmanagement.info/nass/app_usage.cfm).
[1] Source: www.weedscience.org; www.hracglobalcom.
[2] ND = No data were reported for total herbicide applied per year (lb), although the available data indicated that the herbicide was applied in Oregon (Northwest).

Table G- 11. Herbicide Applications to Conventional Sugar Beet Acres in Washington (Northwest Region), 2000

Agricultural Chemical (Herbicide)	Trade Name (typical)	WSSA Mechanism of Action Group No.[1]	Acreage Treated (%)	No. of Applications per Year	Rate per Application (lb/app./acre)	Rate per Acre (lb/acre)	Total Applied per Year (lb)
Clethodim	Select®	1	41%	1.9	0.24	0.12	3,000
Cycloate	Ro-Neet™	8	32%	1	1.57	1.57	14,000
Desmedipham	Betanex®	5	83%	2.6	0.21	0.08	5,000
EPTC	Eptam®	8	38%	1	2.11	2.11	22,000
Ethofumesate	Nortron®	8	57%	1.5	0.28	0.17	5,000
Phenmedipham	Betamix®	5	83%	2.6	0.2	0.07	5,000
Triflusulfuron-methyl	Upbeet®	2	80%	2.4	0.03	0.01	1,000

Pesticide Usage Source: National Agriculture Statistics Service, Agricultural Chemical Use Database (http://www.pestmanagement.info/nass/app_usage.cfm).
[1] Source: www.weedscience.org; www.hracglobalcom.

Appendix F. APHIS Threatened and Endangered Species Analysis and Decision Tree for U.S. Fish and Wildlife Service Consultations

Threatened and Endangered Species Analysis

Congress passed the Endangered Species Act (ESA) of 1973, as amended, to prevent extinctions facing many species of fish, wildlife, and plants. The purpose of the ESA is to conserve endangered and threatened species and the ecosystems on which they depend as key components of America's heritage. To implement the ESA, the U.S. Fish & Wildlife Service (USFWS) works in cooperation with the National Marine Fisheries Service (NMFS); other Federal, State, and local agencies; Tribes; non-governmental organizations; and private citizens. Before a plant or animal species can receive the protection provided by the ESA, it must first be added to the Federal list of threatened and endangered wildlife and plants.

A species is added to the list when it is determined by the USFWS/NMFS to be endangered or threatened because of any of the following factors:

- The present or threatened destruction, modification, or curtailment of its habitat or range;
- Overutilization for commercial, recreational, scientific, or educational purposes;
- Disease or predation;
- The inadequacy of existing regulatory mechanisms; and
- The natural or manmade factors affecting its survival.

Once an animal or plant is added to the list, in accordance with the ESA, protective measures apply to the species and its habitat. These measures include protection from adverse effects of Federal activities.

Section 7 (a)(2) of the ESA requires that a Federal agency, in consultation with the USFWS or NMFS, ensure that any action the agency authorizes, funds, or carries out is not likely to jeopardize the continued existence of a listed species or result in the destruction or adverse modification of designated critical habitat. It is the responsibility of the Federal agency taking the action to assess the effects of the agency's action and to consult with the USFWS or NMFS if it is determined the action "may affect" listed species or critical habitat. To facilitate the APHIS ESA consultation process, APHIS met with the USFWS from 1999 to 2003 to discuss factors relevant to APHIS' regulatory authority and effects analysis for petitions for nonregulated status, and developed a process for conducting an effects determination consistent with the Plant Protection Act (PPA) of 2000 (Title IV of Public Law 106-224). This process is described in a decision tree document, which is presented as Appendix I. APHIS uses this process to help fulfill its obligations and responsibilities under section 7 of the ESA for biotechnology regulatory actions.

APHIS' regulatory authority over GE organisms under the PPA is limited to those GE organisms for which it has reason to believe might be a plant pest or those for which APHIS does not have sufficient information to determine that the GE organism is unlikely to pose a plant pest risk (7 CFR § 340.1). APHIS does not have authority to regulate the use of any herbicide, including glyphosate. After completing a plant pest risk analysis, if APHIS determines that H7-1 sugar beet does not pose a plant pest risk, then H7-1 sugar beet would no longer be subject to the plant pest provisions of the Plant Protection Act or to the regulatory requirements of 7 CFR part 340, and therefore, APHIS must grant it non-regulated status. As part of its Environmental Impact Statement (EIS) analysis, APHIS is analyzing the potential effects of H7-1sugar beets on the environment including any potential effects to threatened and endangered species and critical habitat. As part of this process, APHIS thoroughly reviews genetically engineered product information and data related to the organism (generally a plant species, but may also be other genetically engineered organisms). For each transgene(s)/transgenic plant, APHIS considers the following information, data, and questions:

- A review of the biology and taxonomy of the crop plant and its sexually compatible relatives;
- Characterization of each transgene with respect to its structure and function and the nature of the organism from which it was obtained;
- A determination of where the new transgene and its products (if any) are produced in the plant and their quantity;
- A review of the agronomic performance of the plant, including disease and pest susceptibilities, weediness potential, and agronomic and environmental impacts;
- Determination of the concentrations of known plant toxicants (if any are known in the plant); and
- Analysis to determine if the transgenic plant is sexually compatible with any threatened or endangered plant species or a host of any threatened or endangered plant or animal species.
- Any other information that may inform the potential for an organism to pose a plant pest risk.

In following this review process, APHIS, as described below, has evaluated the potential effects that a determination of nonregulated status of H7-1 sugar beet plants (here-to generically referred to as sugar beets) for both seed and root production may have, if any, on federally listed threatened and endangered species and species proposed for listing, as well as designated critical habitat and habitat proposed for designation. Based upon the scope of the EIS and production areas identified in section III.B.1.c(1), APHIS reviewed the list of TES (listed and proposed) for each state where sugar beet is commercially produced from the USFWS Environmental Conservation Online System (ECOS; as accessed (August 19, 2011) at http://ecos.fws.gov/tess_public/pub/stateListingAndOccurrence.jsp). Prior to this review, APHIS considered the potential for H7-1 sugar beets to extend the range of sugar beet production and also the potential to expand agricultural production into new natural areas. From 2005-2010, when H7-1 sugar beets had nonregulated status it was extensively commercialized, and it currently accounts for approximately 95 percent of the sugar beet production in the United States. Considering that H7-1 sugar beets account for such a high percentage of the total area planted with sugar beets, it is reasonable to expect that a second full deregulation would result in H7-1 sugar beets being planted in areas similar to where it was planted prior to the 2010 court order vacating the deregulation decision. The genetic transformation does not impart any phenotypic characteristic that would allow for the planting of H7-1 sugar beets in areas unsuitable to sugar beet varieties currently available. In addition, as described in detail in section III.D.1.b, even when deregulated, sugar beet production requires close coordination under contractual agreements between the grower and the processor. All sugar beets are shipped to a processor to efficiently extract the sugar from the beet. All sugar beet processors in the United States are now structured as cooperatives, with the exception of Wyoming Sugar Beet Company, LLC, who is, nonetheless, owned mostly by sugar beet producers as well. The cooperatives own the processing facilities, and the sugar beet farmers are members of the cooperatives. To contain shipping costs, sugar beet production is effectively limited to areas typically within 60 miles of a processing facility, although some fields may be located up to 100 miles away (Western Sugar Cooperative, 2006). Because of the high costs associated with construction of a processing facility, and the required coordination with potential growers, expansion of production into new areas is not anticipated in the foreseeable future.

Potential Effects of H7-1 Sugar Beet Plants and Plant Products on TES

To identify any potential effects of H7-1 sugar beets on threatened and endangered plant species, APHIS evaluated the potential of H7-1 sugar beets to cross with a listed species. Sugar beets are in the genus *Beta* and have the ability to cross with several species of wild beets in the same genus, but are not known to cross with any other plant species without human assistance (OECD, 2001). After reviewing the list of threatened and endangered plant species in the States where sugar beets are grown (see appendix H), APHIS determined that H7-1 sugar beets would not be sexually compatible with any listed threatened or endangered plant species or plant proposed for listing as none of these listed plants are in the same genus nor are known to cross pollinate with species of the genus *Beta*.

To identify potential effects on threatened and endangered animal species, APHIS evaluated the risks to threatened and endangered animals from consuming H7-1 sugar beets. As discussed in section III.F.1.a(4), there is no difference in the composition and nutritional quality of H7-1 sugar beets compared with conventional sugar beets. APHIS also examined the allergenicity and toxicity of the H7-1 sugar beet CP4 EPSPS protein, and based on the research summarized and referenced in section III.F.1.a(5), concludes that no differences exist compared to conventional sugar beet EPSPS protein. Both types of proteins are ubiquitous in nature, are normally present in food and feeds derived from these plant and microbial sources, and when used to impart tolerance to glyphosate in corn, cotton, and soybean plants, the CP4 EPSPS protein has not resulted in any adverse human health effects despite being grown on hundreds of millions of acres across the United States over the past decade. Finally, the research cited and summarized in section III.F.1.a(5) also finds no difference in allergenicity between conventional and H7-1 sugar beet pollen. Therefore, based on these analyses, APHIS concludes that consumption of H7-1 sugar beet plant parts (seeds, leaves, stems, pollen, or roots) would have no effect on any listed threatened or endangered animal species or animal species proposed for listing.

APHIS considered the possibility that H7-1 could serve as a host plant for a threatened or endangered species. A review of the species list reveals that there are no members of the genus *Beta* that serve as a host plant for any threatened or endangered species.

As part of the analysis for threatened and endangered species and critical habitat, APHIS considered if the new phenotype imparted to H7-1 sugar beets may allow the plant to naturalize in the environment and potentially have an effect on TES. In doing so, APHIS assessed whether H7-1 sugar beets are any more likely to become a weed than the non-transgenic recipient sugar beet line or other currently cultivated sugar beets. Weediness could potentially affect threatened and endangered species or critical habitat if H7-1 sugar beets were to become naturalized in the environment. The assessment considers the basic biology of sugar beets and an evaluation of unique characteristics of H7-1 sugar beets. As discussed in section III.C.3.c, no *Beta* species are listed as weeds on any of the 12 weed lists from the USDA PLANTS database (USDA–NRCS, 2010). Sugar beets possess few of the characteristics of plants that are notable as successful weeds. APHIS considered data on plant vigor, bolting, seedling emergence, seed germination, seed dormancy, and other characteristics that might relate to increased weediness (USDA–APHIS, 2005). During field trials, no differences were observed between H7-1 lines and non-transgenic lines with respect to the plants' ability to persist or to compete as a weed (Schneider, R.W. and G. Strittmatter. 2003). No unusual characteristics were noted that would suggest increased weediness of H7-1 plants. Additionally, no characteristics relating to disease or insect resistance that might affect weediness were noted that were consistent over all trial locations. H7-1 sugar beets are still susceptible to the typical insect and disease pests of sugar beets. Collectively, this information indicates that H7-1 sugar beets are unlikely to naturalize and persist in the environment.

After reviewing the potential effects of H7-1 sugar beets on the environment that could result from a determination of nonregulated status of H7-1 sugar beets, APHIS has not identified any stressor that could affect the reproduction, numbers, or distribution of a listed threatened or endangered species or species proposed for listing. As a result, a detailed site-specific (or spatially explicit) exposure analysis for individually listed threatened or endangered species is not needed for APHIS to reach a determination of nonregulated status for H7-1 sugar beets. APHIS considered the effect of H7-1 sugar beet production on designated critical habitat or habitat proposed for designation and could identify no difference from effects that would occur from the production of other sugar beet varieties. Sugar beets are not considered a particularly competitive plant species and are ecologically limited due to susceptibility to plant pathogens and herbivores and are not typically described as weeds outside of agricultural fields (Bartsch et al., 2001). Sugar beets are not considered weedy and feral populations of sugar beet have not been identified in the U.S. H7-1 sugar beets are not sexually compatible with, or serve as a host species for, any listed species or species proposed for listing. Consumption of H7-1 sugar beet by any listed species or species proposed for listing will not result in a toxic or allergic reaction. Based on these factors, APHIS has determined that H7-1 sugar beets would have no effect on listed threatened or endangered plant or animal species or such species proposed for listing and would not affect listed threatened or endangered plant or animal species' designated critical habitat or habitat proposed for designation. Because of this no effect determination, consultation under Section 7(a)(2) of the Act or the concurrence of the USFWS or NMFS is not required.

Potential Impacts of Glyphosate Use on TES

As part of the EIS process, APHIS met with USFWS officials on June 15, 2011 to discuss whether APHIS has any obligations under the ESA regarding analyzing the impacts of herbicide use associated with all GE crops on TES. As a result of these joint discussions, USFWS and APHIS have agreed that it is not necessary for APHIS to perform an ESA effects analysis on herbicide use associated either with H7-1 sugar beets or with all GE crops currently planted because EPA has both complete regulatory authority over the labeling of pesticides and the necessary technical expertise to assess pesticide effects on the environment under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). APHIS has no statutory authority to authorize or regulate the use of glyphosate, or any other herbicide, by sugar beet growers. Under APHIS' current Part 340 regulations, APHIS only has the authority to regulate H7-1 sugar beets or any GE organism as long as APHIS believes it may pose a plant pest risk. For GE organisms, APHIS has no regulatory jurisdiction over any other risks associated with GE organisms including risks resulting from the use of herbicides or other pesticides on those organisms. Nevertheless, APHIS is aware that there may be potential environmental impacts resulting from the use of glyphosate on H7-1 sugar beet, including potential impacts on TES and critical habitat, based on assessments provided to it by the EPA and as available in the peer reviewed scientific literature. APHIS is providing the available information of potential environmental impacts resulting from glyphosate use on H7-1 sugar beet below.

It is important to note that the use of herbicides in the production of sugar beet is not unique to the production of H7-1 sugar beet and that H7-1 sugar beet is not dependent on the use of glyphosate for its production life cycle. Non-glyphosate herbicides are typically used to control weeds during production of conventional sugar beet varieties, and these herbicides could presumably be used in production of H7-1 sugar beet. An analysis of herbicide use in H7-1 and conventional sugar beets and the risks associated with them is thoroughly described in Section IV. In summary, because of their toxicity, many of the herbicides historically used in conventional sugar beet production potentially pose greater impacts to non-target organisms than the use of glyphosate and would potentially pose greater impacts to TES as well.

Conservation tillage and no-till practices have a positive impact on wildlife (Towery and Werblow, 2010). Benefits include decreased soil erosion and improved water quality in receiving waters, retention of cover, availability of waste grain on the soil surface for feed, and increased populations of invertebrates as a food source (Sharpe, 2010). As described in section III.B.1.c(2), the use of glyphosate in a H7-1 sugar beet production system facilitates the use of conservation tillage practices, whereas, in conventional sugar beet production, conservation tillage is far more difficult. Therefore, if H7-1 sugar beet is replacing fields of conventional varieties that are not currently utilizing conservation tillage practices and where TES species are present, the production of H7-1 sugar beet could improve baseline conditions and may have a beneficial impact on TES. However, any beneficial impact may have already been realized following the 2005 H7-1 deregulation and the rapid adoption of H7-1, and moreover it would be difficult to assess those impacts retrospectively.

EPA Endangered Species Protection Program (ESPP)

In 1988, Congress enacted Public Law 100-478 (October 7, 1988) to in part address the relationship between ESA and EPA's pesticide labeling program (Section 1010), which required

EPA to conduct a study, and report to Congress, on ways to implement EPA's endangered species pesticide labeling program in a manner that both complies with ESA and allows people to continue production of agricultural food and fiber. This law provided a clear sense that Congress wanted EPA to fulfill its obligation to conserve listed species, while at the same time consider the needs of agriculture and other pesticide users (70 FR 211 2005-11-02).

In 1988 EPA established the ESPP to meet its obligations under the ESA. EPA Endangered Species Protection Program Web site[1] describes the EPA assessment process for endangered species. Some of the elements of that process, reported on the Web site, are summarized below. The goal of EPA's ESPP is to carry out its responsibilities under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) in compliance with the ESA, without placing unnecessary burden on agriculture and other pesticide users consistent with Congress' intent. EPA is responsible for reviewing pesticide information and data to determine whether a pesticide product may be registered for a particular use including those uses associated with the approval of biotechnology products. As part of that determination, the Agency assesses whether listed endangered or threatened species or their designated critical habitat may be affected by use of the pesticide product. All pesticide products that EPA determines "may affect" a listed species or its designated critical habitat may be subject to the ESPP. If limitations on pesticide use are necessary to protect listed species in areas where a pesticide may be used, the information is related through Endangered Species Protection Bulletins. Bulletins identify the species of concern and the pesticide active ingredient that may affect the listed species. They also provide a description of the protection measures necessary to protect the species, and contain a county-level map showing the geographic area(s) associated with the protection measures, depending on the susceptibility of the species. Bulletins are enforceable as part of the product label (http://www.epa.gov/oppfead1/endanger/basic-info.htm).

EPA TES Evaluation Process

EPA evaluates listed species and their critical habitat concerns within the context of pesticide registration and registration review so that when a decision is made, it fully addresses issues relative to listed species protection. If a risk assessment determines that use limitations are necessary to ensure that legal use of a pesticide will not harm listed species or their critical habitat, EPA may either change the terms of the pesticide registration or establish geographically specific pesticide use limitations. (http://www.epa.gov/oppfead1/endanger/basic-info.htm).

EPA's review of the pesticide and its registration decision is independent of APHIS' review and regulatory decisions under 7 CFR 340. EPA does not require data or analyses conducted by APHIS to complete its reviews. EPA evaluates extensive toxicity, ecological effects data, and environmental fate, transport and behavior data, most of which is required under FIFRA data requirements, to assess and determine how a pesticide will move through and break down in the environment. Risks to various taxa, e.g., birds, fish, invertebrates, plants and mammals are routinely assessed and used in EPA's determinations of whether a pesticide may be licensed for use in the United States.

[1] http://www.epa.gov/espp/

EPA's core pesticide risk assessment and regulatory processes ensure that protections are in place for all populations of non-target species, not just threatened and endangered species. EPA has developed a comprehensive risk assessment process modeled after, and consistent with, EPA's numerous guidelines for environmental assessments (http://www.epa.gov/oppfead1/endanger/consultation/ecorisk-overview.pdf) . The result of an assessment, which may go through several refinements, is to determine whether the potential effects of a pesticide's registration to a listed species will result in either a "no effect" or "may affect" determination. EPA consults on determinations that "may affect" a listed species or adversely modify its critical habitat (http://www.epa.gov/oppfead1/endanger). As a result of either an assessment or consultation, EPA may require changes to the use conditions specified on the label of the product. When such changes are necessary only in specific geographic areas rather than nationwide to ensure protection of the listed species, EPA implements these changes through geographically-specific Endangered Species Protection Bulletins, otherwise, these changes are applied to the label for all uses of the pesticide.

Ecological Risks of Glyphosate

The ecological risks associated with use of glyphosate as a herbicide have been assessed several times since 1974 when it was first registered for use in the United States. In addition, EPA has consulted with the USFWS on the effects of glyphosate on listed species and critical habitat. Findings from relevant ecological risk assessments and the results and status of consultations are summarized below.

- In the June 1986 Registration Standard for glyphosate, the EPA discussed consultations with the US Fish and Wildlife Service (FWS) on hazards to crops, rangeland, silvicultural sites, and the Houston toad which may result from the use of glyphosate. Because a jeopardy opinion resulted from these consultations, the agency imposed endangered species labeling requirements in the Registration Standard to mitigate the risk to endangered species.

- In 1993, Glyphosate was assessed by EPA for the Reregistration Eligibility Decision (RED) (EPA 1993b). The RED concluded that direct risks to birds, mammals, invertebrates and fish would be minimal. Under certain conditions, aquatic plants were expected to be at risk from glyphosate use. Additional data were needed for non-target terrestrial plants, including incident data and vegetative vigor testing on non-target terrestrial plants. The assessment stated that many endangered plants may be at risk from use of glyphosate with the registered use patterns. In addition, it was determined that the Houston Toad may be at risk from use of glyphosate on alfalfa. The RED resulted in label changes to provide protection of aquatic organisms.

- In 2003, the USDA Forest Service had a risk assessment conducted for glyphosate uses in Forest Service vegetation management programs (USDA, 2003). For forestry uses, all commercial formulations of glyphosate contained the isopropylamine salt of glyphosate (IPA). Application rates ranged from 0.5 lbs acid equivalent per acre (a.e./A) to 7 lbs a.e./A with the most typical at 2 lb a.e./A. Based on the available data, the USDA concluded that the risks were minimal to mammals, birds, fish, amphibians, invertebrates, and aquatic plants. Risks to fish following application of the more toxic formulations were not considered to be high; however, the assessment did state that at an application rate of 7 lb a.e./A, the acute exposures slightly exceeded the acute LC50 for a more tolerant freshwater fish and exceeded it by a factor of 2 for the less tolerant fish. These values were estimated from a worst-case scenario where there was a severe rainfall of about 7 inches over a 24-hour period in an area where runoff is favored. The USDA assessment did not conduct a separate assessment for amphibians. The document concluded that the amphibian data indicated that glyphosate is no more toxic to amphibians than it is to fish. For terrestrial plants, the assessment concluded that for relatively tolerant plants, when a low-boom spray is utilized as the method of application, there is no indication that glyphosate would result in damage from spray drift at distances from the application site of 25 feet or greater. For more sensitive plants, the distance increased to approximately 100 feet. For applications requiring the use of backpack-directed spray, the distances would be less. No risks to terrestrial plants from runoff were expected.

- In 2004, EPA issued a report, Glyphosate Analysis of Risks to Endangered and Threatened Salmon and Steelhead. The analysis included 11 Evolutionary Significant Units (ESU- a population that is considered distinct for purposes of conservation) in California with one unit extending into southern Oregon. Much of the quantitative information presented and used was derived from the 1993 Registration Eligibility Decision (RED) Ecological Risk Assessment. Testing was performed with formulated products, in addition to glyphosate alone and included acute and chronic toxicity. Testing of the pure product indicate that pure glyphosate is practically non-toxic to the species examined. Glyphosate was moderately toxic to practically non-toxic in formulated products. Since this is somewhat increased over results with the pure chemical the report concluded that it appears likely due to the added agents, generally surfactants. EPA uses a variety of chemical fate and transport data to develop "estimated environmental concentrations" (EECs) from a suite of established models. The EEC's were used with toxicity for the most sensitive species from technical grade testing of the active ingredient to develop acute risk quotients (RQ). The RQ analysis indicates that glyphosate applied at 5.062 lb a.i./A does not present an acute risk to endangered and threatened salmonids from direct effects because the calculated RQ is less than the level of concern (LOC). The primary indirect effect of concern would be for the food source for listed fish. The report concluded that this rate of application does not present indirect effects from loss of food or loss of cover, as the RQs for invertebrates and plants is less than the LOC. However, the assessment determined that use of glyphosate "may affect, but is not likely to adversely affect" the species based on acute toxicity to fish for uses with application rates above 5 lb active ingredient per acre (a.i./A). For uses with application rates below 5 lb a.i./A, the Agency determined glyphosate would have no effect on the 11 ESUs.

- In 2006, the EPA assessed glyphosate for a new use on bentgrass (EPA 2006a, e) (0.74 lb a.i./A) and for new uses on Indian mulberry (noni), dry peas, lentils, garbanzo, (EPA 2006c) safflower and sunflower (EPA 2006d) with the highest proposed ground application rate of 3.73 lbs a.e./A. For all proposed new uses, the EPA concluded that there was minimal risk of direct acute effects to terrestrial animals (birds and mammals) and aquatic animals (fish, amphibians, and invertebrates) and minimal risk to terrestrial plants (both non-target and endangered plant species), aquatic non-vascular (algae and diatoms) and vascular (duckweed) plants from off-target spray drift and runoff from ground-based applications. In addition, there were no chronic risks to animals.

- In 2008, as a part of EPA's threatened and endangered species effects assessment for the California red-legged frog (CRLF) (U.S. EPA, 2008b), EPA evaluated the effect of glyphosate use at rates up to 7.95 lb. a.e./A on fish, amphibians, aquatic invertebrates, aquatic plants, birds, mammals, and terrestrial invertebrates. This assessment determined that at the maximum application rate for in-crop applications of glyphosate to glyphosate-tolerant sugar beets (1.125 lb. a.e./A), there would be no effects of glyphosate use on the following taxa of threatened and endangered species: fish, amphibians, birds, and mammals. The EPA assessment was uncertain of the effects on terrestrial invertebrates, citing the potential to affect small insects at all application rates and large insects at the 7.95 lb. a.e./A acre rate which is above the maximum rate for glyphosate tolerant sugar beets.

- In 2010, EPA issued the memorandum Assessment of Ecological Risk for Glyphosate, potassium salt (PC Code 103613; CAS# 70901-12-1) for Label Supplement to Add Uses on Roundup Ready Sweet Corn. Because of the potential risk from surfactants, a conservative estimation of risk to aquatic organisms was conducted on a formulation basis as well as on a glyphosate acid equivalent basis. The names and CAS numbers of the surfactant are proprietary and are not provided in the assessment. Instead the surfactant polyoxyethylene alkylamine mixture (POEA, CAS # 61791-26-2) was used because it has been used in glyphosate products and is known to be considerably more toxic to aquatic organisms than technical glyphosate. The assessment was completed with the assumption that the proposed surfactants are similar to POEA. Based on the proposed labels, the maximum application rate on a glyphosate acid equivalent basis is 3.71 lbs a.e./A glyphosate and on a formulation basis is 9.35 lbs formulation /A.

  The risk to fish, aquatic phase amphibians, aquatic invertebrates, aquatic plants, birds, reptiles, terrestrial phase amphibians, mammals, terrestrial invertebrates, and terrestrial plants was analyzed. The assessment concluded that there was no risk to fish, aquatic phase amphibians, aquatic invertebrates, aquatic plants, and mammals because the RQs did not exceed the LOCs for any of these groups. Because of the lack of toxicity studies for reptiles and terrestrial phase amphibians, birds are used as a surrogate. None of the available acute and subacute avian studies showed mortality so RQs were not calculated for birds. All of the terrestrial EEC values are lower than the highest dose/concentration tested (3.71 lbs a.e./A glyphosate), but many of the EECs for 20 gram birds were greater than $1/10^{th}$ of that dose. For 100 gram birds, several EECs were greater than $1/10^{th}$ of the highest dose and with the 1.15 lbs a.e./A dose applied 4 times per season. Therefore, there is uncertainty associated with the effect to listed birds, reptiles, and terrestrial phase amphibians. The chronic LOC for birds (LOC = 1) was exceeded for application to short grasses at the highest dose (3.71 lbs a.e./A glyphosate) (RQ = 1.07). However, because there were no effects at the highest concentrations in the bird studies and the RQ was only slightly greater than the LOC, the risk following chronic exposure is expected to be minimal. The assessment concluded that the risk to terrestrial invertebrates is negligible based on glyphosate's classification as practically non-toxic to honeybees. Lastly, for listed terrestrial plants, the RQ is lower than the LOC at the highest application rate when applied via ground applications, but are exceeded for listed and non-listed monocots and dicots when aerially applied at this 3.71 lbs a.e./A glyphosate rate.

- EPA is currently conducting a registration review for glyphosate (U.S. EPA, 2009c). EPA plans to conduct comprehensive human health and ecological risk assessments, including an endangered species assessment for uses and formulations of glyphosate, including risks due to surfactants included in formulations designated only for terrestrial applications. EPA estimates completing the registration review in 2015. The ecological risk assessment planned during the registration review will allow EPA to determine whether glyphosate's use has "no effect" or "may affect" on federally listed threatened or endangered species or their designated critical habitat. When an assessment concludes that a pesticide's use "may affect" a listed species or its designated critical habitat, EPA will consult with the USFWS and/or NMFS, as appropriate, and may develop labels that restrict the pesticide's use or specify certain condition, e.g., minimum separation distances between areas sprayed with glyphosate-based herbicides and habitats of threatened and endangered species.

Potential Impacts of Glyphosate Use in the Production of Sugar Beets

Stachler et al. (2009a, b) surveyed sugar beet growers in Minnesota, North Dakota, and Montana in 2009 regarding weed control and production practices. The results showed that glyphosate is nearly always broadcast-applied to glyphosate-tolerant sugar beets with a ground sprayer and aerial spraying is only used for 3% of applications (Stachler et al., 2009a, b). In Minnesota and eastern North Dakota, the most common herbicide treatment was glyphosate applied at 0.75 lb. a.e. per acre (Stachler et al., 2009a). The average total seasonal rate of glyphosate applied to glyphosate-resistant sugar beets was 1.85 lb. a.e. per acre in 2009, compared to 1.95 lb. a.e. per acre in 2008 in the same region (Stachler et al., 2009a). Similarly, in 2009, in western North Dakota and eastern Montana, the most common herbicide treatment was glyphosate applied at 1.0 lb. a.e. per acre (Stachler et al., 2009b). The average total seasonal rate of glyphosate application was 2.4 lb. a.e. per acre (Stachler et al., 2009b).

In general, States have primary authority for compliance monitoring and enforcing use of pesticides by the label requirements. Violators of the regulations are liable for all negative consequences of their actions (Federal Insecticide, Fungicide, and Rodenticide Act 7 USC 136j (a)(2)(G) Unlawful Acts). Therefore, growers that use glyphosate are very likely to follow its label restrictions. To facilitate pesticide applicators adherence to EPA label use restrictions for glyphosate when applied to glyphosate tolerant crops, Monsanto designed a Web-based program (Pre-Serve[2]).   The purpose of Pre-Serve is to "protect threatened and endangered plant species from potential impacts resulting from the agricultural use of herbicides that contain glyphosate." Pre-Serve instructs growers to observe specific precautions, including buffer zones, when spraying glyphosate herbicides on glyphosate-tolerant crops near threatened and endangered plant species that may be at risk. In addition, label requirements for Monsanto's Roundup® formulations and glyphosate formulations marketed by other manufacturers prohibit application

[2] http://www.pre-serve.org/

in conditions or locations where adverse impact on federally designated threatened or endangered plants or aquatic species is likely.

In summary, glyphosate use in the production of sugar beet is nearly always broadcast-applied with a ground sprayer, the typical application rate on H7-1 is below the maximum allowed by the label, the risk quotients for all effects is below the LOC for the maximum allowable rate, Monsanto instructs growers to observe specific precautions with the Pre-Serve program, and the pesticide label requires precautions to protect threatened and endangered species. Additionally, it is APHIS' understanding that EPA will be evaluating the effect of glyphosate application on H7-1 and consult with USFWS if necessary. Accordingly, the available information suggests that the glyphosate use resulting from the deregulation of H7-1 does not present an increase in potential impacts to TES.

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APHIS Threatened and Endangered Species Decision Tree for U.S. Fish and Wildlife Service Consultations

Decision Tree on Whether Section 7 Consultation with the U.S. Fish and Wildlife Service (USFWS) is Triggered for Petitions of Transgenic Plants

This decision tree document is based on the phenotypes (traits) that have been permitted for environmental releases under Animal and Plant Health Inspection Service (APHIS) oversight (for a list of approved notifications and environmental releases, visit Information Systems for Biotechnology). APHIS will re-evaluate and update this decision document as it receives new applications for environmental releases of new traits that are genetically engineered into plants.

BACKGROUND

For each transgene(s)/transgenic plant, the following information, data, and questions are addressed by APHIS, and the environmental analysis (e.g., environmental assessment [EA] or environmental impact statement [EIS]) for each petition will be publicly available. The APHIS review encompasses:

- A review of the biology, taxonomy, and weediness potential of the crop plant and its sexually compatible relatives;
- Characterization of each transgene with respect to its structure and function and the nature of the organism from which it was obtained;
- A determination of where the new transgene and its products (if any) are produced in the plant and their quantity;
- A review of the agronomic performance of the plant including disease and pest susceptibilities, weediness potential, and agronomic and environmental impact;
- Determination of the concentrations of known plant toxicants (if any are known in the plant); and
- Analysis to determine if the transgenic plant is sexually compatible with any threatened or endangered plant species or a host of any threatened or endangered plant species.

The U.S. Food and Drug Administration (FDA) published a policy in 1992 on foods derived from new plant varieties, including those derived from transgenic plants (see http://www.fda.gov/food/biotechnology/default.htm). Under this policy, FDA considers its existing statutory authorities to be “fully adequate to ensure the safety of new ingredients and foods derived from new varieties of plants, regardless of the process by which such foods and ingredients are produced (U.S. FDA, 1992). Thus, genetically engineered foods must meet the same rigorous safety standards as are required of all other foods. Many of the food crops currently being developed using biotechnology do not contain substances that are significantly different from those already consumed by humans and so may be less likely to require pre-market approval. FDA expects developers to consult with the agency on safety and regulatory questions. A list of consultations is available at http://www.fda.gov/Food/Biotechnology/Submissions/default.htm. APHIS considers the status and conclusion of the FDA consultations in its EAs and EISs.

Below is the description of the APHIS review process to determine if consultation with USFWS is necessary. If the answer to any of the questions below is "yes," APHIS contacts USFWS to determine if consultation is required.

1. Is the transgenic plant sexually compatible with a threatened or endangered plant[3] without human intervention?
2. Are naturally occurring plant toxins (toxicants) or allelochemicals increased over the normal concentration range in parental plant species?
3. Does the transgene product or its metabolites have any significant similarities to known toxins[4])?
4. Will the new phenotype(s) imparted to the transgenic plant allow the plant to be grown or employed in new habitats (e.g., outside the agro-ecosystem)[5]?
5. Does the pest resistance[6] gene act by one of the mechanisms listed below? If the answer is "yes," then consultation with USFWS is NOT necessary.

A. The transgene acts only in one or more of the following ways:

i. As a structural barrier to either the attachment of the pest to the host, to penetration of the host by the pest, to the spread of the pest in the host plant (e.g., the production of lignin, callose, thickened cuticles);
ii. In the plant by inactivating or resisting toxins or other disease causing substances produced by the pest;
iii. By creating a deficiency in the host of a component required for growth of the pest (such as with fungi and bacteria);
iv. By initiating, enhancing, or potentiating the endogenous host hypersensitive disease resistance response found in the plant; or
v. In an indirect manner that does not result in killing or interfering with normal growth, development, or behavior of the pest;

[3] APHIS will provide USFWS a draft EA that addresses the impacts, if any, of gene movement to the threatened or endangered plant.
[4] Via a comparison of the amino acid sequence of the transgene's protein with those found in the protein databases like PIR, Swiss-Port, and HIV amino acid databases.
[5] Such phenotypes might include tolerance to environmental stress such as drought, salt, frost, and aluminum or heavy metals.
[6] Pest resistance would include any toxin or allelochemical that prevents, destroys, repels, or mitigates a pest or affects any vertebrate or invertebrate animal, plant, or micro-organism.

B. A pest derived transgene is expressed in the plant to confer resistance to that pest (such as with coat protein, replicase, and pathogen virulence genes).

For the biotechnologist:

Depending on the outcome of the decision tree, initial the appropriate decision below and incorporate its language into the EA or EIS. Retain a hard copy of this decision document in the petition's file.

___________ BRS has reviewed the data in accordance with a process mutually agreed upon with the U.S. Fish and Wildlife Service to determine when a consultation, as required under Section 7 of the Endangered Species Act, is needed. APHIS has reached a determination that the release following a determination of nonregulated status would have no effects on listed threatened or endangered species and consequently, a written concurrence or formal consultation with the U.S. Fish and Wildlife Service is not required for this EA or EIS.

___________ BRS has reviewed the data in accordance with a process mutually agreed upon with the U.S. Fish and Wildlife Service to determine when a consultation, as required under Section 7 of the Endangered Species Act, is needed. APHIS reached a determination that the release following a determination of nonregulated status is not likely to adversely affect any listed threatened or endangered species and consequently obtained written concurrence from the U.S. Fish and Wildlife Service.

___________ BRS has reviewed the data in accordance with a process mutually agreed upon with the U.S. Fish and Wildlife Service to determine when a consultation, as required under Section 7 of the Endangered Species Act, is needed. APHIS reached a determination that the release following a determination of nonregulated status is likely to adversely affect one or more listed threatened or endangered species and has initiated formal consultation with the U.S. Fish and Wildlife Service.

Appendix E.

Federally Listed Threatened and Endangered Species

Tables E–1 through E–12 list federally threatened and endangered plant and animal species, and species proposed for listing, in those States where sugar beets could be approved by the U.S. Department of Agriculture's Animal and Plant Health Inspection Service and grown for seed production and marketable roots. These States include California, Colorado, Idaho, Michigan, Minnesota, Montana, Nebraska, North Dakota, Oregon, South Dakota, Washington, and Wyoming. The lists of species were obtained from the U.S. Fish and Wildlife Service Environmental Conservation Online System accessed on October 4, 2011 (http://www.fws.gov/endangered/species/index.html) (USFWS, 2011).

Table E- 1. Federally Threatened and Endangered Species in California

Status	Species/Listing Name	Critical Habitat
PLANTS		
Plant species listed in this State and that occur in this State – 179 species		
E	Allocarya, Calistoga (*Plagiobothrys strictus*)	N
E	Alopecurus, Sonoma (*Alopecurus aequalis* var. *sonomensis*)	N
E	Ambrosia, San Diego (*Ambrosia pumila*)	Y
T	Amole, purple (*Chlorogalum purpureum*)	Y
T	Baccharis, Encinitas (*Baccharis vanessae*)	N
E	Barberry, island (*Berberis pinnata ssp. insularis*)	N
E	Barberry, Nevin's (*Berberis nevinii*)	Y
E	Bedstraw, El Dorado (*Galium californicum ssp. sierrae*)	N
E	Bedstraw, island (*Galium buxifolium*)	N
E	Bird's beak, palmate-bracted (*Cordylanthus palmatus*)	N
E	Bird's-beak, Pennell's (*Cordylanthus tenuis ssp. capillaris*)	N
E	Bird's-beak, salt marsh (*Cordylanthus maritimus ssp. maritimus*)	N
E	Bird's-beak, soft (*Cordylanthus mollis ssp. mollis*)	Y
E	Bladderpod, San Bernardino Mountains (*Lesquerella kingii ssp. bernardina*)	Y
T	Bluecurls, Hidden Lake (*Trichostema austromontanum ssp. compactum*)	N
E	Bluegrass, Napa (*Poa napensis*)	N
E	Bluegrass, San Bernardino (*Poa atropurpurea*)	Y
T	Brodiaea, Chinese Camp (*Brodiaea pallida*)	N
T	Brodiaea, thread-leaved (*Brodiaea filifolia*)	Y
E	Broom, San Clemente Island (*Lotus dendroideus ssp. traskiae*)	N
E	Buckwheat, cushenbury (*Eriogonum ovalifolium* var. *vineum*)	Y
E	Buckwheat, Ione (incl. Irish Hill) (*Eriogonum apricum (incl.* var. *prostratum)*)	N
E	Bush-mallow, San Clemente Island (*Malacothamnus clementinus*)	N
E	Bush-mallow, Santa Cruz Island (*Malacothamnus fasciculatus* var. *nesioticus*)	N
T	Butterweed, Layne's (*Senecio layneae*)	N
E	Button-celery, San Diego (*Eryngium aristulatum* var. *parishii*)	N
E	Cactus, Bakersfield (*Opuntia treleasei*)	N
E	Ceanothus, coyote (*Ceanothus ferrisae*)	N
E	Ceanothus, Pine Hill (*Ceanothus roderickii*)	N
T	Ceanothus, Vail Lake (*Ceanothus ophiochilus*)	Y
T	Centaury, spring-loving (*Centaurium namophilum*)	Y
E	Checker-mallow, Keck's (*Sidalcea keckii*)	Y
E	Checker-mallow, Kenwood Marsh (*Sidalcea oregana ssp. valida*)	N
E	Checker-mallow, pedate (*Sidalcea pedata*)	N
E	Clarkia, Pismo (*Clarkia speciosa ssp. immaculata*)	N
E	Clarkia, Presidio (*Clarkia franciscana*)	N
T	Clarkia, Springville (*Clarkia springvillensis*)	N
E	Clarkia, Vine Hill (*Clarkia imbricata*)	N
E	Clover, Monterey (*Trifolium trichocalyx*)	N

Table E- 1. Federally Threatened and Endangered Species in California

Status	Species/Listing Name	Critical Habitat
E	Clover, showy Indian (*Trifolium amoenum*)	N
T	Crownbeard, big-leaved (*Verbesina dissita*)	N
E	Crownscale, San Jacinto Valley (*Atriplex coronata* var. *notatior*)	Y
T	Cypress, Gowen (*Cupressus goveniana ssp. goveniana*)	N
E	Cypress, Santa Cruz (*Cupressus abramsiana*)	N
T	Daisy, Parish's (*Erigeron parishii*)	Y
T	Dudleya, Conejo (*Dudleya abramsii* ssp. *parva*)	N
T	Dudleya, marcescent (*Dudleya cymosa* ssp. *marcescens*)	N
E	Dudleya, Santa Clara Valley (*Dudleya setchellii*)	N
T	Dudleya, Santa Cruz Island (*Dudleya nesiotica*)	N
T	Dudleya, Verity's (*Dudleya verityi*)	N
T	Dudleyea, Santa Monica Mountains (*Dudleya cymosa* ssp*. ovatifolia*)	N
T	Dwarf-flax, Marin (*Hesperolinon congestum*)	N
E	Evening-primrose, Antioch Dunes (*Oenothera deltoides* ssp*. howellii*)	Y
E	Evening-primrose, Eureka Valley (*Oenothera avita* ssp*. eurekensis*)	N
T	Evening-primrose, San Benito (*Camissonia benitensis*)	N
E	Fiddleneck, large-flowered (*Amsinckia grandiflora*)	Y
E	Flannelbush, Mexican (*Fremontodendron mexicanum*)	Y
E	Flannelbush, Pine Hill (*Fremontodendron californicum* ssp*. decumbens*)	N
E	Fringepod, Santa Cruz Island (*Thysanocarpus conchuliferus*)	N
E	Gilia, Hoffmann's slender-flowered (*Gilia tenuiflora* ssp*. hoffmannii*)	N
E	Gilia, Monterey (*Gilia tenuiflora* ssp*. arenaria*)	N
E	Goldfields, Burke's (*Lasthenia burkei*)	N
E	Goldfields, Contra Costa (*Lasthenia conjugens*)	Y
T	Grass, Colusa (*Neostapfia colusana*)	Y
E	Grass, Eureka Dune (*Swallenia alexandrae*)	N
E	Grass, Solano (*Tuctoria mucronata*)	Y
T	Gumplant, Ash Meadows (*Grindelia fraxino-pratensis*)	Y
T	Howellia, water (*Howellia aquatilis*)	N
E	Indian paintbrush, San Clemente Island (*Castilleja grisea*)	N
E	Jewelflower, California (*Caulanthus californicus*)	N
E	Jewelflower, Metcalf Canyon (*Streptanthus albidus* ssp*. albidus*)	N
E	Jewelflower, Tiburon (*Streptanthus niger*)	N
E	Larkspur, Baker's (*Delphinium bakeri*)	Y
E	Larkspur, San Clemente Island (*Delphinium variegatum* ssp*. kinkiense*)	N
E	Larkspur, yellow (*Delphinium luteum*)	Y
E	Layia, beach (*Layia carnosa*)	N
E	Lessingia, San Francisco (*Lessingia germanorum (= L.g.* var. *germanorum)*)	N
E	Lily, Pitkin Marsh (*Lilium pardalinum* ssp*. pitkinense*)	N
E	Lily, Western (*Lilium occidentale*)	N
T	Liveforever, Laguna Beach (*Dudleya stolonifera*)	N

Table E- 1. Federally Threatened and Endangered Species in California

Status	Species/Listing Name	Critical Habitat
E	Liveforever, Santa Barbara Island (*Dudleya traskiae*)	N
E	Lupine, clover (*Lupinus tidestromii*)	N
E	Lupine, Nipomo Mesa (*Lupinus nipomensis*)	N
E	Malacothrix, island (*Malacothrix squalida*)	N
E	Malacothrix, Santa Cruz Island (*Malacothrix indecora*)	N
E	Mallow, Kern (*Eremalche kernensis*)	N
E	Manzanita, Del Mar (*Arctostaphylos glandulosa* ssp*. crassifolia*)	N
T	Manzanita, Ione (*Arctostaphylos myrtifolia*)	N
T	Manzanita, Morro (*Arctostaphylos morroensis*)	N
T	Manzanita, pallid (*Arctostaphylos pallida*)	N
E	Manzanita, Presidio (*Arctostaphylos hookeri* var. *ravenii*)	N
E	Manzanita, Santa Rosa Island (*Arctostaphylos confertiflora*)	N
T	Mariposa lily, Tiburon (*Calochortus tiburonensis*)	N
E	Meadowfoam, Butte County (*Limnanthes floccosa* ssp*. californica*)	N
E	Meadowfoam, Sebastopol (*Limnanthes vinculans*)	N
E	Mesa-mint, Otay (*Pogogyne nudiuscula*)	N
E	Mesa-mint, San Diego (*Pogogyne abramsii*)	N
E	Milk-vetch, Braunton's (*Astragalus brauntonii*)	Y
E	Milk-vetch, Clara Hunt's (*Astragalus clarianus*)	N
E	Milk-vetch, Coachella Valley (*Astragalus lentiginosus* var. *coachellae*)	Y
E	Milk-vetch, coastal dunes (*Astragalus tener* var. *titi*)	N
E	Milk-vetch, Cushenbury (*Astragalus albens*)	Y
T	Milk-vetch, Fish Slough (*Astragalus lentiginosus* var. *piscinensis*)	Y
E	Milk-vetch, Lane Mountain (*Astragalus jaegerianus*)	Y
T	Milk-vetch, Peirson's (*Astragalus magdalenae* var. *peirsonii*)	Y
E	Milk-vetch, triple-ribbed (*Astragalus tricarinatus*)	N
E	Milk-vetch, Ventura Marsh (*Astragalus pycnostachyus* var. *lanosissimus*)	Y
E	Monardella, willowy (*Monardella linoides* ssp*. viminea*)	Y
E	Morning-glory, Stebbins' (*Calystegia stebbinsii*)	N
E	Mountain balm, Indian Knob (*Eriodictyon altissimum*)	N
E	Mountain-mahogany, Catalina Island (*Cercocarpus traskiae*)	N
E	Mustard, slender-petaled (*Thelypodium stenopetalum*)	N
E	Navarretia, few-flowered (*Navarretia leucocephala* ssp*. pauciflora (= N. pauciflora)*)	N
E	Navarretia, many-flowered (*Navarretia leucocephala* ssp*. plieantha*)	N
T	Navarretia, spreading (*Navarretia fossalis*)	Y
E	Niterwort, Amargosa (*Nitrophila mohavensis*)	Y
E	Onion, Munz's (*Allium munzii*)	Y
E	Orcutt grass, California (*Orcuttia californica*)	N
E	Orcutt grass, hairy (*Orcuttia pilosa*)	Y
E	Orcutt grass, Sacramento (*Orcuttia viscida*)	Y
T	Orcutt grass, San Joaquin (*Orcuttia inaequalis*)	Y

Table E- 1. Federally Threatened and Endangered Species in California

Status	Species/Listing Name	Critical Habitat
T	Orcutt grass, slender (*Orcuttia tenuis*)	Y
T	Owl's-clover, fleshy (*Castilleja campestris* ssp*. succulenta*)	Y
E	Oxytheca, cushenbury (*Oxytheca parishii* var. *goodmaniana*)	Y
T	Paintbrush, ash-grey (*Castilleja cinerea*)	Y
E	Paintbrush, soft-leaved (*Castilleja mollis*)	N
E	Paintbrush, Tiburon (*Castilleja affinis* ssp*. neglecta*)	N
E	Penny-cress, Kneeland Prairie (*Thlaspi californicum*)	Y
E	Pentachaeta, Lyon's (*Pentachaeta lyonii*)	Y
E	Pentachaeta, white-rayed (*Pentachaeta bellidiflora*)	N
E	Phacelia, island (*Phacelia insularis* ssp*. insularis*)	N
E	Phlox, Yreka (*Phlox hirsuta*)	N
E	Piperia, Yadon's (*Piperia yadonii*)	Y
E	Polygonum, Scotts Valley (*Polygonum hickmanii*)	Y
E	Potentilla, Hickman's (*Potentilla hickmanii*)	N
T	Pussypaws, Mariposa (*Calyptridium pulchellum*)	N
E	Rock-cress, Hoffmann's (*Arabis hoffmannii*)	N
E	Rock-cress, McDonald's (*Arabis macdonaldiana*)	N
E	Rockcress, Santa Cruz Island (*Sibara filifolia*)	N
T	Rush-rose, island (*Helianthemum greenei*)	N
T	Sandwort, Bear Valley (*Arenaria ursina*)	Y
E	Sandwort, Marsh (*Arenaria paludicola*)	N
E	Seablite, California (*Suaeda californica*)	N
E	Sedge, white (*Carex albida*)	N
E	Spineflower, Ben Lomond (*Chorizanthe pungens* var. *hartwegiana*)	N
E	Spineflower, Howell's (*Chorizanthe howellii*)	N
T	Spineflower, Monterey (*Chorizanthe pungens* var. *pungens*)	Y
E	Spineflower, Orcutt's (*Chorizanthe orcuttiana*)	N
E	Spineflower, Robust (incl. Scotts Valley) (*Chorizanthe robusta (incl.* vars*. robusta and hartwegii)*)	Y
E	Spineflower, slender-horned (*Dodecahema leptoceras*)	N
E	Spineflower, Sonoma (*Chorizanthe valida*)	N
T	Spurge, Hoover's (*Chamaesyce hooveri*)	Y
E	Stonecrop, Lake County (*Parvisedum leiocarpum*)	N
E	Sunburst, Hartweg's golden (*Pseudobahia bahiifolia*)	N
T	Sunburst, San Joaquin adobe (*Pseudobahia peirsonii*)	N
E	Sunflower, San Mateo woolly (*Eriophyllum latilobum*)	N
E	Sunshine, Sonoma (*Blennosperma bakeri*)	N
E	Taraxacum, California (*Taraxacum californicum*)	Y
E	Tarplant, Gaviota (*Deinandra increscens* ssp*. villosa*)	Y
T	Tarplant, Otay (*Deinandra (= Hemizonia) conjugens*)	Y
T	Tarplant, Santa Cruz (*Holocarpha macradenia*)	Y

Table E- 1. Federally Threatened and Endangered Species in California

Status	Species/Listing Name	Critical Habitat
E	Thistle, Chorro Creek bog (*Cirsium fontinale* var. *obispoense*)	N
E	Thistle, fountain (*Cirsium fontinale* var. *fontinale*)	N
E	Thistle, La Graciosa (*Cirsium loncholepis*)	Y
E	Thistle, Loch Lomond coyote (*Eryngium constancei*)	N
E	Thistle, Suisun (*Cirsium hydrophilum* var. *hydrophilum*)	Y
T	Thornmint, San Diego (*Acanthomintha ilicifolia*)	Y
E	Thornmint, San Mateo (*Acanthomintha obovata* ssp*. duttonii*)	N
E	Tuctoria, Greene's (*Tuctoria greenei*)	Y
T	Vervain, Red Hills (*Verbena californica*)	N
E	Wallflower, Ben Lomond (*Erysimum teretifolium*)	N
E	Wallflower, Contra Costa (*Erysimum capitatum* var. *angustatum*)	Y
E	Wallflower, Menzies' (*Erysimum menziesii*)	N
E	Watercress, Gambel's (*Rorippa gambellii*)	N
T	Wild-buckwheat, southern mountain (*Eriogonum kennedyi* var. *austromontanum*)	Y
E	Woodland-star, San Clemente Island (*Lithophragma maximum*)	N
E	Woolly-star, Santa Ana River (*Eriastrum densifolium* ssp*. sanctorum*)	N
E	Wooly-threads, San Joaquin (*Monolopia (= Lembertia) congdonii*)	N
E	Yerba santa, Lompoc (*Eriodictyon capitatum*)	Y
Plant listed species occurring in this State that are not listed in this State – 4 species		
E	Fritillary, Gentner's (*Fritillaria gentneri*)	N
T	Ivesia, Ash Meadows (*Ivesia kingie var. eremica*)	Y
T	Milk-vetch, Ash meadows (*Astragalus phoenix*)	Y
T	Sunray, Ash Meadows (*Enceliopsis nudicaulis var. corrugate*)	Y
Plant species proposed for listing in this State – 1 species		
PE	Manzanita, San Francisco (*Arctostaphylos franciscana*)	N
ANIMALS		
Animal species listed in this State and that occur in this State – 124 species		
E	Abalone, White North America (West Coast from Point Conception, CA, United States, to Punta Abreojos, Baja California, Mexico) (*Haliotis sorenseni*)	N
E	Albatross, short-tailed (*Phoebastria (= Diomedea) albatrus*)	N
T	Beetle, delta green ground (*Elaphrus viridis*)	Y
E	Beetle, Mount Hermon June (*Polyphylla barbata*)	N
T	Beetle, valley elderberry longhorn (*Desmocerus californicus dimorphus*)	Y
T	Butterfly, bay checkerspot (*Euphydryas editha bayensis*)	Y
E	Butterfly, Behren's silverspot (*Speyeria zerene behrensii*)	N
E	Butterfly, callippe silverspot (*Speyeria callippe callippe*)	Y
E	Butterfly, El Segundo blue (*Euphilotes battoides allyni*)	Y
E	Butterfly, Lange's metalmark (*Apodemia mormo langei*)	Y
E	Butterfly, lotis blue (*Lycaeides argyrognomon lotis*)	Y
E	Butterfly, mission blue (*Icaricia icarioides missionensis*)	Y
E	Butterfly, Myrtle's silverspot (*Speyeria zerene myrtleae*)	N

Table E- 1. Federally Threatened and Endangered Species in California

Status	Species/Listing Name	Critical Habitat
T	Butterfly, Oregon silverspot (*Speyeria zerene hippolyta*)	Y
E	Butterfly, Palos Verdes blue (*Glaucopsyche lygdamus palosverdesensis*)	Y
E	Butterfly, Quino checkerspot (*Euphydryas editha quino (= E. e. wrighti)*)	Y
E	Butterfly, San Bruno elfin (*Callophrys mossii bayensis*)	Y
E	Butterfly, Smith's blue (*Euphilotes enoptes smithi*)	Y
E	Chub, bonytail entire (*Gila elegans*)	Y
E	Chub, Mohave tui (*Gila bicolor mohavensis*)	N
E	Chub, Owens tui (*Gila bicolor snyderi*)	Y
E	Condor, California, United States only (*Gymnogyps californianus*)	Y
E	Crayfish, Shasta (*Pacifastacus fortis*)	N
E	Fairy shrimp, Conservancy (*Branchinecta conservatio*)	Y
E	Fairy shrimp, longhorn (*Branchinecta longiantenna*)	Y
E	Fairy shrimp, Riverside (*Streptocephalus woottoni*)	Y
E	Fairy shrimp, San Diego (*Branchinecta sandiegonensis*)	Y
T	Fairy shrimp, vernal pool (*Branchinecta lynchi*)	Y
E	Fly, Delhi Sands flower-loving (*Rhaphiomidas terminatus abdominalis*)	N
E	Flycatcher, southwestern willow (*Empidonax traillii extimus*)	Y
E	Fox, San Joaquin kit (*Vulpes macrotis mutica*)	N
E	Fox, San Miguel Island (*Urocyon littoralis littoralis*)	Y
E	Fox, Santa Catalina Island (*Urocyon littoralis catalinae*)	Y
E	Fox, Santa Cruz Island (*Urocyon littoralis santacruzae*)	Y
E	Fox, Santa Rosa Island (*Urocyon littoralis santarosae*)	Y
T	Frog, California red-legged Entire (*Rana draytonii*)	Y
E	Frog, mountain yellow-legged southern California DPS (*Rana muscosa*)	Y
T	Gnatcatcher, coastal California (*Polioptila californica californica*)	Y
E	Goby, tidewater Entire (*Eucyclogobius newberryi*)	Y
E	Grasshopper, Zayante band-winged (*Trimerotropis infantilis*)	Y
E	June Beetle, Caseys (*Dinacoma caseyi*)	Y
E	Kangaroo rat, Fresno (*Dipodomys nitratoides exilis*)	Y
E	Kangaroo rat, giant (*Dipodomys ingens*)	N
E	Kangaroo rat, Morro Bay (*Dipodomys heermanni morroensis*)	Y
E	Kangaroo rat, San Bernardino Merriam's (*Dipodomys merriami parvus*)	Y
E	Kangaroo rat, Stephens' (*Dipodomys stephensi* (incl. *D. cascus)*)	N
E	Kangaroo rat, Tipton (*Dipodomys nitratoides nitratoides*)	N
E	Lizard, blunt-nosed leopard (*Gambelia silus*)	N
T	Lizard, Coachella Valley fringe-toed (*Uma inornata*)	Y
T	Lizard, Island night (*Xantusia riversiana*)	N
T	Moth, Kern primrose sphinx (*Euproserpinus euterpe*)	Y
E	Mountain beaver, Point Arena (*Aplodontia rufa nigra*)	N
E	Mouse, Pacific pocket (*Perognathus longimembris pacificus*)	N
E	Mouse, salt marsh harvest (*Reithrodontomys raviventris*)	N

Table E- 1. Federally Threatened and Endangered Species in California

Status	Species/Listing Name	Critical Habitat
T	Murrelet, marbled CA, OR, WA (*Brachyramphus marmoratus*)	Y
T	Otter, southern sea except where EXPN (*Enhydra lutris nereis*)	N
T	Owl, northern spotted (*Strix occidentalis caurina*)	Y
E	Pikeminnow (= squawfish), Colorado except Salt and Verde River drainages, AZ (*Ptychocheilus lucius*)	Y
T	Plover, western snowy Pacific coastal pop. (*Charadrius alexandrinus nivosus*)	Y
E	Pupfish, desert (*Cyprinodon macularius*)	Y
E	Pupfish, Owens (*Cyprinodon radiosus*)	N
E	Rabbit, riparian brush (*Sylvilagus bachmani riparius*)	N
E	Rail, California clapper (*Rallus longirostris obsoletus*)	N
E	Rail, light-footed clapper, United States only (*Rallus longirostris levipes*)	N
E	Rail, Yuma clapper, United States only (*Rallus longirostris yumanensis*)	N
E	Salamander, California tiger, United States (CA - Santa Barbara County) (*Ambystoma californiense*)	Y
E	Salamander, California tiger, United States (CA - Sonoma County) (*Ambystoma californiense*)	Y
T	Salamander, California tiger, United States (Central CA DPS) (*Ambystoma californiense*)	Y
E	Salamander, desert slender (*Batrachoseps aridus*)	N
E	Salamander, Santa Cruz long-toed (*Ambystoma macrodactylum croceum*)	Y
T	Salmon, chinook CA Central Valley spring-run (*Oncorhynchus (= Salmo) tshawytscha*)	Y
T	Salmon, chinook CA coastal (*Oncorhynchus (= Salmo) tshawytscha*)	Y
E	Salmon, chinook winter Sacramento River (*Oncorhynchus (= Salmo) tshawytscha*)	Y
T	Salmon, coho OR, CA pop. (*Oncorhynchus (= Salmo) kisutch*)	Y
E	Salmon, coho central CA coast (*Oncorhynchus (= Salmo) kisutch*)	Y
T	Sea turtle, green except where endangered (*Chelonia mydas*)	Y
E	Sea turtle, leatherback (*Dermochelys coriacea*)	Y
T	Sea turtle, loggerhead (*Caretta caretta*)	Y
T	Sea turtle, olive Ridley, except where endangered (*Lepidochelys olivacea*)	N
T	Sea-lion, Steller, eastern pop. (*Eumetopias jubatus*)	Y
T	Seal, Guadalupe fur (*Arctocephalus townsendi*)	N
E	Sheep, Peninsular bighorn, Peninsular CA pop. (*Ovis canadensis nelsoni*)	Y
E	Sheep, Sierra Nevada bighorn, Sierra Nevada (*Ovis canadensis sierrae*)	Y
E	Shrew, Buena Vista Lake ornate (*Sorex ornatus relictus*)	Y
E	Shrike, San Clemente loggerhead (*Lanius ludovicianus mearnsi*)	N
E	Shrimp, California freshwater (*Syncaris pacifica*)	N
E	Skipper, Carson wandering (*Pseudocopaeodes eunus obscurus*)	N
E	Skipper, Laguna Mountains (*Pyrgus ruralis lagunae*)	Y
T	Smelt, delta (*Hypomesus transpacificus*)	Y
E	Snail, Morro shoulderband (= Banded dune) (*Helminthoglypta walkeriana*)	Y
T	Snake, giant garter (*Thamnophis gigas*)	N

Table E- 1. Federally Threatened and Endangered Species in California

Status	Species/Listing Name	Critical Habitat
E	Snake, San Francisco garter (*Thamnophis sirtalis tetrataenia*)	N
T	Sparrow, San Clemente sage (*Amphispiza belli clementeae*)	N
T	Steelhead, Central Valley, CA (*Oncorhynchus (= Salmo) mykiss*)	Y
T	Steelhead, central CA coast (*Oncorhynchus (= Salmo) mykiss*)	Y
T	Steelhead, northern CA (*Oncorhynchus (= Salmo) mykiss*)	Y
T	Steelhead, south central CA coast (*Oncorhynchus (= Salmo) mykiss*)	Y
E	Steelhead, southern CA coast (*Oncorhynchus (= Salmo) mykiss*)	Y
E	Stickleback, unarmored threespine (*Gasterosteus aculeatus williamsoni*)	Y
T	Sturgeon, North American green, United States (CA) Southern Distinct Population Segment (*Acipenser medirostris*)	N
E	Sucker, Lost River (*Deltistes luxatus*)	Y
E	Sucker, Modoc (*Catostomus microps*)	Y
E	Sucker, razorback, entire (*Xyrauchen texanus*)	Y
T	Sucker, Santa Ana, 3 CA river basins (*Catostomus santaanae*)	Y
E	Sucker, shortnose (*Chasmistes brevirostris*)	Y
E	Tadpole shrimp, vernal pool (*Lepidurus packardi*)	Y
E	Tern, California least (*Sterna antillarum browni*)	N
E	Tiger beetle, Ohlone (*Cicindela ohlone*)	N
E	Toad, arroyo (= arroyo southwestern) (*Bufo californicus (= microscaphus)*)	Y
T	Tortoise, desert, United States, except in Sonoran Desert (*Gopherus agassizii*)	Y
T	Towhee, Inyo California (*Pipilo crissalis eremophilus*)	Y
T	Trout, Lahontan cutthroat (*Oncorhynchus clarki henshawi*)	N
T	Trout, Little Kern golden (*Oncorhynchus aguabonita whitei*)	Y
T	Trout, Paiute cutthroat (*Oncorhynchus clarki seleniris*)	N
E	Vireo, least Bell's (*Vireo bellii pusillus*)	Y
E	Vole, Amargosa (*Microtus californicus scirpensis*)	Y
E	Whale, blue (*Balaenoptera musculus*)	N
E	Whale, finback (*Balaenoptera physalus*)	N
E	Whale, humpback (*Megaptera novaeangliae*)	N
E	Whale, killer Southern Resident DPS (*Orcinus orca*)	Y
E	Whale, Sei (*Balaenoptera borealis*)	N
E	Whale, sperm (*Physeter catodon (= macrocephalus)*)	N
T	Whipsnake (= striped racer), Alameda (*Masticophis lateralis euryxanthus*)	Y
E	Woodrat, riparian (= San Joaquin Valley) (*Neotoma fuscipes riparia*)	N
Animal species listed in this State that do not occur in this State – 5 species		
T	Bear, grizzly lower 48 States, except where listed as an experimental population or delisted (*Ursus arctos horribilis*)	Y
E	Jaguar (*Panthera onca*)	N
E	Sea-lion, Steller, western pop. (Eumetopias jubatus)	Y
T	Trout, bull, United States, conterminous, lower 48 States (Salvelinus confluentus)	Y
E	Wolf, gray lower 48 States, except MN and where EXPN. Mexico. (Canis lupus)	Y

Table E- 1. Federally Threatened and Endangered Species in California

Status	Species/Listing Name	Critical Habitat

Source: USFWS, 2011
Notes: T = threatened; E = endangered; EXPN = experimental population, non-essential; DPS = distinct population segment

Table E- 2. Federally Threatened and Endangered Species in Colorado

Status	Species/Listing Name	Critical Habitat
PLANTS		
Plant species listed in this State and that occur in this State – 16 species		
T	Beardtongue, Parachute (*Penstemon debilis*)	N
E	Beardtongue, Penland (*Penstemon penlandii*)	N
T	Bladderpod, Dudley Bluffs (*Lesquerella congesta*)	N
T	Butterfly plant, Colorado (*Gaura neomexicana* var. *coloradensis*)	Y
T	Cactus, Colorado hookless (*Sclerocactus glaucus*)	N
E	Cactus, Knowlton's (*Pediocactus knowltonii*)	N
T	Cactus, Mesa Verde (*Sclerocactus mesae-verdae*)	N
T	Ladies'-tresses, Ute (*Spiranthes diluvialis*)	N
E	Milk-vetch, Mancos (*Astragalus humillimus*)	N
E	Milk-vetch, Osterhout (*Astragalus osterhoutii*)	N
T	Mustard, Penland alpine fen (*Eutrema penlandii*)	N
T	Phacelia, DeBeque (*Phacelia submutica*)	N
E	Phacelia, North Park (*Phacelia formosula*)	N
E	Skyrocket, Pagosa (*Ipomopsis polyantha*)	N
T	Twinpod, Dudley Bluffs (*Physaria obcordata*)	N
E	Wild buckwheat, clay-loving (*Eriogonum pelinophilum*)	Y
ANIMALS		
Animal species listed in this State and that occur in this State – 16 species		
E	Butterfly, Uncompahgre fritillary (*Boloria acrocnema*)	N
E	Chub, bonytail, entire (*Gila elegans*)	Y
E	Chub, humpback, entire (*Gila cypha*)	Y
E	Crane, whooping, except where EXPN (*Grus americana*)	Y
E	Ferret, black-footed, entire population, except where EXPN (*Mustela nigripes*)	N
E	Flycatcher, southwestern willow (*Empidonax traillii extimus*)	Y
T	Lynx, Canada (contiguous United States DPS) (*Lynx canadensis*)	Y
T	Mouse, Preble's meadow jumping, United States, north-central CO (*Zapus hudsonius preblei*)	Y
T	Owl, Mexican spotted (*Strix occidentalis lucida*)	Y
E	Pikeminnow (= squawfish), Colorado except Salt and Verde River drainages, AZ (*Ptychocheilus lucius*)	N
T	Plover, piping except Great Lakes watershed (*Charadrius melodus*)	Y
T	Skipper, Pawnee, montane (*Hesperia leonardus montana*)	Y
E	Sucker, razorback, entire (*Xyrauchen texanus*)	Y

Table E- 2. Federally Threatened and Endangered Species in Colorado

Status	Species/Listing Name	Critical Habitat
E	Tern, least, interior pop. (*Sterna antillarum*)	N
T	Trout, greenback cutthroat (*Oncorhynchus clarki stomias*)	N
E	Wolf, gray, lower 48 States, except MN and where EXPN. Mexico. (*Canis lupus*)	Y
Animal species listed in this State that do not occur in this State – 1 species		
T	Bear, grizzly, lower 48 States, except where listed as an experimental population or delisted (*Ursus arctos horribilis*)	Y
Plant species proposed for listing in this State – 1 species		
PT	Beardtongue, Graham (*Penstemon grahamii*)	N

Source: USFWS, 2011
Notes: T = threatened; E = endangered; PT = proposed threatened; PE = proposed endangered; EXPN = experimental population, non-essential; DPS = distinct population segment

Table E- 3. Federally Threatened and Endangered Species in Idaho

Status	Species/Listing Name	Critical Habitat
PLANTS		
Plant species listed in this State and that occur in this State – 5 species		
T	Catchfly, Spalding's (*Silene spaldingii*)	N
T	Four-o'clock, MacFarlane's (*Mirabilis macfarlanei*)	N
T	Howellia, water (*Howellia aquatilis*)	N
T	Ladies'-tresses, Ute (*Spiranthes diluvialis*)	N
T	Peppergrass, Slickspot (*Lepidium papilliferum*)	N
ANIMALS		
Animal species listed in this State and that occur in this State – 10 species		
T	Bear, grizzly, lower 48 States, except where listed as an experimental population or delisted (*Ursus arctos horribilis*)	Y
E	Caribou, woodland, Selkirk Mountain population (*Rangifer tarandus caribou*)	N
E	Limpet, Banbury Springs (*Lanx* sp.)	N
T	Lynx, Canada (contiguous United States DPS) (*Lynx canadensis*)	Y
T	Snail, Bliss Rapids (*Taylorconcha serpenticola*)	N
E	Snail, Snake River physa (*Physa natricina*)	N
E	Springsnail, Bruneau Hot (*Pyrgulopsis bruneauensis*)	N
T	Squirrel, northern Idaho ground (*Spermophilus brunneus brunneus*)	N
E	Sturgeon, white, United States, (ID, MT), Canada (B.C.), Kootenai River system (*Acipenser transmontanus*)	Y
T	Trout, bull, United States, conterminous, lower 48 States (*Salvelinus confluentus*)	Y
Animal species listed in this State that do not occur in this State – 6 species		
E	Rabbit, pygmy, Columbia Basin DPS (*Brachylagus idahoensis*)	N
T	Salmon, chinook, fall, Snake River (*Oncorhynchus* (= *Salmo*) *tshawytscha*)	Y
T	Salmon, chinook, spring/summer, Snake River (*Oncorhynchus* (= *Salmo*) *tshawytscha*)	Y
E	Salmon, sockeye, United States (Snake River, ID stock wherever found.) (*Oncorhynchus* (= *Salmo*) *nerka*)	Y

Table E- 3. Federally Threatened and Endangered Species in Idaho

Status	Species/Listing Name	Critical Habitat
T	Steelhead, Snake River Basin (*Oncorhynchus (= Salmo) mykiss*)	Y
E	Wolf, gray, lower 48 States, except MN and where EXPN. Mexico. (*Canis lupus*)	Y

Source: USFWS, 2011
Notes: T = threatened; E = endangered; EXPN = experimental population, non-essential; DPS = distinct population segment

Table E- 4. Federally Threatened and Endangered Species in Michigan

Status	Species/Listing Name	Critical Habitat
PLANTS		
Plant species listed in this State and that occur in this State – 8 species		
T	Daisy, lakeside (*Hymenoxys herbacea*)	N
T	Fern, American hart's-tongue (*Asplenium scolopendrium* var. *americanum*)	N
T	Goldenrod, Houghton's (*Solidago houghtonii*)	N
T	Iris, dwarf lake (*Iris lacustris*)	N
E	Monkey-flower, Michigan (*Mimulus glabratus* var. *michiganensis*)	N
T	Orchid, eastern prairie fringed (*Platanthera leucophaea*)	N
T	Pogonia, small whorled (*Isotria medeoloides*)	N
T	Thistle, Pitcher's (*Cirsium pitcheri*)	N
Plant species listed in this State that do not occur in this State – 1 species		
E	Chaffseed, American (*Schwalbea americana*)	N
ANIMALS		
Animal species listed in this State and that occur in this State – 11 species		
E	Bat, Indiana (*Myotis sodalis*)	Y
E	Beetle, Hungerford's crawling water (*Brychius hungerfordi*)	N
E	Butterfly, Karner blue (*Lycaeides melissa samuelis*)	Y
E	Butterfly, Mitchell's satyr (*Neonympha mitchellii mitchellii*)	N
E	Clubshell, entire range; except where listed as experimental populations (*Pleurobema clava*)	N
T	Lynx, Canada (contiguous United States DPS) (*Lynx canadensis*)	Y
E	Plover, piping, Great Lakes watershed (*Charadrius melodus*)	Y
E	Riffleshell, northern (*Epioblasma torulosa rangiana*)	N
T	Snake, copperbelly water, Indiana north of 40 degrees north latitude, Michigan, Ohio (*Nerodia erythrogaster neglecta*)	N
E	Warbler (= wood), Kirtland's (*Dendroica kirtlandii*)	N
E	Wolf, gray, lower 48 States, except MN and where EXPN. Mexico. (*Canis lupus*)	Y
Animal species listed in this State that do not occur in this State – 3 species		
E	Beetle, American burying (*Nicrophorus americanus*)	N
E	Catspaw, white (pearlymussel) (*Epioblasma obliquata perobliqua*)	N
E	Puma (= cougar), eastern (*Puma* (= *Felis*) *concolor couguar*)	N
Animal listed species occurring in this State that are not listed in this State – 1 species		
E	Dragonfly, Hine's emerald (*Somatochlora hineana*)	Y
Animal species proposed for listing in this State – 1 species		

Table E- 4. Federally Threatened and Endangered Species in Michigan

Status	Species/Listing Name	Critical Habitat
PE	Mussel, snuffbox (*Epioblasma triquetra*)	N

Source: USFWS, 2011
Notes: T = threatened; E = endangered; EXPN = experimental population, non-essential; DPS = distinct population segment

Table E- 5. Federally Threatened and Endangered Species in Minnesota

Status	Species/Listing Name	Critical Habitat
PLANTS		
Plant spcies listed in this State and that occur in this State – 4 species		
T	Bush-clover, prairie (*Lespedeza leptostachya*)	N
E	Lily, Minnesota dwarf trout (*Erythronium propullans*)	N
T	Orchid, western prairie fringed (*Platanthera praeclara*)	N
T	Roseroot, Leedy's (*Sedum integrifolium* ssp. *leedyi*)	N
ANIMALS		
Animal species listed in this State and that occur in this State – 7 species		
E	Butterfly, Karner blue (*Lycaeides melissa samuelis*)	Y
E	Higgins eye (pearlymussel) (*Lampsilis higginsii*)	N
T	Lynx, Canada (contiguous United States DPS) (*Lynx canadensis*)	Y
E	Mapleleaf, winged entire; except where listed as experimental populations (*Quadrula fragosa*)	N
T	Plover, piping, Great Lakes watershed (*Charadrius melodus*)	Y
E	Shiner, Topeka (*Notropis topeka* (= *tristis*))	Y
E	Wolf, gray, lower 48 States, except MN and where EXPN. Mexico. (*Canis lupus*)	Y
Animal species listed in this State that do not occur in this State – 4 species		
E	Beetle, American burying (*Nicrophorus americanus*)	N
E	Mussel, scaleshell (*Leptodea leptodon*)	N
T	Plover, piping, except Great Lakes watershed (*Charadrius melodus*)	Y
T	Wolf, gray, MN (*Canis lupus*)	Y
Animal species proposed for listing in this State – 4 species		
PE	Mussel, rayed bean (*Villosa fabalis*)	N
PE	Mussel, sheepnose *(Plethobasus cyphyus)*	N
PE	Mussel, snuffbox (*Epioblasma triquetra*)	N
PE	Mussel, spectaclecase *(Cumberlandia monodonta)*	N

Source: USFWS, 2011
Notes: T = threatened; E = endangered; EXPN = experimental population, non-essential; DPS = distinct population segment

Table E- 6. Federally Threatened and Endangered Species in Montana

Status	Species/Listing Name	Critical Habitat
PLANTS		
Plant species listed in this State and that occur in this State – 3 species		
T	Catchfly, Spalding's (*Silene spaldingii*)	N

Table E- 6. Federally Threatened and Endangered Species in Montana

Status	Species/Listing Name	Critical Habitat
T	Howellia, water (*Howellia aquatilis*)	N
T	Ladies'-tresses, Ute (*Spiranthes diluvialis*)	N
ANIMALS		
Animal species listed in this State and that occur in this State – 9 species		
T	Bear, grizzly, lower 48 States, except where listed as an experimental population or delisted (*Ursus arctos horribilis*)	Y
E	Crane, whooping, except where EXPN (*Grus americana*)	Y
E	Ferret, black-footed, entire population, except where EXPN (*Mustela nigripes*)	N
T	Lynx, Canada (contiguous United States DPS) (*Lynx canadensis*)	Y
T	Plover, piping, except Great Lakes watershed (*Charadrius melodus*)	Y
E	Sturgeon, pallid (*Scaphirhynchus albus*)	N
E	Sturgeon, white ,United States (ID, MT), Canada (B.C.), Kootenai River system (*Acipenser transmontanus*)	Y
E	Tern, least, interior pop. (*Sterna antillarum*)	N
T	Trout, bull, United States, conterminous, lower 48 States (*Salvelinus confluentus*)	Y
Animal species listed in this State that do not occur in this State – 1 species		
E	Wolf, gray, lower 48 States, except MN and where EXPN. Mexico. (*Canis lupus*)	Y

Source: USFWS, 2011
Notes: EXPN = experimental population, non-essential; DPS = distinct population segment

Table E- 7. Federally Threatened and Endangered Species in Nebraska

Status	Species/Listing Name	Critical Habitat
PLANTS		
Plant species listed in this State and that occur in this State – 4 species		
T	Butterfly plant, Colorado (*Gaura neomexicana* var. *coloradensis*)	Y
T	Ladies'-tresses, Ute (*Spiranthes diluvialis*)	N
T	Orchid, western prairie fringed (*Platanthera praeclara*)	N
E	Penstemon, blowout (*Penstemon haydenii*)	N
Plant species listed in this State that do not occur in this State – 1 species		
T	Orchid, eastern prairie fringed *(Platanthera leucophaea)*	N
ANIMALS		
Animal species listed in this State and that occur in this State – 8 species		
E	Beetle, American burying (*Nicrophorus americanus*)	N
E	Crane, whooping, except where EXPN (*Grus americana*)	Y
T	Plover, piping, except Great Lakes watershed (*Charadrius melodus*)	Y
E	Shiner, Topeka (*Notropis topeka* (= *tristis*))	Y
E	Sturgeon, pallid (*Scaphirhynchus albus*)	N
E	Tern, least, interior pop. (*Sterna antillarum*)	N
E	Tiger beetle, Salt Creek (*Cicindela nevadica lincolniana*)	Y
E	Wolf, gray, lower 48 States, except MN and where EXPN. Mexico. (*Canis lupus*)	Y
Animal species listed in this State that do not occur in this State – 2 species		

Table E- 7. Federally Threatened and Endangered Species in Nebraska

Status	Species/Listing Name	Critical Habitat
E	Higgins eye (pearlymussel) (*Lampsilis higginsii*)	N
E	Mapleleaf, winged, entire; except where listed as experimental populations (*Quadrula fragosa*)	N
Animal listed species occurring in this State but not listed in this State – 3 species		
E	Curlew, Eskimo (*Numenius borealis*)	N
E	Ferret, black-footed, entire population, except where EXPN (*Mustela nigripes*)	N
E	Mussel, scaleshell (*Lepodea leptodon*)	N

Source: USFWS, 2011
Notes: T = threatened; E = endangered; EXPN = experimental population, non-essential

Table E- 8. Federally Threatened and Endangered Species in North Dakota

Status	Species/Listing Name	Critical Habitat
PLANTS		
Plant species listed in this State and that occur in this State – 1 species		
T	Orchid, western prairie fringed (*Platanthera praeclara*)	N
ANIMALS		
Animal species listed in this State and that occur in this State – 6 species		
E	Crane, whooping, except where EXPN (*Grus americana*)	Y
E	Ferret, black-footed, entire population, except where EXPN (*Mustela nigripes*)	N
T	Plover, piping, except Great Lakes watershed (*Charadrius melodus*)	Y
E	Sturgeon, pallid (*Scaphirhynchus albus*)	N
E	Tern, least, interior pop. (*Sterna antillarum*)	N
E	Wolf, gray, lower 48 States, except MN and where EXPN. Mexico. (*Canis lupus*)	Y
Animal species listed in this State that do not occur in this State – 1 species		
E	Beetle, American burying (*Nicrophorus americanus*)	N

Source: USFWS, 2011
Notes: T = threatened; E = endangered; EXPN = experimental population, non-essential

Table E- 9. Federally Threatened and Endangered Species in Oregon

Status	Species/Listing Name	Critical Habitat
PLANTS		
Plant species listed in this State and that occur in this State – 15 species		
T	Catchfly, Spalding's (*Silene spaldingii*)	N
T	Checker-mallow, Nelson's (*Sidalcea nelsoniana*)	N
E	Daisy, Willamette (*Erigeron decumbens* var. *decumbens*)	Y
E	Desert-parsley, Bradshaw's (*Lomatium bradshawii*)	N
T	Four-o'clock, MacFarlane's (*Mirabilis macfarlanei*)	N
E	Fritillary, Gentner's (*Fritillaria gentneri*)	N
T	Howellia, water (*Howellia aquatilis*)	N

Table E- 9. Federally Threatened and Endangered Species in Oregon

Status	Species/Listing Name	Critical Habitat
E	Lily, western (*Lilium occidentale*)	N
E	Lomatium, Cook's (*Lomatium cookii*)	Y
T	Lupine, Kincaid's (*Lupinus sulphureus* (= *oreganus*) ssp. *kincaidii* (= var. *kincaidii*))	Y
E	Meadowfoam, large-flowered woolly (*Limnanthes floccosa* ssp. *grandiflora*)	Y
E	Milk-vetch, Applegate's (*Astragalus applegatei*)	N
E	Popcornflower, rough (*Plagiobothrys hirtus*)	N
T	Thelypody, Howell's spectacular (*Thelypodium howellii spectabilis*)	N
E	Wire-lettuce, Malheur (*Stephanomeria malheurensis*)	Y
Plant listed species occurring in this State but not listed in this State – 2 species		
T	Paintbrush, golden (*Castilleja levisecta*)	N
E	Rock-cress, McDonald's (*Arabis macdonaldiana*)	N
ANIMALS		
Animal species listed in this State and that occur in this State – 35 species		
E	Albatross, short-tailed (*Phoebastria* (= *Diomedea*) *albatrus*)	N
E	Butterfly, Fender's blue (*Icaricia icarioides fenderi*)	Y
T	Butterfly, Oregon silverspot (*Speyeria zerene hippolyta*)	Y
E	Chub, Borax Lake (*Gila boraxobius*)	Y
T	Chub, Hutton tui Hutton (*Gila bicolor* ssp.)	N
T	Chub, Oregon (*Oregonichthys crameri*)	Y
T	Dace, Foskett speckled Foskett (*Rhinichthys osculus* ssp.)	N
E	Deer, Columbian white-tailed, Columbia River DPS (*Odocoileus virginianus leucurus*)	N
T	Fairy shrimp, vernal pool (*Branchinecta lynchi*)	Y
T	Lynx, Canada (contiguous United States DPS) (*Lynx canadensis*)	Y
T	Murrelet, marbled, CA, OR, WA (*Brachyramphus marmoratus*)	Y
T	Owl, northern spotted (*Strix occidentalis caurina*)	Y
T	Plover, western snowy, Pacific coastal pop. (*Charadrius alexandrinus nivosus*)	Y
T	Salmon, chinook, fall, Snake River (*Oncorhynchus* (= *Salmo*) *tshawytscha*)	Y
T	Salmon, chinook, lower Columbia River (*Oncorhynchus* (= *Salmo*) *tshawytscha*)	Y
T	Salmon, chinook, spring/summer, Snake River (*Oncorhynchus* (= *Salmo*) *tshawytscha*)	Y
T	Salmon, chinook, upper Willamette River (*Oncorhynchus* (= *Salmo*) *tshawytscha*)	Y
T	Salmon, chum, Columbia River (*Oncorhynchus* (= *Salmo*) *keta*)	Y
T	Salmon, coho, Oregon coast (*Oncorhynchus* (= *Salmo*) *kisutch*)	Y
T	Salmon, coho, OR, CA pop. (*Oncorhynchus* (= *Salmo*) *kisutch*)	Y
T	Sea turtle, green, except where endangered (*Chelonia mydas*)	Y
E	Sea turtle, leatherback (*Dermochelys coriacea*)	Y
T	Sea turtle, loggerhead (*Caretta caretta*)	Y
T	Sea-lion, Steller, eastern pop. (*Eumetopias jubatus*)	Y
T	Steelhead, Snake River Basin (*Oncorhynchus* (= *Salmo*) *mykiss*)	Y
T	Steelhead, middle Columbia River (*Oncorhynchus* (= *Salmo*) *mykiss*)	Y
T	Steelhead, upper Willamette River (*Oncorhynchus* (= *Salmo*) *mykiss*)	Y

Table E- 9. Federally Threatened and Endangered Species in Oregon

Status	Species/Listing Name	Critical Habitat
E	Sucker, Lost River (*Deltistes luxatus*)	Y
E	Sucker, Modoc (*Catostomus microps*)	Y
E	Sucker, shortnose (*Chasmistes brevirostris*)	Y
T	Sucker, Warner (*Catostomus warnerensis*)	Y
T	Trout, bull, United States, conterminous, lower 48 States (*Salvelinus confluentus*)	Y
T	Trout, Lahontan cutthroat (*Oncorhynchus clarki henshawi*)	N
E	Whale, humpback (*Megaptera novaeangliae*)	N
E	Whale, killer, southern resident DPS (*Orcinus orca*)	Y
E	Wolf, gray, lower 48 States, except MN and where EXPN. Mexico. (*Canis lupus*)	Y
Animal species listed in this State that do not occur in this State – 6 species		
T	Bear, grizzly, lower 48 States, except where listed as an experimental population or delisted (*Ursus arctos horribilis*)	Y
E	Condor, California, United States only (*Gymnogyps californianus*)	Y
T	Otter, southern sea, except where EXPN (*Enhydra lutris nereis*)	N
E	Rabbit, pygmy, Columbia Basin DPS (*Brachylagus idahoensis*)	N
T	Salmon, coho, lower Columbia River (*Oncorhynchus* (= *Salmo*) *kisutch*)	Y
E	Sea-lion, Steller, western pop. (*Eumetopias jubatus*)	Y
Animal listed species occurring in this State but not listed in this State – 3 species		
E	Salmon, sockeye, United States (Snake River, ID stock wherever found.) (*Oncorhynchus (= Salmo) nerka*)	Y
T	Steelhead, lower Columbia River (*Oncorhynchus (= Salmo) mykiss*)	Y
T	Sturgeon, North American green, United States (CA) Southern Distinct Population Segment (*Acipenser medirostris*)	N
Animal species proposed for listing in this State – 1 species		

Source: USFWS, 2011
Notes: T = threatened; E = endangered; PT = proposed threatened; EXPN = experimental population, non-essential; DPS = distinct population segment

Table E- 10. Federally Threatened and Endangered Species in South Dakota

Status	Species/Listing Name	Critical Habitat?
PLANTS		
Plant species listed in this State and that occur in this State – 1 species		
T	Orchid, western prairie fringed (*Platanthera praeclara*)	N
ANIMALS		
Animal species listed in this State and that occur in this State – 9 species		
E	Beetle, American burying (*Nicrophorus americanus*)	N
E	Crane, whooping, except where EXPN (*Grus americana*)	Y
E	Ferret, black-footed, entire population, except where EXPN (*Mustela nigripes*)	N
E	Mussel, scaleshell (*Leptodea leptodon*)	N
T	Plover, piping except Great Lakes watershed (*Charadrius melodus*)	Y
E	Shiner, Topeka (*Notropis topeka (= tristis)*)	Y

Table E- 10. Federally Threatened and Endangered Species in South Dakota

Status	Species/Listing Name	Critical Habitat?
E	Sturgeon, pallid (*Scaphirhynchus albus*)	N
E	Tern, least, interior pop. (*Sterna antillarum*)	N
E	Wolf, gray lower 48 States, except MN and where EXPN. Mexico. (*Canis lupus*)	Y
Animal listed species occurring in this State but not listed in this State – 2 species		
E	Curlew, Eskimo (*Numenius borealis*)	N
E	Higgins eye (pearlymussel) (*Lampsilis higginsii*)	N

Source: USFWS, 2011
Notes: T = threatened; E = endangered; EXPN = experimental population, non-essential

Table E- 11. Federally Threatened and Endangered Species in Washington

Status	Species/Listing Name	Critical Habitat?
PLANTS		
Plant species listed in this State and that occur in this State – 9 species		
	Catchfly, Spalding's (*Silene spaldingii*)	N
	Checker-mallow, Nelson's (*Sidalcea nelsoniana*)	N
	Checkermallow, Wenatchee Mountains (*Sidalcea oregana* var. *calva*)	Y
	Desert-parsley, Bradshaw's (*Lomatium bradshawii*)	N
	Howellia, water (*Howellia aquatilis*)	N
	Ladies'-tresses, Ute (*Spiranthes diluvialis*)	N
	Lupine, Kincaid's (*Lupinus sulphureus* (= *oreganus*) ssp. *kincaidii* (= var. *kincaidii*))	Y
	Paintbrush, golden (*Castilleja levisecta*)	N
	Stickseed, showy (*Hackelia venusta*)	N
Plant listed species occurring in this State but not listed in this State – 1 species		
E	Sandwort, Marsh (*Arenaria paludicola*)	N
ANIMALS		
Animal species listed in this State and that occur in this State – 28 species		
E	Albatross, short-tailed (*Phoebastria* (= *Diomedea*) *albatrus*)	N
T	Bear, grizzly lower 48 States, except where listed as an experimental population or delisted (*Ursus arctos horribilis*)	Y
E	Caribou, woodland, Selkirk Mountain population (*Rangifer tarandus caribou*)	N
E	Deer, Columbian white-tailed, Columbia River DPS (*Odocoileus virginianus leucurus*)	N
T	Lynx, Canada (contiguous United States DPS) (*Lynx canadensis*)	Y
T	Murrelet, marbled, CA, OR, WA (*Brachyramphus marmoratus*)	Y
T	Owl, northern spotted (*Strix occidentalis caurina*)	Y
T	Plover, western snowy, Pacific coastal pop. (*Charadrius alexandrinus nivosus*)	Y
E	Rabbit, pygmy, Columbia Basin DPS (*Brachylagus idahoensis*)	N
T	Salmon, chinook, Puget Sound (*Oncorhynchus* (= *Salmo*) *tshawytscha*)	Y
T	Salmon, chinook, fall, Snake River (*Oncorhynchus* (= *Salmo*) *tshawytscha*)	Y
T	Salmon, chinook, lower Columbia River (*Oncorhynchus* (= *Salmo*) *tshawytscha*)	Y

Table E- 11. Federally Threatened and Endangered Species in Washington

E	Salmon, chinook, spring, upper Columbia River (*Oncorhynchus* (= *Salmo*) *tshawytscha*)	Y
T	Salmon, chinook, spring/summer, Snake River (*Oncorhynchus* (= *Salmo*) *tshawytscha*)	Y
T	Salmon, chum, Columbia River (*Oncorhynchus* (= *Salmo*) *keta*)	Y
T	Salmon, chum, summer-run Hood Canal (*Oncorhynchus* (= *Salmo*) *keta*)	Y
T	Salmon, sockeye, United States (Ozette Lake, WA) (*Oncorhynchus* (= *Salmo*) *nerka*)	Y
T	Sea turtle, green, except where endangered (*Chelonia mydas*)	Y
E	Sea turtle, leatherback (*Dermochelys coriacea*)	Y
T	Sea-lion, Steller, eastern pop. (*Eumetopias jubatus*)	Y
T	Steelhead, Puget Sound DPS (*Oncorhynchus* (= *Salmo*) *mykiss*)	Y
T	Steelhead, Snake River Basin (*Oncorhynchus* (= *Salmo*) *mykiss*)	Y
T	Steelhead, lower Columbia River (*Oncorhynchus* (= *Salmo*) *mykiss*)	Y
T	Steelhead, upper Columbia River Basin (*Oncorhynchus* (= *Salmo*) *mykiss*)	Y
T	Trout, bull, United States, conterminous, lower 48 States (*Salvelinus confluentus*)	Y
E	Whale, humpback (*Megaptera novaeangliae*)	N
E	Whale, killer, southern resident DPS (*Orcinus orca*)	Y
E	Wolf, gray, lower 48 States, except MN and where EXPN. Mexico. (*Canis lupus*)	Y
Animal species listed in this State that do not occur in this State – 5 species		
T	Butterfly, Oregon silverspot (*Speyeria zerene hippolyta*)	Y
T	Otter, southern sea, except where EXPN (*Enhydra lutris nereis*)	N
T	Salmon, coho, lower Columbia River (*Oncorhynchus* (= *Salmo*) *kisutch*)	Y
E	Sea-lion, Steller, western pop. (*Eumetopias jubatus*)	Y
T	Steelhead middle Columbia River (*Oncorhynchus* (= *Salmo*) *mykiss*)	Y
Animal listed species occurring in this State but not listed in this State – 3 species		
E	Salmon, sockeye, United States (Snake River, ID stock wherever found.) (*Oncorhynchus (= Salmo) nerka*)	Y
T	Steelhead, upper Willamette River (*Oncorhynchus (= Salmo) mykiss*)	Y
T	Sturgeon, North American green, United States (CA) Southern Distinct Population Segment (*Acipenser medirostris*)	N

Source: USFWS, 2011
Notes: T = threatened; E = endangered; EXPN = experimental population, non-essential; DPS = distinct population segment

Table E- 12. Federally Threatened and Endangered Species in Wyoming

Status	Species/Listing Name	Critical Habitat
PLANTS		
Plant species listed in this State and that occur in this State – 4 species		
T	Butterfly plant, Colorado (*Gaura neomexicana* var. *coloradensis*)	Y
T	Ladies'-tresses, Ute (*Spiranthes diluvialis*)	N
E	Penstemon, blowout (*Penstemon haydenii*)	N
T	Yellowhead, desert (*Yermo xanthocephalus*)	Y

Table E- 12. Federally Threatened and Endangered Species in Wyoming

Status	Species/Listing Name	Critical Habitat
ANIMALS		
Animal species listed in this State and that occur in this State – 5 species		
T	Bear, grizzly, lower 48 States, except where listed as an experimental population or delisted (*Ursus arctos horribilis*)	Y
E	Dace, Kendall Warm Springs (*Rhinichthys osculus thermalis*)	N
E	Ferret, black-footed, entire population, except where EXPN (*Mustela nigripes*)	N
T	Lynx, Canada (contiguous United States DPS) (*Lynx canadensis*)	Y
E	Toad, Wyoming (*Bufo baxteri (=hemiophrys*)	N
Animal species listed in this State that do not occur in this State – 6 species		
E	Chub, bonytail, entire (*Gila elegans*)	Y
E	Chub, humpback, entire (*Gila cypha*)	Y
E	Crane, whooping, except where EXPN (*Grus americana*)	Y
E	Pikeminnow (= squawfish), Colorado except Salt and Verde River drainages, AZ (*Ptychocheilus lucius*)	N
E	Sucker, razorback, entire (*Xyrauchen texanus*)	Y
E	Wolf, gray, lower 48 States, except MN and where EXPN. Mexico. (*Canis lupus*)	Y
Animal listed species occurring in this state that are not listed in this state – 1 species		
T	Mouse, Preble's meadow jumping, United States, north-central CO (*Zapus hudsonius preblei*)	Y

Source: USFWS, 2011

Notes: T = threatened; E = endangered; PT = proposed threatened; PE = proposed endangered; EXPN = experimental population, non-essential; DPS = distinct population segment

Appendix D. Sample Compliance Agreement

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UNITED STATES DEPARTMENT OF AGRICULTURE ANIMAL AND PLANT HEALTH INSPECTION SERVICE BIOTECHNOLOGY REGULATORY SERVICES	**COMPLIANCE AGREEMENT**
1. RESPONSIBLE ENTITY NAME AND ADDRESS	2. AUTHORIZED REPRESENTATIVE NAME AND ADDRESS

3. ARTICLE(S)

H7-1 Sugar Beet Root Crop

4. APPLICABLE FEDERAL STATUTES OR REGULATIONS

Plant Protection Act of 2000, as amended

5. I/WE AGREE TO THE FOLLOWING:

This compliance agreement is required as a condition for partial deregulation of the H7-1 sugar beet root crop and is a legally binding and enforceable agreement that authorizes root crop production activities by the Responsible Entity named above and all persons engaging in root crop production activities in association with or on behalf of the Responsible Entity. By signing this compliance agreement, the authorized representative of the Responsible Entity confirms his/her authority to sign the agreement on behalf of the Responsible Entity named above and all persons engaging in root crop production activities in association with or on behalf of the Responsible Entity. The Responsible Entity confirms its understanding of the requirements/conditions set forth in the agreement and confirms that the Responsible Entity and all persons conducting root crop production activities under this compliance agreement will comply with the requirements/conditions of the agreement. The mandatory requirements/conditions under this agreement are outlined and attached as Appendix A and incorporated into this agreement by reference. The Responsible Entity named above designates XXXXXXXXXXXXXXXX XXXXXXXXXXXXXXX as an Authorized Representative and a point of contact in connection with the performance of this agreement.

6. SIGNATURE	7. TITLE	8. DATE SIGNED
The affixing of the signatures below will validate this agreement which shall remain in effect until canceled, but may be revised as necessary or revoked for noncompliance.		9. AGREEMENT NUMBER
		10. DATE OF AGREEMENT
11. BRS OFFICIAL (NAME AND TITLE)		12. ADDRESS
13. SIGNATURE		
14. US GOVERNMENT/STATE AGENCY		15. ADDRESS
16. SIGNATURE		

Appendix A

The following mandatory requirements/conditions apply to the responsible entity and any person conducting root crop production activities (from obtaining/shipping seed for planting to the transportation of the root crop to the processing facility) in association with or on behalf of the responsible entity under this compliance agreement. The term person in this paragraph includes any individual, partnership, corporation, association, joint venture, or other legal entity.

General Administrative Requirements/Conditions:

Information Required: The responsible entity, through its authorized representative, shall submit to APHIS/BRS, no later than 28 days (emailed or postmarked) after the first day of planting under this compliance agreement and every 28 days thereafter until all planting is completed, a planting report (refer to "RRSB _example planting report") that must include the following information: the names and addresses of all growers, the county and state where each release (planting) occurred, at least one GPS coordinate for each release site and the location of the GPS coordinate (e.g., NW corner of the field), confirmation that the release site has been in agricultural production for at least the past three years, the exact planting date(s) for each release site, and the actual acreage planted at each site. Each report shall include plantings occurring during the prior 28 days (to extent such information is reasonably available at the time of the report) and information for plantings occurring in prior reporting periods for which information was not available at the time the prior report was submitted. The reports may be submitted electronically via email at RRSB.BRS@aphis.usda.gov or via mail at: USDA/APHISIBRS Attn. RRSB Planting Reports, 4700 River Road Unit 91, Riverdale, MD 20737; please for an example of a planting report.

The responsible entity through its authorized representative shall notify APHIS/BRS (via email at RRSB.BRS@aphis.usda.gov, via phone at (301) 734-5690), within 48 hours, of any change in the information provided to APHIS/BRS, either upon application for a compliance agreement or at anytime thereafter, regarding planting and/or movement/importation activities (e.g., changes/updates to planting locations, GPS coordinates, shipping addresses for seed and/or root movement).

Reporting of Incidents of Noncompliance: The responsible entity through its authorized representative shall notify APHIS/BRS, verbally (301-734-5690) and in writing via email (RRSB.BRS@aphis.usda.gov), within 24 hours, after becoming aware of unauthorized releases and/or movements. In addition, the responsible entity through its authorized representative shall notify APHIS/BRS, verbally (301-734-5690) and in writing via email (RRSB.BRS@aphis.usda.gov), within 48 hours, after becoming aware of any instance of noncompliance with the conditions of the compliance agreement. In incidents involving unauthorized releases and/or noncompliance, growers shall give notice immediately to the responsible entity so that the responsible entity may notify APHIS/BRS. When contacting APHIS/BRS, the authorized representative shall describe the incident, the date it occurred, the location (including county and state and GPS coordinate(s) of release site), name and address of grower, and field personnel associated with the incident. The authorized representative shall also provide immediate or short term corrective actions and, if necessary and available, long-term plans to return the situation to compliance and prevent similar incidents from occurring in the future. APHIS/BRS will review the information provided by the authorized representative and request additional information, if necessary, within 24 hours of the receipt of the notice. APHIS/BRS may require additional corrective actions if APHIS/BRS deems it necessary. The responsible entity and all persons engaged in root crop production activities in association with or on behalf of the responsible entity must cooperate with APHIS/BRS until the situation is resolved and the incident brought back to compliance. APHIS/BRS will record the incident and submit a response in writing, summarizing the incident and corrective measures, as per APHIS standard procedure in handling noncompliance incidents, to the authorized representative, no later than 10 days of the receipt of the notice.

Third Party Inspections and Audits

Third Party Inspections**:** APHIS/BRS will evaluate the third party inspectors' credentials provided by the responsible entity through its authorized representative in the request for the compliance agreement. The credentials will be evaluated for information such as, prior experience with biotechnology inspections, general experience in conducting inspections, and overall experience/background in agriculture. After evaluating the inspectors' credentials, APHIS will notify the authorized representative which third party inspectors it believes are qualified to conduct H7-1 sugar beet root crop inspections on behalf of the Agency. The responsible entity will have fifteen business days, from the date of the notice, to retain the services of the third party inspector(s). The responsible entity may choose to retain the services of one or more of the APHIS approved inspectors. Upon retaining the services of the third party inspector(s), the authorized representative shall supply the name(s) of the third party inspector(s) to APHIS/BRS. APHIS officials will contact the third party inspectors to schedule inspection training. (APHIS will provide an inspection form to be used by inspectors to capture inspection data.) The third party inspectors will schedule and conduct inspections according to APHIS' instructions. APHIS/BRS will coordinate with a third party inspector to randomly choose a statistically representative sample of fields, from those fields designated by APHIS to inspect, to conduct inspection for bolters (to satisfy condition 5 under Requirements/Conditions for Planting of the Root Crop). The third party inspectors will submit inspection reports directly to APHIS and APHIS will work directly with the inspectors if the reports require additional information. A large number of the root production fields and facilities will be inspected by the third party inspectors, sufficient to give statistically significant conclusions ($p=0.05$) on overall compliance. If the Compliance Agreement only covers seed movements, no third party inspectors are required.

Third Party Audits: APHIS/BRS will evaluate the third party auditors' credentials provided by the responsible entity through its authorized representative in the request for the compliance agreement. The credentials will be evaluated for information such as, prior experience with biotechnology inspections, general experience in conducting inspections, and overall experience/background in agriculture. After evaluating the auditors' credentials, APHIS will notify the authorized representative which third party auditors it believes are qualified to conduct H7-1 sugar beet root crop audits on behalf of the Agency. The responsible entity will have fifteen business days, from the date of the notice, to retain the services of the third party auditor(s). The responsible entity may choose to retain the services of one or more of the APHIS-approved auditors. Upon retaining the services of the third party auditor(s), the authorized representative shall supply the name(s) of the third party auditor(s) to APHIS/BRS. APHIS officials will contact the third party auditors to schedule audit training. APHIS will provide an audit form to be used by auditors to capture audit information. The third party auditors will schedule and conduct audits according to APHIS' instructions. APHIS will require third party auditors to review shipping records and/or grower records and to submit auditing reports directly to APHIS for review. APHIS will work directly with the auditors if the reports require additional information.

All Activities conducted by the responsible entity and any person engaging in root crop production activities in association with or on behalf of the root crop entity to comply with compliance agreement requirements/conditions may be either inspected or audited by APHIS or third party inspectors or auditors or both.

Access to Records, Planting Locations, and Facilities: The responsible entity shall ensure that all persons conducting root crop production activities under this compliance agreement provide access to all records required to be maintained under this compliance agreement and provide access, during regular business hours, to inspect planting locations, facilities, and transport vehicles, upon request by APHIS/BRS or its authorized representative(s).

Training: The responsible entity shall ensure that all persons conducting root crop production activities under this compliance agreement receive a copy of this compliance agreement and are trained in the processes and procedures necessary to comply with the terms of this compliance agreement. In addition, the responsible entity shall ensure that written documentation of the training is maintained and that all training records are maintained for the duration of this compliance agreement.

Duration of Compliance Agreement: This compliance agreement is valid and effective from the date of issuance (i.e. the date signed by APHIS/BRS) until December 31, 2012, unless revoked or superseded by APHIS/BRS. (The December 31, 2012 date does not preclude the responsible entity from ensuring that monitoring for volunteers continues through the end of the three-year monitoring period as set forth in the compliance agreement).

Cancellation or Revocation of Compliance Agreement: A violation of the requirements/conditions of this compliance agreement is a violation of the Plant Protection Act. In the event of a finding of noncompliance or violation of the requirements/conditions of the compliance agreement, APHIS may, at its discretion, revise, suspend, revoke, or otherwise withdraw the compliance agreement. APHIS may also, at its discretion, use the full range of the Plant Protection Act authorities to impose, as appropriate, criminal and/or civil penalties against any person conducting root crop production activities in violation of this agreement and may take remedial measures including seizure, quarantine, and/or destruction of any H7-1 sugar beet root crop production that is found to be in violation of the conditions set forth in the compliance agreement.

Requirements/Conditions for Planting of the Root Crop:

1. Planting of H7-1 sugar beet seed for root production is not allowed in the state of California, and the following counties in Washington State: Clallam, Clark, Cowlitz, Grays Harbor, Island, Jefferson, King, Kitsap, Lewis, Mason, Pacific, Pierce, San Juan, Skagit, Skamania, Snohomish, Thurston, Wahkiakum, and Whatcom.

2. The planting of H7-1 sugar beet seed for root crop production is only allowed in the following states: Arizona, Colorado, Idaho, Michigan, Minnesota, Montana, Nebraska, North Dakota, Oregon, Washington, and Wyoming.

3. The planting of H7-1 sugar beet seed for root production is only allowed in sites that have been in agricultural production for at least three years prior to planting.

4. Root growers shall ensure that root crop fields are surveyed to identify and eliminate any bolters before they produce pollen or set seed. Fields shall be surveyed at least once every 3-4 weeks beginning April 1. Root growers shall ensure that field personnel maintain

records of their field observations and removal of bolters. Reports where bolters are not observed must be maintained as well. If bolters are found, the responsible entity through its authorized representative shall ensure that APHIS/BRS is notified (via email at RRSB.BRS@aphis.usda.gov, via phone at (301) 851-3867), within 48 hours after finding the bolters, and provided a description of the location and action taken by the field personnel to remove them. The responsible entity shall ensure that all records of inspection and bolter removal are maintained for the duration of this compliance agreement.

5. Third party inspectors procured by the responsible entity (see **Third Party Inspections and Audits** above) will coordinate with APHIS/BRS to randomly choose a statistically representative sample of fields, from those fields designated by APHIS to inspect, to conduct inspection for bolters. (This third party inspection is in addition to the requirement in paragraph 4 above that root growers survey their fields at least once every 3-4 weeks.) If bolters are identified, the root grower shall be notified immediately and those bolters must be removed.

6. Planting/cultivating/harvesting equipment that might be used in chard/red beet production shall not be used or shared for regulated GE material in the same growing year.

7. The responsible entity shall ensure root crop fields are monitored for volunteers for three-years (at least twice per year during the growing season) following harvest, and any volunteer plants must be destroyed. If the same land is used for crop cultivation during the volunteer monitoring period, that crop shall be visually distinct from sugar beets or the fields must be left fallow. The responsible entity shall ensure that records of observations are maintained for the volunteer monitoring period.

8. The responsible entity shall ensure that root growers maintain records of all the activities being carried out under the compliance agreements to demonstrate adherence to the mandatory conditions and restrictions.

Requirements/Conditions for Movement of the Seed for Root Crop Production:

1. The responsible entity shall ensure that, during transport of seed for root crop production, chain of custody and records (such as manifests or receipts) are maintained for the duration of this compliance agreement. Sugar beet seeds shall be transported in a sealed plastic bag(s), envelope(s), or other suitable container(s) (primary container) to prevent seed loss.

2. The primary container for transporting seeds shall be placed inside a sealed secondary container that is independently capable of preventing spillage or loss of seed during transport.

3. Each set of containers (primary and secondary) for transporting seeds shall then be enclosed in a sturdy outer shipping container constructed of corrugated fiberboard, corrugated cardboard, wood, or other material of equivalent strength. Each container shall clearly identify that the seed contents within shall only be used for the planting of sugar beet root crop.
4. The shipping containers for transporting seeds shall be transported in enclosed trucks or trailers with closed sides (unless the seed is already packaged with sufficient levels of packaging as described above).

Requirements/Conditions for Movement of the Root Crop for Processing:

1. The responsible entity shall ensure that, during transport of the root crop to a processing facility or any intermediate holding area, chain of custody and records (such as manifests or receipts) are maintained for the duration of this compliance agreement.

2. Trucks used for the movement of root crop from field to storage/processing shall be loaded in a manner to minimize loss of beets during transport or equipped with a retaining device.

Appendix C. Petitioner's Submission

http://www.regulations.gov/#!documentDetail;D=APHIS-2010-0047-0075

or

http://www.aphis.usda.gov/brs/aphisdocs2/03_32301p_a1.pdf)

Appendix B. Distribution List

Print

Cornucopia Institute
P.O. Box 126
Cornucopia, WI 54827

Director, Office of Environmental Policy and Compliance
Department of the Interior
1849 C Street NW
Washington, DC 20240

Compact Disc

Stan Abramson
Arent Fox LLP
1050 Connecticut Avenue, NW
Washington, DC. 20036-5339

Paul Achitoff
Earthjustice
223 South King Street, Suite 400
Honolulu, HI 96813

Nancy Bryson
Holland and Hart LLP
975 F Street, N.W., Suite 900
Washington, D.C. 20004

Daniel Bukovac
Stinson Morrison Hecker
1201 Walnut Street, Suite 2900
Kansas City, Missouri 64106

Bill Freese
Science Policy Analyst
Center for Food Safety
660 Pennsylvania Ave., SE, Suite 302
Washington, DC 20003

Gilbert Keteltas
1050 Connecticut Avenue, NW
Washington DC 20036

Gregory Loarie
Earthjustice
426 17th Street, 5th Floor
Oakland, CA 94612

Chris Marraro
McKenna Long and Aldridge
1900 K Street NW
Washington, DC 20006

Frank Morton,
Wild Garden Seed
P.O. Box 1509
Philomath, OR 97370

Phil Perry
Latham and Watkins LLP
555 11th Street, N.W., Suite 1000
Washington, D.C. 20004

Paige Tomaselli
Center for Food Safety
2610 Mission Street, Suite 803
San Francisco, CA 94110

Harry Zirlin
Debvoise & Plimpton LLP
919 Third Avenue
New York, NY 10022

Ken Westlake
Chief, NEPA Implementation Section
U.S. Environmental Protection Agency
Region 5
77 West Jackson Blvd.
Chicago, IL 60604-3507

Joe Cothern
Federal Agency & NEPA Coordination Team Leader
U.S. Environmental Protection Agency
Region 7
901 North 5th Street
Kansas City, KS 66101

Larry Svoboda
Director, NEPA Compliance Coordinator
U.S. Environmental Protection Agency
Region 8
1595 Wynkoop Street
Denver, CO 80202

Kathleen Goforth,
Manager, NEPA Review Coordinator
U.S. Environmental Protection Agency
Region 9
75 Hawthorne Street
San Francisco, CA 94105

Teena Reichgott,
Manager, NEPA Review Coordination
U.S. Environmental Protection Agency
Region 10
1200 Sixth Avenue
Seattle, WA 98101

Appendix A. List of Preparers

Name, Project Function	Qualifications
APHIS	
Sidney W. Abel III Assistant Deputy Administrator Reviewer	▪ M.S. Environmental Sciences – Chemistry, The George Washington University ▪ B.S. Special Studies – Environmental Chemistry, University of Maryland ▪ 25 years of professional experience in developing and conducting environmental risk assessments specializing in the fate, transport, and effects of physical, chemical, and biological substances
Patricia K. Beetham Regulatory Biotechnologist Reviewer	▪ Ph.D. Microbiology – Poultry Science, Clemson University ▪ M.S. Microbiology – Food Pathology, Clemson University ▪ B.S. Biology, Appalachian State University ▪ 5 years of professional experience evaluating environmental impacts and 18 years of professional experience in host response to vaccines and environment
David A. Bergsten APHIS Interagency NEPA Contact Project Manager Purpose and Need Reviewer	▪ Ph.D. Environmental Science – Toxicology, University of Texas, School of Public Health, Houston ▪ M.P.H. Disease Control, University of Texas, School of Public Health, Houston ▪ M.S. Entomology, Purdue University, West Lafayette, IN ▪ B.S. Environmental Science, Rutgers University ▪ 30 years of professional experience in environmental toxicology, chemical fate, pesticide research, and environmental protection. ▪ 23 years of experience preparing environmental documentation for APHIS programs.
Michael P. Blanchette Senior Environmental Protection Specialist TES analysis	▪ B.S. Entomology, University of New Hampshire ▪ 22 years of professional experience as an Environmental Protection Specialist with 8 years evaluating plant pest and environmental impacts of genetically engineered crops including effects to threatened and endangered species and critical habitat.
William Doley Biotechnologist Reviewer	▪ Ph.D. Plant Breeding and Genetics, Michigan State University ▪ M.S. Plant Breeding, University of Minnesota ▪ B.S. Plant Science, Pennsylvania State University ▪ 17 years of professional experience developing transgenic crop products ▪ 25 years of professional experience in crop breeding and genetics

Name, Project Function	Qualifications
Samantha Floyd Environmental Protection Specialist Reviewer	▪ M.S. Environmental Science and Policy, Johns Hopkins University, Baltimore, MD ▪ B.S. Biology, James Madison University, Harrisonburg, VA ▪ 7 years of professional experience in environmental documentation for APHIS programs with emphasis on pesticide and drug registration issues
Neil E. Hoffman Science Advisor Project Manager Alternatives Reviewer	▪ Ph.D. Plant Physiology, University of California, Davis ▪ B.S. Plant Biology, Cornell University ▪ 30 years of professional experience in plant biochemistry and molecular biology ▪ 8 years of professional experience in environmental risk assessment of genetically engineered organisms
Margaret J. Jones Plant Pest Risk Assessment	▪ Ph.D. Plant Pathology, University of California, Berkeley ▪ M.A. Cell and Molecular Biology, San Francisco State University ▪ B.A. Botany, Humboldt State University ▪ 10 years of professional experience evaluating plant pest and environmental impacts of genetically engineered crops and 16 years of research in plant pathology and molecular biology.
Susan Koehler Supervisory Biotechnologist Reviewer	▪ Ph.D. Plant Biology, Washington University in St. Louis ▪ B.S. Agronomy, University of Kentucky ▪ 16 years of professional experience evaluating plant pest and environmental impacts of genetically engineered crops and 13 years of research in plant biotechnology, plant biochemistry, and molecular biology
Elizabeth Nelson Environmental Protection Specialist Reviewer	▪ B.S. Biology, Bowie State University, Bowie, MD ▪ M.S. Healthcare Administration, University of Maryland, College Park, MD ▪ M.B.A. University of Maryland, College Park, MD ▪ 11 years of professional experience in environmental documentation for APHIS programs with emphasis on veterinary and human health issues
Craig Roseland Senior Environmental Protection Specialist Reviewer	▪ Ph.D. Developmental and Cell Biology, University of California, Irvine ▪ B.S. Biological Sciences, University of California, Irvine ▪ 11 years of experience in environmental risk assessment and regulatory analysis
Amy Shalom Environmental Protection Specialist Reviewer	▪ B.A. Foreign Language and Literature, Yale University, New Haven, CT ▪ 7 years of professional experience in preparing and reviewing National Environmental Policy Act analysis and documentation

Name, Project Function	Qualifications
Rhonda Solomon Environmental Protection Specialist Reviewer	▪ B.S. Biology, George Mason University, Fairfax, VA ▪ Juris Doctorate, Catholic University, Washington, DC ▪ 6 years of professional experience in environmental documentation for APHIS programs with emphasis on National Environmental Policy Act compliance
Rebecca Stankiewicz Gabel Senior Environmental Protection Specialist Project Manager Cumulative Impacts Reviewer	▪ Ph.D. Genetics, University of Connecticut ▪ M.S. Genetics, University of Connecticut ▪ B.S. Animal Science, University of Connecticut ▪ National Environmental Policy Act Certificate Program – Nicolas School of the Environment, Duke University ▪ 6 years of professional experience in environmental risk assessment of genetically engineered organisms ▪ 10 years of professional experience in molecular biology and genetics, including the development of genetically engineered organisms
Tracy Willard Ecologist Reviewer	▪ Ph.D. Entomology, University of Maryland, College Park, MD ▪ M.S. Entomology, University of Delaware, Newark, DE ▪ B.S. Biology, Eastern University, St. Davids, PA ▪ 11 years of professional experience in environmental documentation for APHIS programs with emphasis on Endangered Species Act compliance

Name, Project Function	Qualifications
ICF International	
Nick Baker Biological Resources – Animals	▪ M.E.M. Conservation Science & Policy, Duke University ▪ B.S. Wildlife Biology, Colorado State University ▪ 5 years of experience in the environmental field
Emily Cella Project Management	▪ Ph.D. (Candidate) Environmental Science and Public Policy, George Mason University ▪ M.S. Environmental Studies, Ohio University ▪ B.S. Biological Sciences - Environmental Biology, Ohio University ▪ 8 years of experience in environmental impact analysis
David Ernst Physical Environment	▪ M.C.R.P. Environmental Policy, Harvard University ▪ B.A. Ethics and Politics, Brown University ▪ B.S. Urban Systems Engineering, Brown University ▪ 30 years of planning, research, analysis, and project management for the air quality and transportation industries
Steve Froggett Biological Resources – Plants	▪ Ph.D. Neuroscience and Behavior, University of Massachusetts ▪ M.S. Biology, University of North Carolina ▪ B.S. Biology and Psychology, Marietta College ▪ 9 years of experience working with government agencies, universities and the private sector on issues related to medical education, health care and food security
Christy Hartmann Project Management	▪ M.E. Environmental Engineering, University of Maryland ▪ B.S. Environmental Engineering, University of Maryland ▪ 9 years of experience in environmental impact assessment, and 6 years of experience in managing and preparing NEPA documents
Audrey Ichida Biological Resources – Plants and Production and Management	▪ Ph.D. Plant Molecular Biology, University of California, San Diego ▪ B.A. Biology, Cornell College ▪ Graduate and post doctoral work in plant molecular biology and 13 years of experience in risk assessment
Kirsten Jaglo Biological Resources – Plants and Production and Management	▪ Ph.D. Crop and Soil Science, Plant Breeding and Genetics, Michigan State University ▪ B.A. Biology (minor in Chemistry) with honors, University of Minnesota 15 years of experience working with federal agencies, universities, and the private sector on issues related to genetic engineering

Name, Project Function	Qualifications
Penny Kellar Document Management	▪ M.S. Ecology, University of California, Davis ▪ B.S. Conservation of Natural Resources, University of California, Berkeley ▪ 24 years of experience working with federal and state agencies, universities, and the private sector in communications about environmental issues and 4 years of experience in NEPA documents
Jim Laurenson Human Health	▪ M.S. Environmental Health Management with Technical Specialty in Risk Assessment, Harvard University School of Public Health ▪ B.S. Animal Science and Pre-veterinary Medicine, University of Massachusetts ▪ 20 years of experience conducting and managing environmental- and human health-related projects
Jason Londo Biological Resources – Plants	▪ Ph.D. Plant Biology, Washington University ▪ B.S. Molecular Biology, Florida Institute of Technology ▪ 3 years of experience in plant population biology and ecology ▪ 6 years of experience in plant population genetics
Bryan Luukinen Human Health	▪ M.S.P.H., Environmental Sciences and Engineering, focus on Environmental Health Sciences, Gillings School of Global Public Health, University of North Carolina-Chapel Hill ▪ B.A. Biology, Willamette University, Salem, OR ▪ 5+ years of experience in technical writing and editing; 3 years experience as a Pesticide Specialist for the National Pesticide Information Center at Oregon State University. Experience in risk assessment, risk communication, and toxicology.
Meg McVey Biological Resources – Animals	▪ NATO Post Doctoral Fellowship, Oxford University, United Kingdom ▪ Ph.D. Animal Behavior and Ecology, The Rockefeller University, New York, NY ▪ B.S. Zoology, University of North Carolina ▪ 30 years of experience in human health and ecological risk assessment
Michael Smith Project Management	▪ Ph.D. Sociology, Utah State University ▪ M.A. Geography, University of Wyoming ▪ B.A. Environmental Studies, University of California, Santa Cruz ▪ 16 years of experience in environmental impact analysis

Name, Project Function	Qualifications
Alex Uriarte Socioeconomics	▪ Ph.D. Development Studies, University of Wisconsin, Madison ▪ M.S. Economics, University of Wisconsin, Madison ▪ M.S. Business Economics, Getúlio Vargas Foundation, São Paulo ▪ B.A. Economics, University of São Paulo ▪ 11 years of experience in socioeconomic assessments and studies, and management and monitoring of economic development projects
Jenna Wallis Project Coordination	▪ M.E.M. Environmental Economics and Policy, Duke University ▪ B.S. Environmental Conservation Studies, University of New Hampshire ▪ 1 year of experience in environmental impact analysis ▪ 3 years of experience in environmental policy
Hova Woods Project Management	▪ M.P.A. Environmental Policy and Management, Indiana University ▪ B.S. Finance, concentration in Science and Technology, Indiana University ▪ 9 years of experience in environmental impact analysis