Dow AgroSciences Petitions (09-233-01p, 09-349-01p, and 11-234-01p) for Determinations of Nonregulated Status for 2,4-D-Resistant Corn and Soybean Varieties

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Executive Summary

Summarized as "Protecting American Agriculture," the mission of the United States Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS) is "To protect the health and value of American agriculture and natural resources." [1] APHIS regulates plant and animal health to achieve its mission. It integrates these regulatory functions to help ensure beneficial impacts on United States (U.S.) domestic agricultural production, commodities, trade in agricultural products, and the environment.

One function critical to the APHIS mission is preventing the introduction and distribution of plant pests. This includes the management of certain plants, animals, and microorganisms that harm plants and cause economic losses to U.S. agriculture. It extends to practices and technologies that have the potential to increase plant pest risks.

The United States Department of Agriculture (USDA), Animal and Plant Health Inspection Service (APHIS) received three requests (petitions) from Dow AgroSciences (DAS) seeking determinations of nonregulated status for genetically engineered (GE) plant varieties referred to as: DAS-40278-9 corn, DAS-68416-4 soybean, and DAS-44406-6 soybean (also known as Enlist™ corn and soybean). Currently, these GE plant varieties are regulated by APHIS, and Dow is seeking authorization from APHIS to grow these varieties without any APHIS regulatory oversight. Since these three GE plant varieties are currently under APHIS' regulatory oversight, Dow must comply with a full range of safeguarding measures to ensure that these regulated GE plant varieties do not transfer or spread from their outdoor plantings while under regulation. A permit is also required to move these regulated varieties interstate. Even if APHIS grants authorization to Dow to grow these varieties, two other agencies, the U.S. Food and Drug Administration (FDA) and the U.S. Environmental Protection Agency (EPA), also provide oversight of genetically engineered plants (described below).

As described in more detail below, APHIS authority for regulation of certain GE organisms is provided in the Plant Protection Act. Once a developer of a GE plant has obtained enough information to conclude that its regulated GE plant is unlikely to cause injury, damage, or disease to plants or plant products (that is, pose a plant pest risk), the developer may petition APHIS to remove the GE plant from regulation. Usually the petition is received when the developer wishes to commercialize a specific GE plant variety. This petition is referred to as seeking "nonregulated status" or as requesting a "deregulation." If the petition for nonregulated status is approved by APHIS, then APHIS' permits would no longer be required to grow or ship the genetically engineered plant and its progeny throughout the U.S. and its territories. This scenario would be the case if APHIS determines that nonregulated status is appropriate for one or more of the three Dow GE varieties. If nonregulated status is granted, herbicide applications

[1] *For more details about the APHIS mission,* visit http://www.aphis.usda.gov/about_aphis/

to these crops would still be under EPA oversight and food safety of the crops would still be under FDA oversight as described below.

Regulatory Authority

APHIS regulates certain GE organisms under authority provided in the Plant Protection Act (PPA) of 2000 as amended (7 U.S.C. §§ 7701–7772), and by APHIS' regulations codified in Title 7, part 340 of the U.S. Code of Federal Regulations (7 CFR part 340). APHIS' part 340 regulations govern a GE organism: if it is a plant pest (such as certain microorganisms or insects that can cause injury or damage to plants); or, if it is created using an organism that is itself a plant pest; or, if APHIS does not know or cannot determine if the GE organism is or may be a plant pest.

Any party can petition APHIS for "nonregulated status" of a GE organism (that is, to discontinue regulating a GE organism that falls under its regulations) through the procedures described in 7 CFR § 340.6. APHIS regulates such a GE organism until the agency evaluates whether the GE organism meets the PPA definition of a plant pest and concludes on the basis of scientific evidence that the GE organism is unlikely to pose a plant pest risk; that is to say that the potential for the GE organism to cause plant disease or damage is unlikely. In this case, the petitioner must provide data usually gathered through confined field tests regulated by APHIS to help inform the agency's decision. APHIS analyzes the data from the petitioner, researches current scientific findings, and prepares a plant pest risk assessment (PPRA) that documents whether or not the GE organism is likely to cause disease or damage. If APHIS concludes that the GE organism is unlikely to pose a plant pest risk, APHIS must then issue a regulatory determination of non-regulated status, since the agency does not have regulatory authority to regulate organisms that are not plant pests. When a determination of nonregulated status has been issued, the GE organism may be introduced into the environment without APHIS' regulatory oversight. If non-regulated status is determined for the GE corn and soybeans discussed in this EIS, Dow will be able to market the GE seeds to farmers for planting, and farmers will be able to grow, harvest, and move their crop into commerce for food and feed without any further authorization from APHIS.

Two other agencies, the U.S. Food and Drug Administration (FDA) and the U.S. Environmental Protection Agency (EPA), also provide oversight of genetically engineered plants. The relative roles of the USDA (through APHIS), FDA, and EPA are described in the "Coordinated Framework," a 1986 policy statement from the Office of Science and Technology Policy that describes the comprehensive policy for ensuring the safety of biotechnology research and products (US-OSTP, 1986).

The FDA's regulation of genetically modified plants is based upon its authority to regulate food safety under the Federal Food, Drug, and Cosmetic Act (FFDCA) 21 U.S.C. §§ 301 – 399. The FDA has the authority to remove adulterated food from the national food supply, which could include removing food derived from genetically modified plants.

The EPA governs the use, sale, and labeling of herbicides used on all plants pursuant to its authority under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) (7 U.S.C. §§

136–136y). FIFRA governs the use, sale, and labeling of herbicides and the EPA's actions under FIFRA directly affect the production methods used on herbicide resistant GE plants. An herbicide must first be "registered" by the EPA before it can be distributed or sold in the United States (7 U.S.C. §§ 136a(a),136j(a)(2)(F)). The EPA registration process starts with the herbicide manufacturer providing the EPA with information about the herbicide (7 U.S.C. §136a(c)(1)(C), (F)). The agency then evaluates any adverse effects it may have on humans and the environment. On the basis of this evaluation, the EPA then determines if it will allow the herbicide's use on a plant, and, if so, in what quantity. The EPA sets the conditions for the herbicide's use and places them in labeling instructions that a user must follow (*see* 7 U.S.C. §136j(a)(2)(G)). The EPA reevaluates the herbicide every fifteen years, as part of a "re-registration process" in which the agency determines if it should continue allowing the herbicide's use (7 U.S.C.§ 136a(g)(1)(A)(iv)). The Enlist™ corn and soybean that are the subject of this EIS have been engineered to be resistant to the herbicide 2, 4-D. The EPA re-registered 2,4-D in 2005 (US-EPA, 2005b). EPA is currently reviewing the use of 2,4-D on Enlist™ corn and soybean to determine whether the herbicide would cause any unreasonable environmental risks if it were applied in accordance with its labeling instructions. The EPA does not regulate Enlist™ corn and soybean plants, because the plant itself does not produce or secrete a pesticide.

Purpose of Enlist™ Corn and Soybean

Dow has developed Enlist™ GE plant varieties as alternatives to currently available GE herbicide-resistant (HR) corn and soybean varieties (see the petitions which are available on APHIS' website http://www.aphis.usda.gov/biotechnology/petitions_table_pending.shtml). Many HR corn and soybean varieties have been engineered over the past 15 to 20 years. These include varieties with resistance to the herbicide glyphosate (the active ingredient in Roundup®); varieties resistant to the herbicide glufosinate (the active ingredient in the herbicide Liberty®); varieties resistant to a class of herbicides known as sulfonylureas (active ingredients in herbicides such as Glean®); varieties resistant to the synthetic auxin known as dicamba (the active ingredient in herbicides such as Banvel®), and varieties resistant to isoxaflutole and mesotrione (the active ingredient in herbicides such as Balance® and Callisto®). By far, Roundup Ready® crops have been the most widely adopted by growers. Roundup Ready® crops greatly simplified weed management for growers and reduced their weed management costs. These Roundup Ready® crops were so successful that many growers grew only Roundup Ready® crops on their farms. As another example of this success, most soybean growers could manage weeds by using glyphosate as the only herbicide, whereas three to four herbicides were previously needed.

This nearly exclusive use of glyphosate over the past fifteen years led to the selection of glyphosate-resistant (GR) weeds, weeds that could survive an application of the herbicide that once would kill earlier generations. Herbicides do not create resistant weeds, but rather, through time, individual plants may survive a treatment. In a field of weeds, individual plants vary in their genetic makeup and in their resistance to a particular herbicide. Plants that survive the herbicide treatment may produce seed, resulting in even more plants that are resistant to the herbicide. Plants that are not resistant die and do not leave off-spring. In this way, the herbicide "selects" for resistant plants and against sensitive plants and the resistant plants are disseminated as a result of seed production and dispersal. (To read more about herbicide-resistant weeds see Appendix 6.)

Where GR weeds are widespread, the benefits of the Roundup Ready® system are diminished, and weed management is more costly. To manage GR weeds, growers have reverted to other herbicides and to mechanical cultivation practices used to manage weeds before the introduction of Roundup Ready® crops. Growers are also increasingly adopting glufosinate-resistant and other HR crops. (To read about the socioeconomic impacts of resistant weeds, see Section 5.7.1.)

The primary purpose of Enlist™ corn and soybean varieties is to help growers manage GR weeds. Each of the Enlist™ varieties has a trait that makes the plant resistant to the herbicide 2,4-D. 2,4-D is an active ingredient in hundreds of herbicide formulations and is commonly found in lawn care products (for example Scotts® Turf Builder® Weed and Feed). These 2,4-D products are used by homeowners and professional lawn care companies. Many lawn grasses are naturally resistant to 2,4-D. It is the third most widely used herbicide in the U.S. (glyphosate and atrazine are number one and two, respectively) and is widely available to consumers at retail outlets and home and garden centers. 2,4-D is also a relatively inexpensive herbicide. Increasingly, corn and soybean growers are using herbicide formulations that contain 2,4-D to manage GR weeds, often applying the herbicide before planting the crop. (To read more about trends in herbicide use on corn and soybean see Appendix 4.) Corn, for example, is naturally resistant to 2,4-D during certain early stages of growth. The Enlist™ traits would allow growers to apply 2,4-D when the corn is older.

Enlist™ corn is also resistant to, quizalofop, an herbicide found in herbicide formulations such as Assure® and Matador®. Corn is normally sensitive to quizalofop and this herbicide is sometimes used to control corn volunteers (i.e., corn that sprouts in fields now being used to grow so-called rotation crops such as soybean). Therefore, these herbicide formulations would no longer be useful for controlling volunteer Enlist™ corn in soybean fields. (For more discussion of the control of corn volunteers see Plant Communities in Section 4.1.2.)

Soybean is extremely sensitive to 2,4-D, so the herbicide can only be used on soybean fields at least 30 days before planting the soybeans. In contrast, growers could apply 2,4-D to soybeans with the Enlist™ trait, after the soybeans start to grow, killing the weeds but not the soybeans. Consequently, Enlist™ soybean will be valuable to control the many weeds that begin to grow later in the season after the soybean has begun to grow.

In addition to resistance to 2,4-D, the commercial seed varieties of Enlist™ corn are expected to have resistance to glyphosate and quizalofop and the commercial varieties of soybean are expected to have resistance to glyphosate and glufosinate. For the technical details on the creation of these three GE plants, see the petitions which are available on APHIS' website (http://www.aphis.usda.gov/biotechnology/petitions_table_pending.shtml).

Purpose and Need for Agency Action

APHIS's regulations require that APHIS make decisions on the petitions it receives for nonregulated status. The Agency can choose to approve a petition in whole or in part, or it can deny the petition. The decision is based on a plant pest risk assessment for the GE plants that are the subject of the petition. Plant pest risks are those risks that can cause injury, damage, or disease to plants or plant products.

The purpose of the petition process and the decisions made under the regulations is to protect plant health. Developers who can demonstrate through this process that their products do not cause plant pest risks can enter their products into commerce without restrictions after a determination of nonregulated status is made. APHIS must make a decision that is consistent with the Agency's regulatory and statutory authority.

Public Involvement

In response to the receipt of the three Dow petitions, APHIS prepared preliminary PPRAs to assess the plant pest risk for each plant variety. Additionally, APHIS conducted an environmental analysis consistent with its obligations under the National Environmental Policy Act (NEPA). NEPA regulations provide that an agency shall conduct an environmental assessment (EA) to determine if an agency action will significantly affect the environment (40 CFR § 1501.4). If the agency concludes in its EA that its action will not significantly impact the environment, the agency issues a "Finding of No Significant Impact," and the agency can proceed with its proposed action without preparing an environmental impact statement (EIS). If this initial assessment finds that the agency's action may significantly affect the environment, the agency must then prepare an EIS.

APHIS examined the environmental impacts of its potential decisions for nonregulated status of the Enlist™ corn and soybean by preparing EAs for two of the three petitions: petition 09-233-01p for Enlist™ corn and petition 09-349-01p for Enlist™ soybean (this EA only considered the Enlist™ soybean variety, DAS-68416-4). Each EA included a public comment period (corn: December 27, 2011-February 27, 2012; soybean: July 13-2012-September 11, 2012). For the corn and soybean EAs, comments are accessible at http://www.regulations.gov/#!documentDetail;D=APHIS-2010-0103-0001 and http://www.regulations.gov/#!documentDetail;D=APHIS-2012-0019-0001. An EA was not prepared for the Enlist™ soybean variety, DAS-44406-6, because it was submitted considerably later than the other Enlist™ corn and soybean petitions. By the time an EA would have been started, a decision had been made to prepare an EIS for all three of the Enlist™ plant varieties. As an EIS involves a more detailed environmental review, an EA was no longer necessary. APHIS has included the petition 11-234-01p corresponding to the Enlist™ soybean DAS-44406-6 in this EIS analysis because this soybean variety exhibits the same or similar HR traits as DAS-68416-4 soybean, so it presents similar environmental issues. APHIS also had a public comment period on the Notice of Intent (NOI) to prepare this EIS (May 16, 2013-July 17, 2013). APHIS received 41 comments on the NOI (See Appendix 2).

The draft EIS was available for public comment from January 10, 2014-March 11, 2014. APHIS held a public meeting on the draft EIS attended by 110 participants. Twenty four participants made comments, with 9 opposed and 15 in favor of deregulation (APHIS-2013-0044). APHIS received 10,147 submissions on the draft EIS docket (APHIS 2013-0042). Of these 8940 opposed and 1082 supported the use of Enlist™ corn and soybean. The remaining 125 comments consisted of submission of attachments, requests for extensions, or were submissions to the wrong docket. The comment summary and responses to the draft EIS are included in Appendix 9.

During the comment periods, the public identified three main issues. Following is a brief representation of those issues with a summary of our responses:

1) The concern that natural and biological resources would be adversely impacted by 2,4-D in anticipation of increased amounts of this herbicide being used on Enlist™ corn and soybean should these products be deregulated.

Although many commenters raised the issue about the potential for adverse impacts to the environment from the expected increased use of 2,4-D, these direct and indirect impacts are outside the scope of this EIS because the authority to regulate the impacts of herbicide use resides with the EPA under FIFRA. The EPA has conducted independent assessments of direct and indirect effects associated with the use of 2,4-D on Enlist™ corn and soybean (US-EPA, 2013a; b; c) and is making an independent action to determine whether to approve registration of Enlist Duo™ (US-EPA, 2014).USDA's authority comes from the Plant Protection Act, which limits APHIS authority to the regulation of plant pests and noxious weeds only. The three petitions submitted by Dow are evaluated pursuant to Part 340. Under APHIS's Part 340 regulations, APHIS can only consider plant pest risks when making a determination of nonregulated status. APHIS has no authority to regulate herbicide use. The EPA's registration process under FIFRA ensures that pesticides will be properly labeled and that, if used in accordance with label specifications, pesticides will not cause unreasonable harm to humans and the environment. Thus, the EPA has the authority to regulate the effects of herbicide use on humans and the environment. The EPA's regulatory responsibilities are more fully discussed in Section 1.4.2. The risk assessments used by the EPA are explained in Section 5.4.

2) The need by growers for Enlist™ corn and soybean to help them manage GR weeds already present on many farms across the country.

Growers are changing management practices to manage GR weeds including increasing tillage, hand weeding, and use of different herbicide chemistries. APHIS considers the impacts of GR weeds in the No Action Alternative (Section 4.1.1 Herbicides). Enlist™ crops will allow the post-emergent use of 2,4-D for weed control. In this way, they are expected to better enable growers to manage GR weeds. APHIS considers the potential for its decision on these petitions, combined with EPA's decision on the labeling of the Enlist Duo™ herbicide (a combination of 2,4-D and glyphosate) to influence management practices and to control GR weeds in Chapter 5.

3) The concern that increased use of 2,4-D on Enlist™ corn and soybean would hasten the selection of 2,4-D-resistant weeds.

APHIS has identified the possible selection of HR weeds resulting from the change in management practices associated with the adoption of Enlist™ corn and soybean as a potentially significant environmental impact. This impact is a cumulative impact because it would only result from the combined action of USDA on the subject petitions and of the

EPA's action to register 2,4-D for use on Enlist™ corn and soybean. If 2,4-D-resistant weeds were to be selected as a result of these combined actions, growers who rely on 2,4-D for effective and inexpensive weed control are likely to experience increased socioeconomic impacts from more costly and restrictive weed control alternatives.

Because of the likely adverse socioeconomic impacts that would result in the event that 2,4-D-resistant weeds would be selected from the expected increased 2,4-D use on Enlist™ crops, APHIS believed these impacts may be significant. Therefore APHIS decided, for the three Enlist™ varieties that are the subject of this EIS, to exercise its discretion to prepare an EIS to further analyze the potential for selection of 2,4-D-resistant weeds and other potential impacts that may occur from making determinations of nonregulated status for these varieties. This EIS limits its analysis of herbicide use to the cumulative impacts that occur from the selection of HR weeds and the changes in management practices that result so as not to duplicate the analysis independently conducted by the EPA (US-EPA, 2013a; b; c) (US-EPA, 2014)

Alternatives Analyzed

In this EIS, APHIS considers four alternatives regarding the possible deregulation of these three GE organisms. The four alternatives are: (1) No Action; (2) approve the petitions for nonregulated status of Enlist™ corn and soybean; (3) approve the petition for nonregulated status of Enlist™ corn only; and (4) approve both petitions for nonregulated status of Enlist soybean™ only.

Alternative 1: No Action Alternative—Continuation as Regulated Articles

Under the No Action Alternative, APHIS would deny the three petitions and these GE plant varieties would continue to be regulated by APHIS. Permits issued or notifications acknowledged by APHIS would still be required for the introduction of Enlist™ corn and soybean, and measures to ensure physical and reproductive confinement would continue to be implemented. This Alternative is not the Preferred Alternative because APHIS has concluded in its PPRAs that Enlist™ corn and soybean are unlikely to pose plant pest risks (USDA-APHIS, 2010b; 2012a; b). Choosing this alternative would not satisfy the purpose and need of making the required regulatory determination that is consistent with the PPA and 7 CFR part 340.6.

Alternative 2: Determination of Nonregulated Status of DAS-40278-9 Corn, DAS-68416-4 Soybean, and DAS 44406-6 Soybean (Preferred Alternative)

Pursuant to its PPA authority, as implemented in 7 CFR part 340, APHIS must respond to a petition to reclassify a regulated article as not subject to regulation under the plant pest provisions of the PPA. Under this alternative, Enlist™ corn and soybean and their progeny would no longer be subject to APHIS biotechnology regulations (7 CFR part 340). Permits issued or notifications acknowledged by APHIS would no longer be required for introductions of these varieties. This alternative meets the purpose and need to respond appropriately to the petitions (DAS, 2010a; DAS, 2010b; DAS, 2011) for nonregulated status, the requirements in 7 CFR part 340, and the Agency's regulatory authority under the plant pest provisions of the PPA, because these varieties are unlikely to pose plant pest risks as evaluated in the PPRA (USDA-APHIS, 2010b; 2012a; b). Therefore, this is the Preferred Alternative because approving the petitions for nonregulated status for all three varieties is consistent with the plant pest provisions of the PPA and the regulations codified in 7 CFR part 340.

Alternative 3: Approve the Petition for a Determination of Nonregulated Status of DAS 40278-9 Corn Only

Under this alternative, only Enlist™ corn and progeny derived from its cultivation would no longer be subject to the PPA regulations. Permits issued or notifications acknowledged by APHIS would no longer be required for this corn and its progeny. This alternative meets the purpose and need to respond appropriately to the petition for nonregulated status for Enlist™ corn, the requirements in 7 CFR part 340 and the Agency's regulatory authority under the plant pest provisions of the PPA, because it is unlikely to pose a plant pest risk evaluated in the PPRA (USDA-APHIS, 2010b; 2012a; b). Therefore, approving the petition for a determination of nonregulated status for Enlist™ corn is consistent with the plant pest provisions of the PPA and the regulations codified in 7 CFR part 340. However because APHIS has concluded in its PPRAs that the two Enlist™ soybean varieties are unlikely to pose plant pest risks (USDA-APHIS, 2010b; 2012a; b), choosing this alternative would not satisfy the purpose and need of making the required regulatory determination that is consistent with the PPA and 7 CFR part 340.6.

Alternative 4: Approve the Petition for a Determination of Nonregulated Status of DAS-68416-4 Soybean and DAS-44406-6 Soybean Only

Under this alternative, only the two Enlist™ soybean events (an event is a plant line produced from the insertion of a specific DNA into a plant species) and progeny derived from their cultivation would no longer be subject to the PPA regulations. Permits issued or notifications acknowledged by APHIS would no longer be required for their introduction and progeny derived from them. This alternative meets the purpose and need to respond appropriately to the petitions (DAS, 2010b; DAS, 2011) for nonregulated status for the two Enlist™ soybean varieties, the requirements in 7 CFR part 340 and the Agency's regulatory authority under the plant pest provisions of the PPA, because it is unlikely that they pose a plant pest risk evaluated in the PPRA (USDA-APHIS, 2010b; 2012a; b). Therefore, the Agency's deregulation of the two Enlist™ soybean varieties is consistent with the plant pest provisions of the PPA and the regulations codified in 7 CFR part 340. However, because APHIS has concluded in its PPRAs that Enlist™ corn is unlikely to pose plant pest risks (USDA-APHIS, 2010b; 2012a; b), choosing this alternative would not satisfy the purpose and need of making the required regulatory determination that is consistent with the PPA and 7 CFR part 340.6.

Affected Environment

In order to determine the extent of the potential environmental impacts that could result from APHIS' decision whether to grant nonregulated status, APHIS used information provided by the National Agricultural Statistics Service (USDA-NASS) to identify those regions of the country where corn and soybeans are grown. To describe the ecological features of corn and soybean regions, APHIS compared these growing areas to maps that group regions having similar ecological attributes such as soil, landform, or major vegetation types (CEC 2009). These regions are termed ecoregions and are identified as Regions A through M in this EIS (see section 3.1.3).

To identify the types of land cover and crops grown in each region, APHIS analyzed information in the USDA-NASS online tool, "Cropscape" an information source that compiles these data from satellite imagery.

Potential Environmental Consequences of Alternatives

Environmental issues are assessed individually in Chapter 4 (Potential Environmental Consequences). As stated previously, APHIS has regulatory authority over the Enlist™ corn and soybean plants, and the EPA has regulatory authority over the Enlist™ Duo herbicide (a premix of 2,4-D and glyphosate). The scope of this EIS covers the direct and indirect impacts that would result from the cultivation and use of the plant. The EPA, in its registration process, is considering any direct and indirect impacts from the use of the herbicide on Enlist™ plants. The USDA is relying on the EPA's authoritative assessments and will not duplicate the assessment prepared by the EPA. USDA also considers in this EIS (Chapter 5), cumulative impacts that result in the event that USDA approves the petitions for non-regulated status to Enlist™ corn and soybean and the EPA registers the use of herbicides on these crops.

APHIS determined that Enlist™ corn and soybean varieties would not result in an increase in acres in areas already in corn and soybean production. In addition, APHIS determined that there were no direct or indirect impacts on the environment from the cultivation of Enlist™ corn and soybean plants themselves, because these GE varieties are not agronomically different from non-GE corn and soybean plants or other GE corn or soybean plants that are no longer regulated by the Agency. These three GE plant varieties do not affect natural (e.g., soil, water, air) or biological (e.g., animal, insect, plant) resources directly. Rather, the management practices (e.g., pesticide applications and tillage practices) associated with their use could impact natural and biological resources. For example, herbicide applications can lead to the selection of weeds resistant to that herbicide, and tillage can adversely affect soil, water, and air quality and increase greenhouse gas emissions. While Enlist™ corn and soybean can resist damage from the application of the Enlist Duo™ herbicide, APHIS' selection of a particular alternative does not in itself allow the use of Enlist Duo™ herbicide on Enlist™ corn and soybean plant varieties. The EPA regulates the use of herbicides under FIFRA and is making a separate decision which may or may not allow use of Enlist Duo™ herbicide on these plants.

In Chapter 5, the environmental analysis considers potential cumulative impacts, including how herbicide use may change if the requested EPA actions are approved in conjunction with those of APHIS. APHIS approval of the three petitions for nonregulated status for Enlist™ corn and soybean and the independent decision by EPA to register Enlist Duo™ herbicide for use on these GE plant varieties is reasonably foreseeable. This herbicide product contains a unique formulation of 2,4-D mixed with glyphosate devised to reduce the off-target movement of 2,4-D. Its use is required by a Stewardship Agreement for anyone planting Enlist™ corn and soybean. For more on off-target movement see Appendix 7. One farmer group, the Save Our Crops Coalition, consisting of growers who raise 2,4-D sensitive crops, was initially opposed to Enlist™ crops due to concerns about off-target movement from the application of 2,4-D. However, their position changed based on discussions between the Save our Crops Coalition and Dow. As a result of those discussions, Dow committed to foster stewardship practices by Enlist™ technology users and amended its pending label submitted to the EPA to include further mitigation language (APHIS-2013-0042-7255 at regulations.gov). The mitigation language aimed at drift reduction includes a requirement of Enlist™ technology users to use only Enlist Duo™, a low volatility formulation, a specific nozzle type and maximum wind speed for application, applicator reporting requirements, and a 30-foot buffer zone from sensitive areas on areas to be sprayed.

As part of the cumulative impacts analysis, APHIS analyzed trends in 2,4-D use and, with information supplied by Dow, predicted 2,4-D use in the future under each of the Alternatives (see Appendix 4, Table 4-12). Based on the existing trend of increased use of 2,4-D over the last decade (i.e., without these 2,4-D-resistant crops), APHIS projects that 2,4-D use on crops will increase by nearly 75 percent by 2020 under the No Action Alternative. If EPA registers Enlist Duo™ herbicide for Enlist™ corn and soybean and APHIS adopts the Preferred Alternative, APHIS expects that 2,4-D use will further increase on crops by 200 to 600 percent by 2020 (depending on the assumptions made) relative to current use.

Deregulation of Enlist™ crops and approval of use of 2,4-D on those crops will cause growers to change management practices; namely 2,4-D use is expected to increase beyond the increase expected without these crops. Furthermore, 2,4-D use is expected to be used over a wider part of the growing season. The change in management practices expected under the Preferred Alternative is expected to increase the pressure for selection of 2,4-D-resistant weeds. Growers themselves can influence this selection pressure by the management practices they choose. Some examples of the practices that can be followed to reduce or delay the selection of HR weeds include, rotating crops, rotating types of herbicides, using cover crops, scouting for weeds, and using mechanical tillage to prevent weeds from flowering(see Section 5.7.2 for additional discussion). Societies such as the Weed Science Society of America (WSSA), university extension agents, and industry, have made a concerted effort to increase grower awareness of best management practices for HR weeds (see for example APHIS-2013-0042-1911 and -6165). The extent to which growers will adopt best management practices is unknown and, therefore, it is difficult to accurately predict when and the extent to which 2,4-D-resistant weeds will become a problem.

As noted above, 2,4-D is already the third most widely used herbicide in the United States. Among agricultural uses, 2,4-D is widely used for weed control on small grains (wheat, barley, oats, and sorghum) and orchards (see Appendix 4, Table 4-7 for a more complete list). If 2,4-D resistant weeds become more prevalent as a result of its use on Enlist™ corn and soybean, growers of these other crops that rely on 2,4-D for weed control may need to modify management practices to control weeds that become resistant to 2,4-D. The management changes would increase the complexity and cost of weed management programs for these growers. Growers most likely to be affected include those who grow small grains (See Chapter 5 for additional discussion). To identify which areas are most likely to experience cumulative impacts, APHIS identified areas where corn or soybean and small grains are grown in proximity and represent greater than 20 percent of cropland (see Chapter 5, Table 10). The areas identified include Ecoregion D (coastal southeast), Ecoregion F (Louisiana, Mississippi, Arkansas, Tennessee, Missouri); Ecoregion H (Western North Dakota and South Dakota); Ecoregion I (western Kansas, Nebraska, eastern Wyoming, eastern Colorado, and parts of western Texas and western Oklahoma); and Ecoregion J (central Texas). Because the use of Enlist™ corn and soybean does not require a single specific set of agronomic practices, the magnitude of the impacts discussed depends on the adoption rates of various practices by growers. While the selection pressure for 2,4-D-resistant weeds is expected to be greater under the Preferred Alternative, the selection pressure for GR weeds is expected to be greater under the No Action Alternative. This is because the Enlist™ cropping system decreases grower reliance on glyphosate by including an additional type of herbicide in the weed management system.

The continued emergence of GR weeds under the No Action Alternative will itself call for modification of crop management practices to address these weeds. Growers are expected to become less reliant on glyphosate for the control of weeds it is no longer effective in controlling. Growers will likely continue to use the herbicide because it is still effective on hundreds of weed species. However, farmers are expected to use additional chemical and non-chemical methods to control the GR weeds, too. Changes in management practices are expected to include more use of non-glyphosate herbicides and adjustments to crop rotation and tillage practices (Owen et al., 2011b). Herbicides that kill weeds by mechanisms (referred to as sites of action; see Appendix 3) different than glyphosate are expected to increase as growers face the need to manage GR weeds (see Figures 4.1 and 4.3 in Appendix 4). A site of action refers to the biochemical reaction that is affected by the herbicide. For example, glyphosate and glufosinate inhibit distinct reactions and therefore have different sites of action. 2,4-D affects yet another site of action. Current trends indicate that herbicides representing at least six sites of action are increasing in use and are expected to continue to increase under the No Action Alternative.

Selection of GR weeds is expected to continue where glyphosate is used. Areas where GR weeds are expected to remain a serious concern include the Southeast, Great Plains and Northern Crescent regions, where such weeds have already become widely prevalent. Furthermore, because other non-glyphosate herbicides will still be used to manage GR weeds, weeds resistant to non-glyphosate herbicides will continue to be selected. For many of the non-glyphosate herbicides, resistant weeds have already been selected and are widely prevalent (see Appendix 6 for more details). As a result, herbicide options for weed management may become less attractive under the No Action Alternative and growers may be forced to return to more aggressive tillage systems to maintain soybean yields (Conley, 2013).

Under the Preferred Alternative, 2,4-D use is expected to increase relative to the No Action Alternative, if EPA approves the amended use of 2,4-D on these crops. However, increases in other herbicide sites of action under the Preferred Alternative are expected to be less than under the No Action Alternative because the Enlist Duo™ herbicide is expected to be preferentially adopted if approved for use on these crops by EPA. The availability of inexpensive and effective herbicides in Enlist Duo™ combined with Enlist™ corn and soybean may delay the adoption of non-chemical management strategies under the Preferred Alternative. Fewer growers would be expected to adopt aggressive tillage when herbicides remain effective for weed control. Selection of weeds resistant to glyphosate and non-glyphosate herbicides will still occur under the Preferred Alternative. The selection pressure for HR weeds under the Preferred Alternative relative to the No Action Alternative will depend on the management practices employed under each alternative and cannot be predicted. More diversified weed management practices will result in less selective pressure for resistance to any given herbicide or management technique.

Under the No Action Alternative, natural resources are expected to be negatively impacted by a return to more aggressive tillage practices. If conventional tillage increases to control glyphosate- and other herbicide-resistant weeds, there may be an impact on soil quality from increased erosion; on air quality from increased air particulates and increased emission due to more use of farm equipment; on water quality from increased sedimentation; on climate change from increased release of greenhouse gases from burning additional fossil fuels and soil disruption that releases sequestered carbon; and on biodiversity from habitat loss. The total acreage that may be impacted by such an increase in tillage would be based on the extent of resistant weeds present in a field and the weed management strategy chosen by a grower. Adoption of Enlist™ soybean can provide growers with an alternative herbicide to glyphosate and glufosinate and could provide growers with an alternative to intensive tillage practices that may be used to manage HR weeds. However, the eventual occurrence of weeds resistant to glyphosate, 2,4-D and glufosinate will over time limit the use of Enlist™ crops and any benefit to natural resources that may arise. The magnitude of the benefit or the loss of the benefit is uncertain because decisions on crop production management are made by individual growers.

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ACRONYMS and ABBREVIATIONS

2,4-D	2,4-dichlorophenoxyacetic acid
2,4-DB	2,4-dichlorophenoxybutyric acid
2mEPSPS	double mutant 5-enolpyruvylshikimate-3-phosphate synthase
AAD-1	aryloxyalkanoate dioxygenase
AAD-12	arylalkanoate dioxygenase
ACCase	acetyl CoA carboxylase
ae	acid equivalent
a.i.	active ingredient
ALS	acetolactate synthase
AOPP	aryloxyphenoxypropionate
AOSCA	American Organization of Seed Certifying Agencies
APHIS	Animal and Plant Health Inspection Service (USDA)
ARMS	Agricultural Resource Management Survey
ARS	Agricultural Research Service (USDA)
BMPs	best management practices
BNF	biotechnology notification file
BRS	Biotechnology Regulatory Services (USDA)
CAA	Clean Air Act
CEC	Canada-Mexico-U.S. Commission for Environmental Cooperation
CEQ	Council on Environmental Quality
CH_4	methane
CO	carbon monoxide
CO_2	carbon dioxide
CRP	Conservation Reserve Program
CWA	Clean Water Act
DAS	Dow AgroSciences
DEIS	Draft Environmental Impact Statement
DMA	dimethylamine
DNA	deoxyribonucleic acid
DT_{50}	dissipation time needed for herbicide to degrade to half of its original concentration
EA	Environmental Assessment
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
EPSPS	5-enolpyruvylshikimate-3-phosphate synthase
ERS	Economic Research Service (USDA)
ESA	Endangered Species Act
EO	Executive Order
FAO	Food and Agriculture Organization of the United Nations
FDA	U.S. Food and Drug Administration
FEIS	Final Environmental Impact Statement
FFDCA	Federal Food, Drug, and Cosmetic Act
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act

fl oz/A	fluid ounces per acre
FQPA	Food Quality Protection Act
FONSI	Finding of No Significant Impact
FR	Federal Register
GE	genetically engineered
GHG	greenhouse gases
GMO	genetically modified organism
GR	glyphosate resistant
GT	glyphosate tolerant
HPPD	4-hydroxyphenylpyruvate dioxygenase
HR	herbicide resistant
HRAC	Herbicide Resistance Action Committee
IPCC	Intergovernmental Panel on Climate Change
IPM	Integrated Pest Management
IPPC	International Plant Protection Convention
ISPM	International Standard for Phytosanitary Measure
lb ae	pounds acid equivalent
lb ai	pounds active ingredient
LMO	living modified organism
MOU	memorandum of understanding
MCPA	(4-chloro-2-methylphenoxy) acetic acid/2-Methyl-4-chlorophenoxyacetic *acid*
MSO	methylated seed oil
N_2O	nitrous oxide
NAAQS	National Ambient Air Quality Standards
NAP**P**O	North American Plant Protection Organization
NASS	National Agricultural Statistics Service (USDA)
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NLCD	National Land Cover Dataset
NMFS	National Marine Fisheries Service
NO_2	nitrogen dioxide
N_2O	nitrous oxide
NOI	Notice of Intent
NPS	nonpoint source
NRC	National Research Council
NRCS	Natural Resources Conservation Service
O_3	ozone
OECD	Organization for Economic Co-operation and Development
OPP	Office of Pesticide Programs (EPA)
PAT	phosphinothricin acetyltransferase
Pb	lead
PCR	polymerase chain reaction
PM	particulate matter
$PM_{2.5}$	particulate matter with aerodynamic diameter of 2.5 micrometer or less

PM_{10}	particulate matter with aerodynamic diameter of 10 micrometer or less
PPA	Plant Protection Act
PPO	protoporphyrinogen oxidase
PPRA	plant pest risk assessment
PRA	pest risk analysis
RR	Roundup Ready™
SO_2	sulfur dioxide
SOA	site of action
TES	threatened and endangered species
Tg CO_2 Eq	teragrams of CO_2 Equivalent
USDA	U.S. Department of Agriculture
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
WPS	worker protection standard
WSSA	Weed Science Society of America

1 PURPOSE AND NEED

1.1 Introduction

Summarized as "Protecting American Agriculture," the mission of the United States Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS) is "To protect the health and value of American agriculture and natural resources." [2] APHIS regulates plant and animal health to achieve its mission. It integrates these regulatory functions to help ensure beneficial impacts on United States (U.S.) domestic agricultural production, commodities, trade in agricultural products, and the environment.

One function critical to the APHIS mission is preventing the introduction and distribution of plant pests. This includes the management of certain plants, animals, and microorganisms that harm plants and cause economic losses to U.S. agriculture. It extends to practices and technologies that have the potential to increase plant pest risks.

The biochemistry and molecular biology of genetic inheritance provides the framework of modern biotechnology. Genetic engineering is an application of biotechnology that involves the precise removal of selected genetic traits from organisms and insertion into other organisms. It enables the transfer of genes without the need for classical cross-breeding, so individual, highly specific, beneficial genetic traits can be moved between unrelated species.

APHIS regulates those GE organisms that have the potential to be plant pests or to increase plant pest risks. It performs extensive, science-based analyses to determine whether or not a GE organism is a plant pest. Results are recorded by the Agency in a plant pest risk assessment (PPRA). If the conclusion of the PPRA is that a GE organism is unlikely to be a plant pest, the Agency conducts an environmental review consistent with regulations codified under authority of the National Environmental Policy Act (NEPA) before making a formal determination about its regulatory status.

1.2 APHIS Regulatory Authority

The Plant Protection Act of 2000 (PPA) as amended (7 U.S.C. §§ 7701–7772) provides APHIS with legal authorization to implement its mission. Regulations promulgated for this enabling legislation are codified in Title 7, part 340, of the U.S. Code of Federal Regulations (7 CFR part 340). The defining mandate of the PPA is authorization for APHIS to regulate, manage and control plant pests.

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[2] *For more details about the APHIS mission,* visit http://www.aphis.usda.gov/about_aphis/

1.2.1 Context for This FEIS

Pursuant to its PPA authority, as implemented in 7 CFR part 340, APHIS must respond to a petition to reclassify a regulated article as not subject to regulation under the plant pest provisions of the PPA. APHIS, as a Federal agency, must also comply with applicable U.S. environmental laws and regulations, such as NEPA, prior to a decision on a petition.

This final environmental impact statement (FEIS) is prepared pursuant to the NEPA process for the three petitions submitted by Dow AgroSciences (Dow), LLC, Indianapolis, Indiana. These petitions seek determinations of nonregulated status for GE corn and soybean cultivars engineered for resistance[3] to herbicides. Each petition identifies a different variety. In each, Dow presents data supporting the claim the variety does not represent a plant pest risk and should not be regulated by APHIS under the PPA and 7 CFR part 340. A brief summary of defining characteristics for each variety described in these petitions follows.

> APHIS Petition 09-233-01p (DAS, 2010a) is for non-regulatory status designation of event (an event is a line produced from the insertion of a specific DNA into a plant species)DAS-40278-9 corn (*Zea mays*). It is engineered for increased resistance to certain broadleaf herbicides in the phenoxy auxin group such as 2,4-D (2,4-dichlorophenoxyacetic acid). DAS-40278-9 corn is also resistant to grass herbicides classified as aryloxyphenoxypropionate (AOPP) acetyl coenzyme A carboxylase (ACCase) inhibitors, such as quizalofop-p-ethyl (quizalofop), that are referred to as fop herbicides.
>
> APHIS Petition 09-349-01p (DAS, 2010b) is for non-regulatory status designation of event DAS-68416-4 soybean (*Glycine max*). It is engineered for increased resistance to 2,4-D and the nonselective herbicide, glufosinate ammonium (glufosinate).
>
> APHIS Petition Number 11-234-01p (DAS, 2011a) is for non-regulatory status designation of event DAS-44406-6 soybean, which is genetically engineered for increased resistance to certain broadleaf herbicides, including the nonselective herbicides glufosinate, glyphosate, and those in the phenoxy auxin group such as 2,4-D.

[3]*Resistance* to herbicides is defined by the Herbicide Resistance Action Committee (HRAC) as the inherited ability of a plant population to survive and reproduce following repeated exposure to a dose of herbicide normally lethal to the wild type HRAC (2013) Guideline to the management of herbicide resistance, Vol. 2013: Herbicide Resistance Action Committee. Resistance may be induced by genetic engineering or selection of variants produced by tissue culture or mutagenesis ibid. This is distinguished from *tolerant*, which is defined by HRAC as the inherent ability of a plant 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 ibid. Developers may use these terms differently. “Herbicide-Tolerant” is a term used by the petitioner to be synonymous with “herbicide resistant” as it is used in this FEIS.

All of the varieties described here are currently regulated under 7 CFR part 340. Interstate movement and field trials of each (DAS-40278-9 corn, DAS-68416-4 soybean, and DAS-44406-6 soybean) were conducted under permits issued or notifications acknowledged by APHIS since 2006, 2008, and 2009, respectively. The field trials were conducted within selected growing areas in the U.S. (see Appendix 1 for a list of notifications and states approved for environmental releases for each of the petitions). Data from field trials are reported in the petitions (DAS, 2010a; b; 2011a) and were analyzed in separate PPRAs prepared by APHIS (USDA-APHIS, 2010b; 2012a; b) for each event (i.e., DAS-40278-9 corn, DAS-68416-4 soybean, and DAS-44406-6 soybean).

If APHIS makes a determination of nonregulated status for each of these GE varieties, they will cease to be subject to the PPA and 7 CFR part 340. If they are not regulated, crosses between them and conventional, non-GE varieties will not be regulated either, nor will crosses between them and other biotechnology-derived varieties that have been classified previously by APHIS as not subject to regulation as plant pests under the PPA and 7 CFR part 340.

1.3 Purpose of These Products

Dow has developed HR (herbicide-resistant) DAS-40278-9 corn, DAS-68416-4 soybean, and DAS-44406-6 soybean as alternatives to currently available GE HR corn and soybean varieties (DAS, 2010a; b; 2011a). Most GE HR crops in the U.S. have historically included only a glyphosate-resistant (GR) trait. This situation has limited the diversity of herbicides used for weed management and resulted in intense reliance on glyphosate. This trend has been accompanied by a corresponding increase in glyphosate resistance in some weeds in corn and soybean production systems (USDA-APHIS, 2012b). The new corn and soybean varieties developed by Dow (DAS-40278-9 corn, DAS-68416-4 soybean, and DAS-44406-6 soybean) provide for greater flexibility in the choices growers have when selecting herbicides to control troublesome weeds. The availability of these varieties should diversify weed control and resistance management strategies. Additional details about each of these new varieties are summarized in the following subsections.

1.3.1 DAS-40278-9 Corn

DAS-40278-9 corn was genetically engineered to express the aryloxyalkanoate dioxygenase (AAD-1) protein. The *aad-1* gene encodes the AAD-1 protein which provides the plant with increased resistance to treatment with phenoxy auxin herbicides and AOPP ACCase inhibitors. The most well-known and widely-used phenoxy auxin herbicide is 2,4-D, which has been used for many decades as a pre-plant or post-emergent herbicide to control dicotyledonous (dicot or broadleaf) weeds in cornfields.

AOPP ACCase inhibitors, or “fop” herbicides, are post-emergent graminicides. They provide selective, post-emergent control of monocotyledonous (monocot) weed species in the grass family (Poaceae). Since corn is a poaceous monocot species, it is sensitive to treatment with “fop” herbicides. Therefore, these herbicides typically are not labeled for corn, so cannot be used for weed control in cornfields.

If no longer subject to the regulatory requirements of 7 CFR part 340 and the PPA, Dow intends to make DAS-40278-9 corn commercially available as the first corn variety with increased resistance to 2,4-D. Dow has announced its plans to market DAS-40278-9 corn hybrids stacked with a GR trait that will be marketed under the name Enlist™ corn.

1.3.2 DAS-68416-4 and DAS-44406-6 Soybean

DAS-68416-4 soybean is genetically engineered to express the arylalkanoate dioxygenase (AAD-12) protein and the phosphinothricin acetyltransferase (PAT) protein. The *aad-12* gene encodes the AAD-12 protein which provides the plant with increased resistance to several aryloxyalkanoate-based herbicides, including 2,4-D, MCPA (4-chloro-2-methylphenoxyacetic acid), and 2,4-DB (2,4-dichlorophenoxybutyric acid). It also conveys resistance to pyridyl oxyacetate herbicides, such as triclopyr and fluroxypyr (DAS, 2010b).

The *pat* gene encodes the PAT protein that inactivates the herbicide glufosinate (DAS, 2010b). If APHIS determines that these varieties are not subject to the regulatory requirements of the PPA and 7 CFR part 340, DAS intends to make DAS-68416-4 soybean commercially available as the first soybean variety with resistance to 2,4-D.

As its counterpart described above (DAS-68416-4 soybean), DAS-44406-6 soybean has been genetically engineered to express the AAD-12 and the PAT proteins to confer resistance to the herbicides 2,4-D and glufosinate. In addition, the *double mutant 5-enolpyruvylshikimate-3-phosphate synthase (2mEPSPS)* gene has been incorporated in DAS-44406-6 soybean via genetic engineering. It encodes the 2mEPSPS protein. This results in a soybean plant with decreased sensitivity to the herbicide glyphosate (DAS, 2011a).

DAS has indicated its intention to stack glyphosate resistance into DAS-68416-4 lines by conventional breeding to a previously deregulated soybean event with glyphosate resistance(DAS, 2010b). It is expected that soybean lines containing either event DAS-68416-4 or DAS-44406-6 will be resistant to the same three herbicides: 2,4-D, glufosinate, and glyphosate. The only difference between these two soybean events is that resistance to glyphosate in DAS-68416-4 soybean will be achieved by traditional breeding with another soybean containing a glyphosate resistance trait, while DAS-44406-6 soybean has been genetically engineered with the *2mEPSPS gene*.

1.4 Coordinated Regulatory Framework for Genetically-Engineered Organisms

The U.S. government has regulated GE organisms since 1986 under Federal regulations published in the *Federal Register* (51 FR 23302; 57 FR 22984) entitled “The Coordinated Framework for the Regulation of Biotechnology” (henceforth referred to here as the Coordinated Framework). 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. It also explains how Federal agencies will use existing Federal statutes to ensure public health and environmental safety while maintaining regulatory flexibility to avoid impeding the growth of the biotechnology industry.

Three central guiding principles form the basis for the Coordinated Framework:

> (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 a biotechnology product, not the process by which it was 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 organisms: USDA APHIS, the Environmental Protection Agency (EPA), and the Food and Drug Administration (FDA). A summary of each role follows.

1.4.1 USDA-APHIS

As noted in 1.2, the PPA authorizes APHIS to regulate, manage and control plant pests. With regard to organisms and products altered or produced through genetic engineering which are plant pests or which there is reason to believe are plant pests, APHIS regulates their introduction (i.e., importation, interstate movement, or release into the environment). 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 part 340.2) and is also considered a plant pest. A GE organism is also regulated under 7 CFR part 340, when APHIS has reason to believe that the GE organism may be a plant pest or APHIS does not have sufficient information to determine if the GE organism is unlikely to be a plant pest risk. A GE organism is no longer subject to the plant pest provisions of the PPA or to the regulatory requirements of 7 CFR part 340, when APHIS determines that it is unlikely to pose a plant pest risk.

An individual may petition the Agency for a determination that a particular regulated article is unlikely to be a plant pest risk, and should not be regulated under the plant pest provisions of the PPA and the regulations at 7 CFR part 340. Under §340.6(c)(4), the petitioner must provide information regarding the plant that the Agency can use to determine whether or not a regulated article is a plant pest risk. A GE organism or other regulated article is subject to the regulatory requirements of 7 CFR part 340 of the PPA until APHIS determines that it is unlikely to be a plant pest risk.

1.4.2 Environmental Protection Agency

The EPA is responsible for regulating the sale, distribution, and use of pesticides, including herbicides and those that are expressed by an organism modified using techniques of modern biotechnology. Such pesticides are regulated by the EPA as plant-incorporated protectants under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) (7 U.S.C. 136 *et seq.*). The EPA also regulates certain biological control organisms under the Toxic Substances Control Act (TSCA) (15 U.S.C. 53 *et seq.*). Before planting a crop containing a plant incorporated protectant, an individual or company must seek an experimental use permit from the EPA. Commercial production of crops containing plant incorporated protectants for purposes of seed increase and sale requires a FIFRA Section 3 registration with the EPA.

Under FIFRA (7 U.S.C. 136 *et seq.*), the EPA requires registration of all pesticide products for all specific uses prior to distribution for sale. Before granting a registration, the EPA evaluates the toxicity of the ingredients of a pesticide product, the particular site or crop on which it is to be used, the amount, frequency, and timing of its use, and storage and disposal requirements. Prior to registration for a new or amended use for a new or previously registered pesticide, the EPA must determine through testing that the pesticide does not cause unreasonable adverse effects on humans, the environment, and non-target species, when used in accordance with label instructions. EPA must also approve the language used on the pesticide label in accordance with 40 CFR part 158.

Once registered, a pesticide may only be legally used in accordance with directions and restrictions on its label. The purpose of the label is to minimize risks to human health and the environment. The Food Quality Protection Act (FQPA) of 1996, (Pub. L. No. 104 – 170, 110 Stat. 1489) amended FIFRA, enabling the EPA to implement periodic registration review of pesticides to ensure they are meeting current scientific and regulatory standards of safety and continue to have no unreasonable adverse effects (US-EPA, 2011d).

The EPA also sets tolerances (maximum residue levels) or establishes an exemption from the requirement for a tolerance, under the Federal Food, Drug, and Cosmetic Act (FFDCA). A tolerance is the amount of pesticide residue that can remain on or in food for human consumption or animal feed. Before establishing a pesticide tolerance, the EPA is required to reach a safety determination based on a finding of reasonable certainty of no harm under the FFDCA, as amended by the FQPA. The FDA enforces the pesticide tolerances set by the EPA.

1.4.3 Food and Drug Administration

The FDA regulates GE organisms under the authority of the FFDCA (21 U.S.C. 301 *et seq.*). The FDA published its policy statement concerning regulation of products derived from new plant varieties, including those derived from genetic engineering, on May 29, 1992 (57 FR 22984). Under this policy, the FDA implements a voluntary consultation process to ensure that human food and animal feed safety issues or other regulatory issues, such as labeling, are resolved before commercial distribution of food derived from GE products. This voluntary consultation process provides a way for developers to receive assistance from the FDA in complying with their obligations under Federal food safety laws prior to marketing.

In June 2006, the FDA also published recommendations in “Guidance for Industry: Recommendations for the Early Food Safety Evaluation of New Non-Pesticidal Proteins Produced by New Plant Varieties Intended for Food Use” (US-FDA, 2006). This establishes voluntary food safety evaluations for new non-pesticidal proteins produced by new plant varieties intended to be used as food, including GE plants. Early food safety evaluations help ensure that potential food safety issues related to a new protein in a new plant variety are addressed early in development. These evaluations are not intended as a replacement for a biotechnology consultation with the FDA, but the information may be used later in the biotechnology consultation.

1.5 Purpose and Need for This APHIS Action

APHIS is required to respond, consistent with its PPA authority and regulations at 7 CFR part 340.6, to three petitions from Dow. Each petition is for a different GE HR event: DAS-40278-9 corn, DAS-68416-4 soybean, and DAS-44406-6 soybean. In its submissions, the petitioner has provided information consistent with that described in §340.6(c)(4), which is required to inform APHIS of the full range of biological and chemical properties of the plant, so that APHIS can assess the plant pest risk of each of these events to determine if they are unlikely to be a greater plant pest risk than the unmodified organisms from which they were derived. Therefore, APHIS must respond to these petitions from Dow, who requests a determination of nonregulated status for each of these GE HR resistant plant varieties. If the Agency determines that a regulated article is unlikely to be a plant pest risk, a GE organism is no longer subject to the regulatory provisions of the PPA and the regulations of 7 CFR part 340.

Under the provisions of the National Environmental Policy Act (NEPA) as amended (42 U.S.C. 4321 *et seq.*), prior to implementation, Federal agencies must examine the potential impacts of proposed major actions that may significantly affect the quality of the human environment. The Agency has considered how to properly examine the potential environmental impacts of its decisions for petitions for determination of nonregulated status, in accordance with NEPA, regulations of the Council on Environmental Quality (CEQ) for implementing the procedural provisions of NEPA (40 CFR parts 1500-1508), USDA regulations implementing NEPA (7 CFR part 1 b), and the NEPA Implementing Procedures (7 CFR part 372) of APHIS.

Historically, for each petition for a determination of nonregulated status for a GE organism that APHIS has evaluated, the Agency has prepared an environmental assessment (EA) to provide the APHIS decisionmaker with a review and analysis that identifies whether there may be any significant environmental impacts. If the Agency makes a finding of no significant impacts (FONSI), the NEPA process is completed and a decision is issued. If significant environmental impacts are identified, the agency is then required to prepare an environmental impact statement (EIS) before a determination is made.

APHIS has prepared draft EAs for two of the petitions, 09-233-01p (DAS-40278-9 corn) and 09-349-01p (DAS-68416-4 soybean), that are the subject of this EIS (see subsections 1.4.2 and 1.4.3 for further information including links to the dockets). These EAs were made available for public comment. In reviewing petitions for determinations of nonregulated status of GE crop cultivars resistant to various herbicides, APHIS has identified the possible selection of HR weeds as an environmental impact. This impact is a cumulative impact that would result from the combined action of USDA on the subject petitions and on the EPA's action to register 2,4-D for use on DAS-40278-9 corn , DAS-68416-4 soybean or DAS-44406-6 soybean. If 2,4-D resistant weeds were to be selected as a result of this combined action, growers who rely on 2,4-D for effective and inexpensive weed control are likely to experience increased socioeconomic impacts from more costly weed control. Therefore, for the decisions on the three DAS petitions, APHIS has prepared this FEIS to further analyze the potential for selection of 2,4-D-resistant weeds and other impacts that may occur.

This EIS provides APHIS decisionmakers with a mechanism for examining the broad and cumulative impacts on the quality of the human environment[4] that may result from determinations of nonregulated status of DAS-40278-9 corn, DAS-68416-4 soybean, and DAS-44406-6 soybean. APHIS has included Petition 11-234-01p (DAS-44406-6 soybean) in this EIS analysis because this soybean variety exhibits the same or similar HR traits as DAS-68416-4 soybean, so presents the same environmental issues.

APHIS has prepared this EIS to consider the potentially significant environmental effects of a determination of nonregulated status, consistent with NEPA/CEQ regulations and USDA-APHIS-NEPA-implementing regulations and procedures (40 CFR parts 1500-1508, 7 CFR part 1b, and 7 CFR part 372).

1.6 Public Involvement

APHIS seeks public comment on EAs and EISs prepared in response to petitions seeking a determination of nonregulated status of a regulated GE organism. APHIS does this through a notice published in the *Federal Register*. A notice seeking public comments on each of the three petitions was published in the *Federal Register*. Notices for two of them, 09-233-01p (DAS-40278-9 corn) and 09-349-01p (DAS-68416-4 soybean), also sought comment on the draft PPRA and draft EA for each petition. An EA was not prepared for the third petition, 11-234-01p (DAS-44406-6 soybean), so that notice only sought comments for the petition. This APHIS used this procedure because a decision to prepare an EIS had been made for the other two petitions, and APHIS, in recognizing the similarity of DAS-44406-6 soybean to the other two petitions, decided to include it as part of this EIS.

A critical issue discussed in this EIS is the potential for significant environmental impacts associated with increased use of herbicides, particularly 2,4-D (and the other chlorophenoxy herbicides to which these crops are resistant), and the risk that these herbicides could contribute to the development of HR weeds. These potential impacts are compared to those that currently occur in corn and soybean production systems. Other issues addressed include those related to the cultivation of corn and soybean using the various agricultural production methods currently practiced, and the environmental and food/feed safety of GE plants.

Issues analyzed in this EIS were identified by considering public comments submitted (1) during the scoping periods for this EIS; (2) for the draft EIS; (3) for the draft EAs prepared for two of the petitions (09-233-01p and 09-349-01p); (4) for the petitions for all three events that are the

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[4] Under NEPA regulations, the "human environment" includes "the natural and physical environment and the relationship of people with that environment" (40 CFR §1508.14).

subject of this EIS (i.e., DAS-68416-4 soybean; DAS-44406-6 soybean; DAS-40278-9 corn); (5) for other EAs previously prepared by APHIS for GE organisms. These issues were analyzed to assess the potential environmental impacts of DAS-40278-9 corn, DAS-68416-4 soybean, and DAS-44406-6 soybean, should they be granted nonregulated status by USDA APHIS. These comments are summarized in Appendix 2 (draft EAs and EIS Notice of Intent) and Appendix 9 (draft EIS).

1.6.1 EIS Scoping: Public Comment Period

APHIS sought comments for the scoping of this EIS in an announcement that was published at http://www.regulations.gov/#!docketDetail;D=APHIS-2013-0042. Its availability was announced in a May 16, 2013 *Federal Register* notice that closed July 17, 2013. In addition, APHIS held two virtual public meetings on June 26, 2013 and June 27, 2013. For comments received during the scoping period see Appendix 2.

1.6.2 Public Comment Period for Draft EIS

APHIS thereafter issued the draft environmental impact statement (DEIS) for the petitions for a determination of nonregulated status for DAS-40278-9 corn, DAS-68416-4 soybean, and DAS-44406-6 soybean, and sought public comment on the DEIS through publication of a Notice of Availability (NOA) for the DEIS in the Federal Register on Jan 10, 2014 (79 FR 1861). The NOA explained how interested agencies, organizations, and individuals could access the DEIS for review and comment. The NOA also explained the process for submitting comments on the DEIS to APHIS. The DEIS was available for public comment for 60 days. APHIS also held a virtual public meeting on the DEIS on January 29, 2014. At the end of the 60-day comment period (Mar 11, 2014), APHIS analyzed and considered comments in preparing this FEIS. There was substantive information provided in public comments that was considered in the analysis for this FEIS. Our Response to Comments that we have prepared in order to address all the comments received in reference to the DEIS is in Appendix 9.

1.6.3 Public Comment Period for Draft EA for Petition 09-233-01p

APHIS published Petition 09-233-01p from Dow, the draft PPRA and the draft EA on December 27, 2011, for a 120-day comment period that closed April 27, 2012. The docket file is published at http://www.regulations.gov/#!docketDetail;D=APHIS-2010-0103

Most of the substantive comments (summarized in Appendix 2) on the docket were related to the herbicide use on the plant, including increased herbicide use, related health and environmental effects and further development of HR weeds.

1.6.4 Public Comment Period Draft EA for Petition 09-349-01p

APHIS published the petition, draft EA, and draft PPRA on July 11, 2012, for a 60-day public comment period that closed on September 11, 2012 (see Appendix 2 for a summary of comments). The docket file is published at:
http://www.regulations.gov/#!docketDetail;D=APHIS-2012-0019

1.6.5 Public Comment Period for Petition 11-234-01p

APHIS published Petition 11-234-01p (DAS-44406-6 soybean) on July 11, 2012, for a 60-day public comment period that closed on September 11, 2012. The docket file is published at http://www.regulations.gov/#!docketDetail;D=APHIS-2012-0032. As of that date, the docket file contained a total of 291 docket records, reflecting a total 68,462 public comments. The issues identified in the public comments related to DAS-44406-6 soybean are summarized in Appendix 2.

1.7 Issues Considered

The list of resource areas considered in this EIS were identified in part by APHIS from public comments (summarized in Appendix 2) received for the petitions and EAs considered in this EIS, the Notice of Intent, and virtual stakeholder meetings . Relevant concerns and issues cited in comments submitted by the public and various stakeholders in response to previous petitions and EAs for GE organisms also contributed to this process, as did concerns identified in previous unrelated lawsuits. The following list includes the resource areas considered in this EIS:

- Land Use
- Domestic Use of Corn and Soybeans
- Export of Corn and Soybean
- Food and Feed Safety
- Worker Safety
- Animal and Plant Communities
- Biodiversity
- Soil Quality
- Water Quality
- Air Quality
- Climate Change

2 ALTERNATIVES

This FEIS analyzes the potential environmental consequences of a determination of nonregulated status of DAS-68416-4 and DAS-44406-6 soybean, and DAS-40278-9 corn. In responding to the petitions, APHIS must determine whether DAS-68416-4soybean, DAS 44406-6 soybean, and DAS-40278-9 corn are unlikely to pose plant pest risks. Based on its PPRAs (USDA-APHIS, 2010b; 2012a; b), APHIS has concluded that DAS-68416-4 soybean, DAS-44406-6 soybean, and DAS-40278-9 corn are unlikely to pose plant pest risks.

APHIS evaluated four alternatives in this EIS: (1) No Action Alternative; (2) determination of nonregulated status of DAS-68416-4 soybean, DAS-44406-6 soybean, and DAS-40278-9 corn (Preferred Alternative); (3) determination of nonregulated status of DAS-40278-9 corn, only; (4) determination of nonregulated status of DAS-68416-4 soybean and DAS-44406-6 soybean, only. APHIS has assessed the potential for environmental impacts for each alternative in the Potential Environmental Consequences section.

2.1 Alternative 1: No-Action Alternative—Continuation as Regulated Articles

Under the No Action Alternative, APHIS would deny the three petitions (DAS, 2010a; b; 2011a). DAS-68416-4 soybean, DAS-44406-6 soybean, and DAS-40278-9 corn and progeny derived from these event lines would continue to be regulated articles under the regulations at 7 CFR part 340. APHIS would still require permits or notifications for their introduction, and would continue to implement measures to ensure physical and reproductive confinement. APHIS could choose this alternative if there were insufficient data for APHIS to completely evaluate the potential plant pest risks associated with the unconfined cultivation of DAS-68416-4 soybean, DAS-44406-6 soybean, and DAS-40278-9 corn.

This alternative is not the Preferred Alternative because APHIS evaluated the data and concluded in its PPRAs that DAS-68416-4 soybean, DAS-44406-6 soybean, and DAS-40278-9 corn are unlikely to be plant pest risks (USDA-APHIS, 2010b; 2012a; b). Therefore, choosing this alternative would be inconsistent with the purpose and need of the project because it is inconsistent with the scientific evidence before APHIS regarding plant pest risk.

2.2 Alternative 2: Determination of Nonregulated Status of DAS-68416-4 Soybean, DAS 44406-6 Soybean, and DAS-40278-9 Corn (Preferred Alternative)

Under this alternative, DAS-68416-4 soybean, DAS 44406-6 soybean, and DAS-40278-9 corn and progeny derived from their cultivation would no longer be subject to APHIS biotechnology regulations. APHIS would no longer require permits or notifications for introductions of these varieties because they are unlikely to pose plant pest risks (USDA-APHIS, 2010b; 2012a; b). This is the Preferred Alternative because a determination of nonregulated status for all three varieties, DAS-68416-4 soybean, DAS 44406-6 soybean, and DAS-40278-9 corn, would be consistent with the plant pest provisions of the PPA, the regulations codified in 7 CFR part 340, and the biotechnology regulatory policies in the Coordinated Framework.

2.3 Alternative 3: Determination of Nonregulated Status of DAS-40278-9 Corn Only

Under this alternative, only DAS-40278-9 corn and progeny derived from its cultivation would no longer be subject to regulations. DAS-68416-4 and DAS-44406-6 soybean would continue to be regulated as described under Alternative 1. APHIS would no longer require permits or notifications for introductions of DAS-40278-9 corn and progeny derived from this event because it is unlikely to pose a plant pest risk (USDA-APHIS, 2010b). APHIS could choose this alternative if data were not sufficient to complete an evaluation of potential plant pest risks associated with the unconfined cultivation of DAS-68416-4 soybean and DAS-44406-6 soybean. However, APHIS made the determination that these varieties are not likely to be plant pests (USDA-APHIS, 2012a; b) as part of the PPRA process. Therefore, choosing this alternative would be inconsistent with the purpose and need of the project because it is inconsistent with the scientific evidence before APHIS regarding plant pest risk.

2.4 Alternative 4: Determination of Nonregulated Status of DAS-68416-4 Soybean and DAS 44406-6 Soybean Only

Under this alternative, only DAS-68416-4 soybean and DAS 44406-6 soybean, and progeny derived from their cultivation would no longer be subject to regulations. APHIS would no longer require permits or notifications for introductions of DAS-68416-4 soybean and DAS 44406-6 soybean and progeny derived from these varieties because it is unlikely that they pose a plant pest risk (USDA-APHIS, 2012a; b). APHIS could choose this alternative if there was insufficient evidence to demonstrate the lack of plant pest risk from the unconfined cultivation of DAS-40278-9 corn. However, APHIS made the determination that this variety is unlikely to be a plant pest (USDA-APHIS, 2010b) as part of the PPRA process. Therefore, choosing this alternative would be inconsistent with the purpose and need of the project because it is inconsistent with the scientific evidence before APHIS regarding plant pest risk.

2.5 Alternatives Considered but Rejected from Further Consideration

APHIS assembled a list of alternatives considered for DAS-68416-4 soybean, DAS 44406-6 soybean, and DAS-40278-9 corn. The Agency evaluated these Alternatives in accordance with its authority under the plant pest provisions of the PPA, and the regulations at 7 CFR part 340. In this evaluation APHIS considered environmental safety, efficacy, and practicality to identify which alternatives the Agency would further consider for DAS-68416-4 soybean, DAS 44406-6 soybean, and DAS-40278-9 corn. Based on this evaluation, APHIS rejected several alternatives. These alternatives are described briefly below along with the specific reasons for rejecting each.

2.5.1 Prohibit Any DAS-68416-4 Soybean, DAS-44406-6 Soybean, and DAS-40278-9 Corn from Being Released

In response to public comments that stated a preference that no GE organisms enter the marketplace, APHIS considered prohibiting the release of DAS-68416-4 soybean, DAS 44406-6 soybean, and DAS-40278-9 corn, including denial of any permits associated with field testing. APHIS determined that this alternative is not appropriate because APHIS has concluded that DAS-68416-4 soybean, DAS-44406-6 soybean, and DAS-40278-9 corn are unlikely to be plant pest risks (USDA-APHIS, 2010b; 2012a; b). Therefore, choosing this alternative would be inconsistent with the purpose and need of the project because it is inconsistent with the scientific evidence before APHIS regarding plant pest risk.

In enacting the PPA, Congress included findings in Section 402(4) that: “decisions affecting imports, exports, and interstate movement of products regulated under this title [i.e., the PPA] shall be based on sound science.”

On March 11, 2011, in a Memorandum for the Heads of Executive Departments and Agencies, the White House Emerging Technologies Interagency Policy Coordination Committee established principles consistent with Executive Order 13563 to guide agencies in the development and implementation of policies for oversight of emerging technologies such as GE that included the following guidance:

> “Decisions should be based on the best reasonably obtainable scientific, technical, economic, and other information, within the boundaries of the authorities and mandates of each agency.”

Consistent with this guidance and based on the findings and scientific data evaluated for the PPRAs (USDA-APHIS, 2010b; 2012a; b), APHIS concluded that DAS-68416-4 soybean, DAS-44406-6 soybean, and DAS-40278-9 corn are unlikely to pose a plant pest risk. Therefore, there is no basis in science for prohibiting the release of these varieties.

2.5.2 Approve the Petition(s) in Part

The regulations at 7 CFR part 340.6(d)(3)(i) state that APHIS may “approve the petition in whole or in part.” However, APHIS has concluded that DAS-68416-4 soybean, DAS-44406-6 soybean, and DAS-40278-9 corn are unlikely to pose any plant pest risks (USDA-APHIS, 2010b; 2012a; b), so there is no regulatory basis under the plant pest provisions of the PPA for granting only partial approval of any of the petitions. Therefore, an approval in part would be inconsistent with the purpose and need of the project because it is inconsistent with the scientific evidence before APHIS regarding plant pest risk.

2.5.3 Production/Geographical Restrictions to Isolate DAS-68416-4 Soybean, DAS-44406-6 Soybean, and DAS-40278-9 Corn from Non-GE Soybean or Corn

In response to public concerns of gene movement between GE and non-GE plants, APHIS considered requiring isolation distances separating DAS-68416-4 soybean, DAS-44406-6 soybean, and DAS-40278-9 corn from non-GE soybean or corn production. However, because APHIS has concluded that DAS-68416-4 soybean, DAS-44406-6 soybean, and DAS-40278-9 corn are unlikely to pose plant pest risks (USDA-APHIS, 2010b; 2012a; b), an alternative based on requiring isolation distances would be inconsistent with the Agency’s statutory authority under the plant pest provisions of the PPA and regulations in 7 CFR part 340 because it is inconsistent with the scientific evidence before APHIS regarding plant pest risk.

APHIS also considered geographically restricting the production of DAS-68416-4 soybean, DAS-44406-6 soybean, and DAS-40278-9 corn based on the location of organic production systems of non-GE soybean and corn or production systems for GE-sensitive markets in response to public concerns regarding possible gene movement between GE and non-GE plants. However, as presented in the APHIS plant pest risk assessments (USDA-APHIS, 2010b; 2012a; b), there are no geographic differences associated with any identifiable plant pest risks for DAS-68416-4 soybean, DAS-44406-6 soybean, and DAS-40278-9 corn. This alternative was not analyzed in detail because APHIS has concluded that DAS-68416-4 soybean, DAS-44406-6 soybean, and DAS-40278-9 corn do not pose plant pest risks, and will not exhibit a greater plant pest risk in any geographically restricted area (USDA-APHIS, 2010b; 2012a; b). Therefore, such an alternative would be inconsistent with the APHIS statutory authority under the plant pest provisions of the PPA and regulations in 7 CFR part 340 and the biotechnology regulatory policies of the Coordinated Framework because it is inconsistent with the scientific evidence before APHIS regarding plant pest risk.

Based on the foregoing considerations, the imposition of isolation distances or geographic restrictions would not meet the APHIS purpose and need to respond appropriately to petitions for nonregulated status as set forth in the requirements in 7 CFR part 340 and the Agency's authority under the plant pest provisions of the PPA. Individuals might choose on their own to geographically isolate their non-GE corn or soybean production systems from DAS-68416-4 soybean, DAS-44406-6 soybean, and DAS-40278-9 corn, or to use isolation distances and other management practices to minimize gene movement between corn and soybean fields. Information to assist growers in making informed management decisions for DAS-68416-4 soybean, DAS-44406-6 soybean, and DAS-40278-9 corn is available from the American Organization of Seed Certifying Agencies (AOSCA, 2010).

2.5.4 Requirement of Testing for DAS-68416-4 Soybean, DAS-44406-6 Soybean, and DAS-40278-9 Corn

During the comment periods for other petitions for nonregulated status, some commenters requested that USDA require and provide testing for GE products in non-GE production systems. However, because DAS-68416-4 soybean, DAS-44406-6 soybean, and DAS-40278-9 corn are unlikely to pose plant pest risks (USDA-APHIS, 2010b; 2012a; b), testing requirements are inconsistent with the plant pest provisions of the PPA, the regulations at 7 CFR part 340 and the biotechnology regulatory policies of the Coordinated Framework. Therefore, for DAS-68416-4 soybean, DAS-44406-6 soybean, and DAS-40278-9 corn, a requirement for testing would not be appropriate for the purpose and need of the project and APHIS's compliance with its regulatory authorities.

2.6 Comparison of Alternatives

Table 1 includes a summary of the potential environmental consequences associated with selection of any of the Alternatives evaluated in this EIS. The potential environmental consequences assessment is presented in Chapter 4 of this EIS. The cumulative impacts are presented in Chapter 5.

Table 1. Summary of Issues and of Potential Impacts of the Alternatives

Attribute/Measure	Alternative 1: No Action (Deny All Petitions)	Alternative 2: Preferred Alternative-Determination of Nonregulated Status for DAS-68416-4 Soybean, DAS-44406-6 Soybean, and DAS-40278-9 Corn	Alternative 3: Determination of Nonregulated Status of DAS-40278-9 Corn Only	Alternative 4: Determination of Nonregulated Status of DAS-68416-4 Soybean and DAS 44406-6 Soybean Only
Meets Purpose and Need	No	Yes	No	No
Socioeconomic and Human Health				
Land Use	The demand for corn production under the No Action Alternative is expected to mirror the most recent USDA projections which predict a decline from 97 million acres to just under 92 million acres in 2014 and a further decline to 88.5 million acres through 2023 (USDA-OCE, 2014). The decrease in overall corn acres is expected to come as a result of increases in soybean, cotton, rice, and about 2.8 million less planted acres of field crops overall. (USDA-OCE, 2014)The most recent USDA projections are for soybean plantings to increase somewhat	Unchanged from No Action, although DAS-68416-4 soybean, DAS-44406-6 soybean, and DAS-40278-9 corn might be expected to replace other varieties of HR soybean or corn currently grown in the U.S., the acreage and location of production under the Preferred Alternative is expected to be the same as for the No Action Alternative. Pressure to convert agricultural grasslands to crop production is expected to be less based on about 2.8 million less planted acres of field crops overall (USDA-OCE, 2014).	Unchanged from No Action, although DAS-40278-9 corn is expected to replace other varieties of HR corn currently grown in the U.S., the acreage and location of corn production under Alternative 3 would be the same as for the No Action Alternative Pressure to convert agricultural grasslands to crop production is expected to be less based on about 2.8 million less planted acres of field crops overall (USDA-OCE, 2014).	Unchanged from No Action, although DAS-68416-4 and DAS 44406-6 soybean might be expected to replace other varieties of HR soybean currently grown in the U.S., the acreage and location of soybean production under Alternative 4 would be the same as for the No Action Alternative. Pressure to convert agricultural grasslands to crop production is expected to be less based on about 2.8 million less planted acres of field crops overall (USDA-OCE, 2014).

Attribute/Measure	Alternative 1: No Action (Deny All Petitions)	Alternative 2: Preferred Alternative- Determination of Nonregulated Status for DAS-68416-4 Soybean, DAS-44406-6 Soybean, and DAS-40278-9 Corn	Alternative 3: Determination of Nonregulated Status of DAS-40278-9 Corn Only	Alternative 4: Determination of Nonregulated Status of DAS-68416-4 Soybean and DAS 44406-6 Soybean Only
	through 2020 (USDA-OCE, 2014). Locations of corn and soybean production are not expected to change. Pressure to convert agricultural grasslands to crop production are expected to be less based on about 2.8 million less planted acres of field crops overall (USDA-OCE, 2014).			

Attribute/Measure	Alternative 1: No Action (Deny All Petitions)	Alternative 2: Preferred Alternative- Determination of Nonregulated Status for DAS-68416-4 Soybean, DAS-44406-6 Soybean, and DAS-40278-9 Corn	Alternative 3: Determination of Nonregulated Status of DAS-40278-9 Corn Only	Alternative 4: Determination of Nonregulated Status of DAS-68416-4 Soybean and DAS 44406-6 Soybean Only
Agronomic Practices	GR weed problems will continue to increase. This will likely force growers to use additional herbicides to control weeds, and/or abandon conservation tillage practices for more aggressive conventional tillage systems to maintain soybean/corn yields. Growers of cereal crops often rely on 2,4-D for inexpensive and effective weed control. Relatively few weeds have developed resistance to 2,4-D.	Enlist-Duo™, a mix of a 2,4-D choline formulation together with glyphosate may replace glyphosate for post-emergent 2,4-D applications in Enlist™ corn and soybean cropping systems contingent on EPA's decision to label the herbicide for this use. More efficient weed control is expected to reduce the need for more aggressive tillage. Under the Preferred Alternative, 2,4-D use and the selection pressure for 2,4-D resistant weeds is expected to increase. If 2,4-D resistant weeds become prevalent, growers who rely on 2,4-D for weed control are expected to adopt more costly alternative weed control measures.	Enlist-Duo™, a mix of a 2,4-D choline formulation together with glyphosate may replace glyphosate for post-emergent 2,4-D applications in Enlist™ corn cropping systems contingent on EPA's decision to label the herbicide for this use. No change is expected from the No-Action Alternative for current GE-soybean cropping systems. Under Alternative 3, 2,4-D use and the selection pressure for 2,4-D resistant weeds is expected to increase. If 2,4-D resistant weeds become prevalent, growers who rely on 2,4-D for weed control are expected to adopt more costly alternative weed control measures.	Enlist-Duo™, a mix of a 2,4-D together with glyphosate may replace glyphosate for post-emergent 2,4-D applications in Enlist™ soybean cropping systems contingent on EPA's decision to label the herbicide for this use. More efficient weed control is expected to reduce the need for more aggressive tillage in soybean cropping systems. Under Alternative 4, 2,4-D use and the selection pressure for 2,4-D resistant weeds is expected to increase. If 2,4-D resistant weeds become prevalent, growers who rely on 2,4-D for weed control are expected to adopt more costly alternative weed control measures.

Attribute/Measure	Alternative 1: No Action (Deny All Petitions)	Alternative 2: Preferred Alternative- Determination of Nonregulated Status for DAS-68416-4 Soybean, DAS-44406-6 Soybean, and DAS-40278-9 Corn	Alternative 3: Determination of Nonregulated Status of DAS-40278-9 Corn Only	Alternative 4: Determination of Nonregulated Status of DAS-68416-4 Soybean and DAS 44406-6 Soybean Only
Trade	Corn is the dominant feed grain traded internationally (USDA-OCE, 2011b). In 2010/11, the U.S. produced 38 percent of the total world supply of corn (USDA-OCE, 2011b). Primary importers of corn from the U.S. include Japan, Mexico, Korea, Egypt, Taiwan, Syria, the EU and China (USDA FAS, 2012b). Approximately 15 to 20 percent of U.S. corn production is exported. The U.S. was responsible for 38 percent of the world's bulk soybean exports, 13 percent of the world's soybean meal exports, and 11 percent of the world's soybean oil exports in 2011/12. (USDA-ERS, 2012b).	The U.S. will continue to be an exporter of corn and soybeans. Dow has submitted or is planning to submit requests for regulatory approvals in the main export markets for corn and soybean for DAS-68416-4 soybean, DAS-44406-6 soybean, and DAS-40278-9 corn. Therefore, the presence of these traits in exported commodities will not affect trade differently than other approved GE traits in commerce.	The U.S. will continue to be an exporter of corn and soybeans. Dow has submitted or is planning to submit requests for regulatory approvals in the main export markets for corn for DAS-40278-9 corn. Therefore, the presence of this trait in exported commodities will not affect trade differently than other approved GE traits in commerce.	The U.S. will continue to be an exporter of corn and soybeans. Dow has submitted or is planning to submit requests for regulatory approvals in the main export markets for soybean for DAS-68416-4 soybean and DAS 44406-6 soybean. Therefore, the presence of these traits in exported commodities will not affect trade differently than other approved GE traits in commerce.
Food and Feed	Both corn and soybean produced in the U.S. are used for food and feed. It is the responsibility of	No change is expected relative to the No Action Alternative.	No change is expected relative to the No Action Alternative.	No change is expected relative to the No Action Alternative.

Attribute/Measure	Alternative 1: No Action (Deny All Petitions)	Alternative 2: Preferred Alternative- Determination of Nonregulated Status for DAS-68416-4 Soybean, DAS-44406-6 Soybean, and DAS-40278-9 Corn	Alternative 3: Determination of Nonregulated Status of DAS-40278-9 Corn Only	Alternative 4: Determination of Nonregulated Status of DAS-68416-4 Soybean and DAS 44406-6 Soybean Only
	food and feed manufacturers to ensure that the products they market are safe and labeled properly. Dow has completed consultations with FDA for DAS-40278-9 corn (US-FDA, 2011a) DAS-68416-4 soybean (US-FDA, 2011b) and DAS-44406-6 soybean (US-FDA, 2013a).			
Worker Safety	Workers are exposed to corn and soybean plants. Workers use farm equipment for field cultivation and pesticide application. EPA sets the conditions for pesticide use on the label to achieve a standard of a "reasonable certainty of no harm." The current labels for 2,4-D, quizalofop, glufosinate, and glyphosate include label use restrictions intended to protect humans, including protective	EPA is currently considering the use of Enlist Duo™ and quizalofop on DAS-40278-9 corn and Enlist Duo™ on DAS-68416-4 soybean and DAS-44406-6 soybean. EPA sets the conditions for pesticide use on the label to achieve a standard of a "reasonable certainty of no harm."	Impacts are similar to those under the Preferred Alternative.	Impacts are similar to those under the Preferred Alternative.

Attribute/Measure	Alternative 1: No Action (Deny All Petitions)	Alternative 2: Preferred Alternative- Determination of Nonregulated Status for DAS-68416-4 Soybean, DAS-44406-6 Soybean, and DAS-40278-9 Corn	Alternative 3: Determination of Nonregulated Status of DAS-40278-9 Corn Only	Alternative 4: Determination of Nonregulated Status of DAS-68416-4 Soybean and DAS 44406-6 Soybean Only
	equipment to be worn during mixing, loading, applications and handling, equipment specifications to control pesticide application, and reentry periods establishing a safe duration between pesticide application and exposure to the pesticide in the field. Used in accordance with the label, these herbicides have been determined to not present a health risk to humans.			
Biological Resources				
Animal Communities	No impacts are expected from pesticide use because EPA sets the conditions for pesticide use on the label to achieve a standard of a “reasonable certainty of no harm.”	Unchanged from the No Action Alternative. No impacts are expected from the AAD-1 protein as it is does not appear to be allergenic or toxic.	Unchanged from the No Action Alternative. No impacts are expected from the AAD-1 protein as it is does not appear to be allergenic or toxic.	Unchanged from the No Action Alternative. No impacts are expected from the AAD-12 protein as it is does not appear to be allergenic or toxic.
Plant Communities	HR weeds will continue to be selected against herbicides that are used.	There may be an increase in the selection of weeds resistant to 2,4-D and with multiple resistance to 2,4-D and glyphosate.	There may be an increase in the selection of weeds resistant to 2,4-D and with multiple resistance to 2,4-D and glyphosate.	There may be an increase in the selection of weeds resistant to 2,4-D and with multiple resistance to 2,4-D and glyphosate.

Attribute/Measure	Alternative 1: No Action (Deny All Petitions)	Alternative 2: Preferred Alternative-Determination of Nonregulated Status for DAS-68416-4 Soybean, DAS-44406-6 Soybean, and DAS-40278-9 Corn	Alternative 3: Determination of Nonregulated Status of DAS-40278-9 Corn Only	Alternative 4: Determination of Nonregulated Status of DAS-68416-4 Soybean and DAS 44406-6 Soybean Only
Biological Diversity	Herbicide use in agricultural fields may impact biodiversity by decreasing weed quantities or causing a shift in weed species present in the field, which would affect those insects, birds, and mammals that use these weeds for habitat or food. Tillage decreases biodiversity. Under the No Action Alternative GR weeds may be difficult to control using herbicides and tillage may increase in soybean. It is uncertain how these two opposing effects would impact the biodiversity of the farming community.	It is uncertain how the Preferred Alternative would impact biodiversity. Enlist™ cropping systems for soybean may help to preserve gains in conservation tillage and increase biodiversity. If tillage is used anyway and herbicide control of weeds is more effective than under the No Action Alternative, biodiversity could decrease relative to the No Action Alternative.	Unchanged from the No Action Alternative.	Unchanged from the Preferred Alternative.

Attribute/Measure	Alternative 1: No Action (Deny All Petitions)	Alternative 2: Preferred Alternative- Determination of Nonregulated Status for DAS-68416-4 Soybean, DAS-44406-6 Soybean, and DAS-40278-9 Corn	Alternative 3: Determination of Nonregulated Status of DAS-40278-9 Corn Only	Alternative 4: Determination of Nonregulated Status of DAS-68416-4 Soybean and DAS 44406-6 Soybean Only
Natural Resources				
Soil Quality	Increased tillage to manage GR weeds may occur in soybean and lead to decreased soil quality from increased soil erosion.	Enlist™ cropping systems for soybean may help to preserve gains in conservation tillage and benefit soil quality in the short term. In the long term, selection of 2,4-D resistant weeds may result in similar aggressive tillage practices that are expected to occur under the No Action Alternative and negate the benefits mentioned above.	Unchanged from the No Action Alternative.	Unchanged from the Preferred Alternative.
Soil Microorganisms	Increased tillage to manage GR weeds may occur in soybean and lead to decreased plant residue and decrease soil organic matter which otherwise benefits soil biota by providing additional food sources (USDA-NRCS, 1996) and increases the diversity of soil microorganisms.	Enlist™ cropping systems for soybean may help to preserve gains in conservation tillage and benefit soil microorganisms in the short term. In the long term, selection of 2,4-D resistant weeds may result in similar aggressive tillage practices that are	Unchanged from the No Action Alternative.	Unchanged from the Preferred Alternative.

Attribute/Measure	Alternative 1: No Action (Deny All Petitions)	Alternative 2: Preferred Alternative- Determination of Nonregulated Status for DAS-68416-4 Soybean, DAS-44406-6 Soybean, and DAS-40278-9 Corn	Alternative 3: Determination of Nonregulated Status of DAS-40278-9 Corn Only	Alternative 4: Determination of Nonregulated Status of DAS-68416-4 Soybean and DAS 44406-6 Soybean Only
		expected to occur under the No Action and negate the benefits mentioned above.		
Water Resources	Increased tillage to manage GR weeds may occur in soybean and lead to increased soil erosion and decreases in water quality from sedimentation.	Enlist™ cropping systems for soybean may help to preserve gains in conservation tillage in the short term. In the long term, selection of 2,4-D resistant weeds may result in similar aggressive tillage practices that are expected to occur under the No Action Alternative and negate the benefits mentioned above.	Unchanged from the No Action Alternative.	Unchanged from the Preferred Alternative.
Air Quality	Increased tillage to manage GR weeds in soybean may occur and lead to decreased air quality from increased air particulates and exhaust from farm equipment.	Enlist™ cropping systems for soybean may help to preserve gains in conservation tillage and benefit air quality in the short term. In the long term, selection of 2,4-D resistant weeds may result in similar aggressive tillage	Unchanged from the No Action Alternative.	Unchanged from the No Action Alternative.

Attribute/Measure	Alternative 1: No Action (Deny All Petitions)	Alternative 2: Preferred Alternative- Determination of Nonregulated Status for DAS-68416-4 Soybean, DAS-44406-6 Soybean, and DAS-40278-9 Corn	Alternative 3: Determination of Nonregulated Status of DAS-40278-9 Corn Only	Alternative 4: Determination of Nonregulated Status of DAS-68416-4 Soybean and DAS 44406-6 Soybean Only
		practices that are expected to occur under the No Action Alternative and negate the benefits mentioned above.		
Climate Change	There is a potential impact on climate change from increased herbicide use and more aggressive tillage regimes to control herbicide-resistant weeds, causing increased release of GHG from burning additional fossil fuels.	Enlist™ cropping systems for soybean may help to preserve gains in conservation tillage and reduce GHG contributions to climate change in the short term. In the long term, selection of 2,4-D resistant weeds may result in similar aggressive tillage practices that are expected to occur under the No Action and negate the benefits mentioned above.	Unchanged from the No Action Alternative.	Unchanged from the No Action Alternative.
Other U.S. Regulatory Approvals	FDA consultations for DAS-40278-9 corn (US-FDA, 2011b), DAS-68416-4 soybean (US-FDA, 2011c), and DAS-4406-6 soybean (US-	Unchanged from the No Action Alternative	Unchanged from the No Action Alternative.	Unchanged from the No Action Alternative.

Attribute/Measure	Alternative 1: No Action (Deny All Petitions)	Alternative 2: Preferred Alternative- Determination of Nonregulated Status for DAS-68416-4 Soybean, DAS-44406-6 Soybean, and DAS-40278-9 Corn	Alternative 3: Determination of Nonregulated Status of DAS-40278-9 Corn Only	Alternative 4: Determination of Nonregulated Status of DAS-68416-4 Soybean and DAS 44406-6 Soybean Only
	FDA, 2013a) are completed. The reregistration decision for 2,4-D was issued in 2005 (US-EPA, 2005b). EPA is currently considering the use of Enlist™ on these DAS corn and soybean events			
Approvals in other Countries	Approvals have been granted for food and feed in Canada, Columbia, Australia, New Zealand, Japan, Korea, Mexico, and South Africa for one or more of the Enlist™ corn and soybean events. Applications are pending in Argentina, Brazil, China, EU, , and Switzerland.	Unchanged from the No Action Alternative.	Unchanged from the No Action Alternative.	Unchanged from the No Action Alternative.
Compliance with Other Laws				
CWA, CAA, E.O.s and EAS	Compliant.	Compliant.	Compliant.	Compliant.

3 AFFECTED ENVIRONMENT

This section includes a review of the prevailing conditions (baseline) of the human environment in the major corn and soybean production regions of the conterminous U.S. that may be further impacted by a determination of nonregulated status of DAS-40278-9 corn, DAS-68416-4 soybean, and DAS-44406-6 soybean. Relevant components of the physical environment, biological resources, human health, animal feed, and socioeconomic resources are considered. They include soil, water and air quality, climate change, land cover and land uses, corn and soybean production practices, animal communities, food and feed uses, worker safety and agricultural markets.

3.1 U.S. Corn and Soybean Production Practices

U.S. corn and soybean acreage combined is concentrated in the eastern two-thirds of the conterminous 48 states. The map shown in Figure 1 illustrates the major regions where one or both of these crops are grown. Very little production occurs in Hawaii, Alaska, and U.S. Territories and is therefore not included on the map. The individual highlighted areas correspond to ecological zones that are described in detail in section 3.1.3.

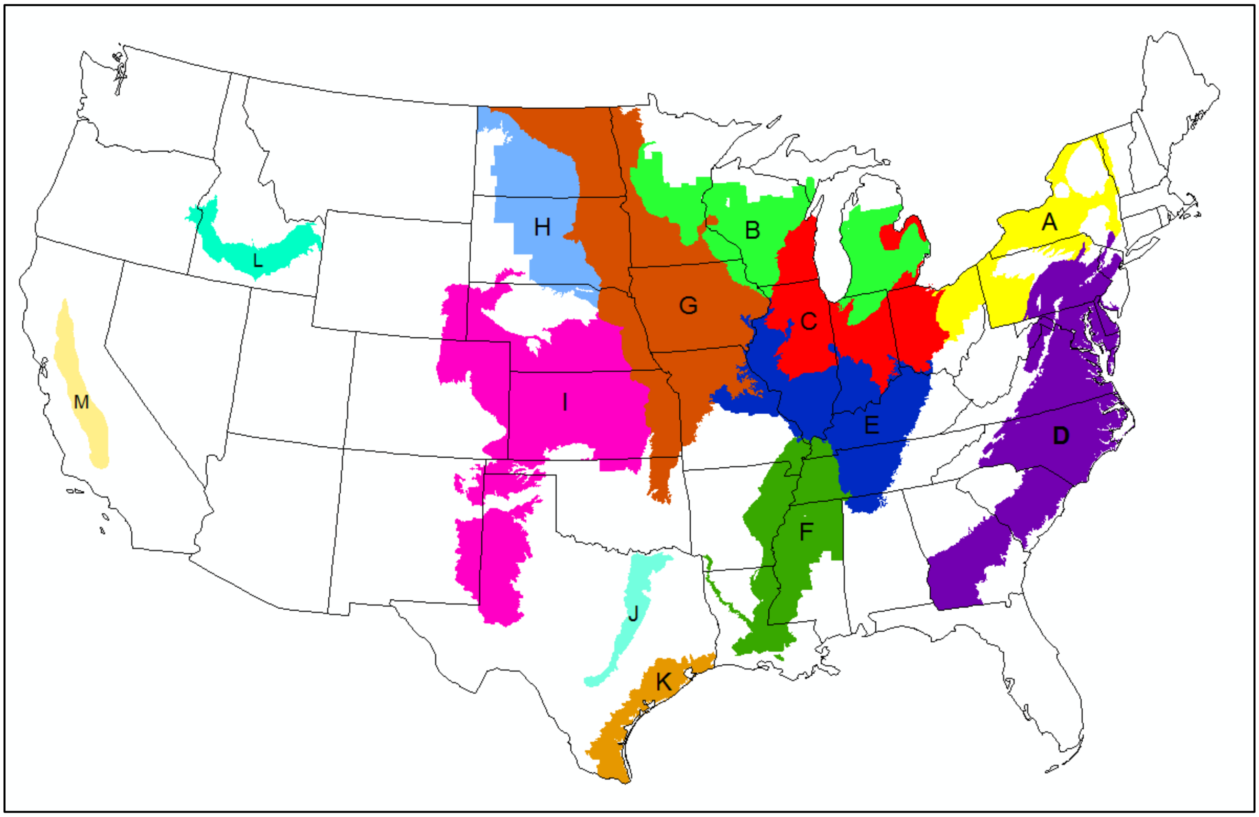

Figure 1. Major Corn and Soybean Cultivation Regions in the U.S.

3.1.1 Corn

Worldwide, corn production is exceeded only by wheat. This is attributable to corn's ability to adapt to a wide range of production environments, including variable conditions of humidity, sunlight, altitude, and temperature (OECD, 2003).

Corn is an annual typically grown in zones of abundant rainfall and fertile soils (OECD, 2003). In the U.S., prevailing moisture levels and the number of frost-free days represent climatic conditions ideal for corn production (IPM, 2004; 2007). According to the 2007 Census of Agriculture, corn was harvested for grain and/or silage in all 48 conterminous U.S. states in 89 percent (2,754) of the 3,109 counties and county equivalents within this region (Figure 2) (USDA-NASS, 2009e).

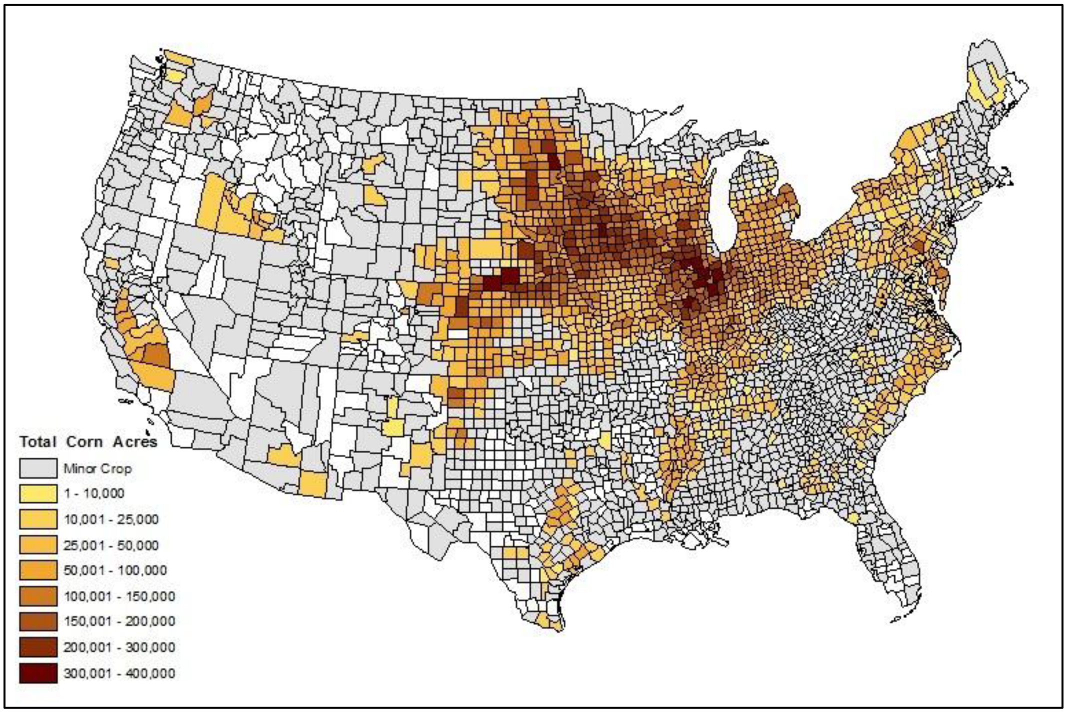

Figure 2. Corn Cultivation in the 48 Conterminous U.S.
Source:(USDA-NASS, 2009e).

Approximately 98 percent of the U.S corn crop is grown in the eastern two-thirds of the U.S. The greatest concentration of production occurs in the Corn Belt, which is loosely defined as Illinois, Iowa, Indiana, southern and western Minnesota, eastern South Dakota and Nebraska, western Kentucky and Ohio, and the northern two-thirds of Missouri (USDA-ERS, 2011c; USDA-NASS, 2010b; 2011b). The leading corn-producing states of Illinois, Iowa and Nebraska account for approximately 40 percent of the annual U.S. harvest (USDA-ERS, 2011b).

3.1.2 Soybean

Soybean (*Glycine max* (L.) Merr.) is an economically important leguminous crop, providing oil and protein from processed seed. Soybean is the most economically important oil-seed-producing crop in the world. It accounts for 58 percent of global oil-seed production (ASA, 2011).

According to the 2007 Census of Agriculture, soybean was harvested in 2,039 (66 percent) counties or county equivalents in the conterminous U.S. (USDA-NASS, 2009d) (Figure 3). About half of the 2012 U.S. crop was concentrated in five states: Iowa, Illinois, Minnesota, Indiana, and Nebraska(USDA-NASS, 2013a).

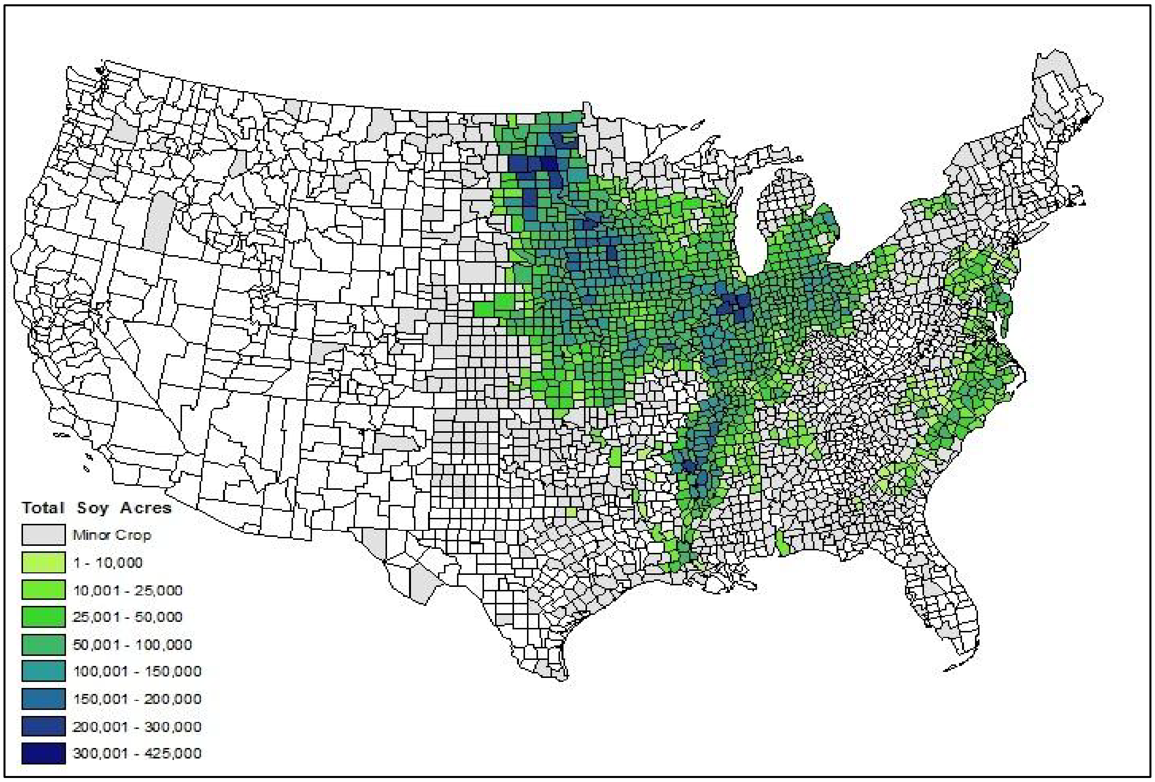

Figure 3. Soybean Cultivation in the Conterminous U.S.
Source: (USDA-NASS, 2009e).

3.1.3 Ecoregions of Major U.S. Corn and Soybean Production Areas

The affected environment includes a number of ecological regions (ecoregions) defined by the EPA and the Canada-Mexico-US Commission for Environmental Cooperation (CEC). Ecoregions are areas that are similar in type, quality, and quantity of environmental resources (CEC, 2009). The CEC uses a hierarchical system to classify ecoregions into three different levels. The broadest one is Level I. It divides North America into 15 ecological regions. These are subdivided into 50 Level II ecoregions that are then further subdivided into 182 Level III subregions. Each Level III subregion is defined by a variety of physical, biological, and human factors. These include location, climate, terrain, hydrology, vegetation, wildlife, and land use associated with human activities. The EPA ecoregions correspond to the CEC Level III subregions. A map showing the Level III subregions of the conterminous U.S. appears in Figure 4.

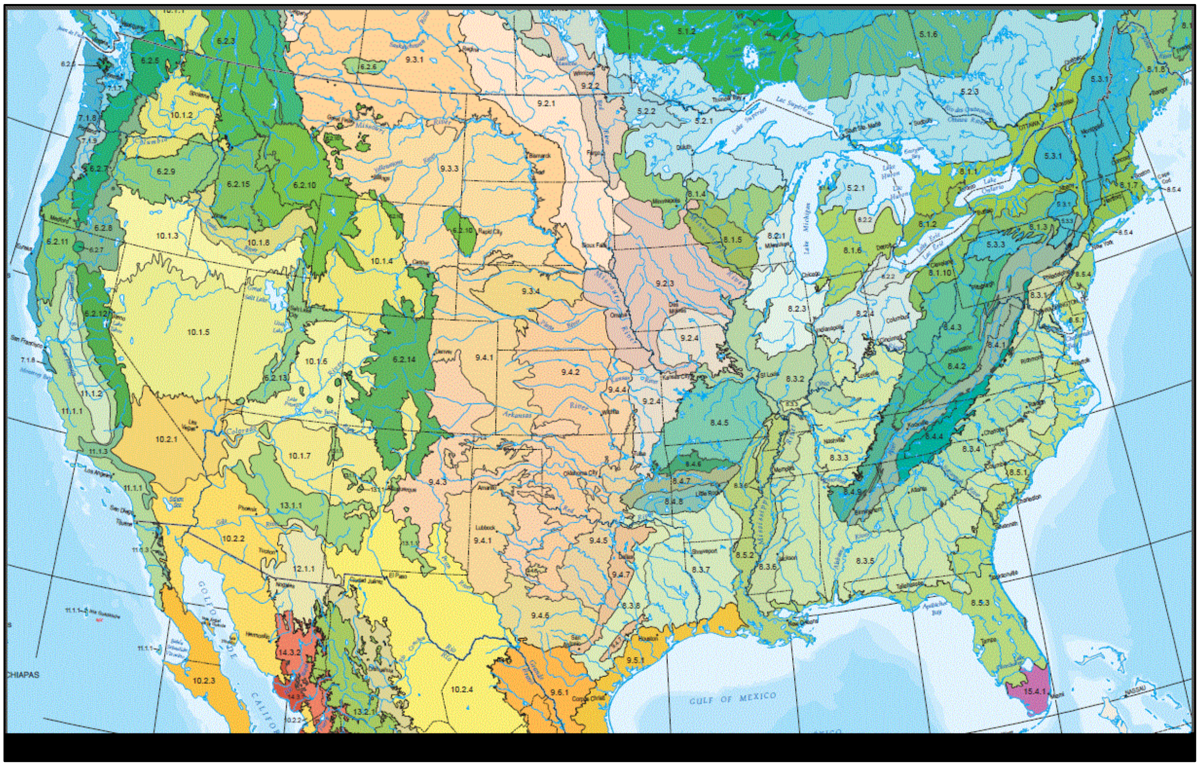

Figure 4. Ecoregions of the Conterminous U.S.
Source: (CEC, 2006)

Descriptions of the physical and biological environments in the discussion that follows are based primarily on CEC and EPA Level III definitions. In some instances, they are supplemented by EPA Level IV definitions unless otherwise cited (CEC, 2011; US-EPA, 2010b).

There are 13 regions within the affected environment in the conterminous U.S. where commercial corn and soybean production occur (Figure 1 and Figure 4, Table 2). Most are in Level I ecoregion 8 (Eastern Temperate Forests: Regions A-G in this EIS) or 9 (Great Plains: Regions H-K in this EIS). Ecoregion 8 covers most of the eastern half of the conterminous U.S. and is distinguished by its moderate to mildly humid climate, dense and diverse forest cover, and high density of human inhabitants, industry, and agriculture. Ecoregion 9 is in the central U.S. It is characterized by a sub-humid to semiarid climate that supports grasslands with minimal topographic relief. The density of agriculture is higher than that of Ecoregion 8 and the density of human inhabitants is lower. Ecoregion 9 is among the largest farming and ranching areas in the world.

A small portion of the environment affected only by corn production is in two Level I ecoregions: 10 (North American Deserts) and 11 (Mediterranean California). Only about 1 percent of U.S. corn cultivation occurs in these two ecoregions combined, but corn cultivation is a significant component of the agriculture production within them, so corn cultivation is locally important to both.

Table 2. Location and Relative Distribution of Corn/Soybean Cultivation

Region	CEC/EPA Ecoregion	Location of Corn and Soybean Cultivation	Area (sq. miles)	Percent of U.S. Harvest*	
				Corn	Soybean
A—Mixed Wood Plains (central portion) —Appalachian Forests (northern portion)	8.1.1/83 8.1.3/60 (corn only) 8.1.10/61 8.4.2/69 (northern, corn only) 8.4.3/70 (northern, corn only)	Upstate NY Northeastern OH Northeastern and western PA Western VT	60,032	2.6%	1.3%
B—Mixed Wood Plains (western portion)	8.1.4/51 8.1.5/52 8.1.6/56 5.2.1/50 (along 8.1.4 border, corn only)	Northwestern IL Northern IN Northeastern IA Central and southern MI Central and western WI	98,213	9.0%	5.7%
C—Central USA Plains	8.2.1/53 8.2.2/57 8.2.3/54 8.2.4/55	Northern and central IL Eastern, central and northwestern IN MI - east of Lake Erie and southeast of Lake Huron Western OH Southeastern WI	83,387	17.8%	17.3%
D—Southeastern USA Plains (eastern portion) —Appalachian Forests (northeastern portion) —Coastal Plains (southeastern portion)	8.3.1/64 8.3.4/45 (northern) 8.3.5/65 (eastern) 8.4.1/67 (northern) 8.5.1/63	DE Central and southwestern GA MD (most) Northwestern and southwestern NJ Eastern and central NC Eastern and central PA Eastern SC Eastern and northwestern VA	131,651	4.3%	5.5%
E—Southeastern USA Plains (northwestern portion)	8.3.2/71 8.3.3/72 8.4.5/40 (northern, along 8.3.2 border)	North-central AL Western and southern IL Southwestern IN Southeastern edge IA Central and western KY Eastern edge and central	97,017	8.4%	9.4%

Region	CEC/EPA Ecoregion	Location of Corn and Soybean Cultivation	Area (sq. miles)	Percent of U.S. Harvest*	
				Corn	Soybean
		MO North-central and south-central TN			
F—Mississippi Alluvial Plains —Southeastern USA Plains (western portion)	8.3.5/65 (western) 8.3.6/74 8.3.7/35 (Red River only) 8.5.2/73 9.5.1/34 (eastern)	Eastern and southwestern AR Western KY Northeastern, central and south-central LA Western and northern MS Southeastern MO Western TN	79,506	3.5%	11.7%
G—Temperate Prairies	9.2.1/46 9.2.2/48 9.2.3/47 9.2.4/40	IA (most) Eastern KS Western and southern MN Northern and western MO Eastern NE Eastern and north-central ND Eastern SD	201,400	33.4%	37.9%
H—West-Central Semi-Arid Prairies (eastern portion)	9.3.1/42 9.3.3/43 (eastern, corn only)	North-central NE (small area) Central and south-central ND Central SD	65,376	2.9%	2.2%
I—South-Central Semi-Arid Prairies (northern and central portions)	9.4.1/25 (corn only) 9.4.2/27 (northern) 9.4.4/28	Eastern CO Kansas (most) Western and south-central NE Eastern NM Texas Panhandle Southeastern WY	183,588	12.3%	6.1%
J—Texas Blackland Prairies	9.4.7/32	Central TX	14,130	0.5%	0%
K—Western Gulf Coastal Plain	9.5.1/34	Central Gulf Coast of TX (corn only)	28,863	0.4%	0%
L—Snake River Plain	10.1.8/12	Southern ID Southeastern OR	20,667	0.4%	0%
M—Central California Valley	11.1.2/7	Sacramento and San Joaquin Valleys CA	17,801	0.6%	0%

*Source: USDA-NASS CropScape 2012 land cover data (USDA-NASS, 2013i); full 2007 dataset not available.

3.2 Physical Environment

The physical environment includes a description of the location and physical terrain within each region, its soil and water resources, air quality, climate and climate change considerations. The primary locations of corn and soybean cultivation within Regions A-M are described in Table 2.

3.2.1 Physical Terrain and Climate

Region A is characterized by rolling hills, level ground or open valleys with low mountains along the NY-PA border; low rounded hills, scattered end moraines, kettles, and areas of wetlands to the west (8.1.10); a variety of deep glacial and marine deposits to the east (8.1.1). It has a severe mid-latitude humid continental climate marked by warm summers and cold winters, with a mean annual temperature of 5-10 degrees Celsius (°C). The frost-free period is 120-200 days. Annual precipitation is 720-1,270 millimeters (mm). Locations in closer proximity to the Great Lakes experience a longer growing season, more winter cloudiness, and greater snowfall.

Region B is characterized by a diverse range of landforms. These include nearly level to rolling plains formed from glacial deposits and outwash (some with thick complex deposits of drift), rolling to hilly moraines, deeply dissected and loess-capped plateau, lacustrine basins, and meltwater channels. It has a severe, mid-latitude, humid continental climate with warm/hot summers and severe winters. There is no distinguishable dry season. The mean annual temperature is 5-10°C with a frost-free period of 130-200 days. Annual precipitation is 600-990 mm. Winters are snowy in the north and west.

Region C is predominantly flat to rolling glacial plains, with some lacustrine clay plains, pitted outwash plains, sand dunes, and moraines. It has a severe, mid-latitude, humid continental climate marked by warm/hot summers and cold winters. The mean annual temperature is 7-13°C. The frost-free period is 150-200 days, and annual precipitation is 700-1,150 mm.

Region D includes low-rounded or irregular hills, ridges, irregular plains and rolling or open valleys to the north and west (8.3.1, 8.3.4, northern 8.4.1). Flat, rolling to smooth coastal plains prevail in the south and east (8.3.5 and 8.5.1). It has a mild, mid-latitude, humid, subtropical climate with hot humid summers and mild winters, except for the northern areas (8.3.1 and northern 8.4.1). The latter have severe, mid-latitude climates or are transitional areas with cold winters. The mean annual temperature range is 8-17°C, and the frost-free period is 145-300 days. Annual precipitation is 900-1,520 mm.

Region E consists of wide, flat-bottomed, terraced valleys, valley slopes, and river bluffs to the north and west (8.3.2). Dissected glacial till plains occur in IL and IN. A broader variety of landforms are found in the east and south (8.3.3), including gently sloping, rolling and irregular plains, dissected plateaus, tablelands and open hills. A severe, mid-latitude, humid, continental climate with hot summers and cold winters occurs in the north and west. A mild, mid-latitude, humid, subtropical climate (hot summers and mild winters) with no distinguishable dry season prevails in the south and east. The mean annual temperature range is 10-16°C. The frost-free period is 160-220 days. Annual precipitation is 850-1,470 mm. Precipitation tends to be higher in the south and east.

Region F has mostly broad and flat alluvial plains with river floodplains, terraces, swales, levees, oxbow lakes, and backswamps to the west (8.5.2 and 8.3.7). Irregular plains with some gently rolling hills occur in the east (8.3.6 and northwestern 8.3.5). Thick deposits of sandy to clayey alluvium occur in the west, thick deposits of loess are found in the central region, and fine-textured clayey sand and some loess prevail in the east and north. The region has a mild, mid-latitude, humid subtropical climate with hot and humid summers, and mild winters. The mean annual temperature range is 13-21°C. The frost-free range is generally 200-300 days, but approaches 350 days near the Gulf of Mexico. Annual precipitation is 1,140-1,650 mm. Rainfall amounts tend to be evenly distributed throughout the year, but tend to be greater in the south.

Region G has flat to gently rolling glacial till plains with thick beds of lake sediments on top and hilly loess plains with thick layers of loess. The southernmost part of the region is topographically hillier than the rest. The region has a severe, mid-latitude, humid continental climate, with a milder humid subtropical climate in the southernmost area (9.2.4). Summers are short but warm. Long cold winters with nearly continuous snow cover occur to the north. Longer hotter summers and cold, but somewhat milder winters are typical in the south. The mean annual temperature range is 3-16°C. The frost-free period is 90-225 days. Annual precipitation is 400-1,145 mm, increasing from northwest to southeast. Most precipitation occurs during the growing season.

Region H is characterized by rolling hills and gentle plains mantled almost entirely by moraine, outwash, and glaciolacustrine sediments. It has a dry, mid-latitude steppe climate with warm to hot summers and cold winters. The mean annual temperature range is between 3°C in the north to 9°C in the south. The frost-free range is 95-150 days. Annual precipitation ranges from 250 mm to 510 mm.

Region I is composed primarily of smooth, level to slightly irregular plains, with broad alluvial valleys and some hillier dissected plains in the central part of the region (9.4.2). Rolling hills and narrow steep valleys occur in the east (9.4.4). Climate varies across both directional gradients (i.e., north-south and east-west). The west has a mid-latitude steppe climate. The east has a mid-latitude humid continental climate. Summers are hot and winters are cold in the north and milder along the gradient southward south. Mean annual temperatures range from 8°C (north) to 18°C (south). The frost-free date range is 120 – 230. Annual precipitation ranges from 300 to 1,065 mm. It tends to be significantly greater in the easternmost part of the region (9.4.4) than elsewhere.

Region J is characterized by nearly level to gently sloping plains that are lightly to moderately dissected. It has a mild mid-latitude humid subtropical climate (i.e., hot summers; mild winters). The mean annual temperature range is 17-21°C and the frost-free period is 240-290 days. Annual precipitation is 760-1,170 mm. It declines along the north to south gradient.

Region K tends to be gently sloping coastal plains in the agricultural areas, with sediments of marine sand, silt, and clay. It has a mild, mid-latitude, humid subtropical (hot summers; mild winters). The mean annual temperature is in the range of 20-25°C. There is a long frost-free period (270 – 365 days). The mean annual precipitation range is 600-1,625 mm. There is a steep increase in precipitation along the southwest to northeast gradient.

Region L is characterized by alluvial valleys, plains, and low hills, interspersed with scattered barren lava fields. It has a dry, mid-latitude steppe climate marked by warm summers and cold winters. The mean annual temperature range is 6-10°C, increasing along the east-to-west gradient. The frost-free period ranges from 90 – 170 days, decreasing from west to east, which corresponds to increasing elevation. The mean annual precipitation range is 150-400 mm.

Region M is characterized by flat fluvial plains filled with deep and well-drained loamy or clayey soils formed by deposits washed down from the surrounding mountains. It has a Mediterranean climate, with long, hot dry summers and mild, slightly wet winters. The mean annual temperature range is 15-19°C, with a frost-free period of 240 to 350 days. The mean annual precipitation ranges from 125 mm in the south to 760 mm in the north.

3.2.2 Soil Resources

Soils are an admixture of weathered minerals, organic matter, air and water. They are formed mainly by the weathering of rocks, the decaying of plant matter, and the deposition of materials such as chemical and biological fertilizers that are derived from other origins.

Particle size, texture and color are important attributes used to classify a soil type into one of twelve taxonomic orders. Properties such as organic matter content and degree of soil profile development are also used (Brady & Weil, 1996) to systematically classify soils according to relationships that define their character (USDA-NRCS, 1999b). Eight soil orders (Table 3) are predominant in areas where corn and soybean are grown.

Corn is cultivated in a wide variety of soils across the U.S. (see, e.g., Corn Crop Profiles provided at www.ipmcenters.org). Soybean production is best suited to fertile, well-drained, medium-textured loam soils, yet they can also be produced in a wide range of soil types (Berglund & Helms, 2003; NSRL, No Date).

Table 3. Affected Environment: Dominant and Major Secondary Soil Types by Region

Soil Order	Description	Region
Alfisols	A dark surface horizon mineral soil, similar to mollisols however, lacking the same level of fertility and more acidic.	A, B, C, D, E, F, G, I, J, K, M
Aridisols	These soils are found in the arid regions of the US. Typically high in calcium, magnesium, potassium and sodium. The soils have an alkaline pH.	L, M
Entisols	This soil order is relatively un-weathered. These soils have no diagnostic horizon development. Often found on floodplains, glacial outwash areas and other areas receiving alluvial materials.	B, F, H, M

Soil Order	Description	Region
Histosols	Dominated by organic soil materials, some consist of a thin layer of organic materials over a root-limiting layer or fragmental materials; commonly called bogs, peats, mucks	B
Inceptisols	Soils of the humid and sub humid region. Weathering has created minimal diagnostic differentiation in the soil column.	A, B, C, D, E, F
Mollisols	Dark colored mineral soils developed under grassland conditions. Rich in nutrients, very fertile. Associated with the corn belt.	A, B, C, E, G, H, I, J, L, M
Ultisols	Highly weathered soils found in hot, moist regions. Typically acidic and low in available nutrients.	D, E
Vertisols	Soils having significant amounts of expanding clay content. Soils typically crack when dry and swell when wet.	F, G, H, J, K, M

Source: (USDA-NRCS, 1999b)

Soil properties are dynamic. Temperature, pH, soluble salts, amount of organic matter, the carbon-nitrogen ratio, numbers of microorganisms, and soil fauna all vary seasonally, and shifts in these parameters also occurs over broader extended periods(USDA-NRCS, 1999b). Soil texture and organic matter levels directly influence shear strength, nutrient holding capacity, and permeability(McCauley et al., 2005). Soil types also influence susceptibility to erosion by wind and water and the capacity to attenuate flooding (McCauley et al., 2005).

Soil erosion is a naturally occurring event and the erosion rates are relatively slow; however, human activity can greatly accelerate the rate of erosion. In general, wind and/or water erosion are important soil resource concerns in the major U.S. corn- and soybean-growing. Wetness and maintenance of organic matter content in the Corn Belt (USDA-FSA, 2010) are of similar importance. Figure 5 depicts a USDA map of erosion exceeding the soil loss tolerance rate on cropland in the U.S. (USDA-NRCS, 2011). Excessively eroding cropland soils are concentrated in Midwest and Northern Plain States and in the Southern High Plains of Texas (regions C, G, and I). Land management practices for crop cultivation can also affect soil quality. Tillage, use of pesticides and fertilizers and other practices can improve soils, but must be applied using good management practices) to avoid degrading soil quality. Several concerns relating to soil and agricultural practices include increased erosion, soil compaction, degradation of soil structure, nutrient loss, increased salinity, change in pH, and reduced biological activity (USDA-NRCS, 2001b). Conventional tillage entails removal of all plant residues and weeds from the soil surface prior to planting. It also requires continued cultivation as the crop develops to control late emerging weeds (NCGA, 2007b). This practice increases the potential for soil loss from wind and water erosion (NCGA, 2007b).

Soil conservation practices, include conservation tillage, reduce field tillage and corresponding soil loss (USDA-NRCS, 2006c). Conservation tillage relies on methods that result in less soil disruption and leaves at least 30 percent of crop residue on the surface(Peet, 2001). No-till farming only disturbs the soil during seeding operations. The new crop is planted into residue or in narrow strips of tilled soil (Peet, 2001), which results in less soil disruption.

Reducing tillage has several benefits for soil health, but there are associated management concerns. Under no-till practices, soil compaction may become a problem because tillage is useful for breaking up compacted areas (USDA-NRCS, 1996). Reducing tillage may also enhance conditions for development of economically significant pest populations that are managed more efficiently with conventional tillage (NRC, 2010). Another consideration is soil type because not all soils (such as wet and heavy clay soils in northern latitudes) are suitable for no-till practices.

Inorganic and organic matter in soil supports a diversity of fungi, bacteria, and arthropods that are important components of the growth medium for terrestrial plant life (USDA-NRCS, 2004). Soil microorganisms are critical for soil structure formation, decomposition of organic matter, toxin removal, nutrient cycling, and most biochemical soil processes (Garbeva et al., 2004; Jasinski et al., 2003; Young & Ritz, 2000). They also suppress soil-borne plant diseases and promote plant growth (Doran et al., 1996).

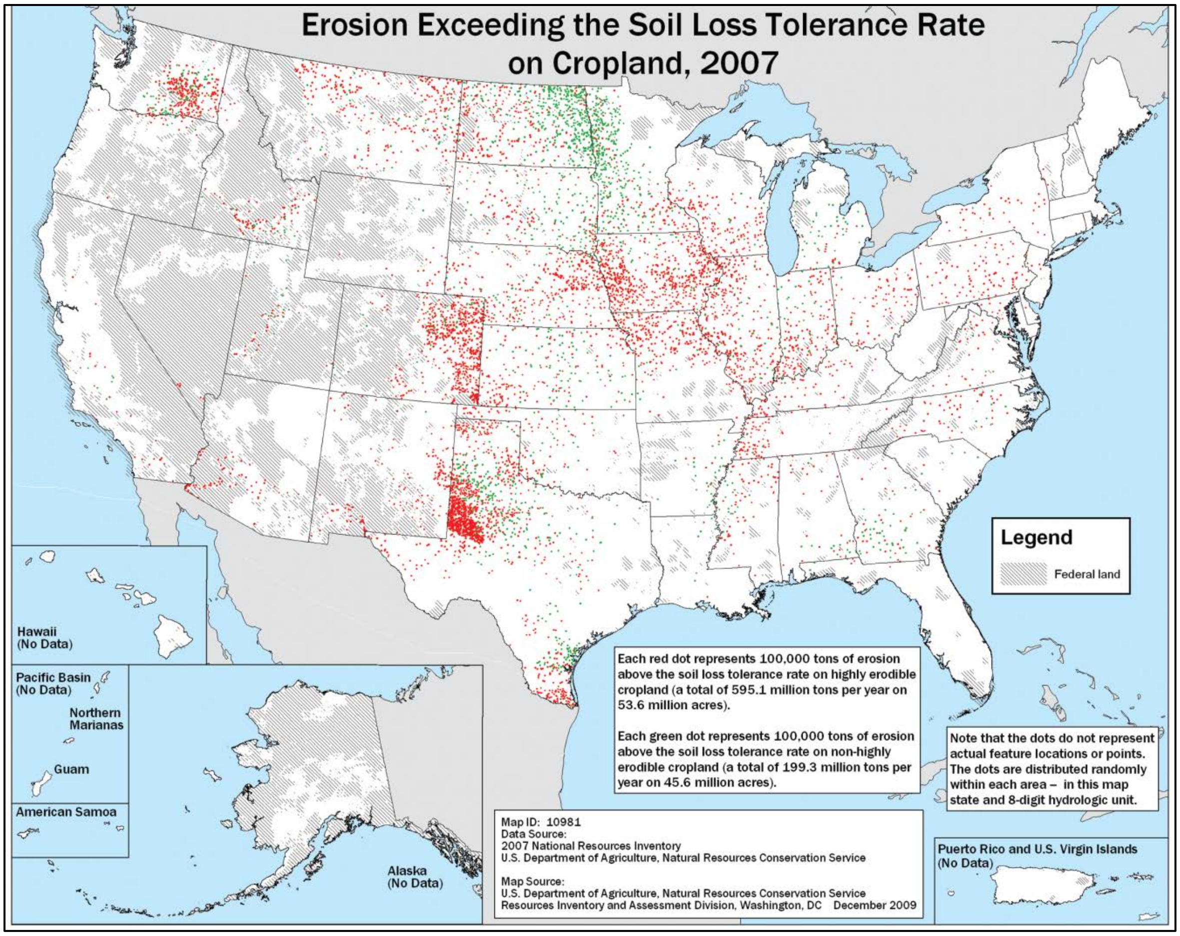

Figure 5. Locations of Excessively Eroding U.S. Croplands
Source: (USDA-NRCS, 2011)

The main factors affecting microbial population size and diversity include: (1) the plant species, cultivars, and developmental stages present, which provide specific carbon and energy inputs into the soil; (2) soil type (determined by texture, structure, organic matter, aggregate stability, pH, and nutrient content); (3) geographic location; (4) season; (5) weather; (6) agricultural management practices (crop rotation, tillage, herbicide and fertilizer application, and irrigation) (Garbeva et al., 2004; Kowalchuk et al., 2003; Young & Ritz, 2000).

Plant roots, including those of soybean, release a variety of compounds into the soil that created a unique environment for microorganisms in the rhizosphere. These include mycorrhizal fungi, nitrogen-fixing bacteria, and some free-living microbes that have co-evolved with plants that supply nutrients to obtain food from their plant hosts (USDA-NRCS, 2004). Microbial diversity in the rhizosphere may be extensive and differs from the microbial community in the bulk soil (Garbeva et al., 2004). Tillage disrupts multicellular relationships among microorganisms, and crop rotation changes soil conditions in ways that favor different microbial communities.

3.2.3 Water Resources

Resources analyzed in this section include the quality and quantity of water in surface and groundwater. Impacts from human consumption, particularly water for irrigating agricultural production, are also reviewed.

Surface water in rivers, streams, creeks, lakes, reservoirs, wetlands and estuaries provides water for drinking, irrigation, industrial, recreational and other public uses. About 66 percent of water used in the U.S. in 2005 (about 410 billion gallons per day) was from fresh surface water sources (USDA-FSA, 2010).

Groundwater from aquifers sustains ecosystems by releasing a continuous supply of water into wetlands, and permanent streams and rivers. In 2005, it contributed about 19 percent of freshwater used in the U.S. (USDA-FSA, 2010). Groundwater supplies drinking water for approximately 47 percent of the U.S. population (McCray, 2009).

Water in agriculture is used for irrigation, pesticide and fertilizer applications, crop cooling (e.g., light irrigation), and frost control (US-CDC, 2009). Moisture availability and use for crop irrigation are important determinants of yield. Irrigation maintains adequate moisture for a crop, so it contributes to agriculture production by increasing yields per acre, and by making more acreage (i.e., dry lands) usable. It also moderates fluctuations in product quality. Moisture requirements for most crops tend to vary during development. An adequate water supply permits irrigation during critical periods of the growing cycle, so is an important contributor to both optimal quality and yield (US-EPA, 2012b).

Irrigation is especially important to agriculture in the western U.S. and the Mississippi River Valley (Figure 6). Most irrigation in California (region M) is used for alfalfa, cotton, orchards, and vegetables rather than corn. In Idaho (region L), most irrigation is for wheat, alfalfa and row crops (USDA-NASS, 2009a). Nationally, less than 10 percent of soybean acres and approximately 15 percent of corn acres are irrigated. However, corn accounts for about 25 percent of irrigated acres nationally, while soybean accounts for about 25 percent of irrigated acres in the eastern 31 states (Schaible & Aillery, 2012). Corn is heavily irrigated in the western plains states (region I; particularly Nebraska, Kansas, and the Texas panhandle). Soybean is heavily irrigated in central Nebraska (region I) and both corn and soybean are heavily irrigated in the Mississippi River Valley (region F) (USDA-NASS, 2009b; c).

Both groundwater and surface water can be used for irrigation, which accounted for approximately 28 percent of withdrawals from fresh surface water sources and about 67 percent of withdrawals from fresh groundwater sources in 2005 (USDA-FSA, 2010). Groundwater sources are especially important for irrigation in the regions mentioned above, with seven states (California, Nebraska, Arkansas, Texas, Idaho, Kansas, and Colorado) accounting for over 70 percent of total groundwater withdrawals in 2005. In four of these states (Arkansas, Kansas, Nebraska, and Texas), fresh groundwater accounted for 75 to 96 percent of all irrigation water. Groundwater use also exceeded 90 percent of that for irrigation in Mississippi and Missouri (USDA-FSA, 2010). Groundwater serves as the source of about 90 percent of irrigated corn acreage in the U.S. (Christensen, 2002; US-EPA, 2012b).

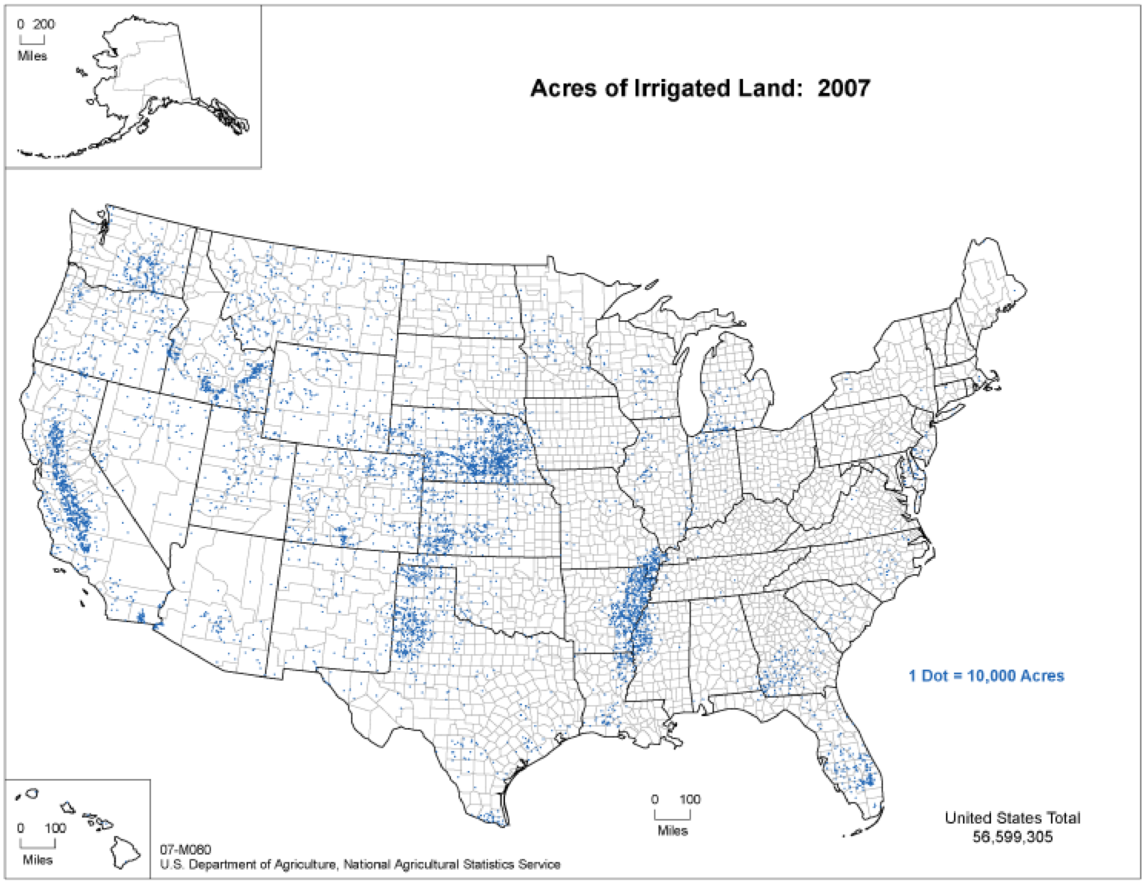

Figure 6. U.S. Irrigated Acreage, 2007
Source: USDA, National Agricultural Statistics Service, Map # 07-M080 (USDA-NASS, 2009a).

In addition to the Level III and Level IV Ecoregion descriptions, information on water resources was obtained from the U.S. Geological Survey (Konikow, 2013; USGS, 2013b).

Region A contains perennial streams, the Hudson River and several other large rivers, Lake Ontario, the Finger Lakes, and a number of small lakes, and abundant wetlands in some areas.

Region B has many perennial streams, with wetlands and lakes more common in northern areas. The northern Mississippi River runs through the region. Groundwater is abundant and is the major source of irrigation water in Minnesota and Wisconsin (USDA-FSA, 2010).

Region C has a low to medium density of perennial streams, which are often intermittent in the southern portions of the region. Some areas have lakes, wetlands, and abundant groundwater. These are major sources of irrigation water in Illinois and Wisconsin. Drainage has been greatly modified in 8.2.2 and 8.2.3, and stream chemistry, turbidity, and habitat have been affected by agriculture.

Region D has a moderate to dense network of streams and rivers. Some reservoirs and a few natural lakes are present in the north. Numerous swamps and marshes prevail in the south. The Roanoke, Savannah, and Susquehanna Rivers run through the region.

Region E has numerous perennial streams and rivers in 8.3.2. Silt and sand dominate lowland channels; upland streams are rockier. There are both perennial and intermittent streams and numerous springs in 8.3.3, with higher nutrient, alkalinity and hardness levels than the streams in 8.3.2. In the Western Pennyroyal region of Kentucky and Tennessee a complex of numerous sinkholes, ponds and well-developed underground drainage system promote rapid surface soil moisture loss. Major rivers crossing this region include the Illinois, Missouri, Mississippi, Ohio, Tennessee and Wabash.

Region F is dominated by the Mississippi River. One of the largest continuous wetland systems in North America was also present in this region, but extensive areas have been modified by channelization, and other navigation and flood control engineering projects. The Red River also runs through the region, and oxbow lakes, backswamps, and ponds also occur. In the eastern part of the region there are few lakes but a moderate to dense network of perennial and intermittent streams and rivers, including the Tombigbee. The Mississippi alluvial valley aquifer is the major groundwater irrigation (USDA-FSA, 2010). Water withdrawals from the aquifer greatly exceed recharge from surface waters (Konikow, 2013).

Region G consists mainly of low density of rivers and intermittent or perennial streams. A higher density of rivers occurs in the south, including the Des Moines, Kansas, and Missouri Rivers. The Minnesota River and the Red River are the major rivers in the north. Many streams and rivers have been channelized. Abundant temporary and seasonal wetlands occur in the north, creating favorable conditions for waterfowl nesting and migration. A few large reservoirs occur in the south. Groundwater is highly mineralized in some areas. Surface and groundwater contamination from fertilizer and pesticide applications, and concentrated livestock production are significant environmental problems in the central part of the region (9.2.3).

Region H includes primarily intermittent streams and some perennial ones. The Missouri River which runs along the western boundary of most of the region is the most important river system. In some areas, a high concentration of semi-permanent and seasonal wetlands occurs.

Region I is characterized by intermittent and ephemeral streams in the western part, and intermittent and perennial steams in the east. There are few lakes, some springs and ephemeral pools and several rivers: Arkansas, Platte, Kansas and their tributaries. The Ogallala aquifer underlies large portions of this ecoregion and it is the major source of irrigation water within it (USDA-FSA, 2010). Withdrawals from this aquifer greatly exceed recharge from surface waters (Konikow, 2013; Steward et al., 2013).

Region J has intermittent and perennial streams. The region lacks lakes but there are many man-made reservoirs.

Region K has intermittent and perennial streams. Some have been channelized. There are numerous wetlands in the eastern part of the region.

Region L is traversed by the Snake River. Canals and reservoirs are prevalent in and near agricultural areas. Aquifers underlying the Snake River plain are an important groundwater source for irrigation that is secondary to what is supplied from surface water.

Region M has two major river systems, the Sacramento and San Joaquin. Most streams in the region are intermittent, being dry during summer months. Some vernal pools, marshes, and wetlands also occur. The region has an extensive network of water diversions, man-made channels and drainage systems. Management of irrigation water is a priority in the region (USDA-NRCS, 2006d). Although secondary to surface water, central valley groundwater is a major source for irrigation, which is an important consideration since withdrawals currently exceed recharge rates (Konikow, 2013).

3.2.4 Water Quality

Natural features (i.e., the physical and chemical properties) of the land surrounding a water body have the greatest impact on water quality. The topography, soil type, vegetative cover, minerals, and climate also influence water quality. Runoff from rain, snowmelt, or irrigation can affect water quality by depositing sediment, minerals, and natural and human-made pollutants into lakes, rivers, wetlands, and coastal waters. Major sources of pollutants include storage tanks, septic systems, hazardous waste sites, and landfills. Widespread use of road salts, fertilizers, pesticides and other agricultural chemicals are also important sources. All surface water pollutants have the potential to be transported into groundwater.

Agricultural pollution is the leading source of impacts on surveyed rivers and lakes. It's also the third most significant cause of impairment of water quality in estuaries, and a major source of contamination of groundwater and wetlands (USDA-EPA, 2011).

The most common types of agricultural pollutants include excess sediment, fertilizers, animal manure, pesticides and herbicides. Management practices that contribute to water contamination include the type of crop cultivated, plowing and tillage, and irrigation. Irrigation depletes available water and reduces quality by increasing erosion and sedimentation, nutrients dissolved in runoff and chemicals adsorbed onto soil particulates washed into surface water. Some of these pollutants eventually contaminate groundwater by leaching.

Sediment can directly affect fish, aquatic invertebrates, and other wildlife. It also reduces light penetration, which directly impacts aquatic plants. Sediments from erosion contribute to fertilizer runoff, water turbidity, algal blooms, and oxygen depletion (US-EPA, 2005a). Fertilizers and pesticides have been found to be in excess in many water bodies in the EPA (USDA-FSA, 2010) has documented over 3 million acres of water bodies and over 75,000 miles of rivers and streams, large areas of bays and wetlands with excess levels of nitrogen and phosphorus. These two nutrients, when in excess, create harmful blooms of algae and other aquatic flora which deplete oxygen that can result in many detrimental effects including fish kills. According to an EPA Report on the Environment for 2008, groundwater has also been seriously affected by various nutrient and pesticides (USDA-FSA, 2010).

3.2.5 Air Quality

The Clean Air Act (CAA) requires National Ambient Air Quality Standards (NAAQSs). These are intended to protect public health, and are established by EPA for six criteria pollutants: ozone (O_3), nitrogen dioxide (NO_2), carbon monoxide (CO), sulfur dioxide (SO_2), lead (Pb), and inhalable particulates. The latter are subdivided into particulate matter (PM, coarse particulate matter greater than 10 µm [micrometers]), PM_{10} (particulates 2.5-10 µm), and $PM_{2.5}$, (fine particles less than 2.5 µm).

The CAA requires states to achieve and maintain the NAAQSs within their jurisdiction. Each state must prepare a State Implementation Plan with strategies to achieve and maintain the EPA-established national standards or more stringent ones within its boundaries. EPA monitors levels and designates states as attainment or non-attainment areas for each criteria pollutant.

Some agricultural operations impact air quality. They include smoke from burning, exhaust from motorized equipment, and airborne soil particulates from tillage. Aerosols from pesticide applications are another source of impacts on air quality. Effects are complex because aerosols can: 1) drift from the target site; 2) volatilize, which increases the area impacted; 3) adsorb unto soil particles that have the potential to become airborne. Some gases resulting from agricultural activities also impact air quality. They include CO_2 from equipment exhaust and tillage, CO_2 and methane from tillage, and oxides of nitrogen associated with fertilizer applications (Aneja et al., 2009; Hoeft et al., 2000; US-EPA, 2011b; USDA-NRCS, 2006a).

3.2.6 Climate Change

Agriculture is estimated to contribute 6 percent of all human-induced greenhouse gases (GHG) in the U.S. (US-EPA, 2011b). Emissions of GHG released from agricultural equipment (e.g., irrigation pumps and tractors) include carbon monoxide, nitrogen oxides, methane (CH_4), reactive organic gases, particulate matter, and sulfur oxides (US-EPA, 2011b). Nitrogen-based fertilizers applied for crop production are the greatest source of U.S. nitrous oxide (N_2O). Croplands account for 69 percent of total N_2O emissions attributable to agricultural land uses (US-EPA, 2011b). Agriculture sources of CH_4 emissions are associated primarily with enteric emissions of gas from cattle and manure management. CO_2 also is a significant GHG associated with several agricultural practices, including land uses and energy consumption (US-EPA, 2011b).

Tillage contributes to GHG emissions by releasing CO_2 from fuel consumption. The more aggressive the tillage, the greater the fuel consumption and the greater the GHG emissions. At one time it was thought that conservation tillage also promoted carbon sequestration in the soil but more recent observations have called that benefit into question (Baker et al., 2007; Blanco-Canqui & Lal, 2008). Disruption and exposure of soil also promotes CO_2 production from oxidation of soil organic matter (Baker et al., 2005). The carbon footprint for corn production has been estimated to be approximately 300 pounds of carbon equivalent emission per acre (Nelson et al., 2009). The carbon footprint of corn is directly affected by the associated cultivation practices. Corn cultivation has been estimated to produce higher total CO_2 emissions than soybean, and lower total emissions than cotton or rice (Nelson et al., 2009). On-site emissions can be reduced by half for some crops by replacing conventional with no-till systems agriculture (Nelson et al., 2009).

Important factors influencing agricultural impacts on climate change include production practices specific to the production of various types of commodities, the region in which the commodities are grown, and individual choices made by growers. For example, emissions of N_2O, produced naturally in soils through microbial nitrification and denitrification, can be influenced dramatically by fertilization, introduction of grazing animals, cultivation of nitrogen-fixing crops and forage (e.g., alfalfa), retention of crop residues (i.e., no-till conservation), irrigation, and fallowing of land (US-EPA, 2011b). These same agricultural practices can influence the decomposition of carbon-containing organic matter sequestered in soil, resulting in conversion to CO_2 and subsequent loss to the atmosphere (US-EPA, 2011b). Conversion of crop land to pasture increases in carbon and nitrogen sequestration in soils (US-EPA, 2011b).

The EPA has identified regional differences in GHG emissions associated with agricultural practices on different soil types, noting that carbon emission rates differ between mineral soils and organic soils (US-EPA, 2011b). Mineral soils contain from 1 to 6 percent organic carbon by weight in their natural state. Organic soils may contain as much as 20 percent carbon by weight (US-EPA, 2011b). Up to 50 percent of the soil organic carbon in mineral soils can be released to the atmosphere when land is initially converted to crop production. Over time, the soil establishes a new equilibrium that reflects a balance between carbon from decaying plant matter and organic amendments, and carbon released by microbial decomposition (US-EPA, 2011b). Organic soils continue to release carbon to the atmosphere for a longer period of time than mineral-based soils (US-EPA, 2011b) . The EPA has estimated that mineral soil-based cropland areas sequestered over 45.7 Tg CO_2 Eq[5] in 2008. Carbon emissions from croplands with organic soils were estimated to be 27.7 Tg CO_2 Eq (US-EPA, 2011b). Conservation tillage, particularly in Midwest regions where mineral-based soils prevail, had the highest rates of carbon sequestration (US-EPA, 2011b).

Agriculture-related GHG production will not change significantly unless large amounts of crop plantings produce changes in measureable concentrations (USDA-APHIS, 2010b). For example, the EPA has identified a net decline in the sequestration of carbon in soil over an 18-year period. It attributes this to the impact of the Conservation Reserve Program which encouraged growers to take marginal lands out of production (US-EPA, 2011b). To a certain extent, the EPA also noted that adoption of conservation tillage resulted in increases in carbon sequestration on those croplands (US-EPA, 2011b). The highest rates of carbon sequestration in mineral soils occurred in the Midwest, which is the region with the largest area of cropland managed with conservation tillage (US-EPA, 2011b). This is in contrast to the highest emission rates from organic soils noted in the southeastern coastal region, the areas around the Great Lakes, and the central and northern agricultural areas along the West Coast (US-EPA, 2011b).

[5]The global warming potential of greenhouse gases is measured against the reference gas CO_2; reported as teragrams (millions of metric tons) of CO_2 Equivalent, expressed as Tg CO_2 Eq.

One impact of climate change on agriculture is a general increase in the current range of weeds and pests; a trend that is expected to continue. Modification of current agricultural practices will be required to respond to counter these pests (Field et al., 2007).

Climate change may have a positive impact on agriculture in general. The Intergovernmental Panel on Climate Change (IPCC) predicts that potential climate change in North America may result in an increase in crop yield by 5-20 percent during the current century (Field et al., 2007). However, the extent of positive effects on agriculture from climate change is highly speculative and will not be observed in all growing regions. The IPCC report indicates for example that certain regions of the U.S. will be impacted negatively by a significant decline in available water resources. Nevertheless, North American production is expected to adapt to climate change impacts with improved cultivars and responsive farm management (Field et al., 2007).

3.2.7 Land Resources

Land resources are subdivided in this section into land cover and land use. According to the Food and Agricultural Organization of the United Nations (FAO), land cover is the observed physical cover on the surface of the earth as seen from the ground or through remote sensing. It includes vegetation (natural or planted) and human constructions such as buildings and roads (FAO, 1997).

Land use refers to the function or the purpose for which the land is being used. Therefore, land use can be defined as an activity or series of activities undertaken to produce one or more goods or services (FAO, 1997). FAO also indicates that a given land use may take place on one or more parcels, and several different uses may occur on a single parcel. This definition provides a basis for precise and quantitative economic and environmental impact analyses of different uses.

Land cover—Land cover data were obtained for each Level III ecoregion using USDA-NASS CropScape (USDA-NASS, 2013i). Statistical data for acreage generated by CropScape tends to be low, so estimates should be considered raw numbers requiring a correction factor (USDA-NASS, 2013i). However, the bias in estimates of area for different land covers is proportionately equal, enabling accurate comparisons of the area of different land cover classes relative to each other.

NASS uses the 2006 U.S. Geological Survey (USGS) National Land Cover Dataset (NLCD) (USGS-NLCD, 2006) to help identify non-agricultural land cover (USDA-NASS, 2013i). Table 4 compares the land cover groups and classes used in NLCD 2006 to those used in this analysis, and lists the class number used in each categorization. For definitions of land classes, see NLCD (2013).

Table 4. Comparison of NLCD 2006 Land Cover Groups to Classes Used in This EIS

NLCD 2006	This EIS
Water: Open water (11) Perennial ice/snow (12)	Water (1)

NLCD 2006	This EIS
Developed: Open space (21) Low Intensity (22) Medium Intensity (23) High Intensity (24)	Developed (2)
Barren (31)	Barren (3)
Forest: Deciduous (41) Evergreen (42) Mixed (43)	Forest: Deciduous (4a) Evergreen (4b) Mixed (4c)
Shrubland (52)	Shrubland (5)
Herbaceous: Grassland/Herbaceous (71)	Grassland/Herbaceous (6)
---	Pasture and Hay (7) (excluding alfalfa)
Planted/Cultivated: Pasture/Hay (81) (including alfalfa) Cultivated Crops (82) (including orchards; vineyards)	Cropland: Orchards & Vineyards (8a) Row crops (8b) (including alfalfa; non-forestry trees) Fallow (8c)
Wetlands: Woody (90) Herbaceous (95)	Wetlands (9)

Land cover composition varies across the affected environment (Table 5). For example, developed land ranges from 3 to 17 percent of land cover among the regions, accounting for 10 percent or more of the land cover in regions A, B, C, D, J, K, and M. Central Plains regions H and I, and region L in Idaho have much lower amounts of developed land. Wetlands account for 17 percent of the Mississippi Alluvial region F, and 12 to 14 percent of region B and Coastal Regions D and K, but make up much smaller proportions of other regions.

Dominant vegetation types also vary among regions. A summary follows:

Region A: forest is dominant, accounting for nearly 50 percent of land cover, followed by pasture/hay and cropland in roughly equivalent amounts (13 to 15 percent).

Region B: forest is slightly dominant, accounting for about 33 percent of land cover, followed by cropland at about 27 percent and pasture/hay and wetland at approximately 10 percent each.

Region C: cropland is dominant, accounting for approximately 60 percent of land cover, with forest and pasture/hay each covering less land (10 to 12 percent) than developed areas (14 percent).

Region D: forest is dominant, accounting for over 40 percent of land cover, followed by cropland and wetlands at approximately 15 percent each and the combination of pasture/hay and grassland at 12 percent.

Region E: forest is dominant, accounting for about 40 percent of land cover, while cropland and pasture/hay each account for approximately 25 percent of land cover.

Region F: cropland is dominant, accounting for slightly under 40 percent of land cover, while forest covers 20 percent and wetland covers 17 percent of the region.

Region G: cropland is dominant, accounting for about 55 percent of land cover, while pasture/hay and grassland account for about 10 percent each.

Region H: grassland is dominant, accounting for about 55 percent of land cover, while cropland accounts for about 30 percent.

Region I: cropland is slightly dominant, accounting for a little over 40 percent of land cover, while grassland accounts for 30 percent and pasture/hay for 15 percent.

Region J: grassland is slightly dominant, accounting for about 25 percent of land cover, followed closely by cropland at slightly over 20 percent and pasture/hay at slightly over 15 percent.

Region K: cropland and pasture/hay are co-dominant, each accounting for slightly under 25 percent of land cover, followed by shrubland, grassland, and wetland at roughly 12 percent each.

Region L: shrubland is dominant, accounting for over 50 percent of land cover, while cropland accounts for about 25 percent; this region is notable for a fairly high level of barren land (about 5 percent) compared to all other regions (1 percent or less).

Region M: cropland is dominant, accounting for nearly 55 percent of land cover, followed by grassland at about 20 percent of land cover.

Table 5. Land Cover Composition by Region

Land Cover Composition	**Percent* Composition by Region**												
	Region												
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**
1. Water	3	3	1	2	2	3	2	3	<1	2	2	1	1
2. Developed	12	9	14	11	8	6	7	3	4	17	13	4	11
3. Barren	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	1	4	1
4a. Deciduous	43	30	12	24	38	13	7	1	1	10	2	<1	<1
4b. Evergreen	3	2	<1	16	1	5	<1	<1	<1	1	1	1	<1

Land Cover Composition	Percent* Composition by Region												
	Region												
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**
4c. Mixed	3	1	<1	1	<1	2	<1	<1	<1	<1	<1	<1	<1
5. Shrubland	3	1	<1	4	<1	5	<1	<1	6	4	12	52	<1
6. Grassland	1	5	1	4	1	<1	11	56	30	26	11	2	20
7. Pasture/hay	15	10	10	8	23	11	13	5	15	17	23	10	1
8a. Orchards	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	22
8b. Row crops	12	27	59	13	25	34	56	29	36	21	18	23	22
8c. Fallow	1	<1	<1	2	<1	4	<1	1	6	1	5	2	10
9. Wetlands	3	12	2	14	1	17	4	2	1	2	13	1	2

*Rounded to nearest whole percent; totals may not add to 100 percent because of rounding errors. Source: USDA-NASS CropScape land cover data for 2012 (USDA-NASS, 2013i).

Land Use: This analysis includes details about human interactions with their environment, both natural and human-induced. Such analyses address how different land uses interact. It also identifies any potential conflicts between current and new land uses.

The major land uses of the affected environment are agriculture (including crop cultivation, pasture and rangeland, animal production, forestry and logging), industrial, housing/residential (including urban, suburban and rural), and recreational and tourism. However, the relative proportions of major land uses vary between and within regions. Table 6 shows the major crops grown in each region (excluding hay). Data on animal production is from the 2007 Census of Agriculture (USDA-NASS, 2009e).

Region A: Principal crops include corn, soybean, and alfalfa. Grain production is primarily for dairy cattle. Hay exceeds corn production acreage by 40 percent. Orchards, vineyards and row crops are also important in New York. Surface and underground coal mining (USGS, 2013a), and logging are important in parts of western Pennsylvania. As a result, sedimentation and acidification of surface waters are serious environmental problems. Compared with other U.S. regions, there is a relatively high density of road networks, which is consistent with current non-agricultural and non-mineral land-use patterns in the region: industrialization, urbanization, and development for recreation and tourism.

Region B: Agricultural uses include cultivated cropland, pasture, livestock and dairy farming. Corn, soybean, and alfalfa are the principal crops, along with some wheat. Dry beans, potatoes, vegetables, cherries and other fruits are important crops in the eastern part of the region. Dairy farming is prevalent in Wisconsin. Other important land uses are recreation and tourism, and mineral extraction, including peat harvesting, and industrial sand and gravel mining (USGS, 2013a).

Region C: Most land use devoted to agriculture and cropland is extensive throughout the region. The predominant crops are corn and soybeans. Less important crops include wheat, alfalfa, dry beans, and squash. In Wisconsin most of the cropland is devoted to forage and feed grains to support dairy operations. Livestock and egg production are also common. There are several large urban and industrial centers. Smaller urban, suburban and rural residential land uses occur throughout the region.

Region D: Land use in the north is primarily for agriculture or urban and suburban industrial use. Feed and forage crops and soybeans are prevalent. Nurseries for horticultural products and Christmas tree farms occupy some areas. The remainder of the region includes a mosaic of cropland, pasture, woodland and forests. Pine plantations are particularly prevalent to the south. Predominant crops in the region are soybean, corn, cotton, wheat, and peanuts. Other important crops include tobacco, pecans, sweet potatoes, peaches, and watermelon. Hay production areas are approximately equivalent to that for corn. There is also a high density of poultry and hog production in some parts of the region. Land use in coastal areas within the region is characterized by a high density of urban and suburban development with recreation and tourism.

Region E: Land use in the north and west is dominated by cropland agriculture and pasture. The east and south tends to have a higher diversity of land uses that includes cropland, pasture, forest, and woodlots with some expanding urban areas. Corn and soybean are the predominant crops. Wheat is also an important crop in the region, and tobacco is a significant crop in Kentucky. Livestock production, poultry farming and egg production are also common. Mineral extraction is important in some parts of the region. This includes some oil and gas production in the south and east. Surface and underground coal mining are important industries in western Kentucky, southern Illinois and Indiana (USGS, 2013a), and these areas are associated with significantly degraded downstream wetland habitat and water quality.

Region F: Except for the southern-most portion of the Mississippi Alluvial Plain (8.5.2), most of the region is cropland or pasture. Soybean is the predominant crop. Rice is another major crop. More than 70 percent of U.S. rice is produced in this region. Other important crops include corn, cotton, wheat, sugarcane, and sweet potatoes. About 85 percent of U.S. aquaculture is conducted in this region. Principal products are catfish and crawfish from commercial ponds. Important minerals are ball clay mined in western Kentucky and Tennessee (USGS, 2013a), and oil and gas production in the southern part of the region.

Region G: This is one of the most productive agricultural areas in the world. Cropland is extensive, exceeding 75 percent of land use in some parts of the region. Principal crops are corn and soybean. Other important crops include wheat, rapeseed, sunflower, hay and alfalfa, sugar beets, dry beans and peas, and flaxseed. Hog, cattle, and egg production are also significant important.

Region H: The primary land uses in this region are rangeland for cattle grazing and cropland. The dominant crop is wheat. Other major crops are corn, soybean, sunflower, rapeseed, alfalfa, buckwheat, flaxseed, lentils, and peas. Hay production acreage is about 85 percent of that used in corn production.

Region I: Cropland (dryland and irrigated) and rangeland for cattle grazing are the principal land uses. Wheat and corn are the primary crops. Cotton, soybean, sorghum, millet, alfalfa, and triticale are also important. Cattle production and, in a few areas hog production, are also common. Mineral resources, primarily oil and gas, are also important in some parts of the region.

Region J: Most of the region is devoted to cropland, pasture, rangeland, and urban uses. Major crops include wheat, corn, sorghum, cotton and oats. Cropland in many parts of the region is under pressure from development into urban, suburban and industrial uses.

Region K: Much of the region is cropland. Sorghum is the dominant crop. Cotton, corn, rice, and citrus are also important. Grasslands and shrub rangeland provide fodder for livestock grazing. Salt (USGS, 2013a), oil and gas are important mineral production activities. Increased urbanization and industrialization are recent trends in the region.

Region L: A large percent of the alluvial valleys bordering the Snake River are in irrigated agriculture. Principal crops include alfalfa, wheat, barley, corn, and potatoes. Sugar beets, turnips, and other vegetables are also important. Cattle feedlots and dairy operations are also common and sagebrush-grasslands provide rangeland for grazing.

Region M: Land use is dominated by agriculture. Nearly half the land in the region is cropland. Three quarters of it is irrigated. A very wide variety of crops are grown. The major crops by land area are almonds, alfalfa, wheat, grapes, corn, and rice. Other major crops, often constituting over 50 percent of U.S. production, include walnuts and pistachios, tomatoes, fruits (plums, nectarines, pomegranates, apricots, pears, peaches, cherries, and citrus), olives, garlic, melons, vetch, clover and wildflowers, safflower, lettuce, and onions. Cattle and dairy production, largely feedlot-based, are also major agricultural activities. Urban areas and oil and gas production are also important. Wildlife habitat loss and urban sprawl are environmental concerns.

Table 6. Major Cultivated Crops by Region in 2012

Region	Crop*	Cropland: As a Percent of Total Cropland Acreage in the Region§	Cropland: In Region As a Percent of Total U.S. Acreage
A	Corn	51%	3%
	Soybean	20%	1%
	Alfalfa	20%	6%
	Wheat	3%	<1%
	Oats	2%	5%
	Cabbage	<1%	44%
B	Corn	51%	9%
	Soybean	25%	6%
	Alfalfa	16%	17%

Region	Crop*	Cropland:	
		As a Percent of Total Cropland Acreage in the Region[§]	In Region As a Percent of Total U.S. Acreage
	Wheat	4%	1%
	Dry Beans	1%	10%
	Asparagus	<1%	55%
	Cucumbers	<1%	41%
	Cherries	<1%	36%
	Celery	<1%	29%
	Squash	<1%	28%
C	Corn	53%	18%
	Soybean	40%	17%
	Wheat	3%	2%
	Alfalfa	2%	4%
	Dry Beans	<1%	9%
	Cucumbers	<1%	47%
	Gourds	<1%	33%
	Pumpkins	<1%	30%
D	Soybean	33%	6%
	Corn	33%	4%
	Cotton	18%	17%
	Wheat	15%	3%
	Peanuts	7%	55%
	Tobacco	1%	84%
	Pecans	2%	59%
	Sweet Potatoes	<1%	43%
	Peaches	<1%	37%
	Watermelon	<1%	32%
	Christmas Trees	<1%	26%
E	Corn	52%	8%
	Soybean	46%	9%
	Wheat	7%	2%
	Cotton	1%	1%
	Alfalfa	<1%	<1%
	Gourds	<1%	59%
F	Soybean	51%	12%
	Corn	20%	4%
	Cotton	12%	15%
	Rice	11%	70%

Region	Crop*	Cropland: As a Percent of Total Cropland Acreage in the Region§	Cropland: In Region As a Percent of Total U.S. Acreage
	Wheat	10%	3%
	Sweet Potatoes	<1%	36%
	Sugarcane	1%	22%
G	Corn	45%	34%
	Soybean	40%	39%
	Wheat	8%	11%
	Alfalfa	2%	8%
	Canola	1%	61%
	Sugar beets	1%	54%
	Dry beans	1%	41%
	Flaxseed	<1%	37%
H	Wheat	40%	9%
	Corn	23%	3%
	Soybean	14%	2%
	Sunflower	8%	60%
	Alfalfa	4%	3%
	Buckwheat	<1%	60%
	Flaxseed	1%	57%
	Lentils	1%	29%
I	Wheat	38%	29%
	Corn	28%	12%
	Cotton	12%	37%
	Soybean	11%	6%
	Sorghum	8%	51%
	Millet	1%	67%
	Triticale	<1%	29%
J	Wheat	38%	2%
	Corn	26%	1%
	Sorghum	18%	5%
	Cotton	8%	1%
	Oats	7%	10%
K	Sorghum	48%	19%
	Cotton	26%	5%
	Corn	13%	<1%
	Rice	6%	6%
	Citrus	6%	9%

Region	Crop*	Cropland: As a Percent of Total Cropland Acreage in the Region[§]	Cropland: In Region As a Percent of Total U.S. Acreage
L	Alfalfa	31%	6%
	Wheat	20%	1%
	Barley	14%	15%
	Corn	12%	<1%
	Potatoes	10%	30%
	Turnips	<1%	45%
M	Almonds	18%	93%
	Alfalfa	12%	5%
	Wheat	11%	1%
	Grapes	10%	54%
	Corn	10%	1%
	Walnuts	5%	98%
	Plums	1%	95%
	Tomatoes	5%	91%
	Pomegranates	<1%	90%
	Olives	1%	89%
	Nectarines	<1%	84%
	Garlic	<1%	84%
	Pistachios	3%	75%
	Honeydew Melons	<1%	56%
	Apricots	<1%	45%
	Cantaloupes	<1%	43%
	Vetch	<1%	39%
	Clover/Wildflowers	1%	36%
	Pears	<1%	34%
	Safflower	1%	34%
	Lettuce	<1%	32%
	Rice	9%	22%

*Statistics for hay not included.
[§]Some regional totals may be less than 100 percent because of rounding errors, or greater than 100 percent because of double cropping practices.

3.3 Biological Resources

3.3.1 Animal Communities

Animal communities in this discussion include wildlife species and their habitats. Wildlife refers to both native and introduced species of mammals, birds, amphibians, reptiles, invertebrates, and fish/shellfish. Wildlife may feed on soybean and corn in the field and/or utilize habitat surrounding fields for nesting and refuge. Mammals and birds may seasonally consume soybean and corn, and invertebrates can feed on the plant during the entire growing season. How agricultural and other lands are managed influences the function and integrity of ecosystems and the wildlife populations that they support.

Mammals, Birds, and Reptiles

Several mammals are widespread through many or most of the affected environment. These include white-tailed deer (regions A-I; K), mule deer (regions L and M), coyotes (regions A-C; G-M), foxes (regions A-G; I), raccoons (regions A-G; J), red and/or gray squirrels (regions A-D; F-H), bobcats (regions C-F; H-L), and cottontail rabbits and/or jackrabbits (regions D; G-J, M). Other common or characteristic mammals are more localized:

- Region A: black bear, chipmunk, woodchuck, wolf in northern areas, beaver in the south
- Region B: beaver, otter, mink
- Region D: black bear, chipmunk
- Region E: badger, weasel in the north and west
- Region G: badger and skunk in southern areas
- Region H: pronghorn antelope and prairie dogs
- Region I: pronghorn antelope
- Region J: ringtail cat, armadillo, skunk, gopher
- Region K: ringtail cat, armadillo, ocelots
- Region L: pronghorn antelope, elk, cougar, chipmunk, pika, bats
- Region M: pronghorn antelope, elk, kit fox, ground squirrels, kangaroo rat

Common or characteristic birds and reptiles include:

- Region A: wild turkey, waterfowl, ruffed grouse, woodpecker, warbler, screech owl
- Region B: wild turkey, turkey vulture
- Region C: Canada goose, sandpiper, sparrow
- Region D: wild turkey, herons, cardinal, box turtle, garter snake, rattlesnake
- Region E: cardinal, bobwhite quail, Carolina chickadee, snapping and box turtles, rattlesnake, copperbelly water snake
- Region F: wild turkey, migratory waterfowl, mourning dove, Carolina wren, wood thrush, cormorants, egrets, herons; widespread loss of forest and wetland habitat, has reduced bird populations but this region remains a major migration corridor
- Region G: this region is a major breeding habitat for waterfowl and other birds, including Canada goose, bobwhite quail, sharp-tailed grouse, and pheasants
- Region H: golden eagle, ferruginous hawk, sage grouse, rattlesnakes
- Region I: numerous waterfowl migrate along this region

- Region J: turkey vulture, Texas horned lizard
- Region K: waterfowl, geese, oriole, prairie chicken, alligator
- Region L: migratory waterfowl, chickadee, falcon, raven, thrasher
- Region M: wintering waterfowl, Nuttall's woodpecker, yellow-billed magpie, giant garter snake

Cornfields are generally considered poor habitat for birds and mammals in comparison with uncultivated lands, but the use of cornfields by birds and mammals is not uncommon. Some birds and mammals use cornfields at various times throughout the corn production cycle for feeding and reproduction. Most birds and mammals that utilize cornfields are ground foraging omnivores that feed on corn seed, sprouting corn, and the corn remaining in the fields following harvest.

The types and numbers of birds that inhabit cornfields vary regionally and seasonally, but numbers are general low (Patterson & Best, 1996). Bird species commonly observed foraging on corn include red-winged blackbird (*Agelaius phoeniceus*), horned lark (*Eremophila alpestris*), brown-headed cowbird (*Molothrus ater*), vesper sparrow (*Pooecetes gramineus*), ring-necked pheasant (*Phasianus colchicus*), wild turkey (*Meleagris gallopavo*), American crow (*Corvus brachyrhynchos*), and various grouse and quail species (Dolbeer, 1990; Mullen, 2011; Patterson & Best, 1996). Following harvest, it is also common to find large flocks of Canada goose (*Branta canadensis*), snow goose (*Chen caerulescens*), Sandhill cranes (*Grus canadensis*), and other migratory waterfowl foraging in cornfields (Sherfy et al., 2011; Sparling & Krapu, 1994; Taft & Elphick, 2007).

Large- to medium-sized mammals that are common foragers of cornfields include: white-tailed deer (*Odocoileus virginianus*), raccoon (*Procyon lotor*), feral hogs (*Sus scrofa*), and woodchuck (*Marmota monax*). The most notable of these are the white-tailed deer which often inhabit woodlots adjacent to cornfields and frequent these fields for both food and cover, especially in mid-summer (Vercauteren & Hygnostrom, 1993). White-tailed deer are considered responsible for more corn damage than any other wildlife species (Stewart et al., 2007). Cornfields are vulnerable to deer damage from emergence through harvest (Vercauteren & Hygnostrom, 1993), but any damage at the tasseling stage most directly impacts yield (Stewart et al., 2007). In addition to deer, significant damage to corn by raccoons also has been documented (Beasley & Rhodes, 2008; DeVault et al., 2007). Corn has been shown to constitute up to 65 percent of the diet of raccoons during the late summer and fall (MacGowan et al., 2006).

Small mammal use of cornfields for shelter and forage also varies regionally and includes the deer mouse (*Peromyscus maniculatus*), meadow vole (*Microtus pennsylvanicus*), house mouse (*Mus musculus*), and the thirteen-lined ground squirrel (*Spermophilus tridecemlineatus*) (Nielsen, 2005). Throughout the U.S., the deer mouse is the most common small mammal in agricultural fields (Stallman & Best, 1996; Sterner et al., 2003). Deer mice have been considered beneficial in agroecosystems because they consume both weed and insect pests in addition to seeds (Smith, 2005). The meadow vole feeds primarily on fresh grass, sedges, and herbs, and also on seeds and grains of field crops. Although the meadow vole may be considered beneficial as a consumer of weeds, this vole can be a significant agricultural pest where abundant when it consumes seeds in the field. Meadow vole populations are kept in check by high intensity agriculture methods, including conventional tillage; this vole is often associated with cover surrounding the edge of field, and in limited tillage agriculture and strip crops (Smith, 2005). The lined ground squirrel feeds primarily on seeds of weeds and available crops, such as corn and wheat. This species has the potential to damage agricultural crops, but can also be beneficial by eating pest insects, such as grasshoppers and cutworms (Smith, 2005).

Animals that feed primarily on soybean are seed-feeding insects and rodents found in agricultural fields. Rodents, such as mice or squirrels, may seasonally feed exclusively on soybean seeds. During the winter months, leftover and unharvested soybeans provide a food source for wildlife. White-tailed deer and groundhogs cause feeding damage on soybeans. Eastern cottontail, raccoon, Canada goose, squirrels, and other rodents (such as ground squirrel) also feed on soybean, but cause little damage (MacGowan et al., 2006).

Deer in large numbers may significantly damage soybean in site-specific circumstances by browsing in soybean fields for forage. In some areas, growers may be issued licenses to kill deer outside the regular hunting season to reduce crop damage (Berk A, 2008; Garrison & Lewis, 1987). Deer may also feed on seed left after harvest. In Georgia, feral hogs have also damaged soybean fields through rutting and feeding (GDNR, 2003). It is likely that reptiles and amphibians may also be found in soybean fields, especially if the habitat surrounding the field is suitable to support these types of animals.

Migratory birds were observed to feed on spilled soybean following crop harvest (Galle et al., 2009), although more birds fed on nearby corn and sunflower seed fields. As many as 28 desirable (not crop pest) bird species, as well as another five that can be crop pests in sunflower, have been identified as resident in soybean and corn fields in the Dakotas (Gamble et al., 2002).

Invertebrate Communities

Although many arthropods in agricultural settings are considered pests, such as the European corn borer (*Ostrinia nubilalis*) and the corn rootworm (*Diabrotica* spp.)(Willson & Eisley, 2001), there are many beneficial arthropods which are natural enemies of both weeds and insect pests(Landis et al., 2005). Some of these beneficial species include the convergent lady beetle (*Hippodamia convergens*), carabid beetles, the caterpillar parasitoids (e.g., *Meteorus communis* and *Glyptapanteles militaris*), and the predatory mite (*Phytoseiulus persimilis*)(Shelton, 2011).

Some of the many insects and invertebrates that are detrimental to soybean include: bean leaf beetle (*Cerotoma trifurcata*), beet armyworm (*Spodoptera exigua*), blister beetle (*Epicauta* spp.), corn earworm (*Helicoverpa zea*), grasshopper (*Acrididae* spp.), green cloverworm (*Hypena scabra*), seed corn beetle (*Stenolophus lecontei*), seedcorn maggot (*Delia platura*), soybean aphid (*Aphis glycines*), soybean looper (*Pseudoplusia includens*), soybean stem borer (*Dectes texanus*), spider mites (*Tetranychus urticae*), stink bug (green [*Acrosternum hilare*]; brown [*Euschistus* spp.]); and velvetbean caterpillar (*Anticarsia gemmatalis*) (Palmer et al., No Date; Whitworth et al., 2011).

Aquatic Animal Communities

Common fish include:

- Region A: northern pike, walleye, carp, bass, trout
- Region B: trout, perch, catfish
- Region F: alligator gar, pallid sturgeon, other “big river” species
- Region G: walleye, perch
- Region L: trout
- Region M: Chinook salmon, delta smelt

Aquatic ecosystems potentially impacted by agricultural activities include water bodies adjacent to or downstream from crop field, including impounded bodies, such as ponds, lakes, and reservoirs, and flowing waterways, such as streams or rivers. If near coastal areas, aquatic habitats affected by agricultural production may also include marine ecosystems and estuaries. Aquatic species that may be exposed to sediment from soil erosion and, nutrients and pesticides from runoff and atmospheric deposition include freshwater and estuarine/marine fish and invertebrates, and freshwater amphibians. Although some ecological research has shown that farming practices can be detrimental to stream health (Genito et al., 2002), recently some research suggests that agricultural lands may support diverse and compositionally different aquatic invertebrate communities when compared to nearby urbanized areas(Lenat & Crawford, 1994; Stepenuck et al., 2002; Wang et al., 2000).

3.3.2 Plant Communities

Plant communities vary by region. Table 5 describes land cover in each of the regions. The types of plants vary with the land cover. As described on page 44, vegetation can include forest, shrubland, cropland, pastures, and grasslands.

Dominant vegetation types among regions are summarized in section 3.2.7.

Weeds of corn and soybean are also plants found within the corn and soybean growing regions. These weeds are identified in Appendix A.3.

4 POTENTIAL ENVIRONMENTAL CONSEQUENCES

This chapter examines the effects of four alternative actions on Natural and Biological Resources, Socioeconomic effects and Human Health. In this chapter, APHIS only examines the direct and indirect effects of its action on the regulatory status of the plants. While we recognize that the plants were engineered to be resistant to the application of certain herbicides, those herbicides are not currently labeled for use on DAS-40278-9 corn, DAS-68416-4 soybean, or DAS-444Ø6-6 soybean. We do not examine the effects of our action combined with future actions that may be taken by other Agencies in this chapter. The EPA is currently evaluating the use of certain herbicides on these plants. APHIS considers the potential cumulative effects of herbicide use for the alternatives, if the EPA should take that action in the future, on these same resource areas in Chapter 5.

4.1 No Action Alternative

The No Action Alternative represents the status quo, i.e. the situation that would occur if APHIS denies the three petitions (see Section 2.1). Under the No Action Alternative APHIS would not approve the petitions. Nevertheless, over ninety percent of the corn and soybean crop would continue to be GE varieties that have previously been approved for planting and represent the status quo. This section describes the effects that are currently occurring on natural and biological resources and the interrelated social and economic effects. The analysis examines the effects of soybean and corn production on natural and biological resources to allow for a comparison for APHIS' Action Alternatives which would allow for the introduction of new soybean and corn varieties.

4.1.1 Socioeconomic and Human Health

Land Use

Over the last two decades there has been an increase in the acres planted to both corn and soybeans. The combined acreage has increased by nearly a third. Many factors have influenced the overall increase in acres planted.

Since 2006, U.S. corn planted acreage has increased as market prices have favored the planting of corn over alternative crops (USDA-NASS, 2010b; 2011a). The increase in corn acreage has been linked to the increase in demand for corn as a feed stock for ethanol production (Hart, 2006; USDA-ERS, 2010c). The increase in acreage has involved all varieties of corn and is occurring throughout the corn growing areas (USDA-ERS, 2010c).

From 2000 to 2009, many U.S. cotton growers increased production of corn and soybean because of favorable prices (USDA-ERS, 2009b). The increase in production of these crops has been accompanied by decreases in other crops, including upland cotton, corn grown for silage, spring and specialty wheat, and oats (USDA-ERS, 2011c).

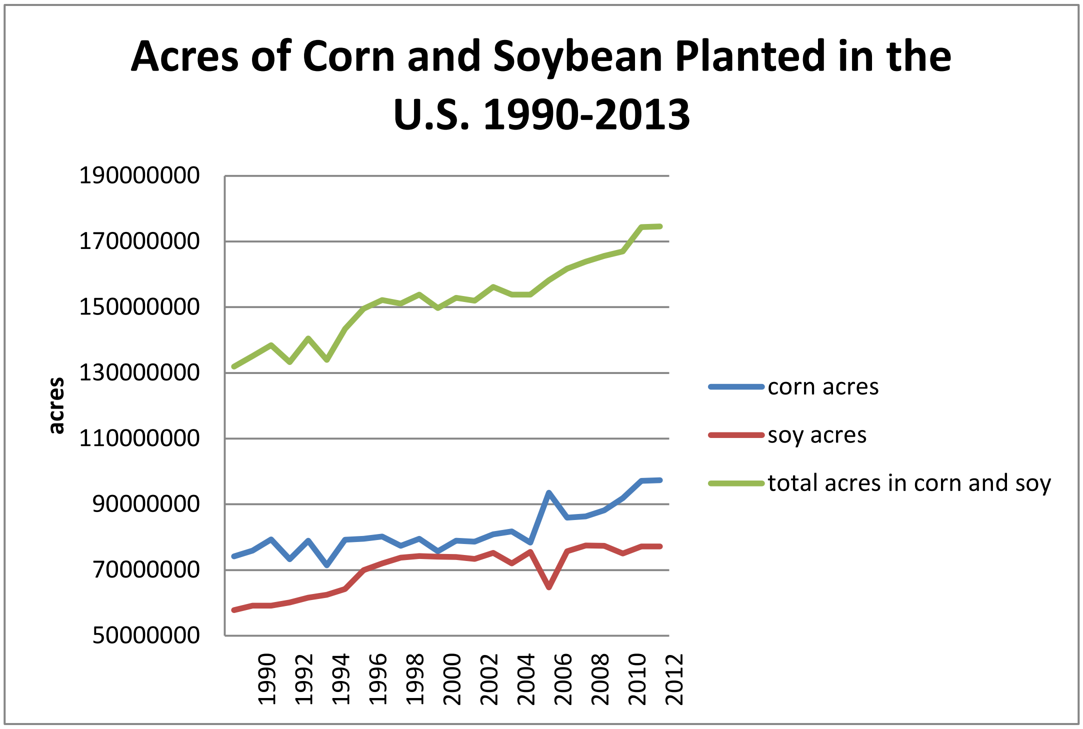

Figure 7. Acres of Corn and Soybean Planted in the U.S. 1990-2013
The acreage of both corn and soybean planted over the past two decades has increased. Total acreage has increased by approximately 43 million acres or 32 percent. (USDA-NASS, 2013f; g)

Corn acreage planted was projected to reach a peak in 2012, with 94 million acres planted (USDA-OCE, 2011a). However, in 2012, actual acreage planted was 97.2 million acres and, in 2013, acreage planted continued to increase to 97.4 million acres (USDA-NASS, 2013e). Regionally, Regions G and I (see Figure 1) accounted for the majority of the acres of both corn and soybean added in the past 20 years. These same regions saw a decrease in wheat and small grains and hay production acres (NASS 2013). One study asserts that over 1 million acres of grass-dominated land cover in areas of North Dakota, South Dakota, Nebraska, Minnesota, and Iowa, were converted to corn and soybean production (Wright & Wimberly, 2013). Grass-dominated lands include native prairie, grass and agricultural grasslands such as pasture, hay lands, and retired cropland converted to perennial grasses through the Conservation Reserve Program (CRP). Because hay production and CRP lands have declined in the past decade ((USDA-ERS, 2012c; USDA-NASS, 2013d) while cropland totals have remained fairly constant (USDA-NASS, 2013d), it is likely that the reported reduction in grass lands is primarily from conversion of agricultural grasslands to corn and soybean production as opposed to the conversion of native grasslands into new agricultural land.

The demand for corn production under the No Action Alternative is expected to mirror the most recent USDA projections which predict a decline in corn from 97 million acres to just under 92 million acres in 2014 and a further decline to 88.5 million acres through 2023 (USDA-OCE, 2014). The decrease in overall corn acres is expected to come as a result of increases in soybean, cotton, rice, and about 2.8 million less planted acres of field crops overall. (USDA-OCE, 2014). During the peak demand for corn spurred by demand for corn for ethanol, many growers in the upper Midwest converted to a three year rotation schedule where consecutive years of corn were followed by soybean (Hart, 2006). The decreased demand for corn and the increased demand for soybean may reduce the frequency of the three-year rotation of corn in favor of the two-year corn/soybean rotation.

Corn currently is produced commercially in 48 states (USDA-NASS, 2011b) . Under the No Action Alternative, the number of states involved in corn cultivation is not expected to change over the next decade. However, the amount of corn cultivated in each state may change.

From 1990 to 2013, acreage planted with soybean increased from 59 million acres to greater than 77 million acres (Figure 7); the second most widely planted crop in the U.S., behind corn. The increase in soybean acreage was related to strong prices, the absence of acreage set-aside programs, increased crop rotations with soybeans, and optimum soybean planting conditions. The elimination of nearly all supply controls on U.S. field crop production by the 1996 Farm Bill allowed farmers to increase soybean acreage in response to market signals. A sharp increase in soybean acreage between 1996 and 2001 is attributed to low production costs, at least partially due to the adoption of HR varieties and conservation tillage practices (Foreman & Livezey, 2002). The most recent USDA projections are for soybean plantings to increase slightly through 2020 (USDA-OCE, 2014) and this projection is expected to continue under the No Action Alternative.

Soybeans are widely grown in the U.S., the top five producing states (Iowa, Illinois, Minnesota, Indiana, and Nebraska) accounted for just more than half of the total U.S. crop in 2012 (USDA-NASS, 2013c).

In summary, the trend to increase the land used for corn at the expense of other agricultural land is expected to end under the No Action Alternative. Soybean production is expected to increase slightly and overall field crop production is expected to decline.

Domestic Use of Corn and Soybean in the U.S. Economy

In 2013, U.S. growers planted 97.4 million acres of corn, representing the highest planted acreage ever (USDA-NASS, 2013b). U.S. corn growers are expected to produce a record-high 13.9 billion bushels of corn in 2013, up 29 percent from drought-hit 2012 (USDA-NASS, 2013h). As of January 2014, NASS estimated the 2013/2014 corn yield at 155.8 bushels per acre (USDA-NASS, 2014b). The price of corn was $4.50 per bushel(USDA-NASS, 2014c), well below the 2012-2013 price of $6.90 per bushel and the price of $6.22 per bushel for 2011/2012 (Doran, 2013). Despite increased demand for corn for ethanol and exports (Figure 8), increased production in the Central Plains and South has increased supplies (Doran, 2013). The per bushel price of corn over the last ten years is shown in Figure 9.

“Corn has food, feed, and industrial uses (Figure 8). It is a major component of livestock feed. Feed use, a derived demand, is closely related to the number of animals (cattle, hogs, and poultry) that are fed corn. The amount of corn used for feed also depends on the crop's supply and price, the amount of supplemental ingredients used in feed rations, and the supplies and prices of competing ingredients.

As ethanol production increases (Figure 8), the supply of ethanol co-products will also increase. Both the dry-milling and wet-milling methods of producing ethanol generate a variety of economically valuable co-products, the most prominent of which is distillers dried grains with solubles (DDGS), which can be used as a feed ingredient for livestock. Each 56-pound bushel of corn used in dry-mill ethanol production generates about 17.4 pounds of DDGS. In the U.S., cattle (both dairy and beef) have been the primary users of DDGS as livestock feed, but larger quantities of DDGS are making their way into the feed rations of hogs and poultry.

Corn is also processed for human consumption and other industrial uses. Currently food, seed, and industrial uses of corn account for about one-third of domestic utilization and this distribution is expected to continue under the No Action Alternative. During processing, corn is either wet or dry milled depending on the desired end products:

- Wet millers process corn into high-fructose corn syrup glucose and dextrose, starch, corn oil, beverage alcohol, industrial alcohol, and fuel ethanol.

- Dry millers process corn into flakes for cereal, corn flour, corn grits, corn meal, and brewer's grits for beer production.

The market for food made from corn has grown in recent years with the expanding Latin American population in the U.S. Under the No Action Alternative, food uses for corn are expected to expand at the rate of population growth. Research is continuing to expand the various industrial uses for corn and corn byproducts. (http://www.ers.usda.gov/topics/crops/corn/background.aspx)

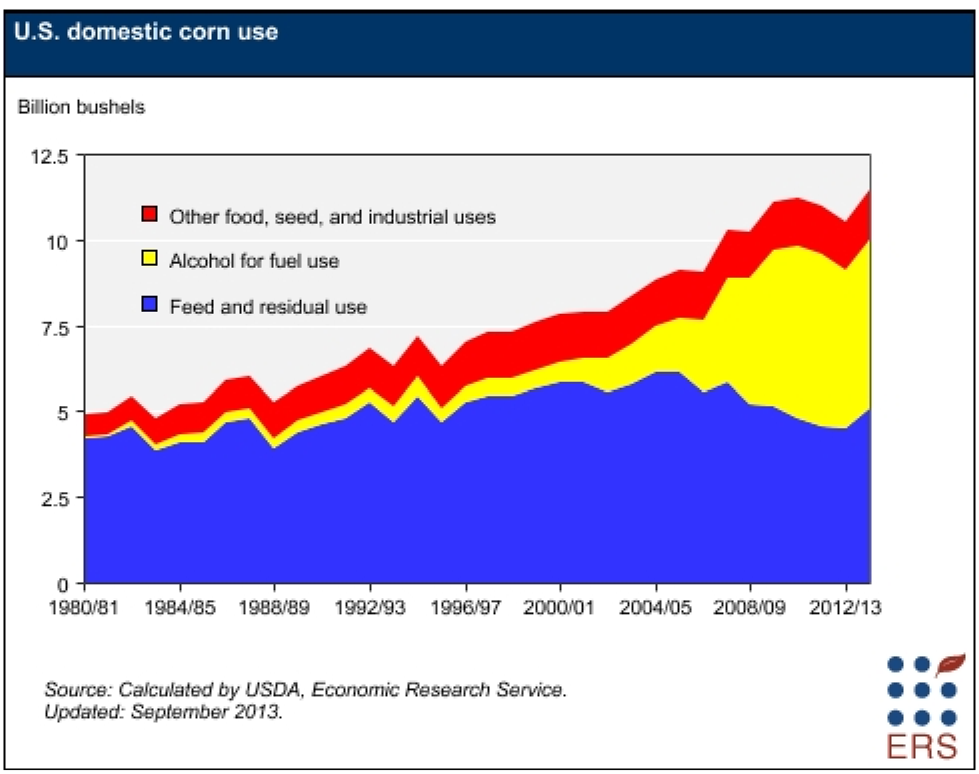

Figure 8. U.S. Domestic Corn Use

U.S. soybean production totaled 3.29 billion bushels in 2013, up 8 percent from last year. NASS estimated that 75.9 million acres of soybeans were harvested in 2013 (USDA-NASS, 2014b). The production was the third largest on record (USDA-NASS, 2014b). The price per bushel for soybeans in 2013 was $12.70/bushel (USDA-NASS, 2014c). The per bushel price of soybeans over the last ten years is shown in Figure 9.

The value of U.S. soybean production for beans was $41.8 billion in 2013, down from $43.6 billion in 2012 (USDA-NASS, 2014c), this value was 23 percent of the total value of field and miscellaneous crops in 2012. The Heartland region (Illinois, Indiana, Iowa, Kentucky, Minnesota, Missouri, and Ohio) alone accounted for more than 58 percent of the total U.S. crop value in 2012. There is significant variation in yields and costs across soybean production regions. In 2013, U.S. soybean yields averaged 43.3bushels/acre, from a low of 25bushels/acre in Texas to 53 bushels per acre in Nebraska (USDA-NASS, 2014b). The majority of soybeans are used for oil and animal feed. Some soybean oil is used to produce industrial products such as inks, crayons, candles, and foam cushions (NC Soybean Producers Association, 2011). Under the No Action Alternative, these uses are expected to continue.

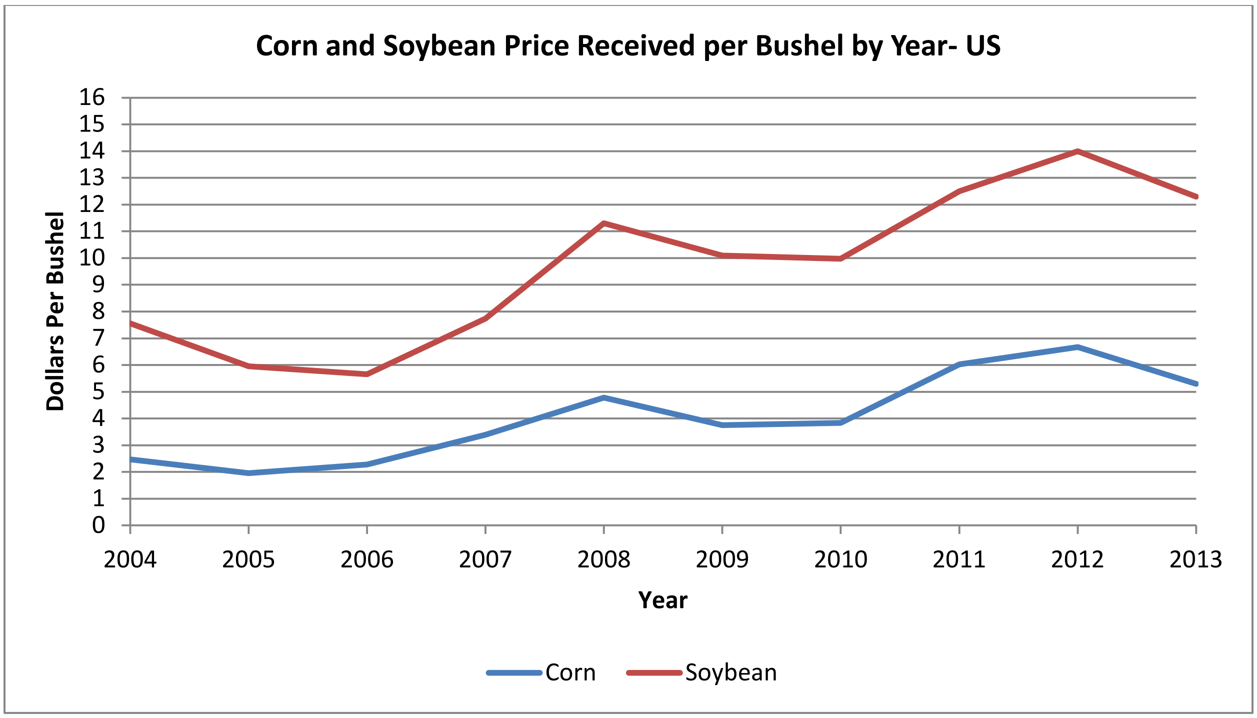

Figure 9. Corn and Soybean Price per Bushel
Source:(USDA-ERS, 2013d)

<u>Corn and Soybean Agronomic Practices and Costs of Production</u>

Organic Corn and Soy

Agronomic practices associated with corn and soybean production include several crop management systems that are available to producers. Conventional farming covers a broad scope of farming practices, including the use synthetic fertilizers and pesticides. Conventional farming also includes the use of GE varieties that are no longer subject to the regulatory requirements of

7 CFR part 340 or the plant pest provisions of the PPA. Organic systems exclude certain production methods, such as synthetic agricultural inputs and GE crops.

Organic production plans prepared pursuant to the National Organic Program include practical methods to protect organically-produced crops from accidental commingling with GE materials. Commingling of organic corn with GE corn varieties is a concern because corn naturally cross-pollinates (Coulter et al., 2010). Typically, organic growers use more than one method to prevent unwanted material from entering their fields, including isolation of the farm; physical barriers or buffer zones between organic production and non-organic production; planting border or barrier rows to intercept pollen; changing planting schedules to ensure flowering at different times; and formal communications between neighboring farms (Baier, 2008; NCAT, 2003; NOAA-NMFS, 2011). These practices follow the same system utilized for the cultivation of certified seed under the AOSCA procedures. During the cultivation period, commingling is managed by understanding corn pollen dispersal and maintaining adequate distances between fields (Mallory-Smith & Sanchez-Olguin, 2010; Thomison, 2009). A minimum isolation distance of 250 feet between varieties is recommended, while 700 feet is preferred (Diver et al., 2008). Cross-pollination between corn fields can be reduced to 0.5 percent or less with a separation distance of 984 feet (Place & Goodman, 2011).

Organic corn production begins with certified organically grown seed (Diver et al., 2008). The organic farming plan used as the basis for organic certification should include a description of practices to be observed during certain farming operations to prevent or reduce the likelihood of contamination by unwanted substances like GE pollen or seed (Krueger, 2007; Kuepper, 2002; Riddle, 2004; Roth, 2011). Organic farming plans should include how the risk of GE pollen or co-mingling of seed will be monitored (NOAA-NMFS, 2011). Co-mingling can occur from impure seed, seed admixture, volunteer plants, and residual non-organic seed in equipment, vehicles, and facilities (Coulter et al., 2010; Mallory-Smith & Sanchez-Olguin, 2010). Growers using organic methods should let neighboring growers know that they are using organic production practices and request that the neighbors also help the organic grower reduce potential cross-pollination (Krueger, 2007; NCAT, 2003). Although conventional corn yields tend to be higher than organic yields, net returns from organic acres continue to be greater than that from conventional acres, with a 16 percent premium received for organic growers reported in 2008 (Coulter et al., 2010; Kuepper, 2002; Roth, 2011). Certified organic corn acreage is a relatively small percentage of overall corn production in the U.S. The most current data show 234,470 acres of certified organic corn production in 2011 (USDA-ERS, 2013b). This is 0.26 percent of the 91.9 million acres of corn planted in 2011 (USDA-NASS, 2014b).

Thomison and Geyer (Thomison & Geyer, 2011) estimated that approximately 5 percent of the total corn acreage, or approximately 4 million acres, was devoted to specialty corn varieties. Specialty corn varieties have been developed and marketed as Value Enhanced Corn (USDA-FAS, 2004). Varieties cultivated as specialty corn included high oil, white, waxy, blue corn, hard endosperm/food grade, high-amylose, high lysine, high oleic oil, low phytate, nutritionally enhanced, high extractable starch, high total fermentable (for ethanol), popcorn, pharmaceutical and industrial corns, and organic (Thomison, 2011). The leading specialty corn states include Illinois, Iowa, Nebraska, and Indiana (Thomison, 2011). The amount of specialty corn produced under the No Action Alternative is not expected to change.

Similar to the production of conventional seed, industry quality standards for specialty crop products have led these seed producers and growers to employ a variety of techniques to ensure that their products are not pollinated by or commingled with conventional or GE crops (Bradford, 2006). Common practices include maintaining isolation distances to prevent pollen movement from other corn sources, planting border or barrier rows to intercept pollen, and employing natural barriers to pollen (NCAT, 2003; Wozniak, 2002). No changes in the deployment of these practices is expected under the No Action Alternative.

All producers of organic or specialty corn crops must address the potential for cross-pollination with undesired varieties, which may include GE varieties. Methods such as isolation distances, use of border or barrier rows, and differing planting schedules are used by producers of specialty crops to prevent unwanted material from entering their fields (Bradford, 2006; NCAT, 2003; Roth, 2011; Thomison, 2009; Wozniak, 2002). Several categories of specialty soybeans are currently grown in the U.S. and marketed both domestically and internationally. Producers of organic and other specialty soybeans currently have production and handling procedures in place to ensure that their product meets standards specified either in the USDA National Organic Plan regulations or through contracts, as relevant.

APHIS recognizes that producers of non-GE corn and soybean, particularly producers who sell their products to markets sensitive to GE traits (e.g., organic or some export markets), reasonably can be assumed to be using practices on their farm to protect their crop from unwanted substances and thus maintain their price premium. As over 90 percent of corn and soybean grown in the U.S. is already GE, APHIS will assume as APHIS' baseline for the analysis of the alternatives, that growers of organic corn and soybean are already using, or have the ability to use, these common practices. . This view is supported by a comment received from Food and Water Watch (APHIS-2013-0042-10152), "a recent survey of certified organic field crop producers located mostly in the Midwest found that 95 percent of [organic growers] plant buffer crops to protect against genetic contamination at an average annual cost per farm of $4,776 for planting, harvesting, storing, and selling buffers to conventional rather than organic markets. Three-quarters of organic corn producers and 78 percent of organic soybean growers delay planting to protect against genetic contamination, averaging annual costs of $16,699 for organic corn growers and $8,713 for organic soybean producers." Delayed planting has been used successfully by some organic corn producers to control weeds and to avoid potential contamination by GE pollen from adjacent fields (NOAA-NMFS, 2011). The late planting allows the grower to conduct a secondary tillage pass before planting to control early emerged weeds and results in a later silking in the corn flower, thus avoiding pollen contamination from GE fields that have been planted earlier (NOAA-NMFS, 2011). The Food and Water Watch survey also reports that 59 percent of organic corn growers and 57 percent of organic soybean producers who have found or suspected "GMO presence" on their farm had grain rejected by a buyer. Because the very high baseline of GE corn and soybean grown currently is expected to continue under the No Action Alternative, no changes are expected in the amounts of transgenic contamination observed in the specialty and organic corn and soybean market under the No Action Alternative.

Organic and other non-GE specialty corn and soybeans offer consumers the option of choosing non-GE products if that is their preference. The consumer reaction to GE crops since their commercialization has been well researched, particularly as to whether consumers would prefer non-GE and whether they support labeling of foods containing GE ingredients. The hundreds of surveys that have been done over the years present contradictory evidence, likely due to differences in sampling techniques, the survey instruments used, and the way questions are framed (Kalaitzandonakes et al., 2005). Further, preferences expressed in surveys may not be consistent with actual purchasing behavior (Fernandez-Cornejo & Caswell, 2006). For example, a study of consumers in the Netherlands from 1997 to 2000, a period of time during which GE ingredients were required to be labeled and similar products were available to consumers with and without GE ingredients, showed no significant changes in purchasing behavior with respect to the GE-labeled products despite an increasingly negative public sentiment against them (Kalaitzandonakes et al., 2005). Under the No Action Alternative, consumers will still have the option of purchasing organic and other non-GE specialty corns and soybeans.

Tillage

Prior to planting, the soil is typically stripped of weeds that would otherwise compete with the crop for space, water, and nutrients. Field preparation is accomplished through a variety of tillage systems, with each system defined by the remaining crop residue on the field. Crop residues are materials left in an agricultural field after the crop has been harvested, including stalks and stubble (stems), leaves and seed pods (USDA-NRCS, 2005). These residues aid in conserving soil moisture and reduce wind and water-induced soil erosion (Heatherly et al., 2009; USDA-ERS, 1997; USDA-NRCS, 2005).

A number of different tillage and planting systems are used in corn and soybean production, including primary and/or secondary tillage, or no pre-plant tillage operations (IPM, 2007). Conservation and reduced tillage practices include: mulch-till, eco-fallow, strip-till, ridge-till, zero-till, and no-till (IPM, 2007). Conventional tillage is associated with intensive plowing and leaving less than 15 percent crop residue in the field; reduced tillage is associated with 15 to 30 percent crop residue; and conservation tillage, including no-till practices requiring herbicide application on the plant residue from the previous season, is associated with at least 30 percent crop residue and substantially less soil erosion than other tillage practices (US-EPA, 2010c). Increases in total acres dedicated to conservation tillage have been facilitated in part by an increased use of herbicide-resistant GE crops, reducing the need for mechanical weed control (Towery & Werblow, 2010; USDA-NRCS, 2006b; 2010b). According to USDA Agricultural Resource Management Survey (ARMS) data, conservation tillage ranging from no-till to reduced-till conserving 15 to 30 percent of residues was used on 75 percent of planted corn acres in 2010 (USDA-ERS, 2012).

Conservation tillage, although highly valued as a means to enhance soil quality and preserve soil moisture, itself has been identified as a potential challenge for corn disease and pest management. The surface residues have been identified as an inoculum source for certain disease-causing organisms (Robertson et al., 2009). This is especially a problem for growers whose crop rotation includes corn-after-corn with minimal tillage (Robertson et al., 2009). Diseases identified as related to corn residues include Anthracnose (caused by the fungus *Colletotrichum graminicola*), Eyespot (caused by the fungus *Kabatiella zeae*), Goss's wilt (caused by the bacteria *Corynebacterium nebraskense*), Gray leaf spot (caused by the fungus *Cercospora zeae-maydis*), and Northern corn leaf blight (caused by the fungus *Helminthosporium turcicum*) (Robertson et al., 2009). For each of these diseases, the disease agent overwinters in the cool and moist soil, and inoculum from the corn residue then infects the new year crop (Robertson et al., 2009). Disease control measures include cultivation of resistant hybrids, crop rotation, and more careful balancing of conservation tillage with residue management (Robertson et al., 2009).

Tillage in soybean production systems is used to prepare a seedbed, address soil compaction, incorporate fertilizers and herbicides, manage water movement both within and out of a production field, and control weeds (Heatherly et al., 2009). A soybean grower's choice of tillage system may be based on factors such as: crop rotation, soil characteristics, nutrient management, herbicide program, planting equipment, and management ability and risk (Randall et al., 2002). No-till soybean production is not suitable for all producers or areas. For example, no-till soybean production is less successful in heavier, cooler soils more typical of northern latitudes (Kok et al., 1997; NRC, 2010).

Introduction of improved herbicides and planters in the mid-1980s facilitated better weed control and good seed placement in no-tillage systems, which some farmers began to adopt at that time (Owen, 2011; Randall et al., 2002). Adoption of conservation tillage systems in general accelerated in the 1990s after soil conservation policy was incorporated into the Food Security Act of 1985 (NRC, 2010). The introduction of glyphosate-tolerant soybeans in 1996 fit into the ongoing trend of increasing adoption of conservation tillage by allowing growers to control weeds effectively with herbicide obviating the need for tillage (Carpenter & Leonard, 1999; NRC, 2010).

Between 1996 and 2008, adoption of conservation tillage practices by soybean farmers increased from 51 percent to 63 percent, and the adoption of no-till increased from 30 percent to 41 percent 2013 (CTIC, 2011). In an early study of the relationship between the adoption of herbicide-tolerant soybeans and the adoption of conservation tillage practices using data from 1997, researchers found that soybean farmers using no-till practices had a higher probability of adoption of herbicide-tolerant soybeans. However, adoption of herbicide-tolerant soybeans did not appear to affect no-till adoption rates (Fernandez-Cornejo & McBride, 2002). A later study using data from 2002 found that farmers who adopted no-till practices were more likely to adopt herbicide-tolerant soybeans and that adopters of herbicide-tolerant soybeans were more likely to adopt no-till systems (Mensah, 2007). In a study of the long-term relationship between the adoption of conservation tillage, adoption of herbicide-tolerant soybeans, and herbicide use between 1996 and 2006, analysis suggested that herbicide-tolerant soybean adoption induces farmers to adopt conservation tillage practices (Fernandez-Cornejo et al., 2002).

Conservation tillage practices vary by region. According to the ARMS database, (USDA-ERS, 2013a) there are no clear trends in adoption of conservation tillage practices by region over the past 15 years. Based on the most recent survey data, in many states the use of conservation tillage in corn and soybean exceed that of conventional tillage (Table 7). According to the most recent ARMS data, states in regions D, E, C, B, G , H, and I use more no-till in corn and soybean than conventional tillage (Table 7). Interestingly, in some states no-till is adopted on a greater percent of the soybean acres than conventional tillage, but in those same states conventional tillage is used on a greater percent of the corn (Table 7; IN, MI, MO). The percent of the crop cover planted in corn exceeds soybean in most of the states where conventional tillage is used more frequently on corn and no till is more frequently used in soybean, indicating that more acres of agricultural land may be in conventional tillage in those states than in no-till production.

Because no till agriculture can reduce soil erosion rates to those close to natural erosion (Montgomery, 2007), its use is encouraged. Increases in the use of tillage for HR weed management in soybean is occurring in some regions of the U.S. Monsanto submitted to APHIS third party proprietary data on tillage trends in support of the NEPA analysis for the determination of nonregulated status of Dicamba tolerant soybean and cotton (Dicamba EIS Appendix 9). This analysis of tillage practices shows that no-till increased in soybean in all parts of the country from 1998-2007 but has decreased from 2007-2012 in the Midwest and the Mid-South, became flat or decreased in the East, became flat in the southeast, and continued to increase in the west. In cotton no-till increased in all regions in the country from 1998-2007 but decreased from 2007-2012 in the Southeast, the Midwest, the Midsouth, but continued to increase in the West. GR weeds are not yet problematic in the west and this remains the only area where no-till is still increasing. In areas where GR weeds have become problematic, no-till is on the decline or has stopped increasing. The trend in the decline of no-till is significant and pervasive throughout the country where glyphosate weeds are prevalent and is expected to continue under the No Action Alternative.

Table 7. Tillage Practices by Crop

Tillage Method	Soybean	Corn
Acres in No-Till Exceeds Conventional Tillage	Illinois Indiana Kansas Kentucky Maryland Michigan Missouri North Carolina Ohio Pennsylvania South Dakota Virginia Wisconsin	Pennsylvania Colorado Iowa Kansas South Dakota Kentucky Nebraska
Acres in Conventional Tillage Exceeds Other Types of Tillage	Arkansas Louisiana	Georgia, Indiana, Michigan Minnesota Missouri North Dakota Texas Wisconsin
Mulch Till Exceeds Other Types of Tillage	Iowa Minnesota Nebraska North Dakota New York	Iowa

Source: (USDA-ERS, 2013a)

Crop Rotation

Crop rotation is the successive planting of different crops in the same field over a particular period of years. Crop rotation has the two primary goals of sustaining the productivity of the agricultural system and maximizing economic returns (Hoeft et al., 2000). Sustaining the agricultural system is achieved by rotating crops that may improve soil health and fertility with more commercially beneficial "cash crops." Because soybeans fix nitrogen in soil, the yield of some crops following a soybean crop, such as corn or wheat, may increase (Berglund & Helms, 2003). Moreover, the rotation of crops can effectively reduce disease, pest incidence, weediness, and selection pressure for weed resistance to herbicides (Berglund & Helms, 2003; USDA-ERS, 1997). Crop rotation may also include fallow periods, or sowing with cover crops to prevent soil erosion and to provide livestock forage between cash crops (Hoeft et al., 2000; USDA-NRCS, 2010a). Maximizing economic returns is realized by rotating crops in a sequence that efficiently produces the most net returns for a producer over a single- or multi-year period. Many factors at the individual farm level affect the crop rotation system chosen, including the soil type present in an individual field, the expected commodity price, the need to hire labor, the price of fuel, the availability of funding to buy seed, and the price of agricultural inputs (Duffy, 2011; Hoeft et al., 2000; Langemeier, 1997). Figure 10 shows the cropping patterns of the major crops in the U.S. As is evident in the figure, most corn and soybean grown in the U.S. is produced in a corn-soybean rotation. The benefits of corn rotation with, for example, soybean are many and include (Al-Kaisi et al., 2003):

- Improved yield and profitability of one or both crops;
- Decreased need for additional nitrogen on the crop following soybean;
- Increased residue cover resulting in reduced soil erosion;
- Mitigation or disruption of disease, insect, and weed cycles;
- Increased soil organic matter;
- Improved soil tilth and soil physical properties; and
- Reduced runoff of nutrients, herbicides, and insecticides.

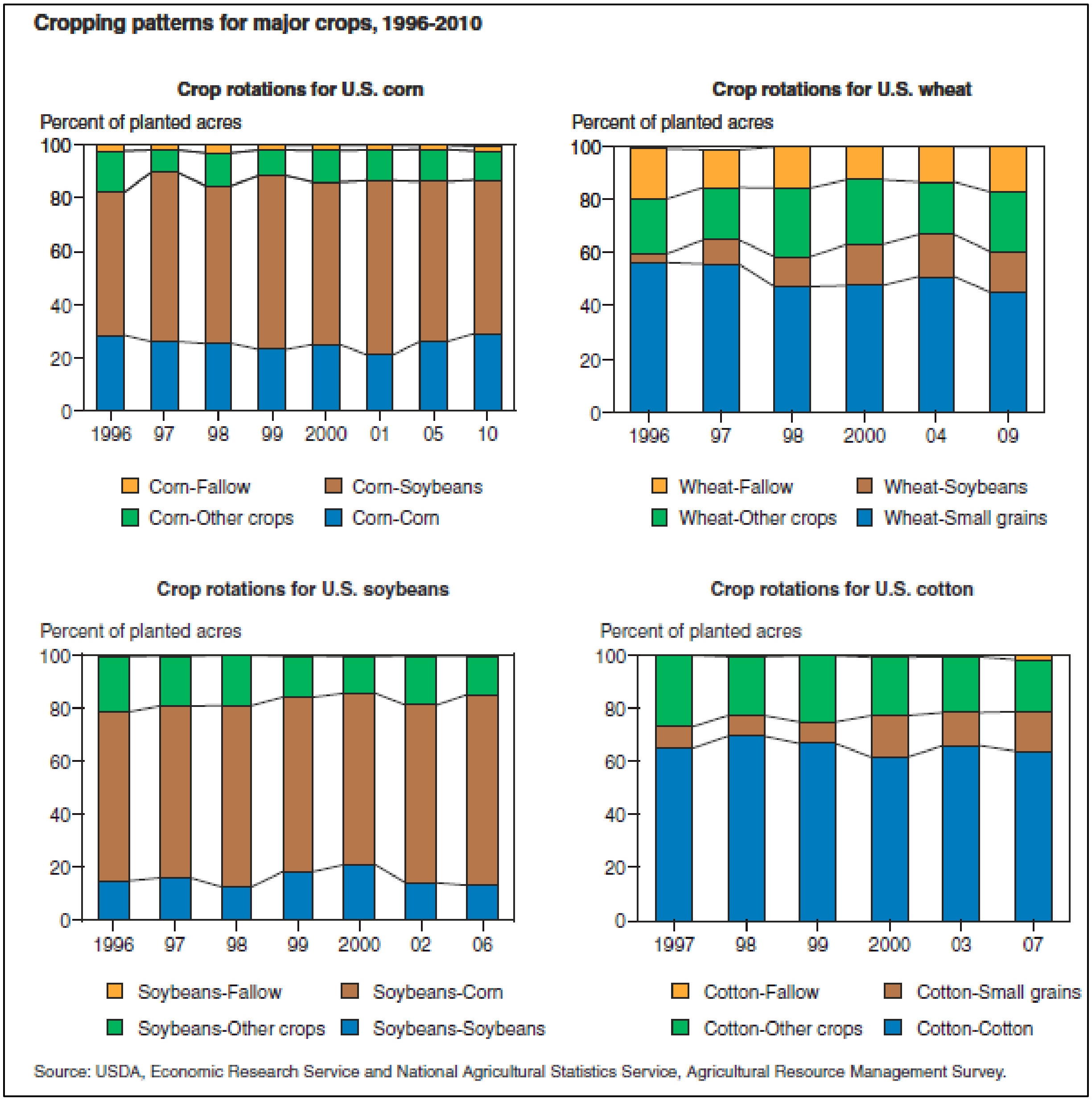

Figure 10. Cropping Patterns for Major Crops
Shows cropping patterns for major crops in the U.S. Source: (USDA-ERS, 2011a)

Since 1991, 75 percent of corn planted acreage has been in some form of rotation (Figure 10) (USDA-ERS, 2010c). Corn can be grown successfully in a conservation tillage system if rotated with other crops such as wheat and soybeans, which will reduce some of the problems encountered with conservation tillage (IPM, 2007) mentioned above.

Crops used in rotation with corn vary regionally and include oats, peanut, soybean, wheat, rye, and forage (USDA-APHIS, 2010b).

About 20 to 30 percent of corn farmers grow continuous corn. Consecutive plantings of corn frequently require at-planting or pre-plant pesticide treatments to control corn pests and pathogens as well as supplemental fertilizer treatments (Erickson & Lowenberg-DeBoer, 2005; IPM, 2004; Sawyer, 2007; Stockton, 2007). Corn-to-corn rotations also may require a change in tillage practices. Corn-to-corn cultivation may produce substantially greater quantities of field residue, requiring additional tillage prior to planting (Erickson & Lowenberg-DeBoer, 2005). The increased adoption of corn-to-corn rotation, mainly in conventional and GE production systems, has been attributed to rising corn demand and prices (Hart, 2006; Stockton, 2007).

Crop rotation is a common practice on U.S. soybean fields. Soybeans are often rotated with such crops as corn, winter wheat, spring cereals, and dry beans (OECD, 2000), the selection of which varies regionally. Corn is the most commonly rotated crop with soybeans. USDA Agricultural Resource Management Survey (ARMS) results for corn and soybean indicate a small increase in corn in rotation and continuous corn over the past decade (Ebel, 2012; US-FDA, 2011b). Returns for producers from a corn-soybean rotation are variable and depend on the price and projected yield of both corn and soybean for an individual operator (Stockton, 2007). Studies have found the soybean yield tends to increase under this rotation sequence and is attributed to an effective break in the soybean disease and pest cycle (Al-Kaisi, 2011; Nafziger, 2007). Soybean itself may be a cover crop in short rotations for its nitrogen contributions (Hoorman et al., 2009). Continuous soybean production is sometimes practiced, but yield can be reduced the second or later years, and pest and disease incidence may increase (Monsanto, 2010a; Pedersen et al., 2001).

In a survey of major corn/soybean production states, corn and soybean were alternated on 72 to 80 percent of acreage, other rotations were grown on 16 to 20 percent of acreage, and soybean was grown continuously on 5 to 12 percent of acreage between 1996–2002 (USDA-ERS, 2006). In 2006, the last year for which USDA survey data are available, 72 percent of soybean acreage was planted on acreage planted to corn in the previous year, soybean (13 percent), cotton (0.5 percent), small grains (8.1 percent), other crops (5.9 percent) and fallow (0.4 percent) (USDA-ERS, 2013c).

As noted in section 4.1.1 Land Use, economic factors favoring the planting of soybean and cotton over corn may decrease plantings of continuous corn and increase rotation of corn to these other crops under the No Action Alternative. Increased diversity in rotation crops has also been advocated as a strategy for weed control and potentially might increase under the No Action Alternative if weed control options increase in cost as expected (see section 4.1.1. herbicides).

Double-cropping soybeans is also an option to increase returns. Soybean is frequently planted in winter wheat stubble to produce a crop in the same growing season. Double-cropping maximizes profits if high commodity prices can support it, but careful management to achieve uniform stands to sustain high yields is needed: the selection of appropriate varieties, a higher seeding rate, closer row spacing, and adequate moisture for germination are important variables affecting profitability (McMahon, 2011).

Use of GE Corn and Soybean

Growers can choose from a large number of corn hybrids produced from traditional breeding or GE systems (NCGA, 2009). Like the major commodity crops cotton and soybean, GE varieties of corn have been adopted during the past decade. Large-scale field testing of GE crops began in the 1980s, but it was not until ten years later the first generation of GE varieties became commercially available (Fernandez-Cornejo & Caswell, 2006). In 2000, approximately seven percent of all corn planted was GE HR, and 25 percent of the total crop was GE (USDA-NASS, 2006). By 2012, a total of 88 percent of the corn crop was GE. Of that number, 73 percent of the U.S. corn crop was GE HR, 67 percent was insect-resistant, and 52 percent of the total crop was stacked with both GE herbicide tolerance and insect resistance (USDA-ERS, 2012a).

Since GE soybeans' initial commercial availability in 1996, their use has expanded to greater than 90 percent of the total U.S. soybean acreage (Figure 11). Although other varieties are available for selection by growers, the Roundup Ready®, GR varieties continue to dominate the market (see, e.g., (Tarter, 2011)). Other cultivated herbicide-tolerant soybeans include the LibertyLink® soybean varieties (a GE soybean that is resistant to glufosinate ammonium herbicide and was granted nonregulated status in 1996) and STS (a conventionally bred sulfonylurea-tolerant soybean first introduced in 1993). As of 2012, 3.9 percent of U.S. soybean acres planted were glufosinate-tolerant (US-EPA, 2013c). Additional GE traits, such as lepidopteran resistance, high oleic acid content, improved fatty acid profile, isoxaflutole resistance, mesotrione resistance, and increased stearidonic acid have nonregulated status (http://www.aphis.usda.gov/biotechnology/petitions_table_pending.shtml). Of these, at this time, only high oleic acid content soybean has been commercialized, in a limited launch. Other GE traits with nonregulated status may be made available for commercial production in the future under the No Action Alternative including resistance to the herbicide dicamba. Under the No Action Alternative, GE corn and soybean varieties are expected to still comprise over 90% of the corn and soybean planted in the U.S.

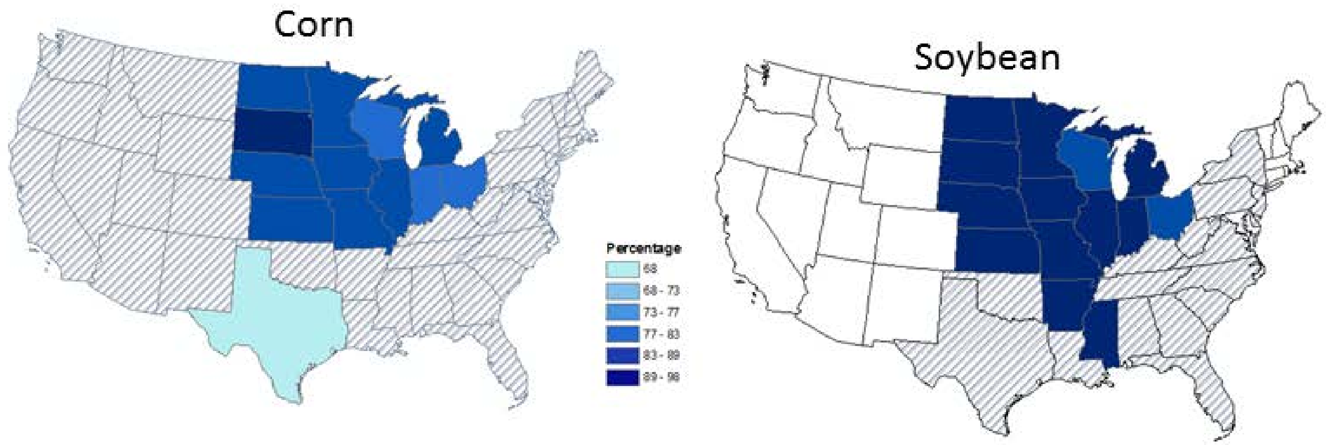

Figure 11. Percent Adoption of GE Herbicide-Resistant Corn and Soybean in the U.S.

HR GE corn and soybeans have been widely adopted throughout the major corn and soybean growing regions. Dark blue represents greater than 89 percent of the crop acres are planted to an HR GE crop. The hatch marks represent the states in the survey area where data is not presented on a state level for GE crop adoption. ERS reports that the average adoption for GE HR corn and HR soybean in the “other” states as 82 percent and 92 percent respectively (USDA-ERS, 2012a).

GR soybeans were first commercialized in 1996, and adoption by growers was rapid, reaching 54 percent already by 2000 and more than 90 percent by 2007 (USDA-NASS, 2012). While some potential herbicide cost savings may have driven adoption, early studies recognized the primary reason that growers adopted the technology as the simplicity and flexibility of a weed control program that relied heavily on a single herbicide to control a broad spectrum of weeds without crop injury or crop rotation restrictions. The increased cost of GE herbicide-resistant seed was outweighed by the often lower cost of glyphosate-based weed control programs, although this cost advantage was quickly eroded by reductions in the prices of other conventional herbicides. The GR soybean weed control program reinforced on-going trends towards post-emergence weed control and the adoption of conservation tillage programs (Carpenter & Leonard, 1999). For 1997, USDA estimated that herbicide-resistant soybeans led to a 3 percent increase in yields and a reduction in weed control costs (including, application, scouting, cultivation, herbicides, and technology fees) of $3.50/acre (10.65 percent) in the Heartland (Price et al., 2003).

The simplicity and flexibility of the GR soybean program has resulted in reduced management time. The time savings related to adoption of herbicide-resistant soybeans was estimated to be 14.5 percent in 2002 (Gardner et al., 2009). Off-farm income has been found to be an important source of household income for many soybean producers, with approximately two-thirds of soybean-growing farm families receiving income from off-farm work (Foreman & Livezey, 2002). The adoption of GE soybean varieties has been associated with increases in off-farm income due to reduced on-farm managerial time requirements. In an analysis of soybean producing households between 1996 and 2004, a 16 percent increase in off-farm income was associated with a 10 percent increase in the probability of adopting HT soybean (Fernandez-Cornejo, 2007).

The reduction in management time is one of the non-pecuniary benefits that influence farmer adoption decisions, but are not direct contributors to increased profits. In a study of GR soybean in the U.S. in 2002, nonmarket valuation techniques were used to estimate farmer valuation of three non-pecuniary characteristics: increased farmer and worker safety, environmental safety, and convenience. Convenience was most highly valued, followed by environmental safety, and operator and worker safety (Marra & Piggott, 2006). These results are reinforced by an analysis of nationwide survey results from 2007, which found that growers rated characteristics such as consistency of control, crop safety, and family and employee health as very important more often than herbicide cost. In addition, health and environmental concerns, yield concerns, and herbicide-application concerns were found to influence grower decisions (Hurley et al., 2009).

GR crops have been widely adopted because of the benefits they provide to growers, but the increasing prevalence of GR weeds threatens the sustainability of these benefits. Herbicide-resistant weeds can reduce yields and increase weed control costs.

States with confirmed GR weeds are shown in Figure 12. The problem is the greatest in the Southern States where growing seasons are long. Mississippi has seven GR weed species while Missouri and Arkansas each have six. Some states such as Georgia and Alabama are infested primarily with a single GR weed, Palmer amaranth, but the infestation is very widespread. Figure 13 shows the number of weeds species in each state that are resistant to the sites of action in the Enlist™ crops: 2,4-D, quizalofop, glufosinate, and glyphosate. With the exception of glyphosate, relatively few species are resistant to these herbicide sites of action in the US. In any given state there is no more than a single resistant species and these biotypes are not widespread (Heap, 2013b). There is one species resistant to glufosinate and it occurs in Oregon. For 2,4-D, there are five states that have a resistant species, Washington, Nebraska, Kansas, Michigan, and Ohio. For quizalofop, there are also five states that have a resistant species, Oregon, Idaho, Iowa, Mississippi, and Tennessee. HR weeds are discussed more fully in Appendix 6. Under the No Action Alternative, the increasing trend in the number of weeds resistant to glyphosate and glufosinate is expected to continue.

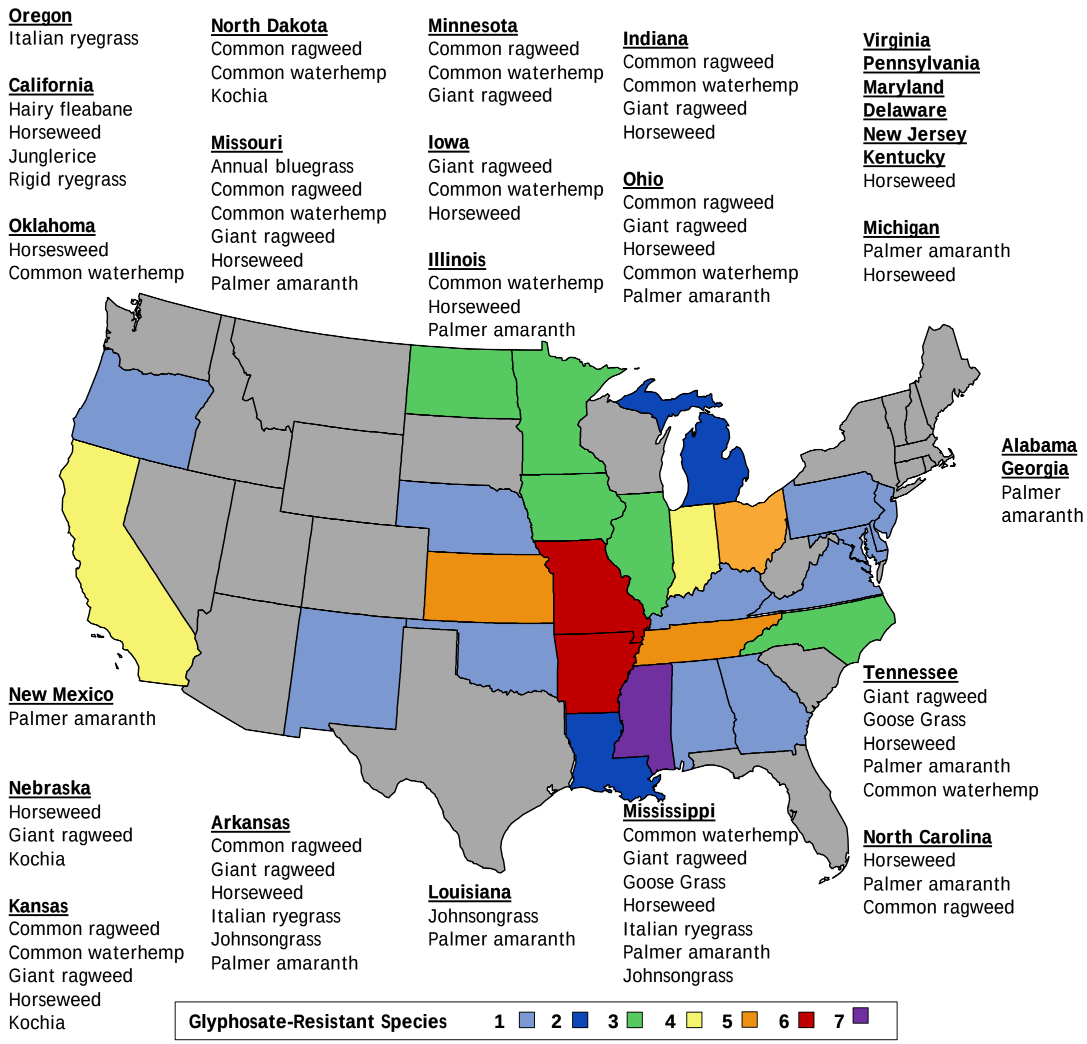

Figure 12. Distribution of Glyphosate-resistant Weeds in the U.S.
Source: WSSA, 2012 (Accessed Dec 14, 2012)

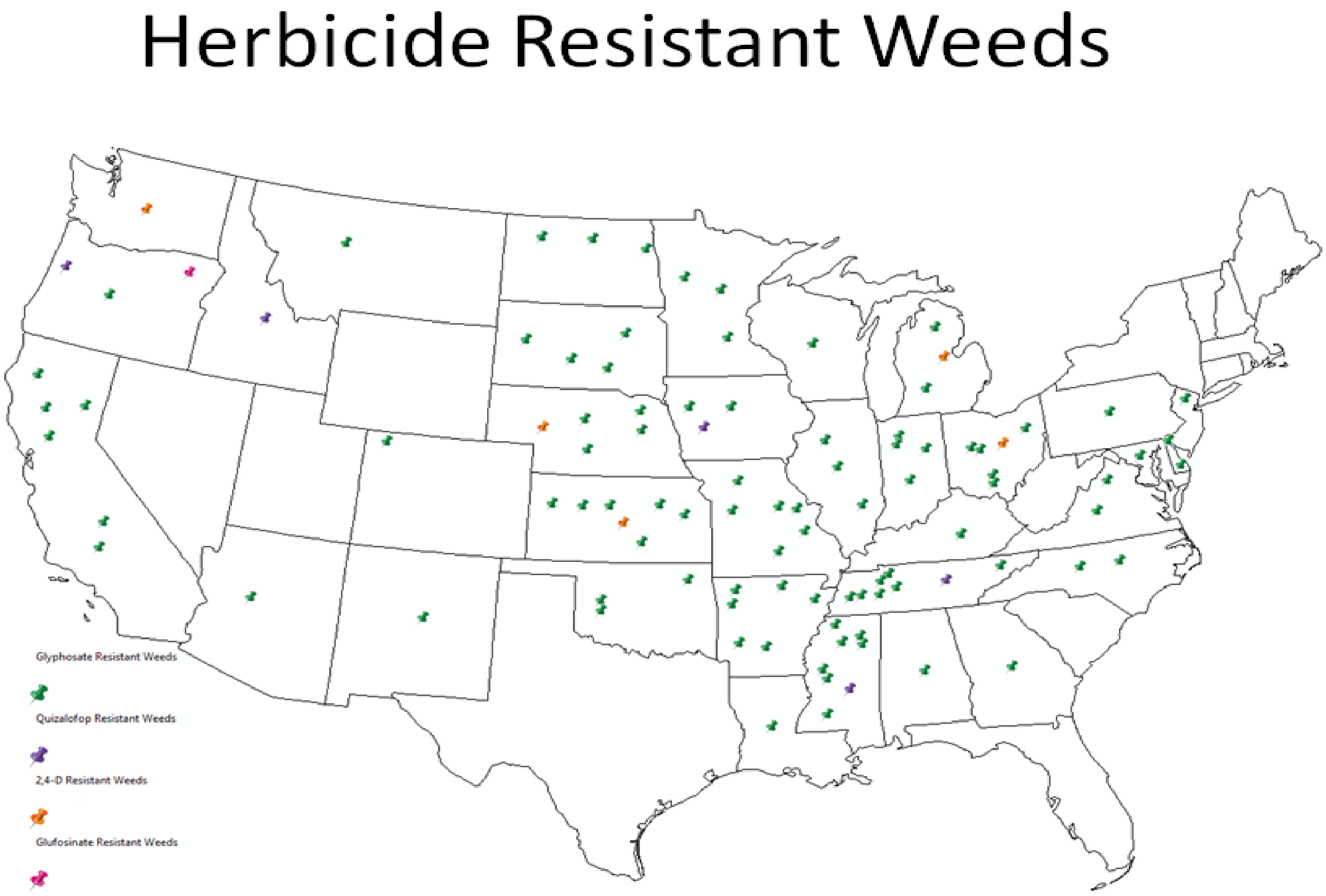

Figure 13. Number of Weed Species Resistant to Certain Herbicides in the U.S. by State

Agronomic Inputs

Corn and soybean production typically involves the extensive use of agronomic inputs to maximize grain yield (Ritchie et al., 2008). Agronomic inputs include fertilizers to supplement available nutrients in the soil; pesticides to reduce weed, insect, microbial, and nematode populations; and water to ensure normal plant growth and development (Howell et al., 1998; IPM, 2007).

Nutrients/Fertilizer

Given the importance of nutrient availability to corn agronomic performance, fertilization with nitrogen, phosphorus, and potassium is practiced widely (Ritchie et al., 2008). In 2010 (the date of the last USDA Agricultural Chemical Usage Summary to include corn), fertilizers were applied to 97 percent of corn acreage in Program States (USDA-NASS, 2010c). Of the reported corn acres, nitrogen was applied to 97 percent of the corn acreage at an average of 78 pounds per acre (lb/acre); phosphate was applied to 78 percent of corn acreage at an average rate of 52 lb/acre; potash was applied to 61 percent of corn acreage at a rate of 73 lb/acre; and sulfur was applied to 15 percent of the corn crop at an average rate of 11 lb/acre (USDA-NASS, 2010c). Under the No Action Alternative, these fertilizer requirements are unlikely to change from current use.

Because soybean is a nitrogen fixer, nitrogen is not as frequently added to soybean fields. A 2006 survey reported by USDA National Agricultural Statistics Service (NASS) (USDA-NASS, 2009e) found that among 19 select states, nitrogen was applied to 18 percent of the planted soybean acreage in those states at an average rate of 16 lb/acre per year, and phosphate was applied to 23 percent of the planted acres at an annual average rate of 46 lb/acre. Potash was applied to 25 percent of the planted acreage at an average annual rate of 80 lb/acre, and sulfur was applied to 3 percent of the planted acres at an average annual rate of 11 lb/acre (USDA-NASS, 2009e). Other micronutrient supplements such as zinc, iron, and magnesium were applied as needed (NSRL, No Date; USDA-NASS, 2007; Whitney, 1997). Under the No Action Alternative, these fertilizer requirements are unlikely to change from current use.

Inoculates

To improve yields by an average of 1 bushel/acre, some growers inoculate soybean with the bacteria *Bradyrhizobium japonicum* (Conley & Christmas, 2005). Historically, a non-sterile peat powder applied to the seed at planting had been the carrier for the inoculant into the field. More recently, improvements have been made in inoculant manufacturing, such as the use of sterile carriers, the addition of adhesives for inoculates to stick to seed, the introduction of liquid carriers, the use of concentrated frozen products, the introduction of new organism strains, the use of pre-inoculants, and the introduction of inoculants with extended biofertilizer and biopesticidal properties (Conley & Christmas, 2005). Industry has approximated that about one-third of U.S. soybean acreage was inoculated in 2009 (Seed Today, 2009). Under the No Action Alternative, the use of inoculates is unlikely to change from current use.

Insecticides

In addition to herbicides, pesticides can be used in corn production. In 2010, approximately 12 percent of the corn-planted acreage was treated with insecticides, with the most abundantly applied being tefluthrin for control of corn rootworm (3 percent); cyfluthrin for corn rootworm, earworms and European corn borer (2 percent); lambda-cyhalothrin for European corn borer (2 percent); bifenthrin for grubs, wireworms, seed-corn maggot, and cutworms (2 percent); and tebupirimphos for corn rootworm and seed corn maggot (2 percent) (USDA-NASS, 2010b).

A wide variety of pests can hinder soybean production, and many require agricultural pesticidal inputs for their control. Several groups and types of insects can feed on the foliage, seed pods and roots of the soybean plant, and can reduce yield if not adequately controlled (Lorenz et al., 2006; Whitworth et al., 2011). A major pest for soybean producers is the soybean nematode that has no effective pesticidal treatment, especially the soybean cyst nematode (Nelson & Bradley, 2003). Nematodes are microscopic organisms that feed on the roots of various plants, including soybeans. Several races or different groups of nematodes exist, and their control is difficult. Some soybean varieties have resistance to some of the races, but often these resistant varieties have yielded less than other commercially available soybean varieties. A combination of crop rotation to a non-susceptible host and the use of resistant varieties can help alleviate the problem (Nelson & Bradley, 2003).

Insect infestation thresholds have been established to indicate when insecticide applications are actually necessary (Higgins, 1997). The thresholds are commonly based on number of insects found in field sampling surveys and/or in established standard defoliation thresholds, such as those provided by the National Information System of the Regional Integrated Pest Management Centers in pest management strategic plans (USDA-AMS, 2011). A 2006 survey (USDA-NASS, 2009e) found that insecticides were applied to 16 percent of the 72.9 million soybean acres planted in surveyed states in 2006. Of the 12 reported insecticides, the three most common—lambda-cyhalothrin, chlorpyrifos, and esfenvalerate—were applied to 6 percent, 5 percent, and 3 percent of the planted acres, respectively (USDA-NASS, 2009e). Other methods of addressing insect infestations include the introduction of beneficial pests that prey on targeted insects obtained from commercial suppliers, as well as crop rotation and tillage as discussed above. Under the No Action Alternative, use of insecticides on corn and soybean is unlikely to change from current use.

Herbicides

The following section provides a brief background of herbicide use in corn and soybeans in the U.S. It is provided to give the context for the analyses related to HR weed selection. For further information on these subjects see Appendix 3. Weed Management and Herbicide Use; Appendix 4: Herbicide Use Trends and Predicted Use on Enlist™ Corn and Soybean; Appendix 5: Common Weeds in Corn and Soybean; Appendix 6: Herbicide Resistance; Appendix 7: Off-Target Pesticide Movement; Appendix 8: EPA Assessments of Herbicides Used on DAS Corn and Soybean.

Herbicide use in corn differs substantially from that in soybean both in the types of herbicides used and the variety of herbicide sites of action (see Appendix 3 and 4). Corn yields are more negatively impacted by early season weed competition than soybeans. Corn is also planted in wider rows than soybeans, and the resulting penetration of light allows weed germination over a longer period of time than in soybeans. For these reasons, post emergent applications of glyphosate are not as beneficial in corn as they are in soybean. To obtain the best corn yields, growers manage weeds with pre-plant or pre-emergent herbicide applications. Historically they have used atrazine, and chloroacetamide herbicides such as acetochlor, metolachlor, and more recently metolachlor-S. They also relied on both dicamba and 2,4-D. Even after GR corn was widely adopted, most corn growers have continued to use residual herbicides (such as atrazine and chloroacetamides) followed by application of post emergent herbicides as needed to provide good weed control and maximize yield potential.

In contrast, soybean growers have come to rely almost exclusively on glyphosate for weed control. Prior to the adoption of GR soybean, growers relied heavily on ALS and microtubule inhibitors. With the adoption of GR soybean, glyphosate was used on greater than 95 percent of soybean acreage and for 75% of soybean growers, glyphosate represented the only herbicide site of action used. As GR weeds have become more prevalent, the trend among soybean growers is to use more sites of action including 2,4-D, chloroacetamides, PPO and ALS inhibitors. There has also been an increased adoption of glufosinate resistant soybean varieties resulting in a tripling of glufosinate use from 2011 to 2012 (from 1.3 percent of soybean acres to 3.9 percent; see Appendix 4). This trend in the increased use of glufosinate is expected to continue under the No Action Alternative

As described in more detail in Appendix 4, the trend to use more herbicides with different modes of action is observed for both corn and soybean. There also has been a trend to use more 2,4-D. In 2002, all uses of 2,4-D use was estimated to be 46 million pounds but that increased to 64 million pounds in 2011 (Appendix 4). 2,4-D is widely used for agricultural and industrial purposes. In 2011, about 40 percent of 2,4-D was used on crops, 38 percent was used on turf and ornamentals, and 22 percent was used on range, pasture and for industrial vegetation management such as to control unwanted vegetative growth on utility corridors, rights-of-way, roadsides, railroads, cemeteries, non-crop areas, and managed forest. It is also used to control aquatic and nuisance weeds, e.g., purple loosestrife (Industry Task Force II, 2005). 2,4-D is very widely used for non-agricultural use (see Appendix 4 for more details). Agriculturally, it is used on a variety of grass crops including pasture/hay, small grains (spring wheat, winter wheat, rice, sorghum, barley, millet, oats), corn, and sugar cane and on nut and fruit tree crops (almonds, apples, apricots, cherries, citrus, hazelnuts, nectarines, peaches, pears, pecans, pistachios, plums, and walnuts). It is also used as a pre-plant treatment in a number of crops such as soybean and cotton. There are at least 33 crops where 10 percent of the crop is sprayed with 2,4-D (see Appendix 4). As described in more detail in Appendix 4, 2,4-D use on soybean alone increased 70 percent from 2008 to 2011. The trend in the increased use of 2,4-D is expected to continue under the No Action Alternative.

In selecting an herbicide, a grower must consider, among other factors, whether an herbicide can be used on the crop (herbicides are registered by the EPA for specific uses/crops), 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. Herbicides have different ways of acting on plant physiology (i.e., sites or mechanisms of action) to affect the health of a given plant (see

Appendix 3). Some common sites of herbicide action include auxin growth regulators like 2,4-D; amino acid inhibitors such as glyphosate; photosynthesis inhibitors such as atrazine; lipid biosynthesis inhibitors like quizalofop; and glutamine synthase inhibitors such as glufosinate (UW-NPMP, No Date) and (Appendix 3). Applications of herbicides to a crop may occur pre-plant (i.e., burndown), pre-emergence, or post-emergence (Schneider & Strittmatter, 2003). Herbicide use is not regulated by APHIS but regulated by EPA under FIFRA and its amendments.

Weeds have been estimated to cause a potential yield loss of 37 percent in world-wide soybean production (Heatherly et al., 2009). Weeds compete with soybean for light, nutrients, and soil moisture; can harbor insects and diseases; and also can interfere with harvest, causing extra wear on harvest equipment (Loux et al., 2008). In addition to weed density, the time that weeds compete with the soybean crop influences the level of yield loss. The later the weeds emerge, the less impact they will have on yield. Soybean plants withstand early season weed competition longer than corn because the soybean canopy closes earlier (Boerboom, 2000). The extent of canopy closure restricts the light available for weeds and other plants growing below the soybean. In addition, canopy closure occurs more quickly when soybean is drilled or planted in narrow rows (Boerboom, 1999); however, in some studies it has also been observed that, depending on factors such as weed species, environmental conditions (i.e., rainfall amounts) and soybean cultivar, soybeans are able to compete with weeds with no resulting yield reduction (Krausz et al., 2001).

Herbicides have been the primary tactic used to manage weed communities in soybeans since the mid-1960s and are likely to continue to be an important feature of row crop weed management for the foreseeable future. One study, which examined aggregated data on crop yield losses and herbicide use, estimated that even if additional tillage and hand weeding labor replaced the use of herbicides, U.S. crop production would decline by 20 percent with a $16 billion loss in value if herbicides were not used (Gianessi & Reigner, 2007).

GR crops have become adopted widely since their introduction in the mid-late 1990s for several reasons. Glyphosate works non-selectively on a wide range of plant species, is a relatively low-cost herbicide, enhances ‘no-till’ farming practices, and has minimal animal toxicological and environmental impacts (USDA-APHIS, 2010a). However, increased selection pressure resulting from the wide-spread adoption of GR crops, along with the reductions in the use of other herbicides and weed management practices, has resulted in both weed population shifts and growing numbers of GR individuals among some weed populations (Duke & Powles, 2009; Owen, 2008).

As herbicide-resistant weeds have become increasingly prevalent, costs of weed control have also increased. Extension weed scientists estimate that corn growers with GR weeds may incur increased weed control costs of up to $35/acre compared with commonly used glyphosate-based programs, primarily due to applying herbicides with an additional mode of action (Carpenter & Gianessi, 2010). However, growers may be able to control GR weeds in corn without increasing costs, due to the availability of low-cost herbicides such as 2,4-D and dicamba, with efficacy against GR weeds such as waterhemp and giant ragweed (Carpenter & Gianessi, 2010).

Extension weed scientists estimated the increased cost of the additional herbicides needed to control GR weeds in soybean to be as much as $42/acre (for Palmer amaranth in Tennessee), with most estimates of the increased costs falling in the range of up to $20 to $30/acre (Carpenter et al., 2002). These costs will vary depending on the specific weed species present in any particular field. However, as resistance to glyphosate and other herbicides has developed and spread in weed populations, these costs may have increased since these estimates were made. For example, there are waterhemp populations in Iowa corn and soybean production fields with resistance to five herbicide sites of action (Owen, 2012) and Appendix 4. The continued selection of weeds resistant to glyphosate and other herbicides used are expected to continue under the No Action Alternative. According to comment APHIS-2013-0042-1911 from a weed science expert, "the greatest risk for developing herbicide resistance is actually occurring at this moment with the PPO herbicides and glufosinate. These products are being over used as growers have no other effective herbicidal options. New technologies such as dicamba or 2,4-D could be used to delay resistance development to the PPO herbicides and glufosinate. As such crop management practices will require modifications to address these weeds. These include management practices including the use of alternative herbicides for weed control, as well as mechanical cultivation practices, and crop rotation."

Recent work in Australia is leading the development of new technologies that utilize non-chemical weed control strategies that destroy weed seeds during commercial grain harvest thereby facilitating weed seedbank decline (Walsh & Newman, 2007; Walsh et al., 2013; Walsh & Powles, 2007; Walsh et al., 2012). These technologies have been named harvest weed seed control (HWSC) and include systems such as chaff carts, narrow windrow burning, bale direct, and the Harrington Seed Destructor. Their promising use in Australia may lead to adoption in the United States, especially if weed control using herbicides declines in effectiveness. Under the No Action Alternative, it is likely that the cost of weed management and the time spent managing weeds will continue to increase and methods used for weed control will diversify.

Growers choose certain pesticides based on weed, insect and disease pressures, cost of seed and other inputs, technology fees, human safety, potential for crop injury, and ease and flexibility of the production system (Farnham, 2001; Heiniger, 2000; University of Arkansas, 2008). Growers have traditionally used multiple herbicides for weed control. For pre-plant application, herbicides that have residual activity are typically used (see Appendix 3). For post- emergent late season weed control in corn, synthetic auxins such as 2,4-D and dicamba are often used. For post-emergent weed control in soybean, in addition to glyphosate, ALS and PPO inhibitors are often used (see Appendices 3 and 4).

Most growers are not expected to increase tillage in the short-term due to the economic (reduced fuel use, less time in the field) and environmental benefits (reduced soil erosion and better moisture retention) associated with these practices. The fact that tillage is increasing in soybean production in the Midwest and Midsouth (Shaw et al., 2012) (and see discussion under tillage in Section 4.1.1)., suggests that this increasing tillage trend may continue under the No Action Alternative as herbicide-resistant weeds become more difficult to control with available herbicide chemistries. In an attempt to offset the increase in tillage that might otherwise result in the effort to manage HR weeds, the Natural Resources Conservation Service is offering farmers technical and financial assistance to manage HR weeds while maintaining conservation stewardship through two programs: the Conservation Security Program and the Environmental Quality Incentives Program (Robinson, 2011; 2013). Among the practices that qualify for financial and technical incentives are the use of cover cropping and crop rotation (Robinson, 2013). As a result, cover cropping and crop rotation, both of which have shown promise in reducing weed pressure (Devore et al., 2013; Murphy et al., 2006; Sosnoskie et al., 2009) may increase under the No Action Alternative. Crop rotation may be altered to facilitate the use of additional herbicide chemistries, such as glufosinate in the case of Liberty Link® crops, which as noted above has increased three fold nationally primarily due to an increased use of glufosinate in the Southeast. Crop rotation also may become more diverse to leverage differences in crop ecology to shift the dominant weed species and thereby lessen the size of the resistant weed seed bank (Murphy et al., 2006; Sosnoskie et al., 2009). Whereas crop rotation is extensively used today, cover cropping currently is only used on 1 percent of cropland acreage (Wallander, 2013). The fact that cover cropping has been slow to be adopted at present suggests that this practice may be even less likely to be adopted under the Action Alternatives where the more familiar option, an additional herbicide chemistry through Enlist™ technology, will be available to manage glyphosate resistant weeds. Similarly, more diversified crop rotation may be less likely to be implemented under the Action Alternatives because the economic returns from growing additional crops are likely to be lower than a simple corn soybean rotation.

Export of Corn and Soybean

Corn is the dominant feed grain traded internationally (USDA-OCE, 2011b). In 2010/11, the U.S. produced 38 percent of the total world supply of corn (USDA-OCE, 2011b). Primary importers of corn from the U.S. include Japan, Mexico, Korea, Egypt, Taiwan, Syria, the EU and China (USDA FAS, 2012b). Approximately 15 to 20 percent of the U.S. corn production is exported, with the volume of exports projected to increase over the next decade (DAS, 2010a; USDA-OCE, 2011a). Egypt, the EU, Japan, Mexico, Southeast Asia, and South Korea are net importers of corn (USDA-FAS, 2011; USDA-OCE, 2011a; b). China is projected to become a net importer of corn to support its expanding livestock and industrial sectors (USDA-OCE, 2011b). The increase in China's imports is expected to account for one-third of the growth in world corn trade (USDA-OCE, 2011b).

Value enhanced, specialty corn is an important part of the U.S. export market for corn. High oil corn, for example, is in high export demand as a replacement for animal fats in feed rations (USDA-FAS, 2004). The challenges associated with maintaining variety identity in international commodity movement increases the costs, as well as the premiums paid, for these specialty crops (USDA-FAS, 2004). Trade in feed for livestock has been a driver of this international trade. Corn gluten feed is a major product in international trade in feed ingredients (CRA, 2006a). Large volumes of U.S. corn gluten feed are exported to the European Union (EU) (CRA, 2006a). The U.S. is the largest exporter of corn in the world market, exporting 48,500 tons of corn in 2010, against a global export market of 92,875 tons (USDA-FAS, 2011). How and where the corn and corn products will be used will be subject to global market conditions.

Soybean exports in the form of bulk beans, meal, and oil are a major share of the total agricultural exports for the U.S., representing 16.1 percent of the total value of U.S. agricultural exports. The value of U.S. agricultural exports was $136 billion in 2011 (USDA-ERS, 2013c).

Bulk soybeans accounted for $17.59 billion of this total, ranking first among all agricultural commodities, while soybean meal, at a value of $3.2 billion, and soybean oil, at a value of $1.3 billion, ranked 11th and 22nd, respectively (USDA-ERS, 2012c). The U.S. was responsible for 38 percent of the world's bulk soybean exports, 13 percent of the world's soybean meal exports, and 11 percent of the world's soybean oil exports in 2011/12. (USDA-ERS, 2012c).

In 2011/12 soybean meal represented 67 percent of the protein meal produced worldwide, although soybean oil ranked behind palm oil in terms of worldwide vegetable oil production (USDA-ERS, 2012c). Similarly, soybean held the largest share of protein meal consumed worldwide mainly as animal feed, with soybean oil again coming in second behind palm oil in terms of worldwide vegetable oil consumption (USDA-FAS, 2013b).

In 2011/12, the U.S. was responsible for 35 percent of the world's soybean production, 21 percent of world's soybean meal production, and 21 percent of the world's soybean oil production (USDA-FAS, 2013a). The U.S., China, Argentina, and Brazil are the major producers of soybean, soybean meal, and soybean oil (USDA-FAS, 2013a).

The U.S., along with Brazil, Argentina, Paraguay, and Canada, accounted for 96 percent of the bulk soybean exported in 2011/12, while Argentina, Brazil, the U.S., India, and Paraguay accounted for 93 percent of the soybean meal exported in 2011/12. Argentina and Brazil are the dominant countries in terms of soybean oil exports, accounting for 67 percent of the world total in 2011/12. China is the largest importer of U.S. soybeans and soybean products, accounting for 50 percent of the total value of U.S. soybean and soybean product exports in 2012, followed by Mexico (8.9 percent of total) and Japan (4.2 percent) (USDA-FAS, 2013a). China is by far the largest importer of soybean, accounting for 64 percent of world imports in 2011/12, followed by the EU-27 with 13 percent of world imports. The EU-27 accounted for 36 percent of world imports for soybean meal in 2011/12, with Indonesia as the next largest importer (5.7 percent). China and India are the largest importers of soybean oil, accounting for 18 percent and 14 percent of world imports in 2011/12, respectively (USDA-FAS, 2013a).

Over the next decade, global trade in soybeans is expected to increase by 31 percent, soybean meal by 17 percent, and soybean oil by 12 percent. The U.S., Brazil, and Argentina are expected to continue to account for 88 percent of global exports of soybeans and soybean products. Underlying these projections is an assumption that China would continue to be heavily reliant on soybean imports, which are projected to rise 59 percent to 90 million tons in 2021/22 (USDA-OCE, 2013).

The increasing cost of weed control due to further development of herbicide-resistant weeds may potentially reduce U.S. competitiveness, although these problems are not unique to the U.S. Under the No Action Alternative, the U.S. is expected to continue to be a leading producer and exporter of corn, soybeans, corn products, and soybean products.

Food and Feed

In the past 30 years, public consumption of corn-based products has more than doubled. Per capita consumption of corn products rose from 12.9 pounds annually per capita in 1980 to 33 pounds in 2008; and consumption of corn sweeteners increased from 35.3 pounds annually per capita to 69.2 pounds during that period (USCB, 2011). During the same time period, the share of corn that was GE increased from 0 to 80 percent (USDA-ERS, 2010a).

Much of the corn consumed by humans has been processed, and processing can reduce residual pesticide levels. There are three principal corn product industries in the U.S.: corn refiners, dry millers, and distillers. Corn refiners produce starches, sweeteners, ethanol, feed ingredients, corn oil, organic acids, amino acids, and polyols (CRA, 2006a). Dry millers manufacture flaking grits, snack grits, corn meals, and corn flours and distillers produce beverage and industrial alcohol (CRA, 2006a). The production processes in each of these industries frequently involve several sequential mechanical and chemical processes. Depending on the final product, these processes include washing, heating, adjusting pH, steeping in an acid solution, fermentation, mechanical milling and centrifugal separation, extrusions, pressing and solvent extraction, evaporation and filtration, and final refining (Corn Refiners Association, 2006). Each step in the production process reduces residual pesticides in the finished product (CRA, 2000). Manufacturing operations also have been shown to degrade and denature proteins in corn (Hammond & Jez, 2011).

Corn comprises approximately 95 percent of the total feed grain production and use (USDA-ERS, 2011c). The production of corn for feed use is a derived demand, i.e., production of corn for feed will vary depending on the number of animals (cattle, hogs, and poultry) being fed corn (USDA-ERS, 2011c). The amount of corn used for feed also depends on the crop's supply and price (USDA-ERS, 2011a). In 2012, beef cattle consumed approximately 30 percent of the total corn feed used in the U.S. Poultry accounted for the next highest consumption of corn feed, approximately 27 percent, while swine were fed approximately 22 percent, dairy cattle approximately 18 percent, and other animals approximately 2 percent (World of Corn, 2013). Animal feed derived from corn comes not only from the unprocessed grain, but also from the residuals derived from three major corn industries: corn refining, corn dry millers, and distillers (CRA, 2006b). Animal feed products from corn refining and wet milling include corn gluten feed, corn gluten meal, corn germ meal, corn steep liquor, and amino acids (CRA, 2006a).

Soybeans yield both solid (meal) and liquid (oil) products. Soybean meal is high in protein and is used for products such as tofu, soymilk, meat replacements, and protein powder; it also provides a natural source of dietary fiber (USB, 2009). Nearly 98 percent of soybean meal produced in the U.S. is used as animal feed, while less than 2 percent is used to produce soybean flour and proteins for food use (Soyatech, 2011). Poultry consume more than 45 percent of domestic soybean meal or 590 million bushels of the U.S. soybean crop, with soybean oil increasingly replacing animal fats and oils in broiler diets (USB, 2011). Soybean can be the dominant component of livestock diets, such as in poultry, where upwards of 66 percent of their protein intake is derived from soybean(Waldroup & Smith, No Date). Other animals fed domestic soybean (by crop volumes consumed) include swine (26 percent), beef cattle (12 percent), dairy cattle (9 percent), other (e.g., poultry, farm-raised fish 3 percent), and household pets (2 percent) (Soy Stats, 2010; USB, 2011).

Soybean liquids are used to produce salad and cooking oils, baking and frying fat, and margarine. Soybean oil is low in saturated fats, high in poly- and monounsaturated fats, and contains essential omega-3 fatty acids. Soybean oil comprises nearly 70 percent of the oils consumed in U.S. households (Soy Stats, 2010).

Although the soybean market is dominated by seed production, soybean has a long history in the U.S. as a nutritious grazing forage, hay, and silage crop for livestock (Blount et al., 2009). Soybean may be harvested for hay or grazed from the flowering stage to near maturity; the best soybean for forage is in the beginning pod stage (Owen et al., 2011a). For silage, it should be harvested at maturity before leaf loss and mixed with a carbohydrate source, such as corn, for optimal fermentation characteristics (Blount et al., 2009). Varieties of soybean have been developed specifically for grazing and hay, but use of the standard grain varieties are recommended by some because of the whole plant feeding value (Weiderholt & Albrecht, 2003).

Non-GE soybean varieties, both those developed for conventional use and for use in organic production systems, are not routinely required to be evaluated by any regulatory agency in the U.S. for human food or animal feed safety prior to release in the market. Under the Federal Food, Drug, and Cosmetic Act (FFDCA), it is the responsibility of food and feed manufacturers to ensure that the products they market are safe and properly labeled. Food and feed derived from any GE crop events must be in compliance with all applicable legal and regulatory requirements.

Food safety reviews frequently compare the compositional characteristics of the GE crop with non-transgenic, conventional varieties of that crop (see also Aumaitre et al., 2002; FAO, 2009). Moreover, this comparison also evaluates the composition of the modified crop under actual agronomic conditions, including various agronomic inputs (see, e.g., Herman et al., 2010). Composition characteristics evaluated in these comparative tests include moisture, protein, fat, carbohydrates, ash, minerals, dietary fiber, essential and non-essential amino acids, fatty acids, vitamins, and antinutrients (Herman et al., 2010).

Antinutrients represent an important element of this comparison. Antinutrients are compounds produced by a plant that interfere with the absorption and metabolism of the consumed vegetable as well as other foods in the digestive tract (Cordain, 1999). Antinutrients in corn include lectins, which interfere with vitamin absorption and have been associated with cellular level metabolic interference, and trypsin inhibitors, which inhibit protein digestion (Cordain, 1999). Antinutrients commonly found in raw soybean also include trypsin inhibitors and lectins (US-FDA, 2011c). Routine processing in moist heat inactivates these antinutrients (US-FDA, 2011c).

There are multiple ways in which organisms can be genetically modified through human intervention. Traditional methods include breeding or crossing an organism to elicit the expression of a desired trait, while more contemporary approaches include the use of biotechnology such as genetic engineering to produce new organisms (NRC, 2004). As noted by the National Research Council (NRC), unexpected and unintended compositional changes arise with all forms of genetic modification, including both conventional hybridizing and genetic engineering (NRC, 2004). The NRC also noted in its 2004 report that no adverse human health effects attributed to genetic engineering have been documented. More recently, the NRC found that the cultivation of GE crops has resulted in changes in pesticide application regimens (applications of fewer pesticides or using pesticides with lower environmental toxicity), and that the cultivation of herbicide-tolerant crops is advantageous because of their superior efficacy in pest control and concomitant economic, environmental, and presumed personal health advantages (NRC, 2010). Reviews on the nutritional quality of GE foods generally have concluded that there are no biologically meaningful nutritional differences in conventional versus GE plants for food or animal feed (Aumaitre et al., 2002; Faust, 2004; Van Deynze et al., 2004).

Human health topics associated with GE crops include the potential toxicity of the introduced genes and their products, the expression of new antigenic proteins, and/or altered levels of existing allergens (Dona & Arvanitoyannis, 2009; Malarkey, 2003). Under the FFDCA, it is the responsibility of food and feed manufacturers to ensure that the products they market are safe and labeled properly. Food and feed derived from GE organisms must be in compliance with all applicable legal and regulatory requirements. GE organisms for food and feed may undergo a voluntary consultation process with the FDA prior to release onto the market. The PAT protein, conferring resistance to glufosinate, has already been evaluated by FDA; soybean (and other crops) containing the *pat* gene are already in commerce. The CP4 EPSPS protein derived from *Agrobacterium* spp. confers resistance to glyphosate and has already been evaluated by FDA; GR crops have been present in commerce since 1996. Consumer consumption of GE soybean is expected to continue to follow current levels in the future.

GE organisms for food and feed typically undergo a voluntary consultation process with the FDA prior to release onto the market. Although a voluntary process, thus far, all applicants who have wished to commercialize a GE variety that would be included in the food supply have completed a consultation with the FDA. In such consultation, a developer who intends to commercialize a bioengineered food meets with FDA to identify and discuss relevant safety, nutritional, or other regulatory issues regarding the bioengineered food and then submits to FDA a summary of its scientific and regulatory assessment of the food. This process includes: 1) an evaluation of the amino acid sequence introduced into the food crop to confirm whether the protein is related to known toxins and allergens; 2) an assessment of the protein's potential for digestion; and 3) an evaluation of the history of safe use in food (Hammond & Jez, 2011). FDA evaluates the submission and responds to the developer by letter with any concerns it may have or additional information it may require.

Dow has provided the FDA with information on the identity, function, and characterization of the genes for DAS-40278-9 corn, DAS-68416-4 soybean, and DAS-44406-6 soybean. Dow has completed consultations with FDA for DAS-40278-9 corn (BNF-120) (US-FDA, 2011c); DAS-68416-4 soybean (BNF-124) (US-FDA, 2011a); and DAS-44406-6 soybean (BNF-133) (US-FDA, 2013a).

Currently over 90 percent of the corn and soybean grown in the U.S. is GE (USDA-NASS, 2006) and this market share is expected to continue under the No Action Alternative. Americans are routinely exposed to the PAT protein and CP4 EPSPS protein found in LibertyLink® and Roundup Ready® biotech crops currently and this exposure is expected to continue under the No Action Alternative. Both of these proteins are considered to be safe for consumption by humans and animals.

<u>Worker Safety</u>

Agriculture is one of the most hazardous industries for U.S. workers. As a result, in 1990, Congress directed the National Institute of Occupational Safety and Health to develop a program to address high-risk issues related to occupational workers. In consideration of the risk of pesticide exposure to field workers, EPA's Worker Protection Standard (WPS) (40 CFR Part 170) was published in 1992 to require actions to reduce the risk of pesticide poisonings and injuries among agricultural workers and pesticide handlers. The WPS offers protections to more than two and a half million agricultural workers who work with pesticides at more than 560,000 workplaces on farms, forests, nurseries, and greenhouses. The WPS contains requirements for pesticide safety training, notification of pesticide applications, use of personal protective equipment, restricted entry intervals following pesticide application, decontamination supplies, and emergency medical assistance. On February 20, 2014, the US-EPA announced proposed changes to the agricultural WPS to increase protections from pesticide exposure for agricultural workers and their families.[6] EPA is proposing to strengthen the protections provided to agricultural workers and handlers under the WPS by improving elements of the existing regulation, such as training, notification, communication materials, use of personal protective equipment, and decontamination supplies. The proposed changes to the current WPS requirements, specifically improved training on reducing pesticide residues brought from the treated area to the home on workers and handlers' clothing and bodies and establishing a minimum age for handlers and early entry workers, other than those covered by the immediate family exemption, mitigate the potential for children to be exposed to pesticides directly and indirectly. EPA expects the revisions, once final, to prevent unreasonable adverse effects from exposure to pesticides among agricultural workers and pesticide handlers; vulnerable groups, such as minority and low-income populations, child farmworkers, and farmworker families; and the general public. Furthermore, the Occupational Safety and Health Administration requires all employers to protect their employees from hazards associated with pesticides and herbicides.

Pesticides, including herbicides, are used on most corn and soybean acreage in the U.S. Changes in acreage, crops, or farming practices can affect the amounts and types of pesticides used and thus the risks to workers. The EPA pesticide registration process, however, involves the design of use restrictions that if followed have been determined to be protective of worker health. Growers are required to use pesticides consistent with the application instructions provided on the EPA-approved pesticide labels. Worker safety precautions and use restrictions are clearly noted on pesticide registration labels. These restrictions provide instructions as to the appropriate levels of personal protection required for agricultural workers to use herbicides. These may include instructions on personal protective equipment, specific handling requirements, and field reentry procedures. Used in accordance with the EPA label, these herbicides have been determined to not present a health risk to workers (US-EPA, 2005b; 2008).

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[6] For the proposed changes see: http://www.epa.gov/oppfead1/safety/workers/proposed/index.html

Under FIFRA, all pesticides (which is inclusive of herbicides) sold or distributed in the U.S. must be registered by the EPA (US-EPA, 2005a). Registration decisions are based on scientific studies that assess the chemical's potential toxicity and environmental impact. To be registered, a pesticide must be able to be used without posing unreasonable risks to people or the environment. All pesticides registered prior to November 1, 1984, such as 2,4-D, must also be reregistered to ensure that they meet the current, more stringent standards. The reregistration decision for 2,4-D was issued in 2005 (US-EPA, 2005b).

The current labels for both 2,4-D and quizalofop include label use restrictions intended to protect humans, including protective equipment to be worn during mixing, loading, applications and handling, equipment specifications to control pesticide application, and reentry periods establishing a safe duration between pesticide application and exposure to the pesticide in the field (DuPont, 2010; Nufarm, 2009). Used in accordance with the label, these herbicides have been determined to not present a health risk to humans (US-EPA; 2007).

Agronomic practices used for corn production, such as the application of agricultural chemicals (pesticides and fertilizers) may become more diverse as growers incorporate more sites of action to manage GR weeds. Growers choose certain pesticides based on weed, insect and disease pressures, cost of seed and other inputs, technology fees, human safety, potential for crop injury, and ease and flexibility of the production system (Farnham, 2001; Heiniger, 2000; University of Arkansas, 2008). Agricultural production of existing nonregulated herbicide-resistant GE and non-GE corn and soybean use EPA-registered pesticides, including glyphosate and 2,4-D for weed management. 2,4-D use is currently authorized by EPA for application to corn and pre-plant application to soybean. Quizalofop is currently authorized by EPA for application to soybean. Glufosinate is authorized for application to both LibertyLink® corn and soybean and its use in increasing on soybean (Appendix 4). It is expected that under the No Action Alternative, more herbicide chemistries will be needed to control glyphosate resistant weeds than under the Action Alternatives and as a consequence, workers are likely to be exposed to a wider range of chemistries. It is also expected that more frequent herbicide applications and tillage will be needed ((Culpepper, 2008; Heap, 2011b; Owen & Zelaya, 2005; Owen, 2008) thereby increasing the use of farm equipment under the No Action Alternative relative to the Action Alternatives.

4.1.2 Biological Resources

Animal Communities

Invertebrates

Invertebrate communities in cornfields represent a diverse assemblage of feeding strategies including predators, crop-feeders, saprophages, parasites, and polyphages (Stevenson et al., 2002). Numerous insects and related arthropods perform valuable functions; they pollinate plants, contribute to the decay and processing of organic matter, reduce weed seed populations through predation, cycle soil nutrients, and attack other insects and mites that are considered to be pests. Although many arthropods in agricultural settings are considered pests, such as the European corn borer (*Ostrinia nubilalis*) and the corn rootworm (*Diabrotica* spp.) (Willson & Eisley, 2001), there are many beneficial arthropods which are natural enemies of both weeds and insect pests (Landis et al., 2005). Some of these beneficial species include the convergent lady beetle (*Hippodamia convergens*), carabid beetles, the caterpillar parasitoids (e.g., *Meteorus communis* and *Glyptapanteles militaris*), and the predatory mite (*Phytoseiulus persimilis*) (Shelton, 2011). Earthworms, termites, ants, beetles, and millipedes contribute to the decay of organic matter and the cycling of soil nutrients (Ruiz et al., 2008). Some high-profile or representative invertebrate species, such as honey bees, earthworms, and butterflies, are generally studied more thoroughly than others. Insects and other invertebrates can be beneficial to soybean production, providing services such as nutrient cycling and preying on plant pests. Insects are considered less problematic than weeds in U.S. soybean production; nevertheless, insect injury can impact yield, plant maturity, and seed quality. Insect pests are managed during the growth and development of soybean to enhance soybean yield (Aref & Pike, 1998; Higley & Boethel, 1994). Insect injury in soybean seldom reaches levels that cause significant economic loss, as indicated by the low percentage (16 percent) of soybean acreage that receive insecticide treatments (USDA-NASS, 2009e). Some of the many insects and invertebrates that are detrimental to soybean crops include: bean leaf beetle (*Cerotoma trifurcata*), beet armyworm (*Spodoptera exigua*), blister beetle (*Epicauta* spp.), corn earworm (*Helicoverpa zea*), grasshopper (*Acrididae* spp.), green cloverworm (*Hypena scabra*), seed corn beetle (*Stenolophus lecontei*),; seedcorn maggot (*Delia platura*), soybean aphid (*Aphis glycines*), soybean looper (*Pseudoplusia includens*), soybean stem borer (*Dectes texanus*), spider mites (*Tetranychus urticae*), stink bug (green [*Acrosternum hilare*]; brown [*Euschistus* spp.]),; and velvetbean caterpillar (*Anticarsia gemmatalis*) (Palmer et al., No Date; Whitworth et al., 2011).

Modern agricultural practices have been noted to simplify the agricultural landscape, with the result that beneficial arthropods may be adversely affected (Landis et al., 2005). Intensively cultivated lands, such as those used in corn and soybean production, provide less suitable habitat for wildlife use than that found in fallow fields or adjacent natural areas. As such, the types and numbers of animal species found in corn and soybean fields are less diverse by comparison.

Birds

Corn and soybean fields have been shown to provide both food and cover for wildlife, including a variety of birds as well as large and small mammals (Palmer et al., 2011; Vercauteren & Hygnostrom, 1993).

The types and numbers of birds that inhabit cornfields vary regionally and seasonally, but for the most part the numbers are low (Patterson & Best, 1996). Most of the birds that use cornfields are ground foraging omnivores that feed on corn seed, sprouting corn, and the corn remaining in the fields following harvest. Bird species commonly observed foraging on corn include red-winged blackbird (*Agelaius phoeniceus*), horned lark (*Eremophila alpestris*), brown-headed cowbird (*Molothrus ater*), vesper sparrow (*Pooecetes gramineus*), ring-necked pheasant (*Phasianus colchicus*), wild turkey (*Meleagris gallopavo),* American crow (*Corvus brachyrhynchos*), and various grouse and quail species (Dolbeer, 1990; Mullen, 2011; Patterson & Best, 1996). Following harvest, it is also common to find large flocks of Canada goose (*Branta canadensis*), Snow goose (*Chen caerulescens*), Sandhill cranes (*Grus canadensis*), and other migratory waterfowl foraging in cornfields (Sherfy et al., 2011; Sparling & Krapu, 1994; Taft & Elphick, 2007).

Migratory birds feed on spilled soybean following crop harvest (Galle et al., 2009) although more birds feed on nearby corn and sunflower seed fields. As many as 28 desirable (non-crop pest) bird species, as well as another five that can be crop pests in sunflower, have been identified as resident in soybean and corn fields in the Dakotas (Gamble et al., 2002).

Mammals

A variety of mammals forage on corn at various stages of production. For the most part, herbivorous and omnivorous mammals feed on the ear at various stages of growth. Large- to medium-sized mammals that are common foragers of cornfields include: white-tailed deer (*Odocoileus virginianus*), raccoon (*Procyon lotor*), feral pigs (*Sus scrofa*), and woodchuck (*Marmota monax*). The most notable of these is the white-tailed deer which often inhabit woodlots adjacent to cornfields and frequent these fields for both food and cover, especially in mid-summer (Vercauteren & Hygnostrom, 1993). The effects of deer herbivory on cornfields have been well-documented. Cornfields are vulnerable to deer damage from emergence through harvest (Vercauteren & Hygnostrom, 1993), but any damage at the tasseling stage most directly impacts yield (Stewart et al., 2007). White-tailed deer are considered responsible for more corn damage than any other wildlife species (Stewart et al., 2007).

In addition to deer, significant damage to corn by raccoons also has been documented (Beasley & Rhodes, 2008; DeVault et al., 2007). Corn has been shown to constitute up to 65 percent of the diet of raccoons during the late summer and fall (MacGowan et al., 2006).

As with these larger mammals, small mammal use of cornfields for shelter and forage also varies regionally and includes (Nielsen, 2005):

- Deer mouse (*Peromyscus maniculatus*),
- Meadow vole (*Microtus pennsylvanicus*),
- House mouse (*Mus musculus*), and
- Thirteen-lined ground squirrel (*Spermophilus tridecemlineatus*).

Throughout the U.S., the deer mouse is the most common small mammal in almost any agricultural field (Stallman & Best, 1996; Sterner et al., 2003). Deer mice feed on a wide variety of plant and animal matter depending on availability, but primarily feed on seeds and insects. Deer mice have been considered beneficial in agroecosystems because they consume both weed and insect pests (Smith, 2005).

The meadow vole feeds primarily on fresh grass, sedges, and herbs, and also on seeds and grains of field crops. Although the meadow vole may be considered beneficial for its role in the consumption of weeds, this vole can be a significant agricultural pest where abundant when it consumes seeds in the field. Meadow vole populations are kept in check by high intensity agriculture methods, including conventional tillage; this vole is often associated with the field edges where cover is found off the field, as well as limited tillage agriculture and strip crops (Smith, 2005).

The lined ground squirrel feeds primarily on seeds of weeds and available crops, such as corn and wheat. This species has the potential to damage agricultural crops, although it also can be considered beneficial when eating pest insects, such as grasshoppers and cutworms (Smith, 2005).

Rodents, such as mice or squirrels, may seasonally feed exclusively on soybean seeds. During the winter months, leftover and unharvested soybeans provide a food source for wildlife. White-tailed deer and groundhogs feed on soybean and cause soybean damage, while eastern cottontail, raccoon, Canada goose, squirrels, and other rodents (such as ground squirrel) also feed on soybean, but their damage is of less importance (MacGowan et al., 2006). Deer in large numbers may significantly damage soybean in site-specific circumstances by browsing in soybean fields for forage, and in some areas, growers may be issued licenses to kill deer outside the regular hunting season to reduce crop damage (Berk A, 2008; Garrison & Lewis, 1987). Deer may also feed on seed left after harvest. In Georgia, feral hogs have also damaged soybean fields through rutting and feeding (GDNR, 2003). It is likely that reptiles and amphibians may also be found in soybean fields, especially if the habitat surrounding the field is suitable to support these types of animals.

The widespread use of conservation tillage and no-till practices associated with the use of herbicides for weed control especially in association with the planting GE HR corn and soybean varieties (Dill et al., 2008; Givens et al., 2009) has benefitted wildlife through improved water quality, availability of waste grain, retention of cover in fields, and increased populations of invertebrates (Brady, 2007; Sharpe, 2010). Conservation tillage practices that leave greater amounts of crop residue serve to increase the diversity and density of birds and mammals (USDA-NRCS, 1999a). Increased residue also provides habitat for insects and other arthropods, consequently increasing this food source for insect predators. Insects are important during the spring and summer brood rearing season for many upland game birds and other birds because they provide a protein-rich diet to fast-growing young, as well as a nutrient-rich diet for migratory birds (USDA-NRCS, 2003).

Corn and soybean production practices can affect terrestrial and aquatic species directly or indirectly. Practices such as tillage, cultivation, pesticide and fertilizer applications, and the use of agricultural equipment can result in run-off, increased soil turbidity, decreased soluble oxygen or habitat destruction. The continued emergence of GR weeds will likely require modifications of crop management practices to address these weeds. Herbicide use may increase to meet the need for additional integrated weed management tactics to mitigate herbicide-resistant weeds in different cropping systems (Culpepper, 2008; Heap, 2011c; Owen & Zelaya, 2005; Owen, 2008). Some of these adjustments may impact the adoption of conservation tillage practices. Under the No Action Alternative, if tillage rates continue to increase as a means of weed suppression, increased soil erosion and indirect adverse impacts on wildlife are expected. Likewise if increased amounts of pesticide are used, adverse impacts on wildlife are also expected. If cover cropping becomes more commonplace, it is expected to have beneficial impacts on wildlife by providing habitat and food. As these management practices may have both beneficial and adverse effects on biological resources, their impacts on biological resources under the No Action Alternative are unknown.

Growers choose pesticides based on weed, insect and disease pressures, cost of seed and other inputs, technology fees, human safety, potential for crop injury, and ease and flexibility of the production system (Farnham, 2001; Heiniger, 2000; University of Arkansas, 2008). Agricultural production of corn and soybean uses EPA-registered pesticides, including glyphosate and 2,4-D, for weed management. The environmental risks of pesticide use on wildlife and wildlife habitat are assessed by EPA in the pesticide registration process and are regularly reevaluated by EPA for each pesticide to maintain its registered status under FIFRA.

Terrestrial and aquatic species in the agroecosystem have been exposed to the CP4 EPSPS protein in glyphosate-tolerant soybeans (and corn) for more than 15 years, without any indication of adverse effects on the animals from that protein, including any allergic effects or toxicity (Economidas et al., 2010; Snell et al., 2012). The plants expressing that protein do not vary substantially in nutritional composition or physical structure from plants lacking protein. The enzyme protein is not biologically active in soil or water, and it is rapidly and fully biodegradable in the environment.

Animal species have also been exposed to the PAT protein in glufosinate-tolerant soybeans (and corn) for many years, likewise without ill-effects from that protein (Economidas et al., 2010; Snell et al., 2012). The safety of food and feed containing the PAT protein was reviewed as part of previous assessments and was shown to present no significant food or feed safety risk. A biotechnology consultation on the PAT protein was conducted in 1998 and does not require additional evaluation by FDA (US-FDA, 1998).

Plant Communities

Weeds are commonly found in corn and soybean fields and, if not controlled, can significantly decrease yields. The most problematic weeds of each crop and the acres that were actively managed in 2006-2008 are shown in Appendix 5. Appendix 3 lists three categories of weeds: annual broadleaf weeds, annual grass weeds, and perennial weeds. Among these three categories, annual broadleaf weeds include the species that have become most difficult to control due to the selection of HR biotypes. For example, velvetleaf and lambsquarters are both somewhat tolerant of glyphosate and for some species such as pigweed, waterhemp, ragweed, and kochia, GR biotypes have been selected (Heap, 2013b). Species such as waterhemp have developed resistance to as many as five different herbicide sites of action (Owen, 2012). Biotypes resistant to 2,4-D have been selected in morning glory(Heap, 2013b), which is one of the other problem weeds of corn and soybean(Appendix 5). Annual grass weeds that inhabit corn and soybean fields are still largely controlled by glyphosate. Foxtail is the most prevalent grass weed and is actively managed on almost all acreage used for corn production and much of the land used for soybean. Perennial weeds are particularly difficult to control because they can regrow every year from rhizomes. (DAS, 2010a). Among the perennial weeds, biotypes of Johnson grass have been selected for glyphosate resistance.

The majority of weeds that are problems in corn are also problems in soybean (see Chapter 5 Cumulative Effects for more details). In addition, corn volunteers are controlled on 2 to 4 million acres of soybean whereas soybean volunteers are generally not managed in corn production fields.

Corn

Corn generally does not survive until the following spring in those regions where freezing temperatures are reached in the winter; however, corn seeds which are incorporated in the soil during either harvest or fall tillage may overwinter and grow the following spring (Stewart, 2011). Volunteer corn lacks vigor and competitiveness because the volunteer plant is two generations removed from the cross which produced the original seed, resulting in a loss of hybrid vigor (Davis, 2009). One cause of volunteer corn is when weather late in the growing season causes ears to drop or lodging occurs, placing ears of corn on the ground where the seed can then germinate the following year. Volunteer corn can be present as single plants or as clumps formed when an ear drops to the ground and is partially buried (Davis, 2009; Wilson et al., 2010).

Volunteer corn is less of a concern in no-till fields than in fall-tilled fields because of the lower probability that corn seed will survive and germinate in the following growing season (Bernards et al., 2010). In no-till fields, the fallen corn is frequently eaten by wildlife and also is subject to winter weather conditions (Bernards et al., 2010). In fall tillage systems, corn seed may be buried in the soil and overwinter. Volunteer corn which has emerged from this overwintered seed requires control with spring tillage or with application of herbicides (Bernards et al., 2010).

Literature clearly notes that genetically engineered corn is a problematic volunteer the year after harvest in soybean, dry beans, sugar beets, and subsequent corn crops (Bernards et al., 2010; Davis, 2009; Hager, 2009; Johnson et al., 2010; Stewart, 2011; Wilson et al., 2011a; Wilson et al., 2010). For example, the presence of volunteer corn in soybeans was identified in 12 percent of the soybean acreage in Illinois in a 2005 survey of soybean acreage in corn–soybean rotation systems (Davis, 2009). Additionally, a 2010 survey of soybean cultivation in Illinois identified a field with up to 500,000 corn plants per acre (Hager, 2010). The effect of volunteer corn on the yields of the intended crop depends on the density of the volunteers (Bernards et al., 2010; Davis, 2009). In controlled agronomic studies, an analysis of yield impacts to soybeans from volunteer corn was evaluated at densities up to 17,800 corn plants per acre of soybean (Alms et al., 2007; 2008). In these controlled studies, volunteer corn densities ranging from zero plants per square meter up to 4.4 plants per square meter were cultivated in soybean, with corresponding soybean yield losses of up to 58 percent (Alms et al., 2007; 2008). Pre-harvest herbicide treatments of the volunteer corn reduced but did not eliminate the yield impacts.

Volunteer glyphosate and glufosinate resistant corn in cornfields can be controlled using inter-row cultivation and several different herbicides (Minnesota, 2009; Sandell et al., 2009). Pre-emergent controls might include Gramoxone Inteon (paraquat) mixed with Atrazine (Monsanto, 2010b; Sandell et al., 2009). If the volunteer corn is stacked to express both glyphosate and glufosinate resistance, inter-row cultivation is the only option for post-emergent control within corn (Sandell et al., 2009). Post-emergent grass herbicide ACCase inhibitors, such as quizalofop, fluazifop, fenoxaprop, sethoxydim, and clethodim (Bernards et al., 2010; Hager, 2009; Johnson et al., 2010) are effective to control volunteer corn in soybean and other broadleaf crops. ALS inhibitors, such as the sulfonylureas, imidazolinone, and triazolopyrimidine also have been identified for potential control of glyphosate- or glufosinate-resistant corn (see, Hager, 2009; Wisconsin, 2011). Herbicide tank mix additives are recommended to increase on-plant spray retention and absorption (see Hager & McGlamery, 1997; Johnson et al., 2010; Sandell et al., 2009). Recommended additives include crop oil concentrate methylated seed oil and ammonium sulfate (Hager & McGlamery, 1997; Johnson et al., 2010; Monsanto, 2010b). Imazethapyr has been identified to control up to 80 percent of the volunteer corn when the corn is still in early growth stages (Bernards et al., 2010). The ACCase-inhibiting herbicides are to be applied prior to the corn reaching the 12- to 24-inch tall stage and the ALS herbicides are effective in controlling smaller (2- to 8-inch) corn (Minnesota, 2009; Monsanto, 2010b).

For volunteer corn in soybean, growers can take advantage of alternate modes of herbicide action if the herbicide resistance differs between the current crop and the volunteer (e.g., glufosinate in LibertyLink® soybean to control a Roundup Ready® GR volunteer corn variety) (Minnesota, 2009). In experimental studies, volunteer corn in soybean were controlled using different application rates of the herbicide Clethodim in the attempt to better quantify soybean yield loss (Alms et al., 2008). Clethodim treatments of the volunteer corn did reduce the volunteer corn density, although even after a 98 percent control of the volunteer corn, soybean yield still suffered a 5 percent reduction in yield (Alms et al., 2008). Under the No Action Alternative, the above listed methods for controlling volunteer corn are expected to continue. These methods of volunteer control are also expected under the Action Alternatives with the exception that quizalofop will no longer be useful for controlling corn volunteers in soybean.

Soybean

Modern soybean harvesting equipment is so efficient that few seeds remain in soybean fields following harvest and few volunteer soybeans are typically seen in subsequent crops with which the beans are rotated. Additionally, volunteer soybeans do not easily compete with other crops and are easily controlled with common agronomic practices. Volunteer soybeans are limited by the geography in which soybean is planted. Soybean requires specific environmental conditions to grow as a volunteer (OECD, 2000). Mature soybean seeds are sensitive to cold and rarely survive in freezing winter conditions (Raper & Kramer, 1987). Volunteer soybeans can occur in regions with warmer climates where temperature and moisture conditions are suitable for viability and germination can occur year-round, such as the Mississippi Delta and the southeast U.S. (Zapiola et al., 2008). York (York et al., 2005) reports that soybean volunteers were found in no-till cotton fields especially where the previous soybean crop harvest was prevented by hurricane and consequently many seeds remained in the field. According to this report, soybean volunteers are becoming more common as Roundup-Ready technology has led to an increase in the adoption of no-till and a decrease in the number of herbicides used in rotation crops (York et al., 2005). For similar reasons, soybean volunteers are also now appearing in corn, too (Gunsolus, 2010). York (York et al., 2005) reported effective control of soybean volunteers in cotton with normal levels of the ALS herbicide, trifloxysulfuron, an herbicide that also controls Enlist® soybean. In corn, volunteer soybean can be effectively controlled by atrazine, dicamba, and clopyralid (Gunsolus, 2010). Use of these herbicides in corn would not be a departure from current agronomic practice as all three are among the ten most commonly used herbicides on corn (FEIS Table 4-1). Under the No Action Alternative, the above listed methods for controlling volunteer soybean are expected to continue. These methods of volunteer control are also expected under the Action Alternatives.

4.1.3 Natural Resources

Soil Quality

Corn is cultivated in a wide variety of soils across the U.S. (see, e.g., Corn Crop Profiles provided at www.ipmcenters.org). Soybean production is best suited to fertile, well-drained, medium-textured loam soils, yet they can be produced in a wide range of soil types (Berglund & Helms, 2003; NSRL, No Date). Similarly, soils that are high in clay and low in humus may impede soybean plant emergence and development (NSRL, No Date). Soils with some clay content may increase moisture availability during periods of low precipitation (Cox et al., 2003).

Land management practices for crop cultivation can affect soil quality. While practices such as tillage, fertilization, the use of pesticides and other management tools can improve soil health, they can also cause substantial damage if not properly used. Several concerns relating to soil and agricultural practices include increased erosion, soil compaction, degradation of soil structure, nutrient loss, increased salinity, change in pH, and reduced biological activity (USDA-NRCS, 2001a).

With conventional tillage, a grower prepares the seedbed by removing all plant residues and weeds from the soil surface prior to planting, and then continues to cultivate the soil while the crop is growing to control late emerging weeds (NCGA, 2007b). This practice can result in soil loss to wind and water erosion (NCGA, 2007b). Conservation practices, including conservation tillage, have been developed to reduce field tillage and thus reduce the corresponding soil loss (USDA-NRCS, 2006c). Conservation tillage employs tools that disturb soil less and leave at least 30 percent of crop residues on the surface (Peet, 2001), whereas no-till farming only disturbs the soil for planting seed. The new crop is planted into the plant residue or in narrow strips of tilled soil (Peet, 2001).

Reducing excessive tillage through practices such as conservation tillage minimizes the loss of organic matter and protects the soil surface by leaving plant residue on the surface. Soil organic matter is probably the most vital component in maintaining quality soil; it is instrumental in maintaining soil stability and structure, reducing the potential for erosion, providing energy for microorganisms, improving infiltration and water holding capacity. It is also important in nutrient cycling, cation exchange capacity,[7] and the breakdown of pesticides (USDA-NRCS, 1996). Other attributes of conservation tillage include the retention of beneficial insects, increased soil water-holding capacity, less soil and nutrient loss from the field, reduced soil

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[7] Cation exchange capacity is the ability of soil anions (negatively charged clay; organic matter; and inorganic minerals, such as phosphate, sulfate, and nitrate) to adsorb and store soil cation nutrients (positively charged ions, such as potassium, calcium, and ammonium).

compaction, and less time and labor required to prepare the field for planting (Peet, 2001) (Leep et al., 2003; NCGA, 2007b; c; USDA-NRCS, 2006b; c).

Total soil loss on highly erodible croplands and non-highly erodible croplands decreased from 462 million tons per year to 281 million tons per year or by 39.2 percent from 1982 to 2003 (USDA-NRCS, 2006a). This decrease in soil erosion carries a corresponding decrease in non-point source surface water pollution of fertilizer and pesticides (NCGA, 2007b). The reduction in soil erosion also is attributed to a decrease in the number of acres of highly erodible cropland being cultivated (USDA-NRCS, 2006b).

All regions showed a decrease in amount of water or wind erosion between 1982 and 2007 (USDA-NRCS, 2010a). The Corn Belt and the Northern Plains were the areas where most water erosion occurred. This is where the majority of the corn and soybean are produced in the U.S.

While conservation tillage does have several benefits for soil health, some management concerns are associated with its use. Under no-till practices, soil compaction may become a problem because tillage is useful for breaking up compacted areas (USDA-NRCS, 1996). Likewise, not all soils (such as wet and heavy clay soils in northern latitudes) are suited for no-till practices. Also, no-till practices may lead to increased pest occurrences that conventional tillage is better suited to managing (NRC, 2010).

Growers producing crops on highly erodible land are encouraged to maintain a soil conservation plan approved by the USDA National Resources Conservation Service (USDA-ERS, 2010b). These soil conservation plans are prepared by the grower pursuant to the 1985 Food Security Act Conservation Compliance and Sodbuster programs to minimize soil erosion (USDA-ERS, 2010b).

Other methods to improve soil quality include careful management of fertilizers and pesticides; use of cover crops to increase plant diversity and limit the time soil is exposed to wind and rain; and, increased landscape diversity with buffer strips, contour strips, wind breaks, crop rotations, and varying tillage practices (USDA-NRCS, 2006b). Weed scientists indicate that an integrated weed management plan defined by a range of weed management strategies must be considered, including mechanical strategies, alternative herbicides, and cultural approaches (University of Georgia, 2009). Nonetheless, if herbicide-resistant weeds become problematic enough where other strategies are not effective, growers will likely have to consider mechanical control strategies which may, in turn, potentially impact soil quality. Residue management that employs intensive tillage and leaves low amounts of crop residue on the surface results in greater losses of soil organic matter (USDA-NRCS, 1996). The total acreage that may be impacted by such an increase in tillage would be based on the extent of resistant weeds present in a field and the weed management strategy chosen by a grower. However, it is important to note that much of the reduction in soil erosion occurred prior to the adoption of GE HR crops and even an increase in some tillage is not expected to return erosion level to those seen in the 1980’s.

Under the No Action Alternative GR weeds are expected to continue to be a concern in the Southeast region, and the likely expansion of resistance into the Great Plains, Northern Crescent, and Heartland regions (Stachler & Christoffers, 2012) would require modifications of crop management practices to address these weeds, which can affect soils. These changes may include diversifying the mode of action of herbicides applied to corn and soybean and making adjustments to crop rotation and tillage practices (Owen et al., 2011a).

Prostko and Wright (Prostko, 2013; Wright, 2013) described changes in management practices in Georgia and Florida as follows: "growers in Georgia, who currently are experiencing herbicide-resistant Palmer amaranth infestations, significantly changed the way they farm. The use of residual herbicides, tillage (moldboard plowing), cover crops, and/or hand-weeding have become the norm for almost all growers." "Most of the little soybean produced in Florida is grown using conservation tillage of various types, although the occurrence of GR palmer amaranth has made this increasingly difficult. There is a move to using small amounts of carefully targeted cultivation at intervals to remove problem weeds." (Prostko, 2013; Wright, 2013).

Herbicide use may increase to control herbicide-resistant weeds in different cropping systems (Culpepper, 2008; Heap, 2011c; Owen & Zelaya, 2005; Owen, 2008). Pesticide use has the potential to affect soil quality due to the impact to the soil microbial community.

The adoption of no-till farming is not uniform across soybean and corn growing areas. Table 7 shows the states where no-till is adopted on a higher percent of the acres than conventional tillage. For the majority of these survey states, the transition to more no-till than conventional tilled acres occurred after 2005 (USDA-ERS, 2012d).

Soil Microorganisms

The inorganic and organic matter in soil is home to a wide variety of fungi, bacteria, and arthropods, and represents the growth medium for terrestrial plant life (USDA-NRCS, 2004). Soil microorganisms play a key role in soil structure formation, decomposition of organic matter, toxin removal, nutrient cycling, and most biochemical soil processes (Garbeva et al., 2004; Jasinski et al., 2003; Young & Ritz, 2000). They also suppress soil-borne plant diseases and promote plant growth (Doran et al., 1996).

The main factors affecting microbial population size and diversity include plant type (providers of specific carbon and energy sources into the soil), soil type (texture, structure, organic matter, aggregate stability, pH, and nutrient content), and agricultural management practices (crop rotation, tillage, herbicide and fertilizer application, and irrigation) (Garbeva et al., 2004; Young & Ritz, 2000). 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.

Microbial diseases affecting corn include those caused by the fungal pathogens northern leaf spot (*Helminthosporium carbonum*); northern corn leaf blight, (*Exserohilum turcicum*); southern corn rust, (*Puccinia polysora*); common corn rust, (*Puccinia sorghi*); anthracnose leaf blight, (*Colletotrichum graminicola)*; and gray leaf spot, (*Cercospora zeae-maydis*) (Ruhl, 2007). Management to control disease outbreaks varies by region and pathogen, but include common practices such as crop rotation, weed control, planting resistant cultivars, and proper planting and tillage practices.

Plant roots, including those of soybean, release a variety of compounds into the soil creating a unique environment for microorganisms in the rhizosphere (root zone). Microbial diversity in the rhizosphere may be extensive and differs from the microbial community in the bulk soil (Garbeva et al., 2004).

An important group of soil microorganisms associated with legumes, including soybean, are the mutualists. These include mycorrhizal fungi, nitrogen-fixing bacteria, and some free-living microbes that have co-evolved with plants that supply nutrients to and obtain food from their plant hosts (USDA-NRCS, 2004). Legumes have developed symbiotic relationships with specific nitrogen-fixing bacteria in the family *Rhizobiaceae* that induce the formation of root nodules where bacteria may carry out the reduction of atmospheric nitrogen into ammonia (NH_3) that is usable by the plant (Gage, 2004). *Bradyrhizobium japonicum* is the rhizobium bacteria specifically associated with soybeans (Franzen, 1999). Since neither soybean nor *B. japonicum* is native to North America, if a field has not been planted with soybean within three to five years, either the seed or seed zone must be inoculated with *B. japonicum* prior to soybean planting (Abendroth & Elmore, 2006).

In addition to beneficial microorganisms, there are also several microbial pathogens that cause disease in soybean, which vary somewhat depending on the region. These include fungal pathogens such as *Rhizoctonia* stem rot (*Rhizoctonia solani*), brown stem rot (*Phialophora gregata*), sudden death syndrome (*Fusarium solani* race A), and charcoal root rot (*Macrophomina phaseolina*); bacterial pathogens bacterial blight (*Pseudomonas syringae*) and bacterial pustule (*Xanthomonas campestris*); the soybean cyst nematode (*Heterodera glycines*); and viral pathogens, soybean mosaic virus and the tobacco ringspot virus (Ruhl, 2007; SSDW, No Date).

Changes in agricultural practices and inputs and natural variations in season, weather, plant development stage, geographic location, soil type, and plant species or cultivar can all impact the microbial community (Kowalchuk et al., 2003; US-EPA, 2009c). Indirect impacts may result from changes in the composition of root exudates, plant litter, or agricultural practices (Kowalchuk et al., 2003; US-EPA, 2009c). Several reviews of the investigations into the impact of GE plants on microbial soil communities found that most of the studies examining distinctive microbial traits concluded that there was either minor or no detectable non-target effects (Hart, 2006; Kowalchuk et al., 2003; US-EPA, 2009b). Under the No Action Alternative, increases in tillage may occur and have an adverse impact on the microbial community.

Water Quality

Surface water in rivers, streams, creeks, lakes, and reservoirs supports everyday life through the provision of water for drinking and other public uses, irrigation, and industry. Surface runoff from rain, snowmelt, or irrigation water can affect surface water quality by depositing sediment, minerals, or contaminants into surface water bodies. Meteorological factors, such as rainfall intensity and duration, and physical factors, such as vegetation, soil type, and topography, influence surface runoff.

Groundwater is the water that flows underground and is stored in natural geologic formations called aquifers (see Figure 14). It sustains ecosystems by releasing a constant supply of water into wetlands and contributes a sizeable amount of flow to permanent streams and rivers. Based on 2005 data, the largest use of groundwater in the U.S. is irrigation, representing approximately 67 percent of all the groundwater pumped each day (McCray, 2009). In the U.S., approximately 47 percent of the population depends on groundwater for its drinking water supply.

Unlike a point source, which is a "discernible, confined and discrete conveyance," nonpoint source (NPS) pollution comes from many diffuse sources. Rainfall or snowmelt moving over the ground, also known as runoff, picks up and carries away natural and human-made pollutants, creating NPS pollution. The pollutants may eventually be transported by runoff into lakes, rivers, wetlands, coastal waters, and groundwater (see Figure 14).

The primary cause of NPS pollution is increased sedimentation in surface waters following soil erosion by surface runoff. Increases in sediment loads to surface waters can directly affect fish, aquatic invertebrates, and other wildlife maintenance and survival. It also reduces the amount of light penetration in water, which directly affects aquatic plants. Indirectly, soil erosion-mediated sedimentation can increase fertilizer runoff, facilitating higher water turbidity, algal blooms, and oxygen depletion (US-EPA, 2005a).

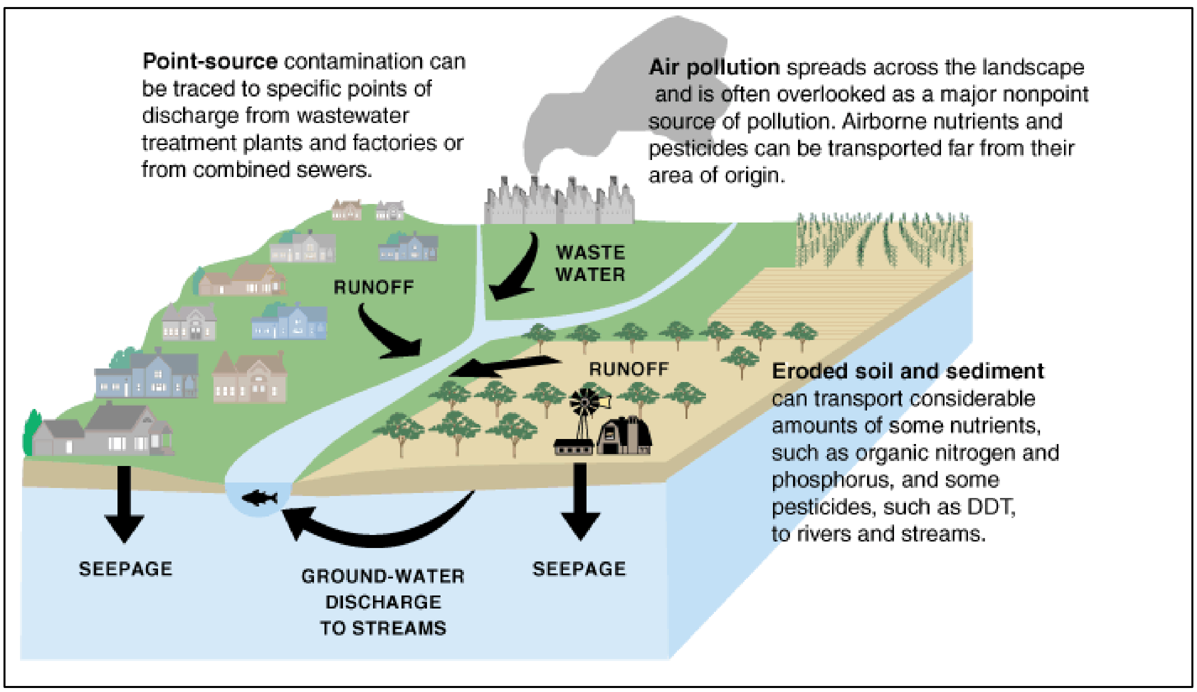

Figure 14. Water Quality
Source (USGS).

Agricultural NPS pollution is the leading source of impacts on surveyed rivers and lakes and the third largest source of impairment to estuaries, as well as a major source of impairment to groundwater and wetlands (USDA-EPA, 2011). Sources of agricultural NPS pollution include animal wastes, fertilizers, and pesticides. Management practices that contribute to NPS pollution include the type of crop cultivated; plowing and tillage; and the application of pesticides, herbicides, and fertilizers.

Use of pesticides for field crop production may introduce these chemicals to water through spray drift, cleaning of pesticide application equipment, soil erosion, or filtration through soil to groundwater. As part of assessing the risk of the exposure of aquatic organisms and the environment to a pesticide, EPA estimates concentrations of pesticides in natural water bodies, such as lakes or ponds. Also as part of the Food Quality Protection Act (FQPA) of 1996, EPA estimates pesticide concentrations in drinking water when it establishes maximum pesticide residues on food (tolerances). For both drinking water and aquatic exposure assessments and for water quality assessments, EPA typically relies on field monitoring data as well as mathematical models to generate exposure estimates (US-EPA, 2012d).

Under the No Action Alternative, increased tillage may occur and lead to increases in sedimentation and corresponding decreases in water quality.

Irrigation

Water in agriculture is used for irrigation, pesticide and fertilizer applications, crop cooling (e.g., light irrigation), and frost control (CDC, 2013). The availability and use of moisture for crop irrigation are important determinants of yield. Irrigation can offer a stable supply of adequate moisture to the crop, thereby providing a potential for increased yields over dryland production and helping stabilize annual fluctuations in yield and seed quality (http://www.aragriculture.org/soil_water/irrigation/crop/soybeans.htm). In addition to the total amount, the timing of the moisture is important for optimizing crop yields. Water requirements are dependent on the type of crop and its stage of development. There are critical periods during the growing season when a crop's soil moisture must be sustained to ensure optimal yields (US-EPA, 2012b). Both groundwater and surface water can be used for irrigation water, although groundwater is the major source of water for irrigation. Wells commonly provide a source of water on farms in many areas and are usually the only source used in the Great Plains (US-EPA, 2012b).

Corn is a water-sensitive crop with a low tolerance for drought. The stress response and yield loss depends on the stage of the corn growth (Farahani & Smith, 2011). The water demand is variable over the growing season, with the greatest water demand during the silk production stage in mid-season. During this stage, the water requirement is estimated at about 2 inches of water per week (or 0.3 inch per day) (Farahani & Smith, 2011; Heiniger, 2000). Corn requires approximately 4,000 gallons through the growing season to produce 1 bushel of grain (NCGA, 2007a).

This water demand is met by a combination of natural rainfall, stored soil moisture from precipitation before the growing season, and supplemental irrigation during the growing season (Farahani & Smith, 2011; Heiniger, 2000). Areas in the U.S. where corn is irrigated is shown in Figure 14. Most of the irrigated areas are found in the TX and OK panhandles, KS, NE, and along the Southern Mississippi River areas of MO, AR, MS, and LA. Groundwater is used on almost 90 percent of irrigated corn acreage in the U.S. (Christensen, 2002). Corn for grain has substantially more irrigated area than any other single crop in the U.S. (Christensen, 2002). In

2007, 13.0 million U.S. corn acres were irrigated, representing 15 percent of all corn acres harvested for grain (USDA-NASS, 2009e).

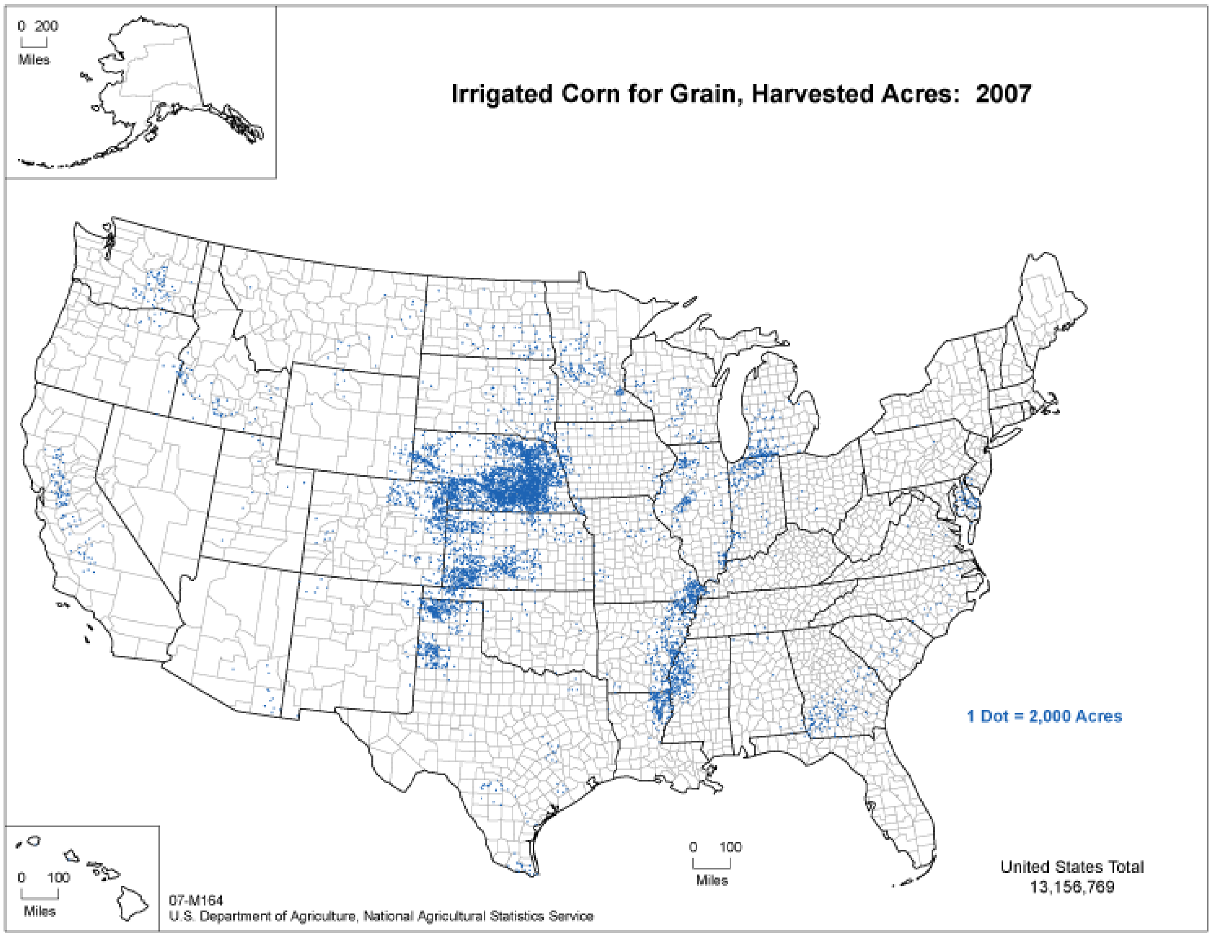

Figure 15. Irrigated Corn for Grain
Source (USDA- Census of Agriculture, 2007).

The soils and climate in the Eastern, Midwestern, and portions of the Great Plains region of the U.S. provide sufficient water supplies under normal climatic conditions to produce a soybean crop. In regions of the U.S. that experience low amounts of rainfall during the growing season or during drought, soybean yields benefit from proper irrigation. Soybeans require approximately 20 to 25 inches of water during the growing season to produce a relatively high yield of 40 to 50 bushels per acre (Hoeft et al., 2000; KSU, 1997; Nafziger, 2007; University of Arkansas, 2006). In 2006 and 2008, approximately 9 percent of the planted acres of soybeans in the U.S. were irrigated (USDA-ERS, 2011d; USDA-NASS, 2010a). In 2007, when approximately 6 percent of the total soybean crop was irrigated, over 92 percent of the irrigation supply was from groundwater supply (USDA-ERS, 2012c).

As shown in Figure 16, a majority (approximately 73 percent) of irrigated soybean acreage occurs in the Missouri and Lower Mississippi Water Resource Regions, and soybean acreage in the states of Nebraska, Arkansas, Mississippi, Missouri, and Kansas accounts for 85 percent of all irrigated acres (USDA-NASS, 2011c). In 2006, approximately 8.4 inches of water per irrigated acre were used, producing an average of more than 51 bushels per irrigated acre (USDA-ERS, 2011d). This yield was approximately 19.8 percent higher than the national average (42.9 bushels per acre) for that year (USDA-NASS, 2011a).

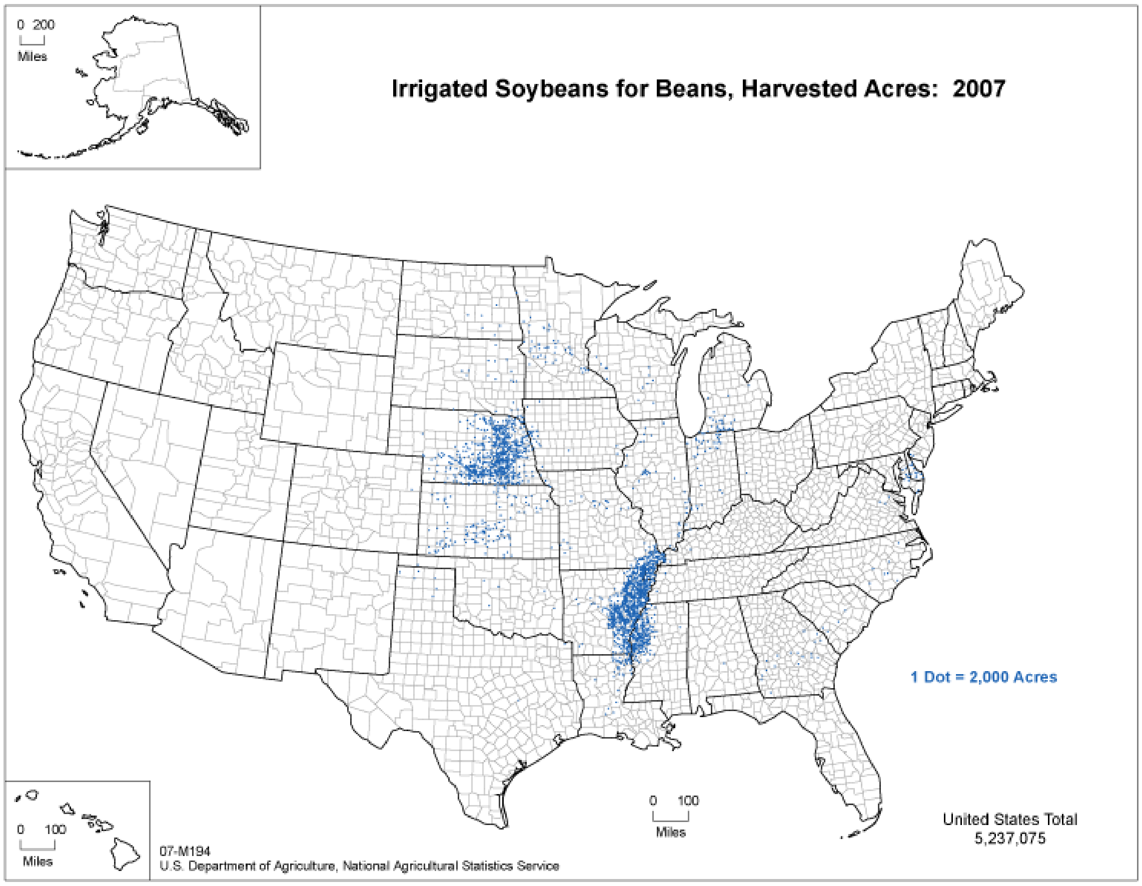

Figure 16. Irrigated Soybeans for Beans

Source: (USDA-NASS, 2009e)

Notes: Each dot represents 2,000 acres of irrigated soybeans for beans harvested in 2007. The largest concentrations of acres are in Nebraska, eastern Arkansas, and northwestern Mississippi.

Certain weed management practices require either adequate rainfall or irrigation in order to work well. Many residual herbicides require water to be activated (Hager et al., 2011). Although the use of residual herbicides are recommended for herbicide resistance weed management, in dry years such as occurred in 2012, residual herbicides were ineffective in areas that lacked rainfall and the use of irrigation water.

Corn production has expanded significantly since 2006 to meet biofuel feedstock demand (see Figure 8). Wallander et al. (Wallander et al., 2011) estimate that from 2006 to 2008, roughly half of the expansion came from acreage shifts from soybean production, one-third came from conversion of uncultivated hay and grazing land and from acreage formerly enrolled under the USDA Conservation Reserve Program (CRP), and the remainder came from increases in corn yields and double cropping and decreases in idled cropland. However, farms shifting from other crops, particularly cotton, offset the shift from soybeans to corn. Production response has varied across regions: shifts in crop acreage from soybean to corn acres have been the dominant production response in regions B, C, E, and southern region G, while expansion in harvested cropland from land formerly used for hay, grazing, and the conservation Reserve Program has dominated southern region F, northern region G and regions H and I. Schaible and Aillery (Schaible & Aillery, 2012) suggest that the expansion of corn acreage to meet biofuel feedstock demand has the "potential for increased reliance on irrigation," particularly for the Plains States. They suggest this would likely involve an increase in consumptive water use, both due to expanded irrigated corn acres and because water consumption by corn plants is greater than that for soybeans, placing additional pressure on groundwater resources where withdrawals have generally exceeded natural recharge. Under the No Action Alternative, the additional pressure on groundwater resources are expected to decline as corn production is expected to decline and soybean production is expected to expand only slightly (USDA-OCE, 2014).

Air Quality

Cultivation of corn and soybeans, like any other agricultural system, may affect air quality. Primary sources of emissions associated with crop production include exhaust from motorized equipment, such as tractors and irrigation equipment; suspended soil particulates from tillage and wind-induced erosion; smoke from burning of fields; drift from sprayed herbicides and pesticides; and nitrous oxide emissions from the use of nitrogen fertilizer (Aneja et al., 2009; Hoeft et al., 2000; USDA-EPA, 2011; USDA-NRCS, 2006a).

Soybean and cornfields typically are tilled just prior to planting. Tillage not only is associated with increased emissions due to burning of fossil fuels but also results in the release of particulate matter into the air (Madden et al., 2009). By generating fewer suspended particulates (dust), reduced tillage also potentially contributes to lower rates of soil wind erosion, thus benefitting air quality (Towery & Werblow, 2010). Although this impact is variable and is affected by factors such as soil moisture and specific tillage regime employed, this observation demonstrates the role of conservation tillage in reducing particulate matter. Reduced tillage minimizes burning of fossil fuels and the production of airborne particulates, both of which are major aspects of agricultural practices that affect air quality. The extent to which reduced tillage reduces burning of fossil fuels is illustrated in Table 8, based on the NRCS Energy Estimator: Tillage Tool (USDA-NRCS, 2013). The tool estimates potential fuel savings of 3,010 gallons or 60 percent savings per year based upon producing 1,000 acres of no-till soybean compared to conventional till soybean in the Urbana, Illinois, postal code[8]. NRCS is careful to note that this estimate is only approximate because many variables can affect an individual operation's actual

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[8] Postal codes are used in the NRCS Energy Estimator to estimate diesel fuel use and costs in the production of key crops for an area.

savings. However, this example serves to illustrate the magnitude of the contribution of minimum tillage to the reducing the impact of agriculture on air quality.

Table 8. Total Farm Diesel Fuel Consumption Estimate

Estimate for 1,000-Acre Soybean Crop (Urbana, Illinois)	Consumption by Tillage Method (gallons per year)			
	Conventional Tillage	Mulch-till	Ridge-till	No-till
Total fuel use	4,980	4,110	3,330	1,970
Potential fuel savings over conventional tillage	--	870	1,650	3,010
Total savings	--	17%	33%	60%

Source: (USDA-NRCS, 2013)

Prescribed burning is a land treatment, used under controlled conditions, to accomplish resource management objectives. Open combustion produces particles of widely ranging size, depending to some extent on the rate of energy release of the fire (US-EPA, 2011a). The extent to which agricultural and other prescribed burning may occur is regulated by individual State Implementation Plans to achieve compliance with the National Ambient Air Quality Standards. Prescribed burning of fields would likely occur only as a pre-planting option for soybean production, based on individual farm characteristics. Volatilization of fertilizers, herbicides, and pesticides from soil and plant surfaces also introduces these chemicals to the air. The USDA Agricultural Research Service (ARS) is conducting a long-term study to identify factors that affect pesticide levels in the Chesapeake Bay Region airshed (USDA-ARS, 2011). This study has determined volatilization is highly dependent on exposure of disturbed unconsolidated soils, and variability in measured compound levels is correlated with temperature and wind conditions. Another ARS study of volatilization of certain herbicides after application to fields has found moisture in dew and soils in higher temperature regimes significantly increases volatilization rates (USDA-ARS, 2011).

Pesticide and herbicide spraying may impact air quality through both drift and diffusion. Pesticides are typically applied to crops by ground spray equipment or aircraft. Small, lightweight droplets are produced by equipment nozzles; many droplets are small enough to remain suspended in air for long periods allowing them to be moved by air currents until they adhere to a surface or drop to the ground. The amount of drift varies widely and is influenced by a range of factors, including weather conditions, topography, the crop or area being sprayed, application equipment and methods, and practices followed by the applicator. Drift is defined by EPA as: "the movement of pesticide through air at the time of application or soon thereafter, to any site other than that intended for application" (Kiely et al., 2004).

Diffusion is gaseous transformation to the atmosphere (Owen, 2008). Factors affecting drift and diffusion include application equipment and method, weather conditions, topography, and the type of crop being sprayed (Kiely et al., 2004). EPA's Office of Pesticide Programs (OPP), which regulates the use of pesticides and herbicides in the U.S., encourages pesticide applicators to use all feasible means available to them to minimize off-target drift. EPA-OPP has introduced several initiatives to help address and prevent the problems associated with drift. Currently, EPA-OPP is evaluating new regulations for pesticide drift labeling and the identification of BMPs to control such drift (US-EPA, 2009c), as well as identifying scientific issues surrounding field volatility of conventional pesticides (US-EPA, 2010c). Additionally, EPA-OPP and its Office of Research and Development are developing a new voluntary program, the Drift Reduction Technology Program, which encourages the development, marketing, and use of application technologies verified to significantly reduce spray drift (US-EPA, 2009c). Additional information on off-target movement of pesticides is included in Appendix 7.

Other conservation practices, as required by USDA to qualify for crop insurance and beneficial federal loans and programs (USDA-ERS, 2009a), effectively reduce crop production impacts to air quality through the employment of windbreaks, shelterbelts, reduced tillage, and cover crops that promote soil protection on highly erodible lands.

Under the No Action Alternative, increased tillage and pesticide use is expected to occur to manage HR weeds. These more intensive management practices are expected to have adverse impacts on air quality.

<u>Climate Change</u>

Climate change represents a statistical change in global climate conditions, including shifts in the frequency of extreme weather (Cook et al., 2008). EPA has identified carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) as the key greenhouse gases (GHGs) affecting climate change. During the 20-year period of 1990 to 2009, total emissions from the agricultural sector grew by 8.7 percent with 7 percent of the total U.S. GHG emissions in 2009 generated from this sector (US-EPA, 2011c).

For agriculture and natural resources, the main GHGs of concern are carbon dioxide, methane and nitrous oxide. Emissions of GHGs released from agricultural equipment (e.g., irrigation pumps and tractors) include carbon monoxide, nitrogen oxides, methane (CH_4), reactive organic gases, particulate matter, and sulfur oxides (US-EPA, 2011c). Agricultural soil management practices, including nitrogen-based fertilizer application and cropping practices, represent the largest source of U.S. N_2O emissions; croplands account for 69 percent of the total N_2O emissions attributable to agricultural land uses (US-EPA, 2011c). Agricultural sources of methane emissions are associated primarily with enteric emissions of gas from cattle and manure management. Carbon dioxide also is a significant GHG associated with several agricultural practices, including land uses and energy consumption (US-EPA, 2011c).

The contribution of agriculture to climate change largely is dependent on the production practices employed to grow various commodities, the region in which the commodities are grown, and the individual choices made by growers. The same factors associated with conventional crop production also determine the impacts of GE crop varieties on climate change.

Conversion of crop land to pasture results in an increase in carbon and nitrogen sequestration in soils (US-EPA, 2011a). Agricultural lands afford great opportunities for sequestering carbon (reducing carbon dioxide levels) and reducing or mitigating emissions of other GHGs. Efforts to quantify and encourage such actions are on-going efforts in the Natural Resources Conservation Service (NRCS).

Global climate change may also affect agricultural crop production (Backlund, 2008). These potential impacts on the agro-environment and individual crops may be direct, including changing patterns in precipitation, temperature, and duration of growing season, or may cause indirect impacts influencing weed and pest pressure (Rosenzweig et al., 2001; Schmidhuber & Tubiello, 2007). A recent Intergovernmental Panel on Climate Change (IPCC) forecast (IPCC, 2007) for aggregate North American impacts on agriculture from climate change projects yield increases of 5 to 20 percent for this century. The IPCC report notes that certain regions of the U.S. will be more adversely impacted because water resources may be substantially reduced. In addition, the current range of weeds and pests of agriculture is expected to change in response to climate change (USGCRP, 2009). While agricultural impacts on existing crops may be substantial, North American production is expected to adapt with improved cultivars and responsive farm management (IPCC, 2007).

Under the No Action Alternative, cropping practices to manage weeds in corn and soybean will likely increase in intensity. Control of glyphosate resistant weeds will likely require increased use and applications of of herbicides together with increased use of tillage (see sections 4.1.1 tillage and 4.1.1 herbicides and Appendix 4). Consequently corn and soybean cultivation will result in greater GHG emissions from the use of fossil fuels to apply herbicides and to till fields. The manufacture of herbicides may also contribute to the release of greenhouse gases but the overall contribution is likely to be a minor contribution. The magnitude of the effect will depend on the HR weed management practices that growers choose to use.

4.2 Preferred Alternative

Under the Preferred Alternative, APHIS would approve all three petitions for nonregulated status. These corn and soybean events and their progeny could be grown and shipped without a permit from APHIS BRS. This section analyzes the impacts of that decision. Here we consider the direct and indirect effects of that decision on the human environment. In general, the direct and indirect impacts on each resource for the Preferred Alternative are the same as for the No Action Alternative because Enlist™ corn and soybean have nearly identical properties as other GE and conventional corn and soybeans. The primary impacts from the Enlist™ technology on each resource derive from herbicide use and these impacts are outside the scope of this EIS because EPA is the federal authority responsible for the analysis of these impacts and thoroughly analyzes them elsewhere (US-EPA, 2013a; b; c; 2014). EPA has shared their risk assessments with USDA and they are cited but not further analyzed in this document. In the past, EPA risk assessments have not included an analysis of the potential for selection of HR weeds and resulting impacts so this analysis is included in this FEIS. This analysis of HR weeds is considered in the cumulative impacts section in Chapter 5 because it only arises from the joint action of both APHIS' approval of the three petitions and EPA's pending decisions on the use of certain pesticides on these events.

4.2.1 Socioeconomic and Human Health

Land Use

Under the Preferred Alternative there would be no direct or indirect effects on land use that result from the decision to approve the petitions, as compared with the No Action Alternative. The drivers of land used for corn and soybean production include the price of corn and soybean and the suitability of the land for this production. Prices of these commodities have risen in recent years, although 2013 saw a decline in the price of corn. The decision to approve these petitions will not affect the demand for corn or soybean. Acreage is expected to decline for corn production and remain high for soybean production over the next few years (USDA-OCE, 2014) regardless of the decision made by APHIS on these three petitions.

Like the No Action Alternative, under the Preferred Alternative, growers of specialty value added corn and soybean crops would see production and demand for these value added crops unchanged by nonregulated status for the three varieties.

Domestic Use of Corn and Soybean in the U.S. Economy

Under the Preferred Alternative there would be no direct or indirect effects on the use of corn or soybean in the U.S. economy. According to the petitions, each of the events is compositionally similar to currently available varieties of corn and soybean. These events would be suitable for use in food, feed, and industrial applications of corn and soybean products. Therefore the use of these events in corn or soybean processes would not change when compared to the No Action Alternative.

Corn and Soybean Agronomic Practices and Costs of Production

Under the Preferred Alternative there would be no direct or indirect effect on corn or soybean agronomic practices or the cost of production because currently growers cannot use any herbicides differently on Enlist™ corn or soybean than are available to them for other corn and soybean varieties. That is because Enlist Duo™ is not registered for use on these corn or soybean events until EPA approves the label. EPA regulates the use of herbicides under FIFRA and is making a separate decision which may or may not allow its use on these plants. Therefore, the types of agronomic practices used to control weeds in these varieties would be similar to those used in other available varieties. Growers would continue to manage weeds using a combination of chemical and cultural methods. HR weeds would be selected for by management practices in the same ways that they are in the No Action Alternative. Under this alternative, like the No Action Alternative, growers may rely on glyphosate to manage weeds in corn and soybean. Weed scientists will continue to encourage growers to use best management practices like under the No Action Alternative.

Export of Corn and Soybean

A determination of nonregulated status of DAS-40278-9 corn, DAS-68416-4 soybean, and DAS-4406-6 soybean are not expected to adversely impact trade under the Preferred Alternative. Dow has submitted applications to several international agencies, including the regulatory authorities in Canada, Brazil, Australia, New Zealand, China, Colombia, EU, Japan, Korea, South Africa, and Switzerland (Orr, 2013) . Approvals for one or more of the Enlist™ crops have occurred in some countries and are pending in others. Regulatory status as of July 8, 2014 is summarized in Table 9. Although the primary U.S. corn and soybean export destinations do not present major barriers to trade in GE products, Dow would need to obtain approval of DAS-40278-9 corn, DAS-68416-4 soybean, and DAS-4406-6 soybean in destination countries before commercialization to avoid adversely affecting current trade flows.

Table 9. Current Approval Status (as of July 8, 2014) of DAS-40278-9 Corn, DAS-68416-4 Soybean, and DAS-44406-6 Soybean in Various Countries

Country	DAS-40278-9 Corn	DAS-68416-4 Soybean	DAS-44406-6 Soybean
Canada (Food/Feed/Cultivation)	approved	approved	approved
Argentina (Food/Feed/Cultivation)	pending	pending	pending
Brazil (Food/Feed/Cultivation)	pending	pending	pending
ANZ (Food/Feed)	approved	approved	approved
China (Food/Feed)	pending	pending	pending
Colombia (Feed)	approved	approved	pending
Colombia (Food)	approved	pending	pending
EU (Food/Feed)	pending	pending	pending
Japan (Food/Feed/Cultivation)	approved	pending	pending
Korea (Food/Feed)	approved	pending	pending
Mexico (Food/Feed)	approved	approved	approved
South Africa (Food/Feed)	approved	pending	approved
Switzerland (Food/Feed)	pending	pending	pending
USA (Food/Feed)	approved	approved	approved
USA (Cultivation)	pending	pending	pending

Source: (DAS, 2013a)

APHIS acknowledges that there may be a requirement in some export markets to test for the presence of GE corn or soybean. Testing may be required if these corn or soybean events are not approved by the importing country, or for non-GM, identity-preserved corn or corn flour shipments (Frank Spiegelhalter, Eurofins, Pers. Comm.). DNA-based polymerase chain reaction (PCR) testing would be done in these cases. If a new DNA-based PCR test would be required for Enlist™ crops, at an estimated cost of between $300-500 per barge (1500 MT), there would be a 10 to15 percent increase in current testing costs (Spiegelhalter, Pers. Comm).

Based on these factors, the trade economic impacts associated with a determination of nonregulated status of Enlist™ corn and soybean are anticipated to be very similar to the No Action Alternative for the bulk of U.S. corn exports, with the exception of a small non-GE, identity-preserved export market, where the costs of testing are likely to increase.

Food and Feed

The direct and indirect effects on food and feed will not be different under the Preferred Alternative when compared to the No Action Alternative. People will continue to consume corn- and soybean-based products as well as animal products from livestock fed corn and soybean products. As described in the petition, Enlist™ corn and soybean are compositionally similar to currently available varieties of corn and soybean. Therefore, they are not expected to have different nutritional qualities than other available corn or soybean varieties.

Dow has provided the FDA with information on the identity, function, and characterization of the genes for DAS-40278-9 corn, DAS-68416-4 soybean, and DAS-44406-6 soybean. Dow has completed consultations with FDA for all three Enlist™ products: DAS-40278-9 corn (US-FDA, 2011b) , DAS-68416-4 soybean (US-FDA, 2011b), and DAS-44406-6 soybean (US-FDA, 2013a). The AAD-1 protein in DAS-40278-9 corn is derived from the common gram-negative soil bacterium *Sphingobium herbicidovorans* (Herman et al., 2010). *Sphingobium* is a member of the sphingomonads, a widely distributed bacteria group isolated from soil and water as well as plant root systems (DAS, 2009; 2010b). The sphingomonads have been used widely in biotechnology applications, including bioremediation of environmental contaminations as well as production of sphingans, bio-based polymers which are used in the food industry (DAS, 2010a; Lal et al., 2006; Pollock & Armentrout, 1999).

The AAD-12 protein in DAS-68416-4 and DAS-44406-6 soybean is derived from the common gram-negative soil bacterium *Delftia acidovorans. D. acidovorans* is non glucose-fermenting, gram-negative, non-spore-forming rod type bacterium present in soil, fresh water, activated sludge, and clinical specimens. It has a history of safe use in the food processing industry, including having been used in transforming ferulic acid into vanillin and related flavor metabolites (DAS, 2010a). Because the AAD-12 protein has a safe history of use in food processing, there are not likely to be any effects on food and feed from growing Enlist™ soybean when compared to the No Action Alternative.

The *pat* gene is derived from *Streptomyces viridochromogenes,* a gram-positive soil bacterium. The *pat* gene conveys resistance to glufosinate (Wohlleben et al., 1988). The PAT protein in DAS-68416-4 and DAS-44406-6 soybean is the same as that used as a selectable marker during development and to confer herbicide resistance in other previously deregulated GE crops (Brenner et al., 2001; Duke & Powles, 2008; USDA-ERS, 2005; USDA-FAS, 2004). Additionally, FDA has previously reviewed submissions regarding the safety of food and feed derived from crops containing the *pat* gene (BNFs 000055, 000073, 000081, 000085, and 000092). Because of the similarity of the PAT protein expressed in DAS-68416-4 and DAS-44406-6 and the other varieties noted above, there are not likely to be any effects on food and feed from growing of Enlist™ soybean when compared to the No Action Alternative.

The *mepsps* gene in DAS-44406-6 is derived from *Zea mays*, corn. It contains two mutations which convey resistance to glyphosate (Lebrun & Leroux, 1996; Lebrun et al., 2003). It is similar to the *epsps* gene expressed in GA21 corn http://www.aphis.usda.gov/brs/aphisdocs/97_09901p.pdf, GHB614 cotton http://www.aphis.usda.gov/brs/aphisdocs/06_33201p.pdf, and HCEM485 corn (Stine, 2011).

GA21 corn (BNF 51), GHB614 cotton, (BNF 109), and HCEM485 corn (BNF 106) have completed consultations with FDA. Because of the similarity of the EPSPS protein expressed in DAS-44406-6 soybean and the corn and cotton varieties noted above, there are not likely to be any effects on food and feed from growing of DAS-44406-6 soybean when compared to the No Action Alternative.

Worker Safety

APHIS has not identified any direct or indirect effects on worker safety that would result from choosing the Preferred Alternative. Hazards to workers occurring through the various management practices that are used to grow corn and soybean are the same as those under the No Action Alternative. Choosing the Preferred Alternative will not result in a change in management practices when compared to the No Action Alternative with the exception that different herbicides will be used, tillage may be less frequent, and farm equipment may be used less often. Workers will continue to use farm equipment and agricultural chemicals. The decision to approve the three petitions does not authorize a change in herbicide use on these corn or soybean varieties. EPA regulates the use of herbicides under FIFRA. EPA considers the effects on human health when approving the use of herbicides. (See Appendix 8 for a discussion of EPA's assessment).

4.2.2 Biological Resources

Animals

Under the Preferred Alternative, the direct and indirect effects of approving these three petitions would be similar to the effects on animals under the No Action Alternative. Animals would continue to feed on corn and soybean in the field. DAS-40278-9 corn, DAS-68416-4 soybean and DAS-44406-6 soybean are compositionally similar to other commercially available corn and soybean varieties. As discussed in "Food and Feed" the PAT and mEPSPS proteins are found in commercial varieties of corn, cotton, and soybeans. Organisms that feed on these crops are exposed to these proteins in previously deregulated varieties with no documented negative effects.

The *aad-1* gene, which expresses the AAD-1 protein, was derived from the gram negative soil bacterium *Sphingobium herbicidovorans* (DAS, 2010a). The *Sphingobium spp.* is a member of the sphingomonads, a widely distributed bacteria group isolated from soil and water as well as plant root systems (DAS, 2009; 2010a). The sphingomonads have been used widely in biotechnology applications, including bioremediation of environmental contaminations as well as production of sphingans, bio-based polymers which are used in the food industry (DAS, 2010a; Lal et al., 2006; Pollock & Armentrout, 1999). The aryloxyalkanoate dioxygenase proteins, including AAD-1, are a class of enzymes found in these soil bacteria; hence there has been animal exposure to these bacteria and enzymes through normal dietary intake of vegetation and incidental ingestion of soil (ANZFS, 2010; 2011; DAS, 2009; 2010a). Dow has presented evidence of phenotypic and agronomic trials conducted in 27 locations in the U.S. and Canada (DAS, 2010a). The trials evaluated incidences of insect and disease damage between the DAS-40278-9 corn variety and other corn hybrids (DAS, 2010a). No statistical differences were noted between the varieties (DAS, 2010a). Insects, particularly insects which feed on corn, were not impacted by ingesting corn in which the *aad-1* gene was incorporated.

DAS has evaluated the potential allergenicity and toxicity of the AAD-1 protein following the weight-of-evidence approach (DAS, 2010a). The AAD-1 protein does not share any meaningful amino acid similarities with known allergens. The AAD-1 protein is degraded rapidly and completely in simulated gastric fluids and the protein is not present in a glycosylated state (DAS, 2010a). The protein does not share any amino acid sequence similarities with known toxins (DAS, 2010a). The results presented by Dow suggest that the AAD-1 protein is unlikely to be a toxin in animal diets. Based on a review of this information, APHIS has found no evidence that the presence of the *aad-1* gene or the expression of the AAD-1 protein would have any impact on animals, including animals beneficial to agriculture (USDA-APHIS, 2010b).

Dow evaluated the potential allergenicity and toxicity of the AAD-12 protein following the weight-of-evidence approach (DAS, 2010a). The AAD-12 protein does not share any meaningful amino acid similarities with known allergens. The AAD-12 protein is degraded rapidly and completely in simulated gastric fluids, and the protein is not present in a glycosylated state (DAS, 2010a). The protein does not share any amino acid sequence similarities with known toxins (DAS, 2010a). The results presented by Dow suggest that the AAD-12 protein is unlikely to be a toxin in animal diets. Based on a review of this information and the assumption that these studies serve as surrogates for direct testing, APHIS has found no evidence that the presence of the *aad-12* gene or the expression of the AAD-12 protein would have any impact on animals, including animals beneficial to agriculture (USDA-APHIS, 2012a).

As described in the No Action Alternative, animals can also be impacted indirectly by agricultural practices, such as tillage. Adopting the Preferred Alternative will not result in any changes in agricultural practices. Growers will continue to use herbicides and cultural practices to manage weeds. Increases in tillage to control weeds can increase soil erosion and the indirect impacts on wildlife. Agricultural production of corn and soybean would use EPA-registered pesticides, including glyphosate, glufosinate, and 2,4-D, for weed management. The environmental risks of pesticide use on wildlife and wildlife habitat are assessed by EPA in the pesticide registration process and are regularly reevaluated by EPA for each pesticide to maintain its registered status under FIFRA.

<u>Plant Communities</u>

Under the Preferred Alternative, the direct and indirect effects of approving these three petitions would be similar to the effects on plants under the No Action Alternative. Choosing the Preferred Alternative would not change the structure of the plant communities in or around corn and soybean fields. Management practices such as herbicide use and mechanical cultivation can select for weeds that are adapted to these management practices. Non-target plant communities in areas surrounding production fields would be exposed to the effects associated with agricultural production, including exposure to various inputs including herbicides. This can select for resistance to herbicides among these populations, just as in production fields, resulting in establishment of novel resistant biotypes. Exposure to herbicide, e.g., through drift could also lead to plant population shifts in non-target populations, just as it could in weed populations associated with production fields. This exposure is the same under the Preferred Alternative and the No Action Alternative because approving the three petitions does not directly or indirectly change the use of herbicides in corn and soybean. Therefore there are no changes to the effects under the Preferred Alternative when compared to the No Action Alternative. While DAS-40278-9 corn, DAS-68416-4 soybean and DAS-44406-6 soybean can resist the application of the Enlist Duo™ herbicide, this decision does not allow for its use on these corn and soybean varieties. EPA regulates the use of herbicides under FIFRA and is making a separate decision which may or may not allow its use on these plants. APHIS considers the potential impacts on plant communities of its decision combined with EPA's decision in Chapter 5.

4.2.3 Natural Resources

Soil Quality

The effects on soil quality of choosing the Preferred Alternative are no different than the effects under the No Action Alternative. Soil quality is affected by agricultural management practices. One factor that is driving agricultural practices is weed management. Growers in the South, regions D and F, are using more tillage to manage weeds (Prostko, 2013; Wright & Wimberly, 2013). Increases in tillage can lead to more soil loss due to erosion USDA-NRCS 1996). Additionally, the trend toward increased herbicide use to control herbicide-resistant weeds in different cropping systems (Culpepper, 2008; Heap, 2011b; Owen & Zelaya, 2005; Owen, 2008) will be similar under the No Action and the Preferred Alternative. Pesticide use has the potential to affect soil quality due to the impact to the soil microbial community.

The decision to approve these petitions will not directly or indirectly affect these grower decisions to use tillage to manage weeds. Approving the petitions would allow these varieties to be planted, but it does not allow for the use of the Enlist Duo™ herbicide on the plants. The use of Enlist Duo™ is regulated by EPA. EPA regulates the use of herbicides under FIFRA and is making a separate decision which may or may not allow its use on these plants. APHIS considers the potential cumulative impacts on soil of its decision combined with EPA's decision in Chapter 5.

Water Quality

Agricultural practices can affect water quality. Under the Preferred Alternative agricultural impacts on water quality are the same as those described under the No Action Alternative. Choosing the Preferred Alternative does not change the way people will grow corn and soybeans or manage weeds in their fields. In areas where tillage is used to control weeds and soil erosion occurs, water may be affected by sediment (Robertson et al., 2009).

Use of pesticides for field crop production may introduce these chemicals to water through spray drift, cleaning of pesticide application equipment, soil erosion, or filtration through soil to groundwater. As part of assessing the risk of the exposure of aquatic organisms and the environment to a pesticide, EPA estimates concentrations of pesticides in natural water bodies, such as lakes or ponds. Also as part of the Food Quality Protection Act (FQPA) of 1996, EPA estimates pesticide concentrations in drinking water when it establishes maximum pesticide residues on food (tolerances). For both drinking water and aquatic exposure assessments and for water quality assessments, EPA typically relies on field monitoring data as well as mathematical models to generate exposure estimates (US-EPA, 2012d).

Approving the petitions would allow these varieties to be planted, but it does not allow for the use of the Enlist Duo™ herbicide on the plants. The use of Enlist Duo™ is regulated by EPA. EPA regulates the use of herbicides under FIFRA and is making a separate decision which may or may not allow its use on these plants. APHIS considers the potential impacts on water quality of its decision combined with EPA's decision in Chapter 5.

Air Quality

Agricultural activities such as tillage, pesticide application, prescribed burning, and farm equipment use can all effect air quality. Growers choose those activities that are most suited for their operations. To manage weeds growers may use a combination of activities including pesticide use. In some areas of the south tillage is increasing under the No Action Alternative. This activity indirectly affects air as particulate matter can increase with increasing tillage. Also conventional tillage can use more fossil fuels than conservation tillage methods (Table 8). Choosing the Preferred Alternative will not directly affect grower's management choices. Approving the petitions would allow these varieties to be planted, but it does not allow for the use of the Enlist Duo™ herbicide on the plants. The use of Enlist Duo™ is regulated by EPA. EPA regulates the use of herbicides under FIFRA and is making a separate decision which may or may not allow its use on these plants. APHIS considers the potential impacts on air quality of its decision combined with EPA's decision in Chapter 5.

Climate Change

The same types of agricultural activities that effect soil, water and air quality can contribute to climate change. As discussed in those other areas, choosing the Preferred Alternative does not change these production practices. Therefore the effects on climate change are the same under the preferred and the No Action Alternative.

4.3 Alternative 3

Under Alternative Three, which approves Petition 09-233-01p, DAS-40278-9 corn, but not Petitions 09-349-01p or 11-234-01p for Dow soybean, the impacts are similar to those described in the Preferred Alternative. Approving the petition would allow the corn variety to be planted without a permit or acknowledged notification. The two soybean lines would continue to be regulated. This decision does not allow for the use of the Enlist Duo™ herbicide on the corn plants. The use of Enlist Duo™ is regulated by the EPA. The EPA regulates the use of herbicides under FIFRA and is making a separate decision which may or may not allow its use on these plants. APHIS considers in Chapter 5 the potential impacts of its decision under Alternative 3 combined with the EPA's decision to register Enlist Duo™.

Because approving all three petitions would not have different effects on natural or biological resources than the No Action Alternative, approving one of the three Enlist™ crops is also not expected to have different direct and indirect effects on those resource areas. In addition, APHIS does not expect Alternative 3 to have different socioeconomic or human health related effects than the Preferred Alternative because the approval of petition 09-233-01p is one of the petitions considered in Alternative 2 and no direct or indirect effects of growing DAS-40278-9 corn were identified in that Alternative when compared to the No Action Alternative.

4.4 Alternative 4

Under Alternative Four, which approves Petitions 09-349-01p or 11-234-01p for Dow soybean but not Petition 09-233-01p for DAS-40278-9 corn, the impacts are similar to those described in the Preferred Alternative. Approving the petition would allow the soybean varieties to be planted without a permit or acknowledged notification. The corn event would continue to be regulated. This decision does not allow for the use of the Enlist Duo™ herbicide on the soybean plants. The use of Enlist Duo™ is regulated by the EPA. The EPA regulates the use of herbicides under FIFRA and is making a separate decision which may or may not allow its use on these plants. APHIS considers the potential impacts of its decision under Alternative 4 combined with the EPA's decision on Enlist Duo™ in Chapter 5.

Because approving all three petitions would not have different effects on natural or biological resources than the No Action Alternative, approval of two of the three Enlist™ crops is also not expected to have different direct and indirect effects on those resource areas. In addition, APHIS does not expect Alternative 4 to have socioeconomic or human health related effects different than the Preferred Alternative because the approval of petitions 09-349-01p or 11-234-01p are two of the petitions considered in Alternative 2 and no direct or indirect effects of growing DAS soybeans were identified in that alternative when compared to the No Action Alternative.

5 CUMULATIVE IMPACTS

This section assesses current and reasonably foreseeable future impacts if APHIS chooses one of the Action Alternatives (Alternative 2, 3, or 4). APHIS considers the impacts of the Action Alternative combined with its past, present, and reasonably foreseeable future actions, as well as those actions of others in this section.

Cumulative impacts are defined as the "impact on the environment, which results 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" (40 CFR 1508.7).

Impacts on natural and biological resources were considered in the analyses. Possible implications of how these impacts might affect the availability of those resources for human use and consumption were also analyzed. The initial step in this process was an analysis of the potential changes in management practices likely to occur if APHIS approves one or more of the Dow petitions, and EPA approves the application rate changes for 2,4-D on GE corn and soybean requested by the petitioner. In the second phase, the way changes in management practices might impact natural and biological resources were analyzed. Possible impacts of an interaction with other APHIS actions (past and those currently pending) were also considered.

Environmental issues were assessed individually in Section 4. From that analysis, APHIS determined there are no direct or indirect impacts from DAS-40278-9 corn, DAS-68416-4 soybean, and DAS-44406-6 soybean, because these varieties are not agronomically different from other GE corn or soybean cultivars that are no longer regulated by the Agency. However, the analysis did not consider potential cumulative impacts that might result if the requested EPA actions are approved in conjunction with those of APHIS. An APHIS determination of nonregulated status for DAS-40278-9 corn, DAS-68416-4 soybean, or DAS-44406-6 soybean, and the independent action by EPA to approve registration of Enlist Duo™ on these crops is reasonably foreseeable. This herbicide product contains choline formulations of 2,4-D together with glyphosate. It is specifically formulated for use on the crops that are the subject of this EIS.

The factors that contribute to increased 2,4-D use on corn and soybean include the application rate (i.e. the pounds applied per acre)[9] and the number of acres to which 2,4-D is applied. For corn, the maximum application rate of 2,4-D is the same for Enlist™ corn and other corn varieties. However, for Enlist™ corn, more acres of corn are expected to be sprayed with 2,4-D. For soybean, the new label would allow for higher application rate and applications at later stages of plant growth than currently approved for 2,4-D use on soybean. In addition, more soybean acres are likely to be sprayed with 2,4-D with Enlist™ soybean than for other varieties. Therefore, one possible cumulative impact is that more 2,4-D will be applied to corn and

[9] For the application rate there is a maximum rate allowed per application and a total seasonal use rate which is the maximum pounds/acre that can be applied in a season. See Appendix 4 for more details.

soybean crops, resulting in increased selection for 2,4-D resistant weeds. Because this impact would occur only if both APHIS and EPA take the actions already described here, APHIS has analyzed the potential cumulative impacts of its action combined with potential Enlist Duo™ applications in more detail in this section. More specifically, this cumulative impacts section analyzes the cumulative impact of weed resistance due to the cumulative use of 2,4-D over time. It includes a discussion of potential cumulative impacts associated with the Action Alternatives (see Section 2), when combined with other past, present, and reasonably foreseeable future actions within the affected environment (described in Section 3).

5.1 Cumulative Impacts Methodology

For this analysis, Alternative 1, the No Action Alternative was the baseline for comparisons. Under Alternative 1, DAS-40278-9 corn, DAS-68416-4 soybean, and DAS-44406-6 soybean could only be grown if regulated under APHIS notifications or permits. Under this circumstance, it is possible that EPA would still approve choline formulations for use on corn and burndown applications in soybean. APHIS assumes that currently available formulations of 2,4-D would also be available as would currently available varieties of corn and soybean.

5.2 Geographic Boundaries for the Analysis of Cumulative Effects

APHIS evaluated impacts at the regional and national levels for this analysis. Regional levels included the ecoregions defined in Section 3 (Affected Environment). The national level is the conterminous U.S. states as little corn is grown outside the 48 states.

5.3 Management Practices Considered in the Analysis of Cumulative Impacts

This analysis addresses the potential impacts of the Alternatives on natural and biological resources and their interrelated socioeconomic impacts within the U. S. DAS-40278-9 corn, DAS-68416-4 soybean, or DAS-44406-6 soybean do not affect natural or biological resources directly, but the management practices (e.g., pesticide applications) associated with cultivation of these crops impact natural and biological resources. If EPA registers Enlist Duo™ for DAS-40278-9 corn, DAS-68416-4 soybean or DAS-44406-6 soybean, APHIS expects that 2,4-D use will increase under the Preferred Alternative. Increased use of 2,4-D could accelerate the selection and distribution of 2,4-D-resistant weeds. As a result, growers of other crops that use 2,4-D for weed control may need to modify their management practices to delay or manage 2,4-D resistant weeds. These changes would increase the complexity and cost of weed management programs for these growers. Because the use of DAS-40278-9 corn, DAS-68416-4 soybean or DAS-44406-6 soybean does not require a single specific set of agronomic practices, the magnitude of the impacts discussed depend on the adoption rates of various practices by growers. This section analyzes the cumulative impacts related to changes in management practices that are likely to be associated with the adoption of DAS-40278-9 corn, DAS-68416-4 soybean or DAS-44406-6 soybean in the context of the impacts that agriculture has on these resources in the areas where corn and soybeans are grown.

5.4 Risk Assessments Used for the Analysis of Cumulative Impacts

The EPA uses risk assessment for registration decisions. It evaluates risk based on exposure and hazard to both humans and other organisms. A pesticide cannot be registered, nor can an existing registration be amended, unless the registered use conforms to the EPA standard of “no unreasonable adverse effects on the environment” as described in FIFRA. There are four general steps in the risk assessment process: hazard identification, exposure assessment, dose/response assessment, and risk analysis. Once the EPA determines that this standard can be met, it issues a registration or modifies an existing one. The registration label includes strict limits on the quantities and methods allowed for the use of a pesticide to ensure that the standard is met.

The EPA has developed exposure assessments for this process to characterize environmental persistence of pesticides and their byproducts from degradation following application. These assessments are based in part on scientific studies that sample and measure residue concentrations for specified time frames. The data are analyzed with statistical procedures referred to as models to extrapolate estimates for environmental fate (i.e., persistence of residues) over longer time frames than the ones sampled.

The EPA uses environmental fate data to predict potential concentration of the pesticide and its degradation products in air, soil, and surface and groundwater. These data are also used to estimate residue levels in the drinking water component of human dietary risk assessments.

Results of environmental fate studies enable the EPA to determine where a pesticide and its degradates (byproducts) go in the environment (i.e., air, water, and soil), how long they persist, and in what quantities. This information is used by the EPA to develop estimated environmental concentrations (EECs) that can be compared to toxicity and ecotoxicology data as part of the risk assessment process. EEC values are based on the maximum allowable application rate for a pesticide although typical application rates are usually lower than the maximum allowed. This approach, along with other factors such as the conditions on the farm field, result in “high-end” to “bounding” estimates of exposure. When these are compared to the most sensitive toxicological endpoints in human and ecological effects studies, the results are conservative risk estimates. If these estimates exceed concern levels, the EPA will refine the exposure estimates using additional information or may perform a probabilistic assessment of risks. The EPA has conducted independent assessments of direct and indirect effects associated with the use of 2,4-D on DAS-40278-9 corn, DAS-68416-4 soybean, or DAS-44406-6 soybean concurrent with the development of this EIS (US-EPA, 2013a; b; c). These effects are outside the scope of this EIS. In the proposed registration, the EPA has established label restrictions for the use of Enlist Duo™ on Enlist™ crops that, when followed, will ensure no unreasonable adverse effects to human health or the environment associated. APHIS’ analysis in this section focuses on cumulative impacts associated with these varieties, including the development of HR weeds, due to herbicide application and changes in management practices resulting from their use.

5.5 Magnitude of Potential Impacts on Resources

APHIS identified changes in management practices that could cause impacts on natural and biological resources. If approved for general use, the degree to which the varieties that are the subject of this EIS are adopted will determine the magnitude of the impacts of the associated new management practices. Because APHIS does not regulate production/management practices, it cannot control them.

5.6 Assumptions

A summary of the assumptions made for the analyses included in this section follow:

- The APHIS PPRA did not identify any changes in DAS-40278-9 corn, DAS-68416-4 soybean, or DAS-44406-6 soybean that would directly or indirectly affect natural or biological resources. These plants are compositionally similar to other corn and soybean plants. The growth habit of the plants is also similar to other corn and soybean plants. APHIS assumes that growers will choose management practices appropriate for the crops planted. APHIS used information available from extension services, trade journals, scientific journals, and public comments for petitions to identify common practices.

- GE HR corn and soybean varieties will continue to be planted under all of the alternatives. Most of the U.S. corn and soybean acreage is currently planted in GE HR varieties.

- Under Alternatives 2, 3, and 4, DAS 40278-9 corn, DAS 68416-4 soybean, or DAS 444406-6 soybean , the deregulated Enlist™ crops could be crossed with any currently available variety including GE varieties no longer regulated by APHIS.

- APHIS assumes that most herbicide applications will conform to the EPA-registered uses for corn and soybean that are summarized in Appendix 7 and 8.

- In addition to corn and soybean, APHIS assumes that most other approved 2,4-D uses (e.g. on pastures, wheat, oats, barley, millet, rye, sorghum, rice, cotton, sugarcane, almonds, apples, apricots, cherries, citrus, hazelnuts, nectarines, peaches, pears, pecans, plums, walnuts) will conform to EPA-registration requirements.

- APHIS assumes that drift from 2,4-D and other pesticide applications will be mitigated to an acceptable level by the registration requirements established by the EPA.

- APHIS assumes that all 2,4-D treatments made to Enlist™ corn and soybean will also include glyphosate because stewardship agreements between DAS and growers will stipulate that Enlist Duo™ products (which are a mixture of glyphosate and 2,4-D) be used.

- Herbicide use estimates were made for 2,4-D, glyphosate, quizalofop, and glufosinate for the four alternatives and discussed in detail in Appendix 4. These estimates were based on the assumption that 2,4-D crop uses will increase, while 2,4-D uses on turf, range, pasture, and industrial management will not change. APHIS also acknowledges that the availability of dicamba resistant soybean varieties on the market is reasonably foreseeable. Dicamba and 2,4-D are both synthetic auxins with very similar herbicide chemistries. They are not likely to be used simultaneously because Enlist™ crops are sensitive to dicamba, dicamba resistant crops are sensitive to 2,4-D, and APHIS is not aware of any cross licensing agreements between Dow and Monsanto that would allow these traits to be stacked. When APHIS estimated the upper bound of 2,4-D use, it was assumed that all herbicide resistant corn (82 million acres) and 68% of the soybean acres

(52 million acres) would have the Enlist™ trait whereas 32% of the soybean acres would have an alternative herbicide resistance trait such as dicamba. Competition with soybean varieties resistant to herbicides such as dicamba, isoxaflutole, mesotrione, and glufosinate may reduce the assumed upper boundary to below 68% of the total soybean acres. In brief, 2,4-D use is expected to increase under the No Action and Action Alternatives. Under the No Action Alternative, 2,4-D use is expected to increase by 75% compared to current day use. Under the Action Alternatives, the increase in 2,4-D use is expected to be greater by up to 300 percent compared to the No Action Alternative. Glyphosate use on corn and soybean is not expected to increase under the No Action and Preferred Alternatives because of market saturation; i.e. as of 2011, 90 percent of the corn acres and 96 percent of the soybean acres are already treated with glyphosate. Quizalofop use is expected to decrease under the Preferred Alternative relative to the No Action Alternative because glyphosate still adequately controls grass weeds and the current use of quizalofop to control corn volunteers in soybean is likely to diminish with adoption of Enlist™ corn. Glufosinate use is expected to increase less under the Preferred Alternative relative to the No Action Alternative based on the expectation that 2,4-D is considered a more favorable option for GR weed control compared to glufosinate.

5.7 Preferred Alternative

5.7.1 Socioeconomic and Human Health Factors

Land Use

U.S. corn and soybean acreage increased over the past two decades. The greatest increase occurred in the northern and western parts of region G and the northeastern section of region I (USDA-NASS, 2013c). During the same period, wheat and small grain acreage decreased in these areas (USDA-NASS, 2013c).

Assuming USDA approval of the three petitions and EPA's independent registration of Enlist Duo™ both occur, corn and soybean acreage in regions A-M are not expected to change because other factors such as corn and soybean prices have a greater influence on planting decisions. Corn acreage is expected to decrease from 97 million acres to 88.5 million acres over the coming decade while soybean acreage is expected to expand from 76.5 million acres to 78 million acres (USDA-OCE, 2014).

Domestic Uses of Corn and Soybean in the U.S.

The uses of corn and soybeans in commerce are described in the No Action Alternative. The Preferred Alternative is not likely to have cumulative impacts on the uses of corn or soybean because the influences on these uses are not related to weed control.

Corn and Soybean Agronomic Practices and Costs of Production

Tillage

Adoption of DAS-40278-9 corn, DAS-68416-4 soybean, or DAS-44406-6 soybean together with EPA approval of the Enlist Duo™ registration label may reverse a trend of increasing tillage that is occurring now and expected to continue under the No Action Alternative. No-till cropping practices are based on effective herbicide weed control (APHIS-2013-0042-5139). Tillage increases are occurring in certain areas where herbicide-resistant weeds are no longer effectively controlled by currently-registered herbicides (see section 4.1.1. Tillage). Reports of increased tillage as a result of GR weeds have already been reported for cotton and soybean (Riar et al., 2012; Shaw et al., 2012). In some Tennessee counties, the area devoted to conservation tillage was decreased by as much as 25 percent in soybean fields infested with GR horseweed (Shaw et al., 2012). Use of DAS-40278-9 corn, DAS-68416-4 soybean, and DAS-44406-6 soybean are expected to improve the control of GR weeds and as a consequence, tillage is less likely to be needed for weed control under the Preferred Alternative. Therefore it is expected that less tillage will occur in areas where GR weeds are widespread under the Preferred Alternative compared to the No Action Alternative. This potential reduction in tillage is most likely to occur with the use of DAS-68416-4 soybean and DAS-44406-6 soybean because the increase in the use of tillage for weed management is occurring in soybeans (Shaw et al., 2012) because corn growers have more herbicide options.

Crop Rotation

Adoption of DAS-40278-9 corn, DAS-68416-4 soybean, or DAS-44406-6 soybean is not expected to change corn and soybean crop rotation practices. However, if 2,4-D-resistant weeds become a problem that reduces the cost effectiveness of growing certain crops, this could change crop rotation practices. For example, small grain crops are sometimes rotated with soybeans (see Figure 10). Input costs are just one factor that determines whether a given rotation crop is grown. Other considerations include benefits to the soil, disease management considerations, and economic returns from growing the rotation crop. Some small grain cereals rely on 2,4-D for inexpensive weed control. If 2,4-D were to become ineffective and the cost of alternative herbicides were too expensive, growers may choose not to grow small grains.

Agronomic Inputs

Adoption of DAS-40278-9 corn, DAS-68416-4 soybean, and DAS-44406-6 soybean is not expected to change corn and soybean production except to increase 2,4-D usage. Fertilizer, insecticide, fungicide, and water use are expected to remain unchanged from the No Action Alternative. Grower weed control costs are expected to be improved relative to the No Action Alternative. Many weed science experts submitted comments to the EIS docket with new information that supports this concept.

From a Professor of Weed Science (APHIS 2013-0042-1911): "Neither dicamba nor 2,4-D are consistently effective in controlling Palmer amaranth larger than 4 inches when applied alone (Culpepper et al., 2011; Culpepper et al., 2010; Merchant et al., 2014), however, weed management systems including these herbicides are more consistently effective than current standards (Beckie, 2011; Braxton et al., 2010; Merchant et al., 2014; Richburg et al., 2012; Shaw & Arnold, 2002). Weed management programs, including 2,4-D or dicamba, would improve a grower's ability to manage this problematic weed in the following ways: 1) improved consistency in weed control, especially on dryland production acres, where residual herbicides often are not activated with rainfall at planting time, 2) more flexibility with herbicide application timings because glufosinate plus dicamba or 2,4-D will consistently control Palmer amaranth up to 6 inches in height (at least 2 inches larger than today's standards), 3) less herbicide carryover to subsequent crops because growers would be less dependent on long lasting residual herbicides, and 4) less yield loss from Palmer amaranth crop competition for light, nutrients, and water (Coetzer et al., 2002; Culpepper et al., 2010; MacRae et al., 2013; Merchant et al., 2014)

From a state weed science extension specialist, (APHIS-2013-0042-5139) "complete weed control before planting helps ensure successful planting and crop emergence. We recommend a mixture of herbicide modes of action. One mode of action commonly used is exhibited in 2, 4-D because of its ability to control several difficult but competitive weeds. Unfortunately, current herbicide labels require planting delays of up to two weeks. Our agronomic research indicates that timely planting is one of the most effective ways to increase corn and soybean yields. Deregulation of Enlist traits will allow for timely planting. Timely planting will increase crop productively and allows for the establishment of a crop canopy earlier, and this helps protect the soil."

"One final comment related to soil conservation. There has been renewed interest in the use of cover crops in soybean and corn cropping systems. Cover crops reduce soil erosion in much the same way as crop residue found in no-tillage. Plant leaves intercept raindrops and dissipate their energy. In addition, roots slow water runoff and hold the soil in place. Plant species in the legume family are popular inclusions in a cover crop mix – especially in corn cropping systems – because of their ability to fix nitrogen. Glyphosate sometimes struggles with providing good legume control. Addition of 2, 4-D to a burndown mix greatly increases cover crop kill, but label restrictions may delay corn or soybean planting. Deregulation of Enlist traits will increase timely corn planting and reduce early competition from cover crop plants." (APHIS-2013-0042-5139).

Herbicides

Proximity of Corn and Soybean to Other 2,4-D Treated Crops

Enlist™ corn and soybean are expected to be attractive to those corn and soybean growers who have or will have difficulty with weed control caused by GR weeds. In the event that Enlist™ corn and soybean become widely used and 2,4-D-resistant weeds become more widespread, there are two types of growers that are most likely to be impacted.

The first are the soybean and corn growers who almost exclusively have adopted GR crops and are already confronted with weed control problems related to GR weeds. Until now, these growers have relied more on glyphosate than 2,4-D, but are expected to adopt Enlist™ crops and develop a reliance on 2,4-D as a solution to the GR weed problem. The ease and effectiveness of 2,4-D use may delay the need to adopt a more diversified weed management program for these growers. Several weed experts commented that for a number of reasons, growers are unlikely to over-rely on Enlist Duo™ the way farmers over- relied on glyphosate (APHIS 2013-0042-1911; 3217; 8196); because Enlist Duo™ will not give the type of control that glyphosate alone gave. According to these experts, for weeds such as Palmer amaranth, growers will have no choice but to use additional residual herbicides through the season in order to get effective weed control. Because auxin herbicides only control Palmer amaranth less than 4 inches in height, they may tank mix Enlist Duo™ with glufosinate in order to control Palmer amaranth less than 6 inches in height. These experts predict that residual herbicides and/or glufosinate would need to be included in weed programs managing GR weeds, and the additional herbicide chemistries would likely delay the selection of 2,4-D resistant weeds.

APHIS acknowledges these comments (APHIS 2013-0042-1911; 3217; 8196) and finds the argument compelling. Nevertheless, APHIS cannot rule out the possibility that some growers will over-rely on Enlist Duo™, either because they are adequately controlling weeds that, unlike Palmer amaranth, are effectively controlled only by Enlist Duo™ or they do so for unforeseen circumstances. It is also possible that some growers may over-rely on synthetic auxins by rotating between Enlist™ crops and dicamba-resistant crops, selecting for weeds that may have cross resistance to these synthetic auxins, despite the availability of herbicide-resistant crops that have other sites of action such as glufosinate and HPPD inhibitors. In the event that 2,4-D-resistant weeds became prevalent in their region, these growers would have to become less reliant on 2,4-D and diversify their management programs in ways that would be similar to that described in the No Action Alternative.

The second type of grower that is most likely to be impacted are growers who already rely on 2,4-D for weed control in applications that do not involve GR crops, growers of certain small grains being one example. These growers are more reliant on 2,4-D than glyphosate for weed control and may not currently be faced with the same degree of weed control problems as the first group. The development of 2,4-D resistant weeds resulting from reliance of the Enlist™ crop adopters on 2,4-D would render the herbicide less effective to those who were already using it on other crops. This could necessitate the need to adopt more costly and less environmentally beneficial weed management practices than are currently in use. One commenter thought that APHIS overstated the potential impacts from 2,4-D resistant weeds to grain growers who rely on 2,4-D. His reasoning was that "common weeds in small grains and pastures are seldom the same species in corn and soybean, and vice versa." (APHIS-2013-0042-3217). APHIS acknowledges this point, but it couldn't rule out the possibility that this observation would no longer be representative if a weed shift occurred from high selection pressure resulting from 2,4-D use in corn, soybean, and wheat fields

No cumulative impacts are expected on organic growers because these growers do not use herbicides such as 2,4-D for weed control and HR weeds would not be harder to control by alternative measures.

To analyze the potential impacts from increased selection for 2,4-D-resistant weeds under the Preferred Alternative, APHIS assumed that the greatest potential for impacts would be in regions where sizeable amounts of corn or soybean were grown in proximity to sizeable amounts of crops that already use 2,4-D for weed management. This impact is likely highest in crops grown in rotation with Enlist™ corn and soybean. The agricultural resource management survey conducted in 2011 reports on crop rotation patterns in major U.S. crops (Figure 10)(USDA-ERS, 2011a). It shows that about 25 percent of corn is planted following corn, but most of corn is followed by soybeans, and an even higher percentage of soybeans are followed by corn (approximately 75 percent). About 10 to 20 percent of corn and soybean is rotated to other crops. About 10 percent of wheat is rotated to soybean and approximately 20 percent of cotton is rotated to other crops including corn and soybean. When moisture is adequate, growers in southern Indiana, Illinois, Missouri and Arkansas may double crop winter wheat and soybeans in the same year. This leads to rotation of much of the winter wheat in this area with soybeans.

However, there are no accurate ways of determining exactly what land is rotated from corn or soybean to other crops reliant on 2,4-D.

APHIS assumed that regional proximity of 2,4-D utilizing crops to corn and soybean would be the primary factor creating the potential for cumulative impacts from the selection of 2,4-D-resistant weeds in corn or soybean. Accordingly, APHIS identified areas where corn or soybean and crops to which 2,4-D is applied comprised the major crops in a given ecoregion. Table 4-7 (Appendix 4), identifies the major crops onto which 2,4-D is applied. A crop was included in this category if 10 percent or more of the crop was treated with 2,4-D. Crops include: almonds, apples, apricots, barley, cherries, citrus, corn, cotton, hazelnuts, millet, nectarines, oats, peaches, pears, pecans, plums, rice, rye, sorghum, soybeans, sugarcane, walnuts, and wheat (US-EPA, 2012a). From Table 6, APHIS obtained the percent of regional cropland devoted to the major crops of each ecoregion. These data are summarized in Table 10.

Ecoregions A, B, C, E, and G are all areas where corn and soybean predominate and crops which receive applications of 2,4-D are minor components of the landscape. If 2,4-D resistant weeds become widely prevalent in these regions, few growers would be affected, though those who are may change their management practices. Similarly, in regions K, L, and M, Enlist™ corn and soybean are not expected to contribute to the cumulative impacts associated with the selection of 2,4-D-resistant weeds because little corn and soybean is grown in these regions relative to the crops on which 2,4-D is applied. In contrast, ecoregions D, F, I, H, and J all represent areas where corn, soybean, and other crops onto which 2,4-D is applied are grown in abundance and in proximity (shaded in gray in Table 10). They offer the highest potential for cumulative impacts on small grain producers, who rely on 2,4-D for weed control, resulting from the selection of 2,4-D resistant weeds in corn or soybean, that might occur due to the potential increased use of 2,4-D on Enlist™ corn and soybean.

Ecoregion D includes the coastal southeast. Principal crops that have 2,4-D applied in this region are wheat and cotton.

Ecoregion F includes southern states bordering the Mississippi River (LA, MS, AR, TN, and MO). Principal crops that have 2,4-D applied in this region are wheat, cotton, rice, and sugarcane. Both ecoregions have a very high incidence of GR weeds, so the potential for selecting weeds with multiple resistance to glyphosate and 2,4-D is high relative to other ecoregions. The likelihood will depend on the extent to which growers rely exclusively on Enlist Duo™ versus employing a range of other management techniques. Because of losses recently experienced with GR weeds, growers may be more motivated to employ best management practices.

Ecoregion H includes parts of western North and South Dakota. The major crop that has 2,4-D applied in this region is wheat. Acreage for wheat in this region is approximately the same as that for corn and soybean.

Ecoregion I consists of western KS, NE, eastern WY, eastern CO and parts of western TX and western OK. Major crops in the region that have 2,4-D applied are wheat, cotton, sorghum, and small grains.

Ecoregion J consists of a part of central Texas. This region grows corn but no soybean. Crops that receive applications of 2,4-D include small grains, cotton, and sorghum. In both Ecoregion I and J, other crops receiving applications of 2,4-D exceed the amount of corn and soybean that is grown. Cumulative impacts are not expected in Ecoregion J under Alternative 4 (deregulation of soybean only) or in the case that Enlist™ corn is not widely adopted in this region.

Table 10. Percent of Regional Cropland Devoted to Corn/Soybean or 2,4-D Utilizing Crops in Each EcoRegion

Percent of Regional Cropland											
	Crops on which 2,4-D is utilized									Total	Total
Region	Corn	Soy	Wheat	Oat, Barley, Millet	Cotton	Rice	Sorghum	Sugarcane	Nut and Fruit Trees	% of Cropland in Corn + Soy	% of Cropland in Other Crops Using 2,4-D
A	51	20	3	2						71	5
B	51	25	4							76	4
C	53	40	3							93	3
D	33	33	15		18				2	66	35
E	52	46	7		1					98	8
F	51	20	10		12	11		1		71	34
`G	45	40	8							85	8
H	23	14	40							37	40
I	28	11	38	1	12		8			39	59
J	26	0	38	7	8		18			26	71
K	13	0			26	6	48		6	13	86
L	12	0	20	14						12	34
M	10		11						25	10	35

Regions shaded in gray indicate areas where corn or soybean are major crops and other 2,4-D utilizing crops are also widely prevalent.

Weed Control, Herbicide Alternatives and 2,4-D Use in Non-GE Crops

To evaluate how crops that currently use 2,4-D for weed control might be impacted if 2,4-D-resistant weeds become more prevalent, APHIS examined the management options and costs for weed control in these crops. Weed control programs vary by crop, weed problem, geography, and cropping system (e.g. no-till, conventional-till, etc.). In those crops where it is labeled for use, 2,4-D is usually just one part of a much broader weed management strategy. Many growers use a combination of weed control techniques including cultural, mechanical, and chemical. From the EPA Screening Level Estimates of Agricultural Uses of 2,4-D (US-EPA, 2012a), APHIS identified 23 crops where as much as 10 percent of the crop is treated with 2,4-D (Table 4-7). Many of these, (e.g., tree crops) are managed similarly and are considered together. For each crop, or group of similar crops, APHIS considered the types and cost of herbicides that are used for broadleaf weed control. APHIS focused on post-emergence, broadleaf weed control as this is the primary use of 2,4-D in these crops.

Pasture

The largest agricultural use of 2,4-D is for pastures (Texas Cooperative Extension). An estimated 10.6 million pounds of active ingredient (ai) are used annually to treat pastures.

Alternative Herbicides and Management Options

Effective management of weeds in pasture and rangeland usually involves a combination of cultural, mechanical, and chemical methods. The primary means of controlling weeds is proper management of desirable forage grasses and legumes. Overgrazing is a major cause contributing to the establishment and proliferation of weeds. Low soil fertility in pastures also contributes to weed problems. Some degraded pastures can be revitalized by reseeding or inter-seeding to improve forage growth and competition. For some situations, burning or mowing can stimulate forage grass growth and suppress weeds. Combined with well-timed herbicide applications, these methods can effectively manage weeds (DAS, 2013b).

Other methods that have a definite place in range management are: chemical, roto-beating, plowing, disking, railing, chaining, burning, reseeding, and changes in grazing schedules. There are specific sites and reasons for use of the controls listed. Each is effective if used properly (DAS, 2013b).

Table 11 shows a range of herbicide products that are currently registered for pastures and rangeland and their estimated costs. Herbicide alternatives to 2,4-D that provide reasonable low-cost herbicide control are shaded in gray. Most pasture is not treated with herbicide. Mowing is a non-chemical control method that is often used and is estimated to cost $13.95/acre in NE (University of Nebraska-Lincoln). (DAS, 2013b).

Table 11. Post-emergence Broadleaf Herbicides Commonly Used in Pastures and Rangeland

Herbicide (common name)	SOA[1]	Rate (lb ae or ai/A)	$/Acre
2,4-D	4	1-2	5.00-10.00

Herbicide (common name)	SOA[1]	Rate (lb ae or ai/A)	$/Acre
Aminopyralid	4	0.06-0.11	16.12-32.11
Metsulfuron	2	0.06-0.6	1.35-13.53
Carfentrazone	14	0.015-0.031	1.70-3.40
Chlorsulfuron	2	0.19-1.0	5.00-25.08
Clopyralid	4	0.14-0.375	13.33-35.70
Dicamba	4	0.5-1.5	9.99-29.97
Fluroxypyr	4	0.6-0.72	20.63-24.76
Picloram	4	0.25	7.50
Triclopyr	4	0.25	3.75
Hexazinone	5	0.67-1.12	25.54-42.69
Paraquat	22	0.25-0.5	3.98-7.96
Tebuthiuron	7	0.4	16.00

Source: (DAS, 2013b; Texas Cooperative Extension)

[1]Weed Science Society of America site of action category
Alternative low cost herbicide options to 2,4-D are shaded.

Potential Impacts to Pasture from Increased Weed Resistance

Although pasture represents the largest agricultural use of 2,4-D receiving 10,600,000 pounds of active ingredient, just 10-15 percent of the pasture is treated with 2,4-D (US-EPA, 2012a). Non-chemical options are most often used, and there are similarly priced chemical alternatives to 2,4-D. Thus, even if 2,4-D-resistant weeds became more prevalent, the increased costs to manage such weeds in pasture are expected to be small under all the alternatives.

Small Grains (Wheat, Barley, Oats.)

An average of 30 percent and up to a maximum of 65 percent of the wheat crop is treated with 2,4-D (US-EPA, 2012a) and it may be rotated with corn or soybeans. In some areas such as Indiana, Illinois, Kentucky, Missouri, and Arkansas, winter wheat is often planted with the intent to double crop with soybeans the same season. Winter wheat is harvested (usually in June) and soybeans are planted in no-till wheat stubble, when there are favorable moisture conditions (Moechnig & Wrage, 2012; North Dakota State University).

An average of 25 percent and up to a maximum of 40 percent of the barley and an average of 15 percent or maximum of 20 percent of the oat crop is treated with 2,4-D (US-EPA, 2012a). Crop rotation is a recommended weed management practice, providing a tangible, recognized level of control where practiced. Conditions are usually very favorable to winter wheat growth in the fall, and the crop out-competes many weeds. Only 40 to 50 percent of the winter wheat receives any herbicide application in these states.

Alternative Herbicides and Management Options

A wide range of herbicide products are currently registered for small grains. Use of pre-plant or pre-emergence herbicides occurs on a small portion of grain acreage usually with 1-2 post-emergence applications. Post-emergence graminicides are often used to control grass weeds such as wild oats and foxtail. Many different herbicides are available for post-emergence broadleaf weed control. Dominant modes of action in small grains are auxins (WSSA Group 4) and ALS inhibitors (WSSA Group 2). While 2,4-D is a widely used herbicide for these crops, it does not provide acceptable control of some key broadleaf weeds such as kochia and wild buckwheat. Therefore, 2,4-D treatments are often combined with one of the herbicides listed in Table 12 (DAS, 2013b).

In low-production areas (e.g., the far western and southern U.S. plains) 2,4-D is sometimes used individually (DAS, 2013b).

Table 12 (DAS, 2013b) lists a number of alternative herbicides and estimated costs. Metsulfuron, an ALS inhibitor for example, can provide control similar to 2,4-D at low cost; however, resistance to ALS inhibitors are widespread. The cost of some other products, such as a premix of pyrosulfotole and bromoxynil, is higher than 2,4-D, but this combination also provides high levels of control of some key broadleaves, such as kochia and wild buckwheat, that 2,4-D does not control (DAS, 2013b).

Some non-chemical control methods can also substitute for 2,4-D or enhance other control measures. Weeds such as common lambsquarters and common ragweed often germinate early in the spring. Tillage just before spring planting can eliminate the major flush of these early emerging weeds. A 2009 USDA report on custom tillage rates estimated the cost of harrowing at $7.30-8.40 per acre in Kansas (DAS, 2013b).

Table 12. Post-emergence Broadleaf Herbicides Currently Available for Use in Wheat, Barley, Oats, and Rye

Herbicide (common name)	SOA[1]	Crops[2]	Application Rate (lb. ae or ai/A)	Cost ($/Acre)	Comments
2,4-D amine	4	WW, SW, B, O, R	0.25-0.5	1.15-2.30	
MCPA	4	WW, SW, B, O, R	0.25-0.5	1.30-3.20	Similar in spectrum to 2,4-D
Bromoxynil	6	WW, SW, B, O, R	0.25-0.5	8.80-19.05	
Carfentrazone	14	WW, SW, B, O, R	0.008-0.031	4.00-15.10	
Chlorsulfuron	2	WW, SW, B, O	0.008-0.015	3.60-7.05	
Clopyralid	4	WW, SW, B, O	0.09-0.12	16.80-22.15	
Dicamba	4	WW, SW, B, O, R	0.06-0.12	2.30-5.25	
Pyrasulfotole	27	WW, SW, B, O	0.028-0.038	8.50-11.55	Available only in premix w/ bromoxynil
Florasulam	2	WW, SW, B, O	0.004	7.20	Available only in premix w/ MCPA
Fluroxypyr	4	WW, SW, B, O	0.11-0.14	10.60-14.15	
Thifensulfuron	2	WW, SW, B, O	0.014-0.019	15.95-31.85	
Tribenuron	2	WW, SW, B	0.008-0.16	4.70-9.35	

Herbicide (common name)	SOA[1]	Crops[2]	Application Rate (lb. ae or ai/A)	Cost ($/Acre)	Comments
Metsulfuron	2	WW, SW, B	0.004	1.50	
Prosulfuron	2	WW, SW, B, O	0.009-0.018	3.65-7.25	
Pyraflufen	14	WW, SW, B, O, R	0.0008-0.0016	1.65-3.30	Primarily pre-plant but can be applied POST
Triasulfuron	2	WW, SW	0.013-0.026	3.00-6.05	
Imazamox	2	WW, SW	0.031-0.047	16.25-24.40	Clearfield varieties only

[1]Weed Science Society of America site of action category
Alternative low cost herbicide options to 2,4-D are shaded.
Abbreviations:
B=barley; O=oats; SW=spring wheat; R=rye; WW=winter wheat
Source: (DAS, 2013b).

Potential Impacts of 2,4-D-Resistance on Small Grains

Winter wheat, spring wheat, barley, and oat growers often do not use herbicides. When needed, 2,4-D provides an inexpensive and effective weed management tool. As noted in the discussion that follows, there are several areas where these crops are rotated with either corn or soybean or grown in proximity. If 2,4-D-resistant weeds were to develop in corn and soybean fields, it is likely that they could eventually be found in wheat and small grain rotation crops on neighboring farms. Most likely, alternative chemical control options would be more expensive. MCPA (2-methyl-4-chlorophenoxyacetic acid) is similarly priced but also has a similar mode of action to 2,4-D, so weeds resistant to 2,4-D may also be resistant to MCPA. Other low cost herbicides, such as the ALS inhibitor metsulfuron, may not be as effective because of widespread resistance to ALS inhibitors. Pyraflufen is a low-cost PPO inhibitor that is usually used pre-plant. It cannot be used post-emergent (unlike 2,4-D) on small grains except wheat, and it has more restrictions than 2,4-D when used on wheat. Thus, chemical alternatives to 2,4-D are less flexible and more costly. This indicates that there would be cumulative impacts to wheat and small grain growers if 2,4-D-resistant weeds become more prevalent.

Fallow and Burndown Uses

For many crops, including corn and soybean, 2,4-D is often used in mixes with other herbicides such as glyphosate, glufosinate, or paraquat in the spring and fall prior to planting. This timing, usually referred to as “burndown,” can run anywhere from 0-30 days prior to planting, depending on the crop, geography, and product used. It is used to improve control of winter annuals, perennials, and early-emerging, summer annual weeds. Examples of weeds controlled include shepardspurse, marestail, dandelion, common lambsquarters, and giant ragweed. Often this is a critical part of an overall weed control program since it removes weeds that will be competing with the crop as it emerges. Burndown herbicide applications are almost obligatory for no-till crop production systems where tillage is not desired. Use of no-till crop culture is common in corn, soybeans, cotton, and wheat. Both soybeans and cotton are largely planted as GR varieties and glyphosate is an important herbicide used in post-emergent weed control. For wheat managed with herbicides, burndown applications are popular because there are few post-emergent options (DAS, 2013b).

Fallowing (i.e., leaving land unplanted) is used in arid areas of the plains and the West as a means to store soil moisture for a following crop. Fallow may encompass the summer season but is usually applied to a longer period of time (often 4-12 months). Weed control on fallowed acres is critical for reducing moisture loss. While tillage is an alternative to herbicidal control, it is usually less desirable because it increases erosion, costs of fuel and labor, and soil moisture loss (DAS, 2013b).

Alternatives to 2,4-D

Herbicides effective for burndown and foliar activity on broadleaf weeds are listed in Table 13. Depending on the crop to be planted and the target weed species, these products can offer an alternative to 2,4-D, but at greater cost. In several cases, these herbicides offer some advantages over 2,4-D such as longer residual control(DAS, 2013b).

Additionally, some non-chemical control methods can substitute for 2,4-D or enhance other control measures. Tillage can substitute for herbicide applications to remove weeds before planting, except where no-till conditions are desired (DAS, 2013b). Using a price for diesel of $3.50/gal, the fuel cost for tillage ranges from $19-25/acre using the USDA energy estimator for tillage in IA, NC, and AR (USDA-NRCS, 2013).

Table 13. Fallow and Burndown Herbicides Available for Use on Selected Crops

Herbicide (common name)	SOA[1]	Crops[2]	Rate (lb ae or ai/A)	Cost ($/Acre)	Comments
2,4-D amine	4	C, SB, CT, SG	0.25-0.5	1.15-2.30	
Atrazine	5	C	1.0	3.20	
Isoxaflutole	6	C	0.05-0.09	14.90-29.80	
Chlorimuron	14	SB	0.033	8.10	Usually in combination with metribuzin ($18/A)
Metribuzin	5	C, SB	0.5-0.75	5.60-8.50	Often at lower rates in combination w/ other herbicides
Dicamba	4	C, SB, CT,SG	0.25	5.25	
Mesotrione	28	C	0.18-0.24	32.00-41.00	
Glyphosate	9	C, SB, CT, SG	1.0-1.5	4.00-6.00	
Flumioxazin	14	CT, SB	0.05-0.1	9.00-18.00	
Sulfentrazone	14	SB	0.14-0.375	23.60-63.00	Obtained at lower cost in premixes
Saflufenacil	14	C, SB, SG	.02	5.45	
Paraquat	22	C, SB, CT, SG	0.5-1.0	9.00-18.00	
Glufosinate	10	C, CT, SB	0.53-0.66	13.60-16.85	
Iodosulfuron	2	C, SB	0.0019	7.20	Fall only for soybeans, up to 30 d before corn

[1]WSSA site of action category
[2]C=corn, SB=soybean, CT=cotton, SG=small grain
Alternative low cost herbicide options to 2,4-D are shaded.
Source: (DAS, 2013b).

Potential Impacts of 2,4-D-Resistant Weeds on Fallow and Burndown Applications

Development of weed resistance to 2,4-D would impact fallow and burndown applications because 2,4-D complements the effectiveness of glyphosate. Some important weeds controlled by 2,4-D are resistant to glyphosate (e.g., marestail and giant ragweed). Others (e.g., lambsquarters) have always been tolerant of glyphosate and are more effectively controlled by

2,4-D. Other herbicides are available for these applications, but are more costly. Therefore, loss of 2,4-D as an effective herbicide would increase management costs. Crops that would be adversely impacted include cotton, soybean, corn, and wheat.

Sorghum

Sorghum is most commonly rotated with wheat, corn, and soybean (Bean & Trostle, 2013). In Texas, sorghum is also rotated with cotton, and sometimes peanuts.

A number of herbicide products are currently labeled for sorghum. Herbicide management for sorghum can include burndown, pre-emergence, and post-emergence herbicide applications. Pre-emergence applications typically use atrazine in combination with an acetamide such as metolachlor. Post-emergence herbicides such as 2,4-D, atrazine, dicamba, bentazon, and bromoxynil are used to control broadleaf weeds that escape the pre-emergence treatment. These herbicides may be combined in premixes or tank mixes to broaden the weed control spectrum. Common combinations include 2,4-D with atrazine, dicamba with atrazine, and bromoxynil with atrazine (DAS, 2013b).

In-season row cultivation has been used in the past to control weeds, but it is less commonly used today because it requires costly fuel and labor expenses (DAS, 2013b).

Alternative Herbicides and Management Options

Several possible alternative herbicides for weed control in sorghum and their estimated costs are summarized in Table 14. Atrazine, for example, provides control equivalent to 2,4-D on most weeds and is similar in cost (DAS, 2013b).

Some non-chemical control methods can also substitute for 2,4-D or enhance other control measures. Weeds such as common lambsquarters and common ragweed often germinate early in the spring. Tillage just before planting can eliminate these early emerging weeds. A 2009 USDA report on custom tillage rates estimated the cost of harrowing at $7.30-8.40 per acre in Kansas. In season row cultivation provides another, non-chemical alternative and costs between $7.00 and $8.00 per acre (DAS, 2013b).

Table 14. Post-emergence Broadleaf Herbicides Currently Available for Use on Sorghum

Herbicide (common name)	SOA§	Rate (lb ae or ai/A)	Cost ($/Acre)	Comments
2,4-D amine	4	0.25-0.5	1.15-2.30	
Atrazine	5	1.0	3.20	
Bromoxynil	6	0.25-0.5	8.80-19.05	
Carfentrazone	14	0.008	4.00	
Bentazon	6	0.5-1.0	12.60-25.20	Not a recommended tank mix on label but not prohibited
Dicamba	4	0.25	5.25	
Prosulfuron	2	0.009-0.018	3.30-6.60	
Halosulfuron	2	0.03	12.50	

*Alternative low cost herbicides to 2,4-D are shaded.
§WSSA site of action category.
Source: (DAS, 2013b).

Potential Impacts of 2,4-D-Resistant Weeds on Sorghum

If 2,4-D resistant weeds were to become a problem, sorghum growers would likely be impacted. 2,4-D and dicamba are often applied with other herbicides such as carfentrazone (a PPO inhibitor) for more rapid activity to improve control. Weeds that 2,4-D effectively controls, such as ragweed, pigweed, and lambsquarters, already have atrazine and ALS resistant biotypes. Therefore, if 2,4-D-resistant weeds become a problem, weed management costs for sorghum would likely increase.

<u>Rice</u>

Rotating rice with corn/soybean is limited to the Mississippi River Valley and Texas (Louisiana State University Research and Extension, 2013; University of Arkansas, 2013).

Effective weed control in rice involves cultural, mechanical and chemical methods. A soybean-soybean-rice rotation is recommended rather than a soybean-rice rotation to allow management of grass weeds in the soybean crops. This reduces the number of grass weeds that emerge with the rice crop. A unique feature of rice culture is fields are permanently flooded after plants reach 6-8 inches. The primary purpose is weed control. Most grass and broadleaf weeds will not germinate after flooding. Therefore, early season weed control prior to flooding is critical for rice production. Control of grass weed species (e.g., barnyardgrass, watergrass, jungle rice, sprangletop species and red rice), is critical early in the growing season. None of these species are controlled by 2,4-D. Broadleaf weeds (e.g., dayflower, hemp sesbania, jointvetch, smartweed and morning glory species), can be controlled before or after flooding without yield or quality loss (DAS, 2013b).

Aquatic and broadleaf weeds that are not controlled prior to flooding can be controlled with a combination of herbicides (e.g., bispyribac, fenoxyprop, cyhalofop, penoxsulam, 2,4-D, or triclopyr) (DAS, 2013b).

Alternative Herbicides and Management Options

When considering the potential for 2,4-D resistant weeds to move from corn or soybean production to rice production, the broadleaf weeds of concern will be those that can survive in the flooded rice culture. They include those typically listed as troublesome in rice. They include hemp sesbania, northern jointvetch, morning glory, smartweed, dayflower, ammania species and the aquatic weeds, alligator weed and ducksalad. Table 15 lists several possible herbicide alternatives to 2,4-D and their estimated costs. Alternative herbicides cost more than 2,4-D, but are currently used because they provide better control of a broader spectrum of broadleaf weeds and grasses. Another advantage of the alternative broadleaf herbicide products is that they are effective for a longer period than 2,4-D.

Table 15. Post-emergence Broadleaf Herbicides Currently Available for Use in Rice Production

Herbicide (common name)	SOA[§]	Rate (lb ae or ai/A)	Cost ($/Acre)	Comments
2,4-D	4	1.25-1.5	5.75-7.00	
Acifluorifen	14	0.125	6.25	
Bensulfuron	2	0.0375-0.0625	15.75-26.25	

Herbicide (common name)	SOA[§]	Rate (lb ae or ai/A)	Cost ($/Acre)	Comments
Bentazon		0.75-1.0	18.00-25.00	
Bispyribac	2	0.32-0.63	41.00-81.00	
Carfentrazone	14	0.025-0.05	12.00-24.00	
Halosulfuron	2	0.023-0.063	12.50-33.75	
Imazosulfuron	2	0.15-0.3	21.00-42.00	
Penoxsulam	2	0.032-0.036	21.00-23.75	
Propanil		3.0-6.0	17.50-35.00	
orthosulfamuron	2	0.053-0.065	12.25-15.00	
Triclopyr	4	0.375	11.00	
quinclorac	4	0.375-0.5	20.00-26.75	
Imazamox	2	0.031-0.047	14.00-21.25	Clearfield varieties only
Imazethapyr	2	0.063-0.094	14.25-21.25	Clearfield varieties only

*Alternative low cost herbicide options to 2,4-D are shaded
[§]WSSA mode of action category
Source(DAS, 2013b).

Potential Impacts to Rice Growers from 2,4-D-Resistant Weeds

Rice growers rely heavily on flooding and herbicides other than 2,4-D for weed control. In several rice growing areas in Arkansas, statutory restrictions limit 2,4-D use (See Appendix 7). Because of the wide range of herbicides and non-chemical methods used for weed control and restrictions on 2,4-D use in some rice-growing areas, the impacts to rice growers in the event of selection and spread of 2,4-D resistant weeds is expected to be minor.

<u>Cotton</u>

Cotton is infrequently rotated with other crops (Figure 10). In Texas for example, few other crops are productive in the conditions of low rainfall and high heat favorable for cotton cultivation. In drought years, cotton may be abandoned on over 30 percent of these Texas acres.

Only in the mid-south is there an exception to this generalization. There, cotton may be rotated with soybeans or corn (University of Georgia).

Weed Management Programs and Options

Cotton is an annual crop that is usually planted in wide rows (38-40 inches apart). Use of no-till crop culture is common in cotton and herbicides are an important means of weed control. Currently, most cotton varieties in the U.S. are GR, so glyphosate is the primary herbicide used. Common practice is a pre-plant or pre-emergence, soil-residual herbicide application followed by 1-2 post-emergence treatments usually with glyphosate. The soil-residual herbicides include a range of modes of action. Although a large portion of cotton acreage was once treated only post-emergence with glyphosate, this practice is declining because GR weeds are now widely prevalent in cotton fields. Glufosinate-resistant varieties are increasingly being used, so post-emergent glufosinate applications are replacing glyphosate. Growers will sometimes apply herbicides such as pyrithiobac to control broadleaf weeds not controlled with glyphosate or post-emergence graminicides such as clethodim or quizalofop to control grasses. Because cotton is naturally sensitive to 2,4-D and other auxin herbicides, the current use of 2,4-D for this crop is limited to pre-plant burndown uses. 2,4-D is usually added to burndown applications to improve control of winter annuals, perennials, and early emerging summer annual weeds. Burndown occurs 0-30 days prior to planting depending on crop, geography, and product used. Burndown herbicide applications are almost obligatory for no-till crop production systems (DAS, 2013b).

2,4-D is typically used in combination with other broad-spectrum herbicides, such as glyphosate, glufosinate or paraquat. Herbicides with utility in burndown and significant foliar activity on broadleaf weeds are listed in Table 13. These herbicides are alternatives to 2,4-D.

Some non-chemical control methods can also substitute for 2,4-D or enhance other control measures. Tillage can substitute for herbicide applications to remove weeds before planting except where no-till conditions are desired. USDA reports on custom tillage rates estimated the cost of most pre-plant tillage at $13-15 per acre.

Potential Impacts to Cotton Growers from 2,4-D-Resistant Weeds

According to EPA estimates, only an average of 10 percent of cotton is treated with 2,4-D (US-EPA, 2012a). 2,4-D use in cotton is limited to pre-plant burndown since cotton is sensitive to the herbicide. However, because of the widespread adoption of no-till in cotton production combined with the prevalence of GR weeds in cotton fields, 2,4-D is an important herbicide for burndown applications in cotton. Consequently, if 2,4-D resistant weeds become more prevalent, weed management costs will likely increase for cotton producers.

Socioeconomic Impacts from Off-target Pesticide Movement

Spray Drift: An assumption in the No Action Alternative is that 2,4-D use will be applied to 30 percent of corn and soybean cropland based on the second assumption that GR weeds will increase from 10 to 30 percent of corn and soybean cropland. The first assumption is based on the observation that 2,4-D use in burndown applications is proving beneficial to control GR weeds such as horsetail and ragweed that emerge by spring and that 2,4-D use on corn and soybean has been steadily increasing (see Appendix 4). Current use of 2,4-D for burndown applications in corn and soybean are 10 percent and 12 percent, respectively. The 2,4-D formulation used under the No Action Alternative is expected to be dimethylamine (DMA) or ester formulations which are those currently used. The ester formulation is about 10 times more volatile than for DMA. No additional stewardship agreements are expected to occur to mitigate potential off-target movement of 2,4-D under the No Action Alternative. It is possible that the choline formulation will be available under the No Action Alternative if EPA approves Enlist-Duo™ but APHIS does not grant nonregulated status to the Enlist™ crops. In that case, the choline formulation might be used on non-Enlist™ crops by growers committed to reducing off target pesticide movement. There would not be stewardship agreements requiring growers to use the choline formulation but growers might choose to use this formulation if Enlist Duo™ is competitively priced.

Under the Preferred Alternative, 2,4-D use on crops would increase 1.75-3 times more than that estimated under the No Action Alternative (see Appendix 4). Unlike the No Action Alternative, the formulation used for the incremental increase in 2,4-D use is expected to be the choline (Enlist Duo™) formulation. This formulation is 50 times less volatile than DMA and 500 times less volatile than ester formulations (see Appendix 7). An independent trial by the University of Georgia extension has corroborated the conclusion that off-target movement is less likely with choline formulations compared to the ester and dimethylamine formulations (APHIS-2013-0042-

1911-A2). The expected increase in 2,4-D use under the Preferred Alternative is not likely to result in more off-target effects because under the Preferred Alternative it will be applied as the choline formulation. This formulation is also likely to replace some current uses of the DMA and ester formulations, so the overall use of volatile formulations are expected to be less under the Preferred Alternative than under the No Action Alternative.

Though off-target pesticide movement is expected to be lower for the Preferred Alternative than for the No Action Alternative, the use of 2,4-D may occur over a longer season under the Preferred Alternative. This could increase exposure of sensitive plants to 2,4-D later in the season. These offsetting impacts (less volatile formulations and potentially greater exposure) make it difficult to predict which Alternative poses the greatest risk from drift damage.

5.7.2 Biological Resources

Animal Communities

As described in the No Action Alternative, agricultural practices can affect wildlife in and around agricultural fields. Wildlife commonly found in each region is described in the Affected Environment, Section 3. As discussed in Section 4, DAS-40278-9 corn, DAS-68416-4 soybean, and DAS-44406-6 soybean will not directly or indirectly impact wildlife differently from the corn and soybean varieties that are currently available under the No Action Alternative. While direct impacts from the changes in herbicide use associated with Enlist Duo™ could affect certain wildlife, they are outside the scope of this EIS.

EPA considers impacts on wildlife as part of its evaluation of the amended label. 2,4-D has an extensive history of safe and effective use. It has been thoroughly reviewed and reregistered by all major regulatory agencies in the world within the last ten years. In 2012, the EPA denied a petition to cancel tolerances and registrations for 2,4-D based on toxicological hazard (US-EPA, 2012c). The Agency affirmed that 2,4-D posed no unreasonable risk when used as directed. Therefore, cumulative impacts on animal resources are not expected to differ between the No Action and Action Alternatives.

Plant Communities

APHIS estimates of herbicide use under the four alternatives are listed in Table 4-14 of Appendix 4. An increase in herbicide use is expected under all four alternatives. 2,4-D use on crops is expected to increase under the No Action Alternative from 25.6 million pounds in 2011 to 44.5 million pounds by 2020. Under the Preferred Alternative, the increase is expected to range from 77.8-176 million pounds, depending on grower adoption rates. The increased use of herbicides under both the No Action and Action Alternatives is expected to result in increased selection pressure for 2,4-D-resistant weeds.

Selection pressure is influenced by factors other than the volume of herbicide applied. The selection pressure is strongly related to the repeated use of one or a limited number of herbicides (Duke, 2005; Durgan & Gunsolus, 2003). It is also a function of the diversity of management practices employed. The greater the diversity of management practices, the smaller the selection pressure for resistant weeds.

All management techniques, including the use of herbicides, hand weeding, mowing, etc., exert pressure to select weeds to resist that management technique. For hand weeding, plants are selected that resemble the crop. For example, spurred anoda and nightshade resemble young cotton so these weeds are often overlooked during hand-weeding (Coble, 2012; University of California Davis, 1996). Mowing selects plants that flower rapidly and grow low to the ground (Radosevich et al., 2007). Mowing alters the stature of some weeds. Repeated mowing can change the appearance of a weed from a single-stemmed, tall, upright form to a plant with multiple shoots that are relatively prostrate. (Radosevich et al., 2007). Herbicides select for plants that are no longer sensitive to its site of action (Owen, 2008).

The increased selection pressure resulting from the wide-spread use of glyphosate on GR crops, the subsequent reductions in the use of other herbicides, and changes in weed management practices (such as the reduction in tillage and decreased use of crop rotation), has resulted in both weed population shifts and increasing glyphosate resistance among some weed populations (Duke & Powles, 2009; Owen, 2008). GR crops themselves do not influence weeds any more than non-transgenic crops. It is the weed control tactics chosen by growers that create selection pressure that gradually shifts these weed communities and may result in the evolution of HR weeds (Owen, 2008).

Herbicide-Resistant Weeds

In this section, the likelihood that problem weeds in corn and soybean, (i.e., those weeds that are actively managed in these crops), will become more resistant to 2,4-D is reviewed. Appendix 5 includes an analysis of the problem weeds of corn and soybean and those that have HR biotypes are described in Appendix 6.

As of March 21, 2013, worldwide, there were 397 instances of HR weeds in 217 species (Heap, 2013b). The first HR biotypes were described in the 1950s. The number of weeds resistant to herbicides increased dramatically in the 1980s and 1990s. Today, resistance to 21 of the 25 known herbicide sites of action has been identified (Heap, 2013a). Of the 25 known herbicide sites of action, 11 are commonly used on corn and soybean (Appendix 4). Furthermore, while there are hundreds of cases of HR weeds, most of these weeds are not actively managed in corn and soybean. The analysis below focuses on weeds that are actively managed in corn and soybean fields and addresses which of these have developed herbicide resistance to the major herbicides used in corn and soybean.

There are 25 broadleaf and 22 grass weed species that require control measures in the major growing regions of soybean and corn (Appendix 5). There are 13 broadleaf and nine grass weeds, respectively, that are a problem in both corn and soybean, four broadleaf and seven grass weeds that are mostly problematic in corn (highlighted in yellow in Table 5-2 in Appendix 5), and eight broadleaf and six grass weeds that are mostly problematic in soybean (highlighted in blue in Table 5-2 in Appendix 5).

The most common types of weed resistance in the U.S. are to ALS and Photosystem II herbicides. There are 15 problem weed biotypes resistant to each mode of action. The problem weed resistant to the most sites of action is waterhemp. It is resistant to six of the eleven sites of action of herbicides commonly used in corn and soybean (Table 6-3 in Appendix 6). Multiple resistance involving biotypes with 13 combinations of sites of action have been reported, including one biotype that is resistant to five sites of action (Owen, 2012). Ragweed, kochia, and horseweed are each reported to have biotypes resistant to four sites of action including biotypes that are multiply resistant to two herbicides (Table 6-3 in Appendix 6). Multiple HR biotypes have also been selected in redroot pigweed and giant ragweed. None of the problem grasses have multiple resistances. A total of seven of the 47 problem weeds in corn and soybean include biotypes resistant to more than one herbicide (Table 6-3, Appendix 6).

To combat this trend and to avoid decreased crop yields resulting from weed competition, growers must continually adapt weed management strategies. Appropriate weed management requires much more than the application of herbicides. Rotation of herbicides with alternative sites of action is one method (DAS, 2010a). Some common sites of herbicide action include auxin growth regulators, amino acid inhibitors, chlorophyll pigment inhibitors, and lipid biosynthesis inhibitors (Ross & Childs, 2011) (Appendix 3). The practice of using herbicides with alternative sites of action could potentially diminish the populations of GR weeds and reduce the likelihood of the development of new HR weed populations (DAS, 2010a; Dill et al., 2008; Duke & Powles, 2008; 2009; Owen, 2008).

Managing Glyphosate-Resistant Weeds

In 2012, the area of U.S. cropland infested with GR weeds expanded to 61 million acres, according to a survey conducted by Stratus Agri-Marketing (Farm Industry News, 2013). Table 6-3 in Appendix 6 lists those weed species that have been identified as HR in at least some part of their range in the U.S. and internationally. The use of glyphosate on corn and soybean is not expected to increase under any of the Alternatives because most corn and soybean in the U.S. already has the GR trait and so glyphosate use is saturated on these crops and the increase of GR weeds only makes glyphosate use less attractive. To manage glyphosate resistance, growers are not using more glyphosate but are using more sites of action in addition to glyphosate. In the southeast, where GR weeds are particularly problematic, there is a decline in glyphosate use on soybean (Appendix 4, Figure 4-3).

Southeastern soybean growers who have adopted no-till production are now including increasingly aggressive tillage in their management programs. They are also applying herbicides with different modes of action, and adopting other stewardship practices that reflect the recommendations for BMPs as outlined by the Weed Science Society of America and the National Science Foundation (Ferrell, 2013; WSSA, 2010). In addition to more tillage, growers are also using pre-plant burndown treatments on their minimum-till acres and are using residual herbicides more frequently. They also are moving to multiple herbicide applications over the course of the growing season, and are applying herbicides with several different sites of action at different times over the course of the season to eliminate weeds (including some HR biotypes). Heavily infested fields are being hand-weeded at a cost of up to $100 per acre (Ferrell, 2013). While these changes are positive in that they diversify weed control, the cost of these treatments poses a substantive threat to soybean production in this region.

HR weeds, particularly GR weeds, are also of increasing concern in all other regions of the U.S. Because warmer weather typical of the Southeast region is conducive to the growth and propagation of HR annual weeds, this problem is a greater concern in that region than in the northern parts of the U.S. However, these weeds are also an ongoing threat in the north. For example, GR weeds, including Palmer amaranth, are becoming more of a concern in parts of the heartland region (Bowman, 2013; Conley, 2013).

In parts of the heartland, GR waterhemp and marestail are widespread (Bowman, 2013). No-till practices are being used increasingly, but the presence of HR weeds and rapidly increasing presence of glyphosate resistance in particular, sometimes necessitate the inclusion of tillage in weed control strategies. Some growers who have adopted no-till regimes are using burndown herbicides. These commonly include both 2,4-D and glyphosate. Currently, there is little yield loss to weeds, indicating that available weed management tools and practices are adequate, but the heavy reliance on glyphosate and the presence of GR weeds could necessitate a return to more aggressive tillage and adoption of more diversified weed management strategies.

In the northern Crescent and northern Great Plains (Regions A ,B, G, and H), growers report the presence of some GR weeds, but because of climatic differences between the north and south, these do not pose the same level of challenge confronting growers in the southern regions of the U.S. (Conley, 2013; Meuller, 2013; Sexton, 2013). In the southern regions of the U.S., warm temperatures persist beyond the time when soybeans are typically harvested. Once the crop is harvested, weed control typically stops. The combination of these conditions provides a substantial window of time during which annual weeds can grow and set seed (Ferrell, 2013). In the more northern regions, temperatures typically drop soon after harvest, reducing the time during which such weeds can grow and spread (Meuller, 2013). However, GR Palmer amaranth has been reported in these regions, and there is increasing concern that it could eventually become a serious problem. Growers in these regions have adoption rates of GE soybeans exceeding 95 percent of the total crop. Much of it consists of GR varieties (Sexton, 2013). Adoption of conservation tillage is limited, but several extension scientists from this region indicated that it is increasing. However, its adoption is threatened by the occurrence of GR weed biotypes. Typically, these growers are using minimal amounts of residual herbicides pre-plant. Where burndown herbicide treatments are used, most growers are using tank-mixes containing 2,4-D and glyphosate.

A variety of strategies have been proposed to help farmers manage GR weeds (Beckie, 2006; Boerboom, 1999; Frisvold et al., 2009; Sammons et al., 2007). Resistance management begins with good agronomic practices, including the implementation of integrated weed management to incorporate diverse weed control practices to reduce the frequency of herbicide applications and decrease selection pressure for HR populations (Norsworthy et al., 2012). Integrated Weed Management integrates practices such as crop rotation, cover crops, competitive crop cultivars, the judicious use of tillage, and targeted herbicide applications to reduce weed populations and selection pressures for HR weeds (Mortensen et al., 2012). The Herbicide Resistance Action Committee, an industry-based group, has developed the following general principles of weed resistance management:

1. Apply integrated weed management practices. Use multiple herbicide sites-of-action with overlapping weed spectrums in rotation, sequences, or mixtures;
2. Use the full recommended herbicide rate and proper application timing for the hardest to control weed species present in the field;

3. Scout fields after herbicide application to ensure control has been achieved. Avoid allowing weeds to reproduce by seed or vegetatively; and
4. Monitor site and clean equipment between sites.

For annual cropping situations also consider the following recommendations of the Herbicide Resistance Action Committee (www.hracglobal.com):

- Start with a clean field and control weeds early by using a burndown treatment or tillage in combination with a pre-emergence residual herbicide as appropriate;
- Use cultural practices such as cultivation and crop rotation, where appropriate; and
- Use good agronomic principles that enhance crop competitiveness.

Under the No Action Alternative, GR weeds are likely to be an increasingly serious concern in the southeast, Great Plains and northern crescent regions. Under the No Action Alternative, growers would likely use additional herbicides to control weeds. The further adoption of conservation tillage practices could be impeded as growers who have already adopted conservation tillage are forced to return to more aggressive tillage systems to maintain soybean yields (Conley, 2013). The continued emergence of GR weeds will require modifications of crop management practices to address these weeds. However, growers are expected to become less reliant on glyphosate for weed control as it loses effectiveness. Instead, they are expected to depend on additional chemical and non-chemical methods. Changes in management practices may include diversifying the mode of action of herbicides applied to corn and soybean and making adjustments to crop rotation and tillage practices (Wilson et al., 2011b). Herbicide use may increase to meet the need for additional integrated weed management tactics to mitigate HR weeds in different cropping systems (Culpepper, 2008; Heap, 2011b; Owen & Zelaya, 2005; Owen, 2008). Among the herbicides that are predicted to increase in use to control GR weeds are 2,4-D, chloroacetamide, and glufosinate. There is a trend of increased use of ALS inhibitors, PPO inhibitors, and HPPD inhibitors (Appendix 4, Figure 4-3). Selection of weeds resistant to all these herbicides is expected to continue.

Under the Preferred Alternative, 2,4-D use is expected to increase relative to the No Action Alternative. However, increases in other herbicides such as chloroacetamides, glufosinate, ALS inhibitors, PPO inhibitors, and HPPD inhibitors are expected to be less than under the No Action Alternative because Enlist™ crops are expected to be adopted. The availability of inexpensive and effective herbicides combined with Enlist™ corn and soybean may delay the adoption of non-chemical management strategies under the Preferred Alternative. Fewer growers would be expected to adopt aggressive tillage when herbicides remain effective for weed control. Selection of weeds resistant to glyphosate, auxins, chloroacetamides, ALS inhibitors, and glufosinate will still occur under the Preferred Alternative. The selection pressure for herbicide-resistant weeds under the Preferred Alternative relative to the No Action Alternative will depend on the management practices employed under each Alternative and cannot be predicted. More diversified weed management practices will result in less selective pressure for resistance to any given herbicide or management technique.

Likelihood That Use of Enlist Duo™ Will Select for 2,4-D Resistant Weeds

The relative risk that a resistant biotype will be selected for a particular herbicide is highly correlated to the herbicide site 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 and auxin type herbicides are considered low risk. Weeds resistant to auxin herbicides have been slowly accumulating over the past seventy years, but none have become particularly problematic. As of 2014, there are 31 species listed that include biotypes that are resistant to auxin herbicides, nine of which are located in the U.S. (Table 16, prepared from data in (Heap, 2013b)). Of the 31 species found world-wide, 17 are known to be resistant to 2,4-D. Of these, 12 are found outside the U.S. (Table 16, highlighted in gray) and five are found in the U.S. (waterhemp, spreading dayflower, field bindweed, wild carrot, and prickly lettuce (Table 16, highlighted black). Of these, GR biotypes are found only for waterhemp. Thus, the combination of glyphosate and 2,4-D currently controls a wide range of problem weeds. Multiple resistance to 2,4-D and another herbicide class has not been reported in the U.S., but has been reported in five weeds species in other countries.

Usually the other resistance is to ALS type herbicides (class 2), though in one case the other herbicide resistance is to a Photosystem II inhibitor. Wild radish has a biotype resistant to three herbicides (ALS, auxin, and carotenoid inhibitors).

Despite the fact that glyphosate and auxin herbicides are considered low risk, resistant biotypes are being selected from the use of these herbicides. GR weeds in a few species such as Palmer amaranth, waterhemp, horseweed, ragweed, and giant ragweed, have become widely prevalent in certain areas and cropping systems, such as cotton and soybean, where glyphosate was the only herbicide used for weed control and continuous cropping and no-till farming was also practiced. The lack of diversity of weed management practices in such situations is believed to have contributed significantly to the selection of resistant biotypes.

Mortensen et al. (2012) argue that increased use of 2,4-D on Enlist™ corn and soybean will likely increase the prevalence of 2,4-D resistant weeds. Though auxin herbicide-resistant weeds have been relatively slow to develop and are not particularly widespread, they note that the same was true for GR weeds prior to the widespread use of glyphosate on GR crops. The selection of GR weeds purportedly came about through the almost exclusive use of glyphosate for weed control in some crops such as cotton and soybean. Thus, depending on how glyphosate and 2,4-D are used on Enlist™ corn and soybean crops, selection of 2,4-D-resistant weeds may be preventable. If growers rely exclusively on 2,4-D and glyphosate for weed control, resistance might be selected quickly. That is because resistant biotypes against both herbicides already exist in a problem weed common to corn and soybean (waterhemp), GR biotypes are found in another four problem weeds common to corn and soybean (giant ragweed, kochia, horseweed, and ragweed) and a 2,4-D-resistant biotype has been selected in another common problem weed (field bindweed) (see Appendix 6, Table 6-3).

The likelihood of selection of 2,4-D-resistant weeds is greater as the selection pressure for resistance increases. Under the Preferred Alternative, selection pressure is expected to be greater than the No Action Alternative because 2,4-D use is expected to be higher by 75 to 300 percent (Appendix 4, Table 4-14). To mitigate the increased selection pressure associated with the increased use of 2,4-D, (DAS, 2012) recommends the following practices for herbicide selection:

- Rotate the use of Enlist Duo™ Herbicide with non-auxin (non-Group 4) and non-glycine (Group 9) herbicides
- Utilize a broad spectrum soil-applied herbicide as a foundation treatment
- Utilize herbicides with alternative sites of action
- Avoid using more than two applications of a Group 4 herbicide within a single growing season unless mixed with another site of action herbicide with overlapping spectrum
- Apply labeled rates of Enlist Duo™ herbicide at the specified time (correct weed size) to minimize escapes of tolerant weeds

Third party proprietary data summarized in Appendix 4, Figure 4.3 and Figure 4.4, indicate a clear trend of growers following these recommended practices. Growers are using more sites of action in both corn and soybean. Corn growers have traditionally relied heavily on soil applied non-auxin and non-glyphosate herbicides such as atrazine and chloroacetamide which have residual activity and serve as a foundation treatment (Appendix 4, Figure 4.1). Soybean growers are showing increased use of this practice with increased use of chloroacetamides, too. Whether growers will maintain this trend if the Preferred Alternative is selected is unknown. One commenter, an expert in the field, indicated his expectation that chloroacetamides would continue to find widespread use in corn and soybean (APHIS-2013-0042-3217). APHIS cannot rule out the possibility that some growers will use both Enlist™ soybean and corn in rotation and they may rely exclusively on glyphosate and 2,4-D for weed control, contrary to recommendations to include additional herbicide chemistries. (Several commenters argued that such reliance would be unlikely due to lower efficacy of 2,4-D on weeds compared to glyphosate (APHIS-2013-0042-1911, 3217, 8196)). Based on the history of selection of GR weeds, it is very likely that 2,4-D-resistant weeds will also be selected if exclusive use were to occur.

The selection and distribution of 2,4-D resistant weeds is impossible to predict because the extent to which growers use best practices is unknown. A 2010 grower survey (Prince et al., 2012) observed that many growers were using practices targeted specifically at preventing or managing GR weeds, but that these practices were not new introductions to their weed management plans. Growers recognized that rotating herbicides, using tank mixes, and increasing tillage would be effective strategies to combat GR weeds, but they did not seem to recognize that HR weeds were the result of repeated use of a herbicide or herbicides with the same site of action (Prince et al., 2012). Education efforts to increase grower awareness are ongoing and there appears to be an increase in grower perception of the effectiveness of practices recommended by the weed science community (Prince et al., 2012). For example one university weed scientist commented on his outreach efforts, (APHIS-2013-0422-1911). According to this comment (APHIS-2013-0042-1911), "it is also critical to stress that, at least in Georgia, no weed management program relies exclusively on herbicides. The University of Georgia Weed Science Extension Team stresses to growers at more than 50 meetings each year that herbicides are only one part of the weed management program. Sustainability is only possible with the adoption and implementation of diverse management programs and Georgia growers have accepted this message as fact (Sosnoskie and Culpepper 2013). Growers are using programs that are complex and diverse integrating herbicides, hand weeding, and tillage or cover crops. Neither dicamba nor 2,4-D would change this approach but would simply be an additional tool to add into these management systems." Under the No Action Alternative, it is likely that the cost of weed management and the time spent managing weeds will continue to increase. Modeling studies suggest that exclusive use of an herbicide can select for HR weeds in as little as five years (Neve et al., 2011). Because growers who adopt Enlist™ crops are expected to be those who have had the most difficulty with GR weeds, the selection of biotypes exhibiting multiple resistance to both glyphosate and 2,4-D is expected to be related to the probability of selecting resistance to just 2,4-D and not the product of selecting resistance to both sites of action. Thus, multiple resistance could be expected to appear in as little as five years if glyphosate and 2,4-D are used exclusively. The southeast (Region D) is expected to be a problem region because GR weeds are already reported to be present in greater than 90 percent of cropland (Farm Industry News, 2013). In this region, Palmer amaranth can no longer be controlled with glyphosate and would be a particular risk for the selection of multiple resistant biotypes. In the heartland (Region C and G) and prairie states (Region I), HR waterhemp has been selected to several herbicides and a biotype resistant to five herbicides has been detected. Furthermore, biotypes with resistance to either 2,4-D or glyphosate have already appeared in Nebraska. A multiple resistant biotype could form by hybridization and disseminate and independent multiply resistant biotypes to Enlist™ are likely to be selected if Enlist™ products are exclusively used.

Table 16. Auxin-Resistant Weeds

	Species	**Year/Location**	**Auxin**	**Situation**	**GR/GT**
1	***Amaranthus tuberculatus (syn. rudis)*** Common Waterhemp	2009 - USA (Nebraska)	2,4-D	Pasture	+
2	***Carduus nutans*** Musk Thistle	1981 - New Zealand	2,4-D	Pasture	
3	***Carduus pycnocephalus*** Italian Thistle	1997 - New Zealand	2,4-D	Pasture	
4	***Centaurea solstitialis*** Yellow Starthistle	1988 - USA (Washington)	Picloram	Roadsides	
5	***Chenopodium album*** Lambsquarters	2005 - New Zealand	Dicamba	Corn	+
6	***Cirsium arvense*** Canada thistle	1979 - Sweden 1985 - Hungary	MCPA 2,4-D and MCPA	Cropland Pasture	
7	***Commelina diffusa*** Spreading Dayflower	1957 - USA (Hawaii)	2,4-D	Sugarcane	
8	***Convolvulus arvensis*** Field Bindweed	1964 - USA (Kansas)	2,4-D	Cropland	
9	***Daucus carota*** Wild Carrot	1957 - Canada (Ontario) 1993 - USA (Michigan) 1994 - USA (Ohio)	2,4-D 2,4-D 2,4-D	Roadsides roadsides and cropland soybean	
10	***Descurainia sophia*** Flixweed	2011 - China	MCPA	winter wheat	
11	***Digitaria ischaemum*** Smooth Crabgrass	2002 - USA (California)	quinclorac	rice	
12	***Echinochloa colona*** Junglerice	2000 - Colombia	quinclorac	rice	+
13	***Echinochloa crus-galli*** Barnyardgrass	1998 - USA (Louisiana) 1999 - Brazil 1999 - USA (Arkansas) *Multiple - 2 SOA's 2000 - China	quinclorac quinclorac propanil and quinclorac quinclorac	rice rice rice rice	+

	Species	Year/Location	Auxin	Situation	GR/GT
		2009 - Brazil *Multiple - 2 SOA's	bispyribac-sodium, imazethapyr, penoxsulam, and quinclorac	rice	
14	***Echinoclhloa crusgalli. Var. zelayensis*** Gulf Cockspur Grass	2013-China			
15	***Echinochloa crus-pavonis*** Gulf Cockspur	1999 - Brazil	quinclorac	rice	
16	***Fimbristylis miliacea*** Globe Fringerush	1989 - Malaysia	2,4-D	rice	
17	***Galeopsis tetrahit*** Common Hempnettle	1998 - Canada (Alberta)	dicamba, fluroxypyr, and MCPA	barley, cereals, cropland, wheat	
18	***Galium spurium*** False Cleavers	1996 - Canada (Alberta) *Multiple - 2 SOA's	imazethapyr, metsulfuron-methyl, quinclorac, sulfometuron-methyl, thifensulfuron-methyl, triasulfuron, and tribenuron-methyl	cereals and wheat	
19	***Kochia scoparia*** Kochia	1995 - USA (Montana) 1995 - USA (ND) 1997 - USA (Idaho) 2010 - USA (Nebraska)	dicamba and fluroxypyr dicamba dicamba and fluroxypyr dicamba	cropland and wheat wheat roadsides corn	+
20	***Lactuca serriola*** Prickly Lettuce	2007 - USA (Washington)	2,4-D, dicamba, MCPA	cereals	
21	***Limnocharis flava*** Yellow bur-head	1995 - Indonesia 1998 - Malaysia *Multiple - 2 SOA's	2,4-D 2,4-D and bensulfuron-methyl	rice rice	
22	***Limnophila erecta*** Marshweed	2002 - Malaysia *Multiple - 2 SOA's	2,4-D and ALS inhibitors (4)	rice	
23	***Matricaria perforata*** Scentless Chamomile	1975 - France 1975 - United Kingdom	2,4-D 2,4-D	cereals cereals	
24	***Papaver rhoeas*** Corn Poppy	1993 - Spain *Multiple - 2 SOA's 1998 - Italy *Multiple - 2 SOA's 1998 - Italy	2,4-D and tribenuron-methyl 2,4-D and ALS inhibitors (2) 2,4-D	cereals and wheat wheat wheat	
25	***Ranunculus acris*** Tall Buttercup	1988 - New Zealand	MCPA	Pastures	
26	***Raphanus raphanistrum***	1999 - Australia (Western Australia)	2,4-D	cereals	

	Species	Year/Location	Auxin	Situation	GR/GT
	Wild Radish	2006 - Australia (South Australia) *Multiple - 3 SOA's	2,4-D, diflufenican, MCPA, and triasulfuron	cereals	
27	***Sinapis arvensis*** Wild Mustard	1990 - Canada (Manitoba) 2008 - Turkey *Multiple - 2 SOA's	2,4-D, dicamba, dichlorprop, MCPA, mecoprop, and picloram dicamba, propoxycarbazone-sodium, thifensulfuron-methyl, triasulfuron, and tribenuron-methyl	barley, cropland, and wheat not specified	
28	***Sisymbrium orientale*** Indian Hedge Mustard	2005 - Australia (South Australia) *Multiple - 2 SOA's	2,4-D, imazethapyr, MCPA, metosulam, and metsulfuron-methyl	cereals	
29	***Soliva sessilis*** Carpet Burweed	1999 - New Zealand	clopyralid, picloram, and triclopyr	golfcourses	
30	***Sphenoclea zeylanica*** Gooseweed	1983 - Philippines 1995 - Malaysia 2000 - Thailand	2,4-D 2,4-D 2,4-D	rice rice rice	
31	***Stellaria media*** Common Chickweed	1985 - United Kingdom 2010 - China	mecoprop fluroxypyr and MCPA	cereals and wheat winter wheat	

17 species with known resistance to 2,4-D worldwide(gray + black)
12 species with known resistance to 2,4-D outside the U.S. (Gray)
5 species with known resistance to 2,4-D in U.S. (black)
Source: (Heap, 2013b)

Biodiversity

Habitat loss is the greatest direct impact agriculture has on biodiversity (Ammann, 2005). Therefore, methods that increase crop yields have the potential to reduce impacts to biodiversity by reducing the amount of land converted to agriculture (Carpenter, 2011). Gains in yields have generally not been obtained by HR cultivars unless higher yielding ones are modified to incorporate an HR trait (NRC, 2010). Yields of corn and soybean have been steadily increasing (USDA-NASS, 2014a) and are expected to increase similarly under all alternatives.

As described in the No Action Alternative and below, agricultural practices can affect biodiversity in and around agricultural fields in opposite ways. Growers have the opportunity to choose many different practices to manage their operations and therefore it is difficult to make generalizations as to how the alternatives will impact biodiversity overall

Agricultural practices have the potential to impact diversity at the farm level by affecting a farm’s biota, including birds, wildlife, invertebrates, soil microorganisms, and weed populations. Conservation tillage leaves a higher rate of plant residue and increases soil organic matter

(Hussain et al., 1999). This benefits soil biota by providing additional food sources (energy) (USDA-NRCS, 1996) and increasing the diversity of soil microorganisms. It also benefits invertebrate detritivores, their predators, and ultimately, birds and other wildlife higher in the food chain (Carpenter, 2011; Towery & Werblow, 2010). Ground-nesting and seed-eating birds, in particular, have been found to benefit from greater food and cover associated with conservation tillage (SOWAP, 2007). Conservation tillage is expected to be greater under the Preferred Alternative. From this aspect, the Preferred Alternative is expected to have a beneficial impact on biodiversity.

Herbicide use in agricultural fields can impact biodiversity by decreasing weed quantities or causing a shift in weed species. This can affect insects, birds, and mammals that use these weeds. The quantity and type of herbicide use associated with conventional and GE crops depends on many variables, including cropping systems, type and abundance of weeds, production practices, and individual grower decisions. Weed control is expected to be better under the Preferred Alternative. From this aspect, the Preferred Alternative is expected to have a more adverse impact on biodiversity.

Because tillage and herbicide use are expected to have opposing impacts on biodiversity under the No Action (more tillage, less effective weed control) and Preferred Alternatives (less tillage, more effective weed control), the net impact is unknown.),

5.7.3 Natural Resources

Under the Preferred Alternative, there is an expectation that the use of 2,4-D will increase. This increase in 2,4-D use has the potential to impact natural resources. APHIS does not regulate the use of 2,4-D. The direct and indirect impacts which arise from this increased use are the result of the action that EPA is taking with respect to labeling Enlist™ for use on the corn and soybean events that are the subject of the three petitions being considered in this EIS. APHIS has considered the cumulative impacts from changes in production practices that may arise from HR weeds.

<u>Soil Quality</u>

The major corn and soybean regions in the U.S. also are areas where soil erosion exceeds replacement (See Figure 5 in affected environment). Many of these intensively farmed areas are also on highly erodible lands. In some of these areas conservation tillage has been adopted as part of the management plan for controlling erosion.

If conventional tillage increases to control glyphosate- and other herbicide-resistant weeds, there may be an impact on soil quality. Residue management that employs intensive tillage and leaves low amounts of crop residue on the surface results in greater losses of soil organic matter (USDA-NRCS, 1996). The total acreage that may be impacted by such an increase in tillage would be based on the extent of resistant weeds present in a field and the weed management strategy chosen by a grower. Adoption of DAS-40278-9 corn, DAS-68416-4 soybean, and DAS-44406-6 soybean can provide growers with an alternative herbicide to glyphosate and glufosinate. Intensive use of glyphosate on GR crops has been associated with increased selection for GR weeds. During the comment periods associated with this EIS, any growers expressed a need for these Dow events because of their weed problems.

Based on individual grower needs, these three events could provide growers with an alternative to intensive tillage practices that may be used to address herbicide resistance issues. This in turn could reduce the potential loss of soil organic matter and soil erosion that may result when more aggressive tillage practices are used to combat HR weeds under the No Action Alternative. However, the selection of weeds resistant to glyphosate, 2,4-D, and glufosinate will limit the use of this product and any benefit to soil that may arise. The magnitude of the benefit or the loss of the benefit is uncertain because decisions on soil management are up to individual growers. Therefore each action contributes incrementally to the problem of soil erosion.

Water Quality

Under the No Action Alternative, increased tillage to manage GR weeds may occur and lead to increased soil erosion and decreases in water quality from sedimentation. Under the Preferred Alternative, Enlist™ cropping systems for corn and soybean may help to preserve gains in conservation tillage in the short term. In the long term, selection of 2,4-D resistant weeds may result in similar aggressive tillage practices that are expected to occur under the No Action Alternative and negate the benefits mentioned above to the extent that best practices are not adopted.

Air Quality

Under the No Action Alternative, increased tillage to manage GR weeds may occur and lead to decreased air quality from increased air particulates and exhaust from farm equipment. Under the Preferred Alternative, Enlist™ cropping systems for corn and soybean may help to preserve gains in conservation tillage and benefit air quality in the short term. In the long term, selection of 2,4-D resistant weeds may result in similar aggressive tillage practices that are expected to occur under the No Action Alternative and negate the benefits mentioned above to the extent that best practices are not adopted.

Climate Change

Under the No Action Alternative, there is a potential impact on climate change from increased herbicide applications and more aggressive tillage regimes to control herbicide-resistant weeds. Together, increased herbicide applications and tillage are expected to result in greater burning of fossil fuel under the No Action Alternative relative to the Preferred Alternative causing increased release of greenhouse gases. Under the Preferred Alternative, Enlist™ cropping systems for corn and soybean may help to preserve gains in conservation tillage and reduce greenhouse gas contributions to climate change in the short term. In the long term, selection of 2,4-D-resistant weeds may result in similar aggressive tillage practices that are expected to occur under the No Action and negate the benefits mentioned above to the extent that best practices are not adopted.

5.8 Alternative 3

5.8.1 Socioeconomic and Human Health

Under Alternative 3, only DAS-40278-9 corn would no longer be subject to regulation. DAS-68416-4 soybean, and DAS-44406-6 soybean would continue to be regulated. Under this alternative, 2,4-D for crop use is predicted to increase 36 to 169 percent relative to the No Action Alternative (Appendix 4, Table 4-14), but is less than the increase expected under the Preferred Alternative. The increased use of 2,4-D may increase the selection of 2,4-D-resistant weeds, which might increase the costs for weed control in small grain cereals, cotton, sorghum, soybean, and fallow applications. The pressure for selecting 2,4-D-resistant weeds is expected to be lower in Alternative 3 than Alternative 2 because 2,4-D-resistant soybeans will not be grown eliminating the possibility that growers will exclusively use Enlist Duo™ in their corn soybean rotations. Because 2,4-D can already be used on corn, it is possible that growers will be less likely to adopt DAS-40278-9 corn if DAS-68416-4 soybean and DAS-44406-6 soybean are not also available. If the adoption rate of DAS-40278-9 corn is lower than predicted, the impacts of Alternative 3 would likely be more similar to the No Action Alternative.

No cumulative impacts from the changes in production practices were identified on Human Health for any of the alternatives. EPA considers the direct and indirect impacts from herbicide use on Human Health as part of their regulatory decision. Therefore those impacts are outside the scope of this FEIS.

5.8.2 Biological Resources

Depending on the adoption rate of DAS-40278-9 corn as well as the management practices employed by growers, there may be an increase in the selection of 2,4-D-resistant weeds under Alternative 3 relative to the No Action Alternative. If Enlist™ corn is widely adopted, overall 2,4-D use can increase by 19% to 91% relative to the No Action alternative (Table 4-12). On corn only, the increase in 2,4-D use may be 100 to 500% (Table 4-12). The impact of increased 2,4-D use on the selection of 2,4-D resistant weeds may be mitigated by best management practices (see section 5.7.2), lessening the difference between the No Action and Preferred Alternatives. Similarly, if Enlist™ corn is not widely adopted, 2,4-D use is not expected to be different between the No Action Alternative and Alternative 3 with no corresponding differences in the selection of 2,4-D resistant weeds under the two Alternatives. As noted in Appendix 4, Enlist™ corn might not be widely adopted because Dow's market share in corn is under 5%. Furthermore as corn is already resistant to 2,4-D for at least part of its growth cycle, growers may not value this trait enough to switch to Dow corn varieties from the more widely used competitor varieties. The selection of 2,4-D-resistant weeds is expected to be less under Alternative 3 than under the Preferred Alternative because the availability of Enlist™ soybeanis expected to further increase 2,4-D use and could facilitate the continuous use of 2,4-D in a corn-soybean rotation under the latter.

5.8.3 Natural Resources

If conservation tillage practices were to decrease, natural resources could be impacted. However, corn growers still have several effective herbicide chemistries to control GR weeds, including atrazine and chloroacetamides. Consequently, under Alternative 3, tillage practices for corn growers are not expected to differ compared to the No Action Alternative.

5.9 Alternative 4

5.9.1 Socioeconomic and Human Health

Under Alternative 4, DAS-68416-4 soybean and DAS-44406-6 soybean would be granted nonregulated status but DAS-40278-9 corn would continue to be regulated. Under this alternative, 2,4-D for crop use is predicted to increase 39 to 139 percent relative to the No Action Alternative (Appendix 4, Table 4-14), but is less than the increase expected under the Preferred Alternative. The increased use of 2,4-D may increase the selection of 2,4-D-resistant weeds which might increase costs for weed control in small grain cereals, cotton, sorghum, soybean, and fallow applications. The pressure for selecting 2,4-D-resistant weeds is expected to be lower in Alternative 4 than the Preferred Alternative because there would be additional 2,4-D use on Enlist™ corn under the latter and the possibility of continuous use of 2,4-D in a corn-soybean rotation. Because soybeans are very sensitive to 2,4-D, Enlist™ soybeans would allow a new post-emergent use of 2,4-D in contrast to corn, where such uses are already possible because of inherent tolerance of corn to 2,4-D. Because soybean growers also have fewer effective herbicides to manage weeds than corn growers, Enlist™ soybean is expected to be more widely adopted than Enlist™ corn. The wide appeal of Enlist™ soybean relative to corn is indicated by the licensing agreements Dow has made for the Enlist™ trait in 35% of the soybean market (Appendix 4). In contrast they have not made any licensing agreements for the Enlist™ trait in the corn market and Dow's market share in corn is under 5%. (Appendix 4). Even though Enlist™ corn will not be grown under Alternative 4, the pressure for selection of 2,4-D-resistant weeds is expected to be greater under Alternative 4 than under Alternative 3 because Enlist™ products can be used for both pre- and post-emergent applications on both corn and Enlist™ soybean. Furthermore, Enlist™ soybean under Alternative 4 is expected to be more widely adopted than Enlist™ corn under Alternative 3 resulting in greater 2,4-D use under Alternative 4. Consequently the likelihood for the selection of 2,4-D resistant weeds is higher under Alternative 4 than Alternative 3 or the No Action Alternative.

No cumulative impacts were identified on Human Health for any of the alternatives.

5.9.2 Biological Resources

Depending on the adoption rate of DAS-68416-4 and DAS-44406-6 soybean, and the management practices used by growers, there may be an increase in the selection of 2,4-D-resistant weeds under Alternative 4 relative to the No Action Alternative. The selection of 2,4-D-resistant weeds is expected to be less than under the Preferred Alternative.

5.9.3 Natural Resources

If conservation tillage practices were to diminish, natural resources could be impacted. Under the No Action Alternative, soybean growers are expected to use less conservation tillage in areas where GR weeds are poorly controlled by herbicides. Under Alternative 4, weed control by herbicides is expected to be more effective in soybean than under the No Action Alternative. Therefore, conservation tillage practices are expected to be more widely practiced under

Alternative 4 than under the No Action Alternative and Natural Resources are less likely to be adversely impacted.

6 OTHER IMPACTS AND MITIGATION MEASURES

This section describes other potential impacts associated with the implementation of the Action 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.

6.1 Unavoidable Impacts

Unavoidable impacts are any adverse environmental effects which cannot be avoided, should the proposal be implemented (40 CFR § 1502.16). Herbicides represent a tool that allows for the economical production of corn and soybean. As long as herbicides are used to produce corn and soybean, selection of weeds resistant to the herbicides will occur. Under all four Alternatives, the selection of herbicide-resistant weeds is an unavoidable impact. Growers may mitigate the rate at which weeds develop resistance by adopting best management practices as described in Section 5.7.2. APHIS does not have the authority to regulate grower management practices, nor does APHIS have the authority to regulate herbicide use.

6.2 Short Term Versus Long Term Effects

In the short term, corn and soybean growers who adopt Enlist™ corn and soybean are likely to experience more efficient and less costly control of GR weeds. Adopters may be better able to maintain conservation tillage programs on their farms. Growers of non-GE crops and non-adopters of the Enlist™ crops may experience a decline in the weed seed bank as overall weed control improves on neighboring farms.

Over the long term, as weeds develop resistance to 2,4-D and multiple resistance to 2,4-D and glyphosate, the efficiency of weed control will diminish and the cost will increase. Some growers may need to employ more aggressive tillage to manage resistant weeds. Adoption of conventional tillage 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 and adverse impacts to biological resources. Non adopters and growers of non-GE crops will again be impacted by weeds from neighboring farms (see section 5.7.1). Growers of small cereal crops, that rely on 2,4-D for managing weeds in their crops, will experience greater weed control costs as alternatives to 2,4-D are usually more costly.

6.3 Irreversible Resource Commitments

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.

No irreversible or irretrievable commitments of resources were identified with the Action Alternatives.

6.4 Mitigation Measures

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.

APHIS does not have the authority to regulate types of management practices or use of herbicides. Mitigation measures to oversee the proper usage of herbicides are determined by EPA and are disseminated to the herbicide users through EPA approved labels. Spray drift mitigation language on the label is intended to limit off site transport of 2,4-D choline salt in spray drift. Weed resistance mitigation language is intended to encourage best practices to minimize selection of resistant weeds and to aggressively and quickly respond to cases of outbreaks to minimize spread. Local governments may also impose restrictions on when and how herbicides can be applied (see Appendix 7).

Dow has taken an active role to foster good stewardship practices with Enlist™ users. All Enlist™ users will be subject to a stewardship agreement. The stewardship agreement is based in part on discussions with the EPA and the Save Our Crops Coalition, a group of farmers who raise 2,4-D sensitive crops. In an agreement with the Save Our Crops Coalition, Dow has proposed a strategy to mitigate adverse environmental effects of Enlist Duo™, through label language specified by EPA, through limitations on application timing, and through the competitive pricing of lower volatility formulations (APHIS-2013-0042-7255). Based on the proposed registration, the lower volatility formulation is the only one that can lawfully be applied to Enlist™ crops. In addition Dow has proposed recordkeeping practices to ensure that applicators are aware and have documented application location, timing, and windspeed in an effort to increase applicator compliance with their responsibilities under the label requirements (APHIS-2013-0042-7255).

Dow committed to the following measures to foster compliance with the stewardship agreement aimed to reduce off-target movement of herbicides (APHIS-2013-0042-7255). These are:

1. Dow commits to assist in the investigation, diagnosis and resolution of alleged non-target claims.
2. Dow commits to include terms within its Technology Use Agreements for 2,4-D tolerant crops that require growers and applicators to keep accurate records of the locations where

2,4-D tolerant crops are planted and where authorized herbicides containing 2,4-D choline salt are applied, and to retain invoices for all seed and herbicide purchases.

3. Dow commits to include language in its Product Use Guide for authorized herbicides containing 2,4-D choline salt that recommends applicators keep accurate spray records, including application location, timing, and wind speed.
4. Dow commits to utilize an independent third party to collect seed and pesticide sales data that will help identify applicators that use non-choline salt forms of 2,4-D (generic 2,4-D) in contravention of present generic 2,4-D label requirements and the Technology Use Agreement.
5. DAS commits to price its technology (both its seeds and its herbicide) competitively to maximize the use of 2,4-D choline salt (and disincentivize the use of non-choline salt formulations of 2,4-D) on 2,4-D tolerant crops.

In addition, EPA has concluded in its proposed registration for Enlist Duo™, that "in order to mitigate risks to non-target plants and animals, label language will be required that is intended to keep the pesticide on the treatment area, thereby reducing the potential for exposure of non-target plants and animals" (US-EPA, 2014). Applicator responsibilities include requirements for specific techniques to reduce the possibility of spray drift such as nozzle type to control droplet size, maximum wind speeds, and a 30 foot downwind buffer for sensitive areas (US-EPA, 2014). In addition, surface and ground water advisories will be required on all labeling, which may further reduce residues in drinking water and exposure of non-target organisms (US-EPA, 2014).

EPA has also proposed to grant the registration for Enlist Duo™ with certain terms necessary to ensure that if weed resistance is likely, EPA can act quickly to address the problem (US-EPA, 2014). The registration requires Dow to develop a stewardship program that will aggressively promote resistance management efforts (US-EPA, 2014). The plan mandates scouting requirements prior to and after herbicide application and reporting any non-performance issues to Dow who in turn must respond immediately to ensure that possible incidents of resistance are promptly investigated and resolved. Best practices included on the label include among others: rotating herbicide chemistries, limiting herbicide applications/season, incorporating non chemical weed control strategies, and preventing weeds from setting seed. The stewardship program also includes educating and training retailers, farmers, and applicators on the appropriate use of Enlist™ technology, reporting verified cases of resistance to Enlist Duo™ to interested parties, and monitoring whether Enlist Duo™ is being used on Enlist™ seed. University extension agents are also engaged in educating growers on best practices for weed management (see for example comment to the docket APHIS-2013-0042-1911. "At least in Georgia, no weed management program relies exclusively on herbicides. The University of Georgia Weed Science Extension Team stresses to growers at more than 50 meetings each year that herbicides are only one part of the weed management program. Sustainability is only possible with the adoption and implementation of diverse management programs and Georgia growers have accepted this message as fact (Sosnoskie and Culpepper 2013). Growers are using programs that are complex and diverse integrating herbicides, hand weeding, and tillage or cover crops. Neither dicamba nor 2,4-D would change this approach but would simply be an additional tool to add into these management systems."

The EPA concluded that "(i) the Agency has satisfactory data pertaining to the proposed uses of Enlist Duo™ on corn and soybeans; and (ii) approving this application as set forth below will not cause any unreasonable adverse effect on the environment. Though the data support the conclusion that no unreasonable adverse effects on the environment will occur when Enlist Duo™ is used as specified on the label, there is uncertainty to the extent it will be used unlawfully and contrary to the label requirements. There is also uncertainty regarding the extent to which Enlist™ technology users will follow the best practices for managing weed resistance as set forth on the label or how aggressively Dow will pursue record keeping and auditing results. There is uncertainty regarding the price of Enlist Duo™, but if pricing is competitive, it seems likely that most growers will not risk harming their neighbors or their relationship with Dow by using the more volatile 2,4-D formulations. Measures are in place to quickly identify, report, and resolve outbreaks of resistant weeds. As this is a new program, there is uncertainty as to how effective these measures will be."

7 THREATENED AND ENDANGERED SPECIES

The Endangered Species Act (ESA) of 1973, as amended, is one of the most far-reaching wildlife conservation laws ever enacted by any nation. Congress passed the ESA 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, 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 federal agencies, in consultation with USFWS and/or the NMFS, ensure that any action they authorize, fund, or carry 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 their action and to consult with the USFWS and NMFS if it is determined that the action "may affect" listed species or designated critical habitat. To facilitate their ESA consultation requirements, 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). APHIS uses this process to help fulfill its obligations and responsibilities under Section 7 of the ESA for biotechnology regulatory actions.

APHIS met with USFWS officials on June 15, 2011, to discuss whether APHIS has any obligations under the ESA regarding analyzing the effects of herbicide use associated with all GE crops on threatened and endangered species (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 with GE crops currently planted because EPA has both regulatory authority over the labeling of pesticides and the necessary technical expertise to assess pesticide effects on the environment under FIFRA. APHIS has no statutory authority to authorize or regulate the use of 2,4-D, quizalofop, glufosinate, glyphosate, or any other herbicide, by corn and soybean growers. Under APHIS' current part 340 regulations, APHIS only has the authority to regulate DAS-68416-4 soybean, DAS-44406-6 soybean, and DAS-40278-9 corn or any GE organism as long as APHIS believes they may pose a plant pest risk (7 CFR part 340.1). 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.

After completing a plant pest risk analysis, if APHIS determines that DAS-68416-4 soybean, DAS-44406-6 soybean, or DAS-40278-9 corn seeds, plants, or parts thereof do not pose a plant pest risk, then these articles would no longer be subject to the plant pest provisions of the PPA or to the regulatory requirements of 7 CFR Part 340. As part of its EIS analysis, APHIS is analyzing the potential effects of DAS-68416-4 soybean, DAS-44406-6 soybean, and DAS-40278-9 corn on the environment including, as required by the ESA, any potential effects on threatened and endangered species and critical habitat. As part of this process, APHIS thoroughly reviews the GE product information and data related to the organism (generally a plant species, but may also be other genetically engineered organisms). For each transgene/transgenic plant, APHIS considers the following:

- 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);
- Analysis to determine if the transgenic plant is sexually compatible with any TES of plants or a host of any TES; and
- 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 DAS-68416-4 soybean, DAS-44406-6 soybean, and DAS-40278-9 corn may have, if any, on federally-listed TES 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 the Affected Environment section of the EIS, APHIS reviewed the USFWS list of TES species (listed and proposed) for each state where soybean and corn are commercially produced from the USFWS Environmental Conservation Online System (USFWS, 2014a; b; c).

Prior to this review, APHIS considered the potential for DAS-68416-4 soybean, DAS-44406-6 soybean, and DAS-40278-9 corn to extend the range of soybean and corn production and also the potential to extend agricultural production into new natural areas. APHIS has determined that agronomic characteristics and cultivation practices required for DAS-68416-4 soybean, DAS-44406-6 soybean, and DAS-40278-9 corn are essentially indistinguishable from practices used to grow other corn and soybean varieties, including other herbicide-tolerant varieties(DAS, 2010a; b; 2011a; USDA-APHIS, 2010b; 2012a; b). Although DAS-68416-4 soybean, DAS-44406-6 soybean, and DAS-40278-9 corn may be expected to replace other varieties of corn and soybean currently cultivated, APHIS does not expect the cultivation of these to result in new corn or soybean acres to be planted in areas that are not already devoted to agriculture. Accordingly, the issues discussed herein focus on the potential environmental consequences of the determination of nonregulated status of DAS-68416-4 soybean, DAS-44406-6 soybean, and DAS-40278-9 corn on TES species in the areas where corn and soybean are currently grown.

For its analysis on TES plants and critical habitat, APHIS focused on the agronomic differences between the regulated articles and corn and soybean varieties currently grown; the potential for increased weediness; and the potential for gene movement to native plants, listed species, and species proposed for listing.

For its analysis of effects on TES animals, APHIS focused on the implications of exposure to the novel proteins expressed in the plants as a result of the transformation, and the ability of the plants to serve as a host for a TES. The novel proteins associated with DAS-68416-4 soybean, DAS-44406-6 soybean, and DAS-40278-9 corn are listed in Table 17.

Table 17. DAS Corn and Soybean Lines

Regulated Article	Protein	Phenotypic Effects
DAS-40278-9 corn	aryloxyalkanoate dioxygenase (AAD-1)	Resistance to herbicides of the aryloxyalkanoate family, including phenoxy auxins (e.g. 2,4-D) and AOPP ACCase inhibitors.
DAS-68416-4 soybean	aryloxyalkanoate dioxygenase-12 (AAD-12)	Resistance to 2,4-D
	phosphinothricin acetyltransferase (PAT)	Resistance to glufosinate
DAS-44406-6 soybean	aryloxyalkanoate dioxygenase-12 (AAD-12)	Resistance to 2,4-D
	phosphinothricin acetyltransferase (PAT)	Resistance to glufosinate
	modified 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS)	Resistance to glyphosate

7.1 Potential Effects of DAS-40278-9 Corn on TES and Critical Habitat

7.1.1 Threatened and Endangered Plant Species and Critical Habitat

The agronomic and morphologic characteristics data provided by DAS were used in the APHIS analysis of the weediness potential for DAS-40278-9 corn, and evaluated for the potential to impact TES and critical habitat. Agronomic studies conducted by Dow tested the hypothesis that the weediness potential of DAS-40278-9 corn is unchanged with respect to conventional corn (DAS, 2010a). No differences were detected between DAS-40278-9 corn and non-transgenic corn in growth, reproduction, or interactions with pests and diseases, other than the intended effect of tolerance to the two herbicides (USDA-APHIS, 2010b). Corn possesses few of the characteristics of successful weeds, and has been cultivated around the globe without any report that it is a serious weed or that it forms persistent feral populations (USDA-APHIS, 2010b).

However, corn seed can germinate in undesired locations and would then be considered a weed, such as when corn emerges as a volunteer in a soybean rotation following a corn crop (USDA-APHIS, 2010b).

Because the expression of the AAD-1 protein in DAS-40278-9 corn results in greater tolerance to two herbicides, there would be fewer options for controlling volunteer corn. However, as there are multiple options for control of volunteer corn, including the use of other ACCase inhibitor herbicides (e.g., the cyclohexadione “dim” herbicides clethodim or sethoxydim) and acetolactate synthesis inhibitors (ALS; e.g., imazamox, imazequin, and imazethapyr) (Heap, 2011a; WSSA, 2011), the expression of the AAD-1 protein herbicide-tolerance trait in DAS-40278-9 corn is unlikely to appreciably improve seedling establishment or increase weediness potential. Based on the agronomic field data and literature survey on corn weediness potential, DAS-40278-9 corn is unlikely to affect TES or critical habitat as a troublesome or invasive weed (USDA-APHIS, 2010b).

APHIS evaluated the potential of DAS-40278-9 corn to cross with listed species. After reviewing the list of threatened and endangered plant species in the States where corn is grown, APHIS determined that DAS-40278-9 corn 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 *Zea*.

Based on agronomic field data, literature surveyed on corn weediness potential, and no sexually compatibility of TES with corn, APHIS has concluded that DAS-40278-9 corn will have no effect on threatened or endangered plant species or on critical habitat.

7.1.2 Threatened and Endangered Animal Species

Threatened and endangered animal species that may be exposed to the gene products in DAS-40278-9 corn would be those TES that inhabit corn fields and feed on DAS-40278-9 corn. As discussed further in Section 3.3.1, Affected Environment, Biological Resources, Animal Communities, cornfields are generally considered poor habitat for birds and mammals in comparison with uncultivated lands, but the use of cornfields by birds and mammals is not uncommon. Some birds and mammals use cornfields at various times throughout the corn production cycle for feeding and reproduction. Most birds and mammals that utilize cornfields are ground foraging omnivores that feed on corn seed, sprouting corn, and the corn remaining in the fields following harvest. Few, if any, TES are likely to use corn fields because they do not provide suitable habitat. For birds, only whooping crane (*Grus americana*), Mississippi sandhill crane (*Grus canadensis pulla*), piping plover (*Charadrius melodus*), interior least tern (*Sterna antillarum*), and Sprague’s pipit (*Anthus spragueii;* a candidate species) occasionally feed in farmed sites (USFWS, 2011a). These bird species may visit corn fields during migration (Krapu et al., 2004; USFWS, 2011a). The whooping crane in particular spends the majority of its foraging time during migration in agricultural fields, although its diet during this time is not well understood (Canadian Wildlife Service and U.S. Fish and Wildlife Service, 2007; ICF, 2014)As discussed thoroughly in Section 3.3.1, many mammals may feed on corn; especially white tailed deer, raccoons, and mice and voles. As for listed species, the Louisiana black bear (*Ursus americanus luteolus*), occurring in Louisiana, Mississippi, and Texas (Johnsen et al., 2005), may occasionally forage on corn among other crops such as sugarcane, winter wheat, and soybean

(MSU, No Date). APHIS considered the risks to threatened and endangered animals from consuming DAS-40278-9 corn. Dow has presented information on the food and feed safety of the AAD-1 protein, comparing the DAS-40278-9 corn variety with conventional varieties and evaluating the differences between varieties with and without herbicide applications (DAS, 2010a). Compositionally, DAS-40278-9 corn grain was determined to be the same as conventional varieties. Compositional elements compared included moisture, protein, fat, carbohydrates, ash, minerals, dietary fiber, essential and non-essential amino acids, fatty acids, vitamins, and antinutrients (DAS, 2010a; Herman et al., 2010). The results presented by Dow show that the incorporation of the *aad-1* gene and the attendant expression of the AAD-1 protein in DAS-40278-9 corn does not result in any biologically-meaningful differences between DAS-40278-9 corn grain and the non-transgenic hybrid grain.

Dow conducted safety evaluations based on Codex Alimentarius Commission procedures to assess any potential adverse effects to humans or animals resulting from environmental releases and consumption of DAS-40278-9 corn (DAS, 2010a; FAO, 2009; US-FDA, 2011b). These safety studies included evaluating protein structure and function, including homology searches of the amino acid sequences with comparison to all known allergens and toxins, an *in vitro* digestibility assay of the proteins, an acute oral toxicity feeding study in mice, and a feeding study in broiler chickens (DAS, 2010a; Herman et al., 2011a; Herman et al., 2010; US-FDA, 2011b). The DAS-40278-9 corn AAD-1 protein was determined to have no amino acid sequence similar to known allergens, lacked toxic potential to mammals, and was degraded rapidly and completely in gastric fluid (DAS, 2010a; US-FDA, 2011b).

In addition to evaluating Dow's comparisons of DAS-40278-9 corn with the non-transgenic near-isoline hybrid variety for potential differences in agronomic and morphology, APHIS also considers the FDA regulatory assessment in making its determination of the potential impacts of a determination of nonregulated status of the new agricultural product. DAS-40278-9 corn would be the first commercially available food crop expressing the AAD-1 protein. In that regard, DAS has submitted food and feed safety and nutritional assessments for DAS-40278-9 corn to the FDA. At this time, the FDA considers the consultation on DAS-40278-9 corn to be complete (US-FDA, 2011b).

APHIS considered the possibility that DAS-40278-9 corn could serve a host plant for a threatened or endangered species. (i.e., a listed insect or other organism that may use the corn plant to complete its lifecycle). A review of the species list reveals that there are none that would use corn as a host plant (USFWS, 2014a; b).Considering the compositional similarity between DAS-40278-9 corn and other varieties currently grown and the lack of toxicity and allergenicity of the AAD-1 protein, APHIS has concluded that exposure and consumption of DAS-40278-9 corn grain would have no effect on threatened or endangered animal species.

7.1.3 Summary

After reviewing the possible effects of allowing the environmental release of DAS-40278-9 corn, APHIS has not identified any stressor that could affect the reproduction, numbers, or distribution of a listed TES or species proposed for listing. As a result, a detailed exposure analysis for individual species is not necessary. APHIS also considered the potential effect of a determination of nonregulated status of DAS-40278-9 corn on designated critical habitat or habitat proposed for designation, and could identify no differences from effects that would occur from the production of other corn varieties. Corn is not considered a particularly competitive plant species and has been selected for domestication and cultivation under conditions not normally found in natural settings (US-EPA, 2010a). Corn is not sexually compatible with, or serves as a host species for, any listed species or species proposed for listing. Consumption of DAS-40278-9 corn by any listed species or species proposed for listing will not result in a toxic or allergic reaction. Based on these factors, APHIS has concluded that a determination of nonregulated status of DAS-40278-9 corn, and the corresponding environmental release of this corn variety will have no effect on listed species or species proposed for listing, and would not affect designated 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.

7.2 Potential Effects of DAS-68416-4 Soybean and DAS-444406-06 Soybean on TES and Critical Habitat

7.2.1 Threatened and Endangered Plant Species and Critical Habitat

The agronomic and morphologic characteristics data provided by Dow were used in the APHIS analysis of the weediness potential for DAS-68416-4 soybean and DAS-44406-6 soybean, and further evaluated for the potential to impact TES and critical habitat. Agronomic studies conducted by Dow tested the hypothesis that the weediness potential of DAS-68416-4 soybean and DAS-44406-6 soybean is unchanged with respect to conventional soybean (DAS, 2010b; 2011b). No differences were detected between DAS-68416-4 soybean and DAS-44406-6 soybean and non-transgenic soybean in growth, reproduction, or interactions with pests and diseases, other than the intended effect of herbicide tolerance (DAS, 2010b; 2011a; USDA-APHIS, 2012b). Soybean possesses few of the characteristics of successful weeds, and has been cultivated around the globe without any report that it is a serious weed or that it forms persistent feral populations (USDA-APHIS, 2010b). Soybean cannot survive in most of the U.S. without human intervention, and it is easily controlled if volunteers appear in subsequent crops (see Subsection 4.1.2, *No Action Alternative – Biological Resources*). The expression of the AAD-12, PAT, and EPSPS proteins providing the herbicide tolerance traits in DAS-68416-4 soybean and DAS-44406-6 soybean are unlikely to appreciably improve seedling establishment or increase weediness potential (DAS 2010, DAS 2011). APHIS has concluded the approval of a petition of nonregulated status for DAS-68416-4 soybean and DAS-44406-6 soybean does not present a risk of weediness, and does not present an increased risk of gene flow when compared to other currently cultivated soybean varieties (USDA-APHIS, 2012a; b).

APHIS evaluated the potential of DAS-68416-4 soybean and DAS-44406-6 soybean to cross with listed species. As previously discussed in the analysis of Gene Movement and Weediness and Plants, APHIS has determined that there is no risk to unrelated plant species from the cultivation of DAS-68416-4 soybean and DAS-44406-6 soybean. Soybean is highly self-pollinating and can only cross with other members of *Glycine* subgenus *Soja*. Wild soybean species are endemic in China, Korea, Japan, Taiwan and the former USSR; in the U.S. there are no *Glycine* species found outside of cultivation and the potential for outcrossing is minimal (OECD, 2000). After reviewing the list of threatened and endangered plant species in the U.S. states where soybean is grown, APHIS determined that DAS-68416-4 soybean and DAS-44406-

6 soybean would not be sexually compatible with any listed threatened or endangered plant species 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 *Glycine*.

Based on agronomic field data, literature surveyed on soybean weediness potential, and no sexual compatibility of TES with soybean, APHIS has concluded that DAS-68416-4 soybean and DAS-44406-6 soybean will have no effect on threatened or endangered plant species or critical habitat.

7.2.2 Threatened and Endangered Animal Species

Threatened and endangered animal species that may be exposed to the gene products in DAS-68416-4 soybean and DAS-44406-6 soybean would be those TES that inhabit soybean fields and feed on DAS-68416-4 soybean and DAS-44406-6 soybean. To identify potential effects on threatened and endangered animal species, APHIS evaluated the risks from consuming DAS-68416-4 soybean and DAS-44406-6 soybean.

Soybean commonly is used as a feed for many livestock. Additionally, wildlife may use soybean fields as a food source, consuming the plant or insects that live on the plants, although TES generally are found outside of agricultural fields. Few if any TES are likely to use soybean fields because they do not provide suitable habitat. Only whooping crane (*Grus americana*), Mississippi sandhill crane (*Grus canadensis pulla*), piping plover (*Charadrius melodus*), interior least tern (*Sterna antillarum*), and Sprague's pipit (*Anthus spragueii;* a candidate species) occasionally feed in farmed sites (USFWS, 2011a). These bird species may visit soybean fields during migratory periods, but would not be present during normal farming operations (Krapu et al., 2004; USFWS, 2011a). In a study of soybean consumption by wildlife in Nebraska, results indicated that soybeans do not provide the high energy food source needed by cranes and waterfowl (Krapu et al., 2004).

The Delmarva fox squirrel (*Sciurus niger cinereus*), which inhabits mature forests of mixed hardwoods and pines, may be found adjacent to agricultural areas of the Delmarva Peninsula (USFWS, 2011b). The squirrel forages for food in woodlots and openings, such as farm fields, with a diet that mainly includes acorns, nuts/seeds of hickory, beech, walnut, and loblolly pine. They also feed on tree buds and flowers, fungi, insects, fruit, and seeds in the spring and mature, green pine cones in the summer and early fall (USF&WS, 1999). The Louisiana black bear (*Ursus americanus luteolus*), occurring in Louisiana, Mississippi, and Texas (Johnsen et al., 2005), may occasionally forage on soybean; however, other crops such as corn, sugarcane, and winter wheat are preferred by the species (MSU, No Date).

The FDA has concluded its review of Dow's submittal of safety and nutritional data for DAS-68416-4 soybean (US-FDA, 2011b) DAS-44406-6 soybean (US-FDA, 2013a). Dow conducted safety evaluations based on Codex Alimentarius Commission procedures to assess any potential adverse effects on humans or animals resulting from environmental releases and consumption of DAS-68416-4 soybean (DAS, 2010b; FAO, 2009; US-FDA, 2011c) and DAS-44406-6 soybean (DAS, 2011a). These safety studies included evaluating protein structure and function, including homology searches of the amino acid sequences with comparison to all known allergens and toxins, an *in vitro* digestibility assay of the proteins, an acute oral toxicity feeding study in mice, and a feeding study in broiler chickens (DAS, 2010b; 2011a; Herman et al., 2011a; Herman et al., 2011b; US-FDA, 2011c). DAS-68416-4 soybean and DAS-44406-6 soybean AAD-12, PAT and EPSPS proteins were determined to have no amino acid sequence similar to known allergens, lacked toxic potential to mammals, and was degraded rapidly and completely in gastric fluid (DAS, 2010b; 2011a; US-FDA, 2011c). At this time, FDA considers the consultation on DAS-68416-4 soybean and DAS-4406-6 soybean to be complete (US-FDA, 2011a; 2013b).

APHIS has examined data on the food and feed safety of DAS-68416-4 soybean and DAS-44406-6 soybean, evaluating the agronomic and morphological characteristics, including compositional and nutritional characteristics, safety evaluations and toxicity tests, as compared to a conventional hybrid soybean variety (DAS, 2010b; 2011a). Compositional elements compared included moisture, protein, fat, carbohydrates, ash, minerals, dietary fiber, essential and non-essential amino acids, fatty acids, vitamins, and anti-nutrients (DAS, 2010b; 2011a; Herman et al., 2011b). As discussed in Section 4.2.1, Preferred Alternative – Socioeconomic and Human Health, the data collected indicate that the PAT and EPSPS proteins present in DAS-44406-6 soybean would be equivalent to those produced in other GE crops that are no longer subject to the regulatory requirements of 7 CFR part 340 or the plant pest provisions of the Plant Protection Act (USDA, 1996; 2001; 2004; 2005). In addition as previously stated, FDA concluded: “food and feed derived from DAS-68416-4 soybean are not materially different in composition, safety, and other relevant parameters from soybean-derived food and feed currently on the market, and that the GE DAS-68416-4 soybean do not raise issues that would require premarket review or approval by FDA (US-FDA, 2011a).” Therefore, the ingestion of the plant or plant parts is unlikely to affect threatened and endangered species. Because there is no toxicity or allergenicity potential with DAS-68416-4 soybean and DAS-44406-6 soybean, there would be no direct or indirect toxicity or allergenicity impacts on animal species that feed on soybean or the associated biological food chain of organisms. Consultations with FDA were successfully completed for the AAD-12, and PAT proteins, which demonstrated a lack of toxicity and allergenicity of DAS-68416-4 soybean for human and animal consumption (US-FDA, 2011a). Therefore, based on these analyses, APHIS concludes that, although unlikely, consumption of DAS-68416-4 soybean and DAS-44406-6 soybean 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 DAS-68416-4 soybean and DAS-44406-6 soybean could serve as host plants for a threatened or endangered species (i.e., a listed insect or other organism that may use the soybean plant to complete its lifecycle). A review of the species list reveals that there are no members of the genus *Glycine* that serve as a host plant for any threatened or endangered species (USFWS, 2014c)

Combining the above information, cultivation of DAS-68416-4 soybean and DAS-44406-6 soybean and their progeny are expected to have no effect on threatened or endangered animals or those proposed for listing.

7.2.3 Summary

After reviewing the possible effects of allowing the environmental release of DAS-68416-4 soybean and DAS-44406-6 soybean, APHIS has not identified any stressor that could affect the reproduction, numbers, or distribution of a listed TES or species proposed for listing. APHIS also considered the potential effect of a determination of nonregulated status of DAS-68416-4 soybean and DAS-44406-6 soybean on designated critical habitat or habitat proposed for designation, and could identify no differences from effects that would occur from the production of other soybean varieties. Soybean is not considered a particularly competitive plant species and has been selected for domestication and cultivation under conditions not normally found in natural settings (US-EPA, 2010a). Soybean is not sexually compatible with, or serves as a host species for, any listed species or species proposed for listing. Consumption of DAS-68416-4 soybean and DAS-44406-6 soybean by any listed species or species proposed for listing will not result in a toxic or allergic reaction. Based on these factors, APHIS has concluded that a determination of nonregulated status of DAS-68416-4 soybean and DAS-44406-6 soybean, and the corresponding environmental release of these soybean varieties will have no effect on listed species or species proposed for listing, and would not affect designated habitat or habitat proposed for designation. Because of this no-effect determination, consultation under Section 7(a)(2) of the Act or the concurrences of the USFWS or NMFS is not required.

8 CONSIDERATION OF EXECUTIVE ORDERS, STANDARDS, AND TREATIES RELATING TO ENVIRONMENTAL IMPACTS

8.1 Executive Orders with Domestic Implications

The following executive orders require consideration of the potential impacts of the Federal action to various segments of the population.

- ***Executive Order (EO) 12898 (US-NARA, 2010), "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations,"*** requires Federal agencies to conduct their programs, policies, and activities that substantially affect human health or the environment in a manner so as not to exclude persons and populations from participation in or benefiting from such programs. It also enforces existing statutes to prevent minority and low-income communities from being subjected to disproportionately high and adverse human health or environmental effects.
- ***EO 13045, "Protection of Children from Environmental Health Risks and Safety Risks,"*** acknowledges that children may suffer disproportionately from environmental health and safety risks because of their developmental stage, greater metabolic activity levels, and behavior patterns, as compared to adults. The EO (to the extent permitted by law and consistent with the Agency's mission) requires each Federal agency to identify, assess, and address environmental health risks and safety risks that may disproportionately affect children.

The No Action and Preferred Alternatives were analyzed with respect to EO 12898 and EO 13045. APHIS anticipates no potential disproportionate adverse impacts to minority, low-income, and Tribal populations, and children as a result of this deregulation because the Enlist crops are agronomically, phenotypically, and biochemically comparable to conventional corn and soybean grown, marketed, and consumed except for the inserted proteins AAD-1, AAD-12, PAT, and m2EPSPS proteins. Additionally, none of the Alternatives are expected to have a disproportionate adverse effect on minority, low-income, and Tribal populations, or children, as a result of this deregulation because of, but not limited to, the appropriate use of personal protective equipment and product use in accordance with product label instructions, which are expected to prevent any adverse human health impacts associated with increased use of herbicides.

FDA completed new protein consultations with Dow on the AAD-1 and AAD-12 proteins on May 19, 2010 (US-FDA, 2010a; c). FDA biotechnology consultations with Dow were completed on DAS-40278-9 corn, DAS-68416-4 soybean, and DAS-44406-6 soybean (US-FDA, 2010b; c; 2011b; c; 2013a; b). As part of the evaluations for these events, FDA reviewed the safety and nutritional assessments submitted by Dow concluding that food and feed derived from DAS-40278-9 corn, DAS-68416-4 soybean, and DAS-44406-06 soybean are not materially different in composition, safety, and other relevant parameters from corn- and soybean-derived food and feed currently on the market.

Dow conducted compositional analyses to establish the nutritional adequacy of forage- and grain-derived products from DAS-40278-9 corn, DAS-68416-4 soybean, and DAS-44406-06 soybean in comparison to conventional counterparts. The studies compared data on key nutrients, secondary metabolites, and antinutrients for DAS-40278-9 corn, DAS-68416-4 soybean, and DAS-44406-06 soybean forage and grain samples and the conventional variety controls. According to Dow, the measured parameters were within the combined literature range for corn and soybean and the comparisons indicated no biologically meaningful differences for food and feed safety and nutrition (US-FDA, 2011b; c; 2013a).

Both the AAD-1 and AAD-12 proteins were investigated for their potential to be a toxin or allergen. Bioinformatics studies confirmed the absence of any biologically significant amino acid sequence similarity to known protein toxins or allergens. Digestibility studies demonstrated that these proteins would be rapidly degraded following ingestion, similar to other dietary proteins. Enzymatic activity of the AAD-1 and AAD-12 proteins was shown to be eliminated under all heating conditions (US-FDA, 2011b; c; 2013a). Acute oral mouse toxicity studies were performed for the AAD-1 and AAD- 12 proteins, as ingestion represents the most likely route of human exposure to these proteins. No clinical signs of toxicity were observed in any of the test animals.

Dow indicated in their submission to FDA that the PAT protein in DAS-68416-4 soybean and DAS-44406-6 soybean was shown to be equivalent to that produced in other transgenic crops and previous assessments have shown it is non-toxic to mammals and does not exhibit any potential to be allergenic to humans. Biotechnology consultations on soybean lines containing the PAT protein were completed on May 15, 1998 (US-FDA, 1998) and also was evaluated as part of the consultation on DAS-68416-4 soybean completed in 2011(US-FDA, 2011a) and DAS-44406-6 soybean completed in 2013 (US-FDA, 2013a). As with the AAD-1 and AAD-12 proteins, Dow evaluated the allergenicity of the PAT protein inserted in DAS-68416-4 soybean and DAS-44406-6 soybean through bioinformatics analyses. No meaningful homologies to known or reputed allergens or toxins were identified. EPA has previously reviewed data on the acute toxicity and digestibility of the PAT protein and concluded that there is a reasonable certainty that no harm will result from aggregate exposure to the U.S. population, including infants and children, to the PAT protein (US-EPA, 1997).

DAS-44406-6 soybean, with the inserted AAD-12, PAT, and m2EPSPS proteins, was evaluated by FDA (BNF 133) (US-FDA, 2013a; b). FDA evaluated Dow's submission to determine whether DAS-44406-6 soybean raises any safety or regulatory issues with respect to the intended modifications or with respect to the food and feed itself. Dow compared the protein sequences of AAD-12, 2mEPSPS, and PAT proteins to those of known toxins and allergens. Dow reported that no significant sequence similarities either to known toxins or to known allergens were identified. Dow analyzed the composition of forage and grain from DAS-44406-6 soybean (unsprayed or sprayed with up to three herbicides) and compared it with Maverick, the recipient line (hereafter referred to as the control), which has the same genetic background as DAS-44406-6 soybean, but does not contain the DAS-44406-6 event. Summarizing the results of its compositional analyses, Dow concluded that the component levels in DAS-44406-6 soybean were found to be either statistically indistinguishable from those in the control line, or consistent with ranges for soybean in the literature or with a reference line. Consequently, Dow concluded that there are no unintended compositional differences between DAS-44406-6 soybean and the control. Dow also concluded that DAS-44406-6 is comparable to conventional soybean. FDA did not identify any issues under the FDCA that would require further evaluation at that time (US-FDA, 2013a; b).

Taken together, the evidence indicates that the AAD-1, AAD-12, PAT, and m2EPSPS proteins are not toxic or not likely to be allergenic to humans. Based on the information submitted by the applicant and reviewed by APHIS, DAS-40278-9 corn, DAS-68416-4 soybean, and DAS-44406-6 soybean are agronomically, phenotypically, and biochemically comparable to conventional corn and soybean grown, marketed, and consumed except for the inserted proteins AAD-1, AAD-12, PAT, and m2EPSPS proteins.

Agricultural workers, which may include children, minorities, and low-income populations, could come into contact with the deregulated Enlist™ crops being grown. Common agricultural practices that would be used with the Enlist™ crops are no different than those utilized on current conventional and GE crops. If EPA approves the additional new uses of 2,4-D on DAS-40278-9 corn, DAS-68416-4 soybean, and DAS-44406-06 soybean, 2,4-D use patterns on these corn and soybean varieties would be different than is currently allowed. As a result, the use of 2,4-D is expected to increase.

EPA regulates the use of herbicides under FIFRA and is making a separate decision which may or may not allow the additional use of 2,4-D on these plants. EPA considers the toxicity of pesticides to humans, including sensitive population, such as children, in its pesticide registration and registration reviews.

Currently, the EPA is proposing to revise the existing Worker Protection Standard (WPS) at 40 CFR part 170 to reduce the incidence of occupational pesticide exposure and related illness among agricultural workers (workers) and pesticide handlers (handlers) covered by the rule. EPA is proposing to strengthen the protections provided to agricultural workers and handlers under the WPS by improving elements of the existing regulation, such as training, notification, communication materials, use of personal protective equipment, and decontamination supplies. EPA expects the revisions, once final, to prevent unreasonable adverse effects from exposure to pesticides among agricultural workers and pesticide handlers; vulnerable groups, such as minority and low-income populations, child farmworkers, and farmworker families; and the general public. This regulation, in combination with other components of EPA's pesticide regulatory program, is intended to prevent unreasonable adverse effects of pesticides among pesticide applicators, workers, handlers, the general public, and vulnerable groups, such as minority and low-income populations.

The results of available mammalian toxicity studies associated with the AAD-1, AAD-12, EPSPS, and PAT proteins establish the safety of DAS-40278-9 corn, DAS-68416-4 soybean, and DAS-44406-6 soybean and associated products to humans, including minorities, low-income populations, and children who might be exposed to them through agricultural production and/or processing. No additional safety precautions would need to be taken with nonregulated DAS-40278-9 corn, DAS-68416-4 soybean, and DAS-44406-6 soybean. Based on these factors, a determination of nonregulated status to DAS-40278-9 corn, DAS-68416-4 soybean, and DAS-44406-6 soybean is not expected to have a disproportionate adverse effect on minorities, low-income and Tribal populations, or children.

Further, the increased cost of seed for HR crops such as Enlist™ relative to conventional seeds is not a barrier to low income producers, since net returns for HR soybean and corn were in the aggregate no different (Fernandez-Cornejo et al., 2014). Regardless of seed premiums charged for GE seeds such as Enlist™, growers select GE herbicide resistant seeds because they are associated with certain conveniences in the production of the crop, such simplifying herbicide practices and gaining ability to spray herbicides at different times in the developmental stages of the crop.

The following executive order addresses Federal responsibilities regarding the introduction and effects of invasive species:

> ***EO 1311 (US-NARA, 2010), "Invasive Species,"*** states that Federal agencies take action to prevent the introduction of invasive species, to provide for their control, and to minimize the economic, ecological, and human health impacts that invasive species cause.

Neither corn nor soybean is listed in the U.S. as a noxious weed species by the Federal government (USDA-NRCS, 2010c), nor are these crops listed as invasive species by major invasive plant data bases (GRN, 2012; University of Georgia and USDOI-NPS, 2009).

While pollen-mediated gene transfer can occur, there are no differences in the potential for gene flow and weediness from conventional or other GE varieties. Outcrossing and weediness are addressed in the PPRAs (USDA-APHIS, 2010b; 2012a; b)and DAS-40278-9 corn, DAS-68416-4 soybean, and DAS-44406-6 soybean are similar to other HR-corn or HR-soybean varieties. The risk of gene flow and weediness of DAS-40278-9 corn, DAS-68416-4 soybean, and DAS-44406-6 soybean is no greater than that of other nonregulated, HR corn or soybean varieties.

The following executive order requires the protection of migratory bird populations:

> ***EO 13186 (US-NARA, 2010), "Responsibilities of Federal Agencies to Protect Migratory Birds,"*** states that federal agencies taking actions that have, or are likely to have, a measurable negative effect on migratory bird populations are directed to develop and implement, within two years, a Memorandum of Understanding (MOU) with the Fish and Wildlife Service that shall promote the conservation of migratory bird populations.

Data submitted by the applicant has shown no substantial difference in compositional and nutritional quality of DAS-40278-9 corn compared with other GE corn or non-GE corn, apart from the presence of the AAD-1 protein. Similarly, except for the presence of the inserted proteins, DAS-68416-4 soybean and DAS-44406-6 soybean have been found to be compositionally and nutritionally comparable to other GE soybean or non-GE soybean varieties. Additionally, the PAT and EPSPS proteins have been cultivated in a wide variety of commercial corn and soybean strains since 1995. The migratory birds that forage in cornfields are unlikely to be affected adversely by ingesting DAS-40278-9 corn, DAS-68416-4 soybean, DAS-44406-6 soybean and associated products.

EPA considers the toxicity of pesticides to birds in its pesticide registration and registration reviews.

8.2 International Implications

> ***EO 12114 (US-NARA, 2010), "Environmental Effects Abroad of Major Federal Actions"*** requires federal officials to take into consideration any potential environmental

effects outside the U.S., its territories, and possessions that result from actions being taken.

APHIS has given this EO careful consideration and does not expect a significant environmental impact outside the U.S. in the event of a determination of nonregulated status of DAS-40278-9 corn, DAS-68416-4 soybean, and DAS-44406-6 soybean. All existing national and international regulatory authorities and phytosanitary regimes that currently apply to introductions of new corn and soybean cultivars internationally apply equally to those covered by an APHIS determination of nonregulated status under 7 CFR part 340.

Any international trade of DAS-40278-9 corn, DAS-68416-4 soybean, and DAS-44406-6 soybean subsequent to a determination of nonregulated status of the product would be fully subject to national phytosanitary requirements and be in accordance with phytosanitary standards developed under the International Plant Protection Convention (IPPC, 2010). The purpose of the IPPC "is to secure a common and effective action to prevent the spread and introduction of pests of plants and plant products and to promote appropriate measures for their control" (IPPC, 2010). The protection it affords extends to natural flora and plant products and includes both direct and indirect damage by pests, including weeds.

The IPPC establishes a standard for the reciprocal acceptance of phytosanitary certification among the nations that have signed or acceded to the Convention (172 countries as of March 2010). In April 2004, a standard for PRA of living modified organisms (LMOs) was adopted at a meeting of the governing body of the IPPC as a supplement to an existing standard, International Standard for Phytosanitary Measures No. 11 (ISPM-11, Pest Risk Analysis for Quarantine Pests). The standard acknowledges that all LMOs will not present a pest risk and that a determination needs to be made early in the PRA for importation as to whether the LMO poses a potential pest risk resulting from the genetic modification. APHIS pest risk assessment procedures for GE organisms are consistent with the guidance developed under the IPPC. In addition, issues that may relate to commercialization and transboundary movement of particular agricultural commodities produced through biotechnology are being addressed in other international forums and through national regulations.

The *Cartagena Protocol on Biosafety* is a treaty under the United Nations Convention on Biological Diversity (CBD) that established a framework for the safe transboundary movement, with respect to the environment and biodiversity, of LMOs, which include those modified through biotechnology. The Protocol came into force on September 11, 2003, and 160 countries are Parties to it as of December 2010 (CBD, 2010). Although the U.S. is not a party to the CBD, and thus not a party to the Cartagena Protocol on Biosafety, U.S. exporters will still need to comply with those regulations that importing countries which are Parties to the Protocol have promulgated to comply with their obligations. The first intentional transboundary movement of LMOs intended for environmental release (field trials or commercial planting) will require consent from the importing country under an advanced informed agreement provision, which includes a requirement for a risk assessment consistent with Annex III of the Protocol and the required documentation.

LMOs imported for food, feed, or processing are exempt from the advanced informed agreement procedure and are covered under Article 11 and Annex II of the Protocol. Under Article 11, Parties must post decisions to the Biosafety Clearinghouse database on domestic use of LMOs for food, feed, or processing that may be subject to transboundary movement. To facilitate compliance with obligations to this protocol, the U.S. Government has developed a website that provides the status of all regulatory reviews completed for different uses of bioengineered products (NBII, 2010). These data will be available to the Biosafety Clearinghouse.

APHIS continues to work toward harmonization of biosafety and biotechnology consensus documents, guidelines, and regulations, including within the North American Plant Protection Organization (NAPPO), which includes Mexico, Canada, and the U.S., and within the Organization for Economic Cooperation and Development (OECD). NAPPO has completed three modules of the Regional Standards for Phytosanitary Measures No. 14, *Importation and Release into the Environment of Transgenic Plants in NAPPO Member Countries* (NAPPO, 2009).

APHIS also participates in the *North American Biotechnology Initiative*, a forum for information exchange and cooperation on agricultural biotechnology issues for the U.S., Mexico, and Canada. In addition, bilateral discussions on biotechnology regulatory issues are held regularly with other countries including Argentina, Brazil, Japan, China, and Korea.

8.3 Compliance with Clean Water Act and Clean Air Act

This EIS evaluated the potential changes in corn and soybean production associated with approving the petition for a determination of nonregulated status to DAS-40278-9 corn, DAS-68416-4 soybean, and DAS-44406-6 soybean (see Subsection, 4.2.1) and determined that the cultivation of DAS-40278-9 corn, DAS-68416-4 soybean, and DAS-44406-6 soybean would not lead to the increase in or expand the area of corn and soybean production that could impact water resources or air quality any differently than currently cultivated corn and soybean varieties. The herbicide resistance conferred by the genetic modification of DAS-40278-9 corn, DAS-68416-4 soybean, and DAS-44406-6 soybean is not expected to result in any changes in water usage for cultivation compared to current corn and soybean production. Based on these analyses, APHIS concludes that an extension of a determination of nonregulated status to DAS-40278-9 corn, DAS-68416-4 soybean, and DAS-44406-6 soybean would comply with the CWA and the CAA.

8.4 Impacts on Unique Characteristics of Geographic Areas

Approving the petition for a determination of nonregulated status to DAS-40278-9 corn, DAS-68416-4 soybean, and DAS-44406-6 soybean is not expected to impact unique characteristics of geographic areas such as parklands, prime farmlands, wetlands, wild and scenic areas, or ecologically critical areas.

Dow has presented results of agronomic field trials for DAS-40278-9 corn, DAS-68416-4 soybean, and DAS-44406-6 soybean that demonstrate there are no differences in agronomic practices, between DAS-40278-9 corn and currently available HR-corn varieties or between DAS-68416-4 soybean or DAS-44406-6 soybean and currently available HR-soybean varieties. The common agricultural practices that would be carried out in the cultivation of DAS-40278-9 corn, DAS-68416-4 soybean, and DAS-44406-6 soybean are not expected to deviate from current practices. The product is expected to be cultivated by growers on agricultural land currently suitable for production of corn or soybean, and is not anticipated to expand the cultivation of corn or soybean to new, natural areas.

The Preferred Alternative for DAS-40278-9 corn, DAS-68416-4 soybean, and DAS-44406-6 soybean does not propose major ground disturbances or new physical destruction or damage to property, or any alterations of property, wildlife habitat, or landscapes. Likewise, no prescribed sale, lease, or transfer of ownership of any property is expected as a direct result of a determination of nonregulated status for DAS-40278-9 corn, DAS-68416-4 soybean, and DAS-44406-6 soybean. This action would not convert land use to nonagricultural use and, therefore, would have no adverse impact on prime farmland. Standard agricultural practices for land preparation, planting, irrigation, and harvesting of plants would be used on agricultural lands planted to DAS-40278-9 corn, DAS-68416-4 soybean, and DAS-44406-6 soybean, including the use of EPA-registered pesticides.

As a result of court orders and settlements, an endangered species assessment evaluating the potential impacts of the use of glyphosate on the federally threatened California red legged frog (CRLF) is underway (US-EPA, 2009c). The EPA has requested initiation of formal consultation with the USFWS under Section 7 of the ESA to address the potential effects of glyphosate on the CRLF (US-EPA, 2009c). The EPA's formal consultation request for the California red legged frog was based on the potential for direct and indirect effects due to decreases in prey items, as well as potential impacts to habitat (See Section 6, Threatened and Endangered Species).

In 2004, the EPA made a "not likely to adversely affect" determination from the use of glyphosate on 11 evolutionarily significant units (ESUs) of salmon and steelhead in California and an ESU of salmon in southern Oregon (US-EPA, 2004) (see Section 6, Threatened and Endangered Species). Formal consultation with the NMFS was initiated by EPA on October 12, 2004 to fulfill a Consent Decree entered into between EPA and the Californians' for Alternatives to Toxics related to the potential effects of various pesticides used on plants and certain threatened and endangered salmon or steelhead species. While this consultation is ongoing, the EPA has allowed glyphosate to remain on the market, and it is approved for continued use in accordance with all label requirements. Submittals to this analysis can be found at the Regulations.gov website under docket designation EPA-HQ-OPP-2009-0361.

EPA plans to conduct a comprehensive ecological risk assessment, including an endangered species assessment, for all uses of glyphosate and its salts (US-EPA, 2009a). Assessments to determine impacts on unique geographic areas include:

- An ecological risk assessment to determine whether the use of glyphosate has "no effect" or "may affect" federally listed TES or their designated critical habitat;
- A spray drift buffer zone analysis to evaluate potential exposure reductions to non-target aquatic and terrestrial plants.

The information gathered during the ecological and endangered species risk assessment will be used by the EPA to make the registration review decision.

Based on these findings, including the assumption that label use restrictions are in place to protect unique geographic areas and that those label use restrictions are adhered to, approving the petition for a determination of nonregulated status to DAS-40278-9 corn, DAS-68416-4 soybean, and DAS-44406-6 soybean is not expected to impact unique characteristics of geographic areas such as park lands, prime farm lands, wetlands, wild and scenic areas, or ecologically critical areas.

8.5 National Historic Preservation Act (NHPA) of 1966 as Amended

The NHPA of 1966 and its implementing regulations (36 CFR 800) require Federal agencies to: 1) determine whether activities they propose constitute "undertakings" that have the potential to cause effects on historic properties; 2) if so, to evaluate the effects of such undertakings on such historic resources and consult with the Advisory Council on Historic Preservation (i.e., State Historic Preservation Office, Tribal Historic Preservation Officers), as appropriate.

The APHIS proposed action, a determination of nonregulated status of DAS-40278-9 corn, DAS-68416-4 soybean, and DAS-44406-6 soybean is not expected to adversely impact cultural resources on tribal properties. Any farming activity that may be taken by farmers on tribal lands would only be conducted at the tribe’s request. Thus, the tribes would have control over any potential conflict with cultural resources on tribal properties.

The APHIS Preferred Alternative would neither impact districts, sites, highways, structures, or objects listed in or eligible for listing in the National Register of Historic Places, nor would it likely cause any loss or destruction of significant scientific, cultural, or historical resources. This action is limited to a determination of nonregulated status of DAS-40278-9 corn, DAS-68416-4 soybean, and DAS-44406-6 soybean.

The APHIS proposed action is not an undertaking that may directly or indirectly cause alteration in the character or use of historic properties protected under the NHPA. In general, common agricultural activities conducted under this action do not have the potential to introduce visual, atmospheric, or noise elements to areas in which they are used that could result in effects on the character or use of historic properties. For example, there is potential for increased noise on the use and enjoyment of a historic property during the operation of tractors and other mechanical equipment close to such sites. A built-in mitigating factor for this issue is that virtually all of the methods involved would only have temporary effects on the audible nature of a site and can be ended at any time to restore the audible qualities of such sites to their original condition with no further adverse effects. These cultivation practices are already being conducted throughout the corn and soybean production regions. The cultivation of DAS-40278-9 corn, DAS-68416-4 soybean, and DAS-44406-6 soybean is not expected to change any of these agronomic practices that would result in an adverse impact under the NHPA.

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