Stine Seed Request (09-063-01p) for an Extension of a Determination of Nonregulated Status to HCEM485

OECD Unique Identifier:
HCEM485

Final Environmental Assessment

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ACRONYMS AND ABBREVIATIONS

2mEPSPS	double mutated 5-enolpyruvylshikimate-3-phosphate synthase
ACCase	acetyl-CoA Carboxylase
AIA	advanced informed agreement
ALS	acetolactate synthase
AMS	Agricultural Marketing Service
AMPA	aminomethyl-phosphonic acid
AOSCA	Association of Official Seed Certifying Agencies
ARMS	Agricultural Resource Management Survey
ARS	Agricultural Research Service
APHIS	Animal and Plant Health Inspection Service
BMP	best management practices
BNF	Biotechnology Notification File
BRS	Biotechnology Regulatory Service's
Bt	*Bacillus thuringiensis*
Ca^{2+}	calcium ion
CAA	Clean Air Act
CAS#	Chemical Abstract Service Number
CBD	Convention on Biological Diversity
CFR	Code of Federal Regulations
CH_4	methane
CO_2	carbon dioxide
CO	carbon monoxide
Coordinated Framework	Coordinated Framework for the Regulation of Biotechnology
CP4 EPSPS	CP4 5-enolpyruvylshikimate-3-phosphate synthase protein derived from the *Agrobacterium* sp. strain
CRLF	California red-legged frog
CWA	Clean Water Act
DIMBOA	2,4-Dihydroxy-7-methoxy-2H-1,4-benzoxazin-3(4H)-one
DNA	deoxyribonucleic acid
EA	Environmental Assessment
ECOS	Environmental Conservation Online System
EEC	estimated environmental concentrations
EIS	Environmental Impact Statement
EO	Executive Order
EPA	U.S. Environmental Protection Agency
EPSPS	5-enolpyruvylshikimate-3-phosphate synthase
ERS	Economic Research Service
ESA	Endangered Species Act
ESPP	Endangered Species Protection Program
ESU	evolutionarily significant unit
FALCPA	Food Allergen Labeling and Consumer Protection Act of 2004
FDA	U.S. Food and Drug Administration
Fe^{2+}	iron ion
FFDCA	Federal Food, Drug, and Cosmetic Act
FFP	food, feed, or processing

ACRONYMS AND ABBREVIATIONS (continued)

FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FR	Federal Register
GE	genetically engineered
GHG	greenhouse gases
HED	Health Effects Division
IP	identity preservation
IPPC	International Plant Protection Convention
ISPM	International Standard for Phytosanitary Measure
K	potassium
lb/Ac	pounds per acre
lb ae/Ac	pounds acid equivalent per acre
lb ai/Ac	pounds active ingredient per acre
LMO	living modified organism
LOC	level of concern
Mn^{2+}	manganese ion
N_2O	nitrous oxide
Na	sodium
NAAQS	National Ambient Air Quality Standards
NAPPO	North American Plant Protection Organization
NASS	National Agricultural Statistics Service
NCGA	National Corn Growers' Association
NEPA	National Environmental Policy Act
NH_4^+	ammonium ion
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NO_2	nitrogen dioxide
NOP	National Organic Program
NPS	nonpoint source pollution
NRC	National Research Council
NRCS	Natural Resources Conservation Service
O_3	ozone
OECD	Organisation for Economic Co-operation and Development
Pb	lead
PDP	Pesticide Data Program
pH	potential for hydrogen measure of acidity or alkalinity
PIPs	plant-incorporated protectants
PM	particulate matter
PM_{10}	coarse particulate matter (PM) greater than 2.5 micrometers and less than 10 micrometers in diameter
$PM_{2.5}$	fine particles less than 2.5 micrometers in diameter
POEA	polyethoxylated tallow amine
PPE	personal protective equipment
ppm	parts per million
PPRA	Plant Pest Risk Assessment

ACRONYMS AND ABBREVIATIONS (continued)

PRA	Plant Risk Analysis
RED	Reregistration Eligibility Decision
RQ	risk quotients
SDWA	Safe Drinking Water Act
SIP	State Implementation Plan
SO_2	sulfur dioxide
SOC	soil organic carbon
SOM	soil organic matter
SSA	Sole Source Aquifer
Stine	Stine Seed Farm, Inc.
TES	Threatened and Endangered Species
TSCA	Toxic Substances Control Act
U.S.	United States
U.S.C	United States Code
USDA	United States Department of Agriculture's
USFWS	U.S. Fish & Wildlife Service
WPS	Worker Protection Standard

1 PURPOSE AND NEED

1.1 Background

1.1.1 Request for an extension of nonregulated status

Stine Seed Farm, Inc. (hereafter Stine) of Adel, Iowa submitted a request (APHIS Number 09-063-01p) to APHIS in 2009 for an extension of a determination of nonregulated status to Maize Line HCEM485 that expresses a modified corn *epsps* gene which confers resistance to the herbicide glyphosate. (Stine, 2011) The extension request cites the antecedent organism GA21 (Monsanto, 1997) for which a petition for nonregulated status was approved on November 18, 1997(62 F.R. 64350). In the event of an extension of a determination of nonregulated status, the nonregulated status for Maize Line HCEM485 would include Maize Line HCEM485, any progeny derived from crosses between Maize Line HCEM485 and conventional corn, and crosses of Maize Line HCEM485 with other biotechnology-derived corn that are no longer subject to the regulatory requirements of 7 CFR part 340 or the plant pest provisions of the Plant Protection Act. Maize Line HCEM485 is currently regulated under 7 CFR part 340. Interstate movements and field trials of Maize Line HCEM485 have been conducted under permits issued or notifications acknowledged by APHIS since 2005. Data resulting from these field trials are described in the extension request (Stine, 2011).

1.1.2 Purpose of Product

The purpose of Maize Line HCEM485 is to provide another corn seed option that confers resistance to the herbicide glyphosate (Stine, 2011). Glyphosate works non-selectively on a wide range of plant species and may be applied at different growth stages; hence, it is easy to use, is a relatively low-cost herbicide, and facilitates conservation tillage farming practices while being relatively lower in toxicity to the environment than other pesticides (Gianessi, 2008; Duke and Powles, 2009). The potential commercial use of Maize Line HCEM485 would offer farmers an additional choice of glyphosate-resistant varieties for the control of weeds.

1.1.3 Coordinated Framework Review

Since 1986, the United States government has regulated genetically engineered (GE) organisms pursuant to a regulatory framework known as the Coordinated Framework for the Regulation of Biotechnology (Coordinated Framework) (51 FR 23302; 57 FR 22984). The Coordinated Framework, published by the Office of Science and Technology Policy, describes the comprehensive federal regulatory policy for ensuring the safety of biotechnology research and products and explains how federal agencies will use existing Federal statutes in a manner to ensure public health and environmental safety while maintaining regulatory flexibility to avoid impeding the growth of the biotechnology industry. The Coordinated Framework is based on several important guiding principles: (1) agencies should define those transgenic organisms subject to review to the extent permitted by their respective statutory authorities; (2) agencies are required to focus on the characteristics and risks of the biotechnology product, not the process by which it is created; (3) agencies are mandated to exercise oversight of GE organisms only when there is evidence of "unreasonable" risk.

The Coordinated Framework explains the regulatory roles and authorities for the three major agencies involved in regulating GE organisms: USDA's Animal and Plant Health Inspection

Service (APHIS), the Environmental Protection Agency (EPA), and the Food and Drug Administration (FDA).

USDA-APHIS

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

A person may petition the agency that a particular regulated article is unlikely to pose a plant pest risk, and, therefore, is no longer regulated under the plant pest provisions of the Plant Protection Act or the regulations at 7 CFR 340. A GE organism is no longer subject to the regulatory requirements of 7 CFR part 340 or the plant pest provisions of the Plant Protection Act when APHIS determines that it is unlikely to pose a plant pest risk.

A person may also request that APHIS extend a determination of nonregulated status to other organisms under §340.6(e)(2) of the regulations. Such a request shall include information to establish the similarity of the antecedent organism and the regulated articles in question.

Environmental Protection Agency

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

Under FIFRA (7 U.S.C. 136 *et seq.*), EPA regulates the use of pesticides (requiring registration of a pesticide for a specific use prior to distribution or sale of the pesticide for a proposed use pattern). EPA examines the ingredients of the pesticide; the particular site or crop on which it is to be used; the amount, frequency, and timing of its use; and storage and disposal practices. Prior to registration for a new use for a new or previously registered pesticide, EPA must determine through testing that the pesticide will 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 not legally be used unless the use is consistent with the approved directions for use on the pesticide's label or labeling. The overall intent of the label is to provide clear directions for effective product performance while minimizing risks to human health and the environment. The Food Quality Protection Act (FQPA) of 1996 amended FIFRA, enabling 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).

EPA also sets tolerances for residues of pesticides on and in food and animal feed, or establishes an exemption from the requirement for a tolerance, under the Federal Food, Drug, and Cosmetic Act (FFDCA). EPA is required, before establishing pesticide tolerance, to reach a safety determination based on a finding of reasonable certainty of no harm under the FFDCA, as amended by the FQPA. FDA enforces the pesticide tolerances set by EPA.

Food and Drug Administration

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, in the *Federal Register* on May 29, 1992 (57 FR 22984). Under this policy, 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 bioengineered food. This voluntary consultation process provides a way for developers to receive assistance from FDA in complying with their obligations under Federal food safety laws prior to marketing.

More recently, in June 2006, FDA 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) for establishing voluntary food safety evaluations for new non-pesticidal proteins produced by new plant varieties intended to be used as food, including bioengineered plants. Early food safety evaluations help make sure 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 FDA, but the information may be used later in the biotechnology consultation.

Maize Line HCEM485 is within the scope of the FDA policy statement concerning regulation of products derived from new plant varieties, including those produced through genetic engineering. Stine initiated the consultation process with the FDA for the commercial distribution of Maize Line HCEM485 and submitted a safety and nutritional assessment of food and feed derived from Maize Line HCEM485 to the FDA in December 2010 in support of the consultation with the FDA for the commercial distribution of Maize Line HCEM485; as of publication of this EA, a determination is still pending (see http://www.accessdata.fda.gov/scripts/fcn/fcnNavigation.cfm?rpt=bioListing for a list of completed consultations).

1.2 Purpose and Need for APHIS Action

Under the authority of the plant pest provisions of the Plant Protection Act and 7 CFR part 340, APHIS has issued regulations for the safe development and use of GE organisms. A person may petition the agency that a particular regulated article is unlikely to pose a plant pest risk, and, therefore, is no longer regulated under the plant pest provisions of the Plant Protection Act or the regulations at 7 CFR 340. A GE organism is no longer subject to the regulatory requirements of 7 CFR part 340 or the plant pest provisions of the Plant Protection Act when APHIS determines that it is unlikely to pose a plant pest risk. A person may also request that APHIS extend a determination of nonregulated status to other organisms under §340.6(e)(2) of the regulations. Such a request shall include information to establish the similarity of the antecedent organism and the regulated articles in question. As required by § 340.6, APHIS must respond to petitioners who request a determination of the regulated status of GE organisms, including GE plants such as Maize Line HCEM485. When a request for an extension of nonregulated status is submitted, APHIS must make a determination if the GE organism is similar to an antecedent organism which has previously been determined to be unlikely to pose a plant pest risk. If APHIS determines based on its Plant Pest Risk Assessment (PPRA) of the antecedent organism that the genetically engineered organism identified in the extension request is unlikely to pose a plant pest risk, the genetically engineered organism is no longer subject to the plant pest provisions of the Plant Protection Act and 7 CFR part 340.

APHIS has prepared this Environmental Assessment (EA) to consider the potential environmental effects of an agency determination of nonregulated status consistent with Council of Environmental Quality's National Environmental Policy Act (NEPA) regulations and the USDA and APHIS NEPA implementing regulations and procedures (40 CFR parts 1500-1508, 7 CFR part 1b, and 7 CFR part 372). This EA has been prepared in order to specifically evaluate the effects on the quality of the human environment[1] that may result from APHIS' response to Stine's extension request for a determination of nonregulated status of Maize Line HCEM485.

1.3 Public Involvement

APHIS routinely seeks public comment on EAs prepared in response to petitions for nonregulated status of GE organisms. APHIS does this through a notice published in the *Federal Register*. The issues discussed in this EA were developed by considering the public concerns as well as issues raised in public comments submitted for other EAs of GE organisms, concerns raised in lawsuits, as well as those issues of concern that have been raised by various stakeholders. These issues, including those regarding the agricultural production of corn using various production methods and the environmental and food/feed safety of GE plants were addressed to analyze the potential environmental impacts of Maize Line HCEM485 corn. This EA will be available for public comment for a period of 30 days. Comments received by the end of the 30-day period will be analyzed and used to inform APHIS' decision to extend the determination of nonregulated status of GA21 to Maize Line HCEM485 and to assist APHIS in determining whether an Environmental Impact Statement (EIS) is required prior to making a determination decision of the regulated status of this corn variety.

Paragraph (e) of § 340.6 provides that APHIS will publish a notice in the *Federal Register* announcing all preliminary decisions to extend determinations of nonregulated status for 30 days before the decisions become final and effective. In accordance with § 340.6(e) of the regulations, APHIS will publish a notice to inform the public of their preliminary decision to

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

extend the determination of nonregulated status of GA21 to Maize Line HCEM485 along with the extension request submitted by Stine and APHIS' PPRA. Issues Considered

The list of resource areas considered in this EA were developed by APHIS through experience in considering public concerns and issues raised in public comments submitted for other EAs of GE organisms. The resource areas considered also address concerns raised in previous and unrelated lawsuits, as well as issues that have been raised by various stakeholders in the past. The resource areas considered in this EA can be categorized as follows:

Agricultural Production Considerations:
- Acreage and Areas of Corn Production
- Agronomic/Cropping Practices
- Corn Seed Production
- Organic Corn Production

Environmental Considerations:
- Soil
- Water Resources
- Air Quality
- Climate Change
- Animals
- Plants
- Gene Flow
- Microorganisms
- Biological Diversity

Human Health Considerations:
- Public Health
- Worker Safety

Livestock Health Considerations:
- Livestock Health/Animal Feed

Socioeconomic Considerations:
- Domestic Economic Environment
- Trade Economic Environment

2 AFFECTED ENVIRONMENT

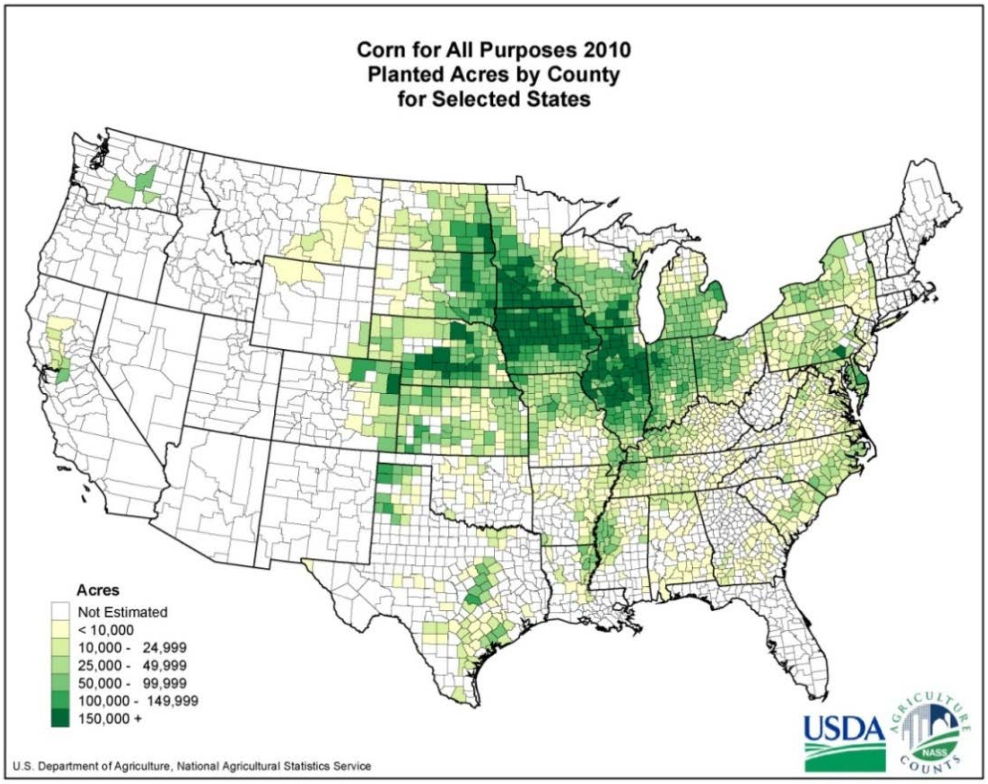
2.1 Agricultural Production of Corn

2.1.1 Acreage and Area of Corn Production

Corn (*Zea mays,* L.) is an annual grass cultivated in the U.S. in temperate regions with adequate frost-free days and moisture to promote plant maturity. It is native to the Americas and is referred to by much of the world as maize, a Native American name for the crop (Hoeft et al., 2000). Corn may be successfully cultivated in many parts of the world, but the U.S. Midwest is the largest area with ideal conditions in the gently rolling topography, medium soil texture with high-moisture holding capacity, and temperature and rainfall regimes most favorable to corn production (Hoeft et al., 2000). Most of the corn produced in the U.S. is hybrid corn varieties adapted to local environmental and soil conditions. Generally, corn agronomic characteristics, such as optimal planting timeframe, disease and pest pressures, length of growing period, and water requirements, also vary by region (Neild and Newman, 1990; Hoeft et al., 2000; USDA-ERS, 2000; Koenning and Wiatrak, 2012). The geographic range of corn production in the U.S. has been expanded by growing the crop under irrigation and breeding programs to increase drought and cold tolerance, shorten length of growing period, and improve disease and pest resistance (Neild and Newman, 1990; Hoeft et al., 2000; Corn and Soybean Digest, 2009; Carena, 2010).

Corn is the largest crop grown in the U.S. in terms of value (USGC, 2010), acreage planted, and geographic area of production. It is so adaptable it is cultivated in every continental U.S. state except Alaska, with winter breeding nurseries in Hawaii and Puerto Rico (Leidy, 2009; Alfaro, 2011). The top corn producing states loosely known as the “Corn Belt” are Iowa, Illinois, Nebraska, Minnesota, South Dakota, Indiana, Kansas, Wisconsin, Ohio, and Missouri and collectively produce over 80% of U.S. corn (USDA-NASS, 2011e). Figure 1 presents planted corn acreage in select states of the continental U.S. as of 2010 (USDA-NASS, 2011d).

The amount of corn planted in the U.S. in 2011 totaled about 92.3 million acres, an increase of approximately 4.1 million acres over 2010 (USDA-NASS, 2011b). From 1991 to 2011, acreage planted with corn increased from just over 76.0 million acres to about 92.3 million acres, nearly a 21% increase (USDA-NASS, 2011i) (Figure 2). Over that 20 year span, U.S. production of field corn for grain increased from approximately 7.5 billion bushels (191 million metric tons) in 1991 to approximately 12.4 billion bushels (315 million metric tons) in 2010, and average annual yield had increased approximately 41% from 108.6 bushels per acre in 1991 to 152.8 bushels per acre in 2010 (USDA-NASS, 2011e). At the same time, the use of corn for bioethanol production substantially contributed to the expansion in U.S. corn acreage. Between 2000 and 2009, U.S. ethanol production increased by nine billion gallons, accompanied with increased demand for feedstock (Wallander et al., 2011). Over the same period, the amount of harvested corn acreage increased by about 7.2 million acres, although, the change in corn production was not only driven by energy prices, but by other market forces such as exchange rates, increased global demand for meat, and weather conditions (USDA-OCE, 2011; Wallander et al., 2011). High prices as a result of increased demand for ethanol feedstocks and meat are expected to increase corn production through 2020 (USDA-OCE, 2011).

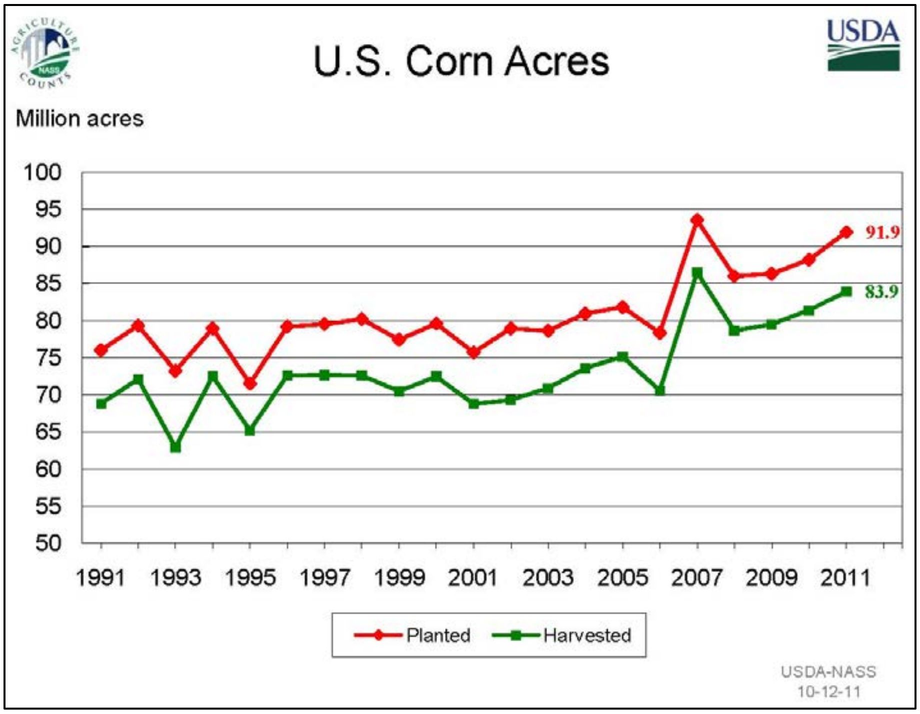


Source: (USDA-NASS, 2011d)

Figure 1. The 2010 estimated amount of planted corn acreage by U.S. county in selected states. Estimates range from those counties that had less than 10,000 acres of planted corn to those with 150,000 acres or more, and also reflect those counties not included in the estimation.

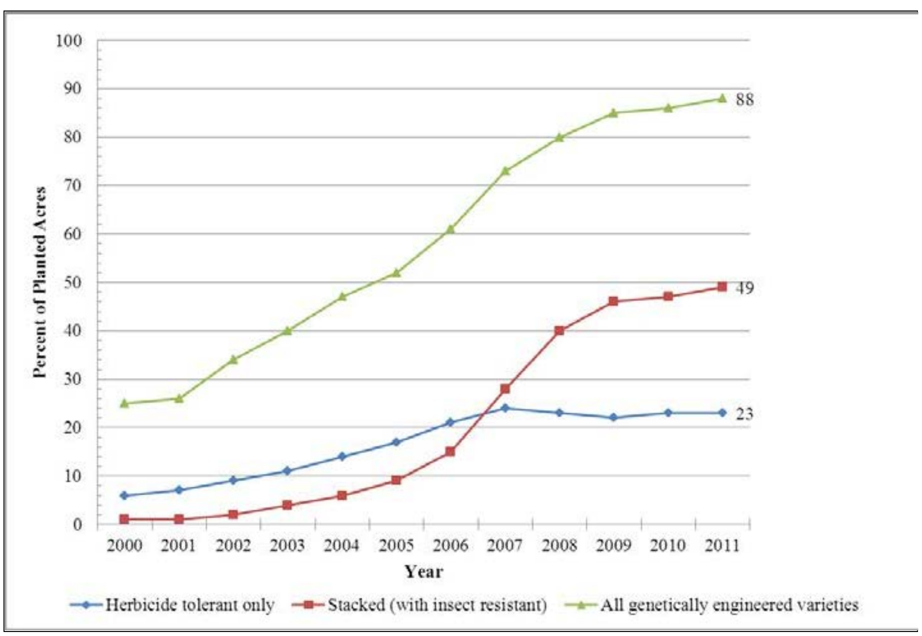
Corn is also used for forage and silage animal feed. From 1991 to 2010, acreage devoted to growing corn for silage decreased from approximately 6.1 million acres to approximately 5.6 million acres; however, annual production of corn silage also increased 32% over that period from approximately 81.2 million tons to nearly 107.3 million tons (USDA-NASS, 2011e).

As of 2011, approximately 88% of all corn planted in the U.S. is GE. Forty-nine percent are stacked (multiple) gene varieties having both herbicide- and insect-resistant traits (Figure 3) (USDA-ERS, 2011a). Herbicide-resistant varieties account for 23%, and insect-resistant-only cultivars comprised 16%. Other value-added corn GE traits include enhanced oil, starch, or nutritional characteristics and drought tolerance (USGC, 2010; USDA-APHIS, 2012). The first herbicide-resistant corn variety released in 1995 was glufosinate resistant and the first stacked hybrid varieties were released in 1997 (USDA-APHIS, 2012). The adoption of herbicide-resistant corn was relatively low in 2000 (approximately 6%), yet all states surveyed as part of the Economic Research Service (ERS) corn estimating program steadily increased their adoption through 2011 (Figure 4) (USDA-ERS, 2011a). The amount of herbicide-resistant-only corn planted in the U.S. increased between 2000 and 2007 from 6% to 24% of all planted corn, yet has remained relatively steady since then at 22% to 23% of all planted corn (USDA-ERS, 2011a). In addition, adoption of stacked corn varieties (those containing both herbicide- and insect-resistant traits) increased from 1% in 2000 to 49% in 2011 (USDA-ERS, 2011a).



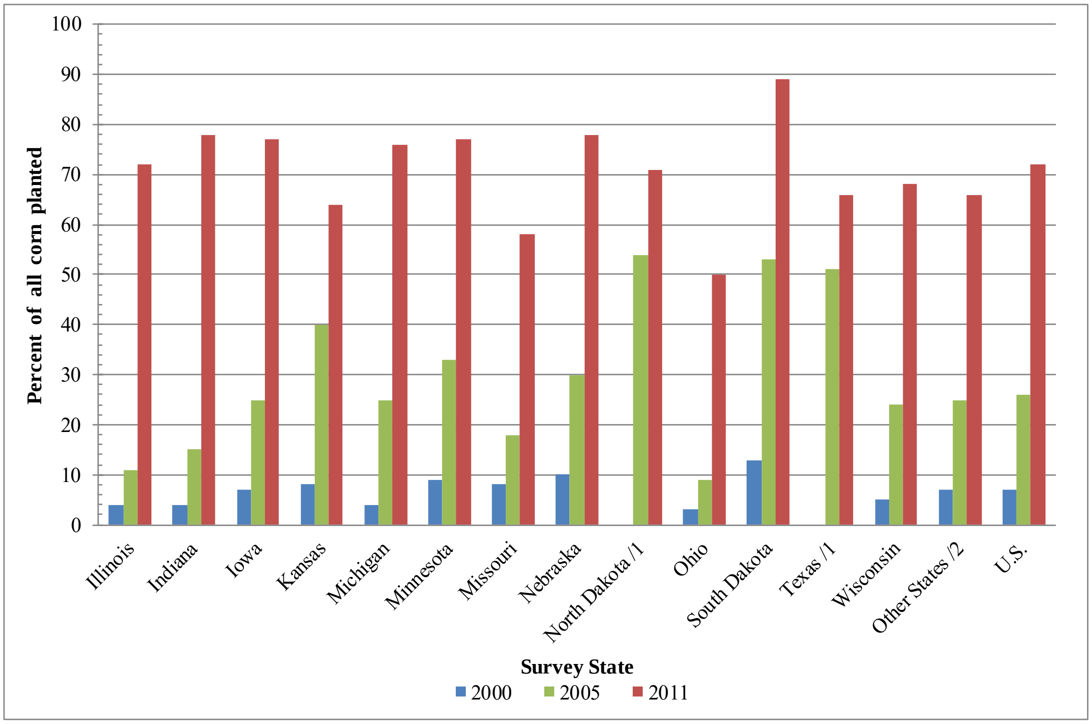
Source: (USDA-NASS, 2011j)

Figure 2. The amount of planted and harvested corn acreage in millions of acres within the U.S. from 1991 through 2011.



Source: (USDA-ERS, 2011a)

Figure 3. The percentage of U.S. planted corn acreage with GE varieties from 2000 through 2011. All GE varieties are inclusive of insect-resistant-only (*Bacillus thuringiensis* (Bt)), herbicide-resistant-only, and stacked varieties (having both insect- and herbicide-resistant traits).



Source: (USDA-ERS, 2011a)
[1] Estimates published individually beginning in 2005.
[2] Includes all other states in the corn-estimating program.

Figure 4. The adoption, as a percentage of all planted corn, of herbicide-resistant corn (including herbicide-resistant-only and stacked herbicide- and insect-resistant varieties) in 2000, 2005, and 2011 of corn estimating program states.

Each year, the ERS updates its ten-year projections of supply and utilization for major field crops, including corn, soybeans, and wheat grown in the U.S. The ERS long-term projections are a conditional scenario based on specific assumptions about the macroeconomy, agricultural and trade policies, the weather, and international developments (USDA-OCE, 2011). Factors incorporated into the projection models include global economic growth, population trends, the value of the U.S. dollar and other currencies, oil prices, U.S. and international agricultural policy, the U.S. and international biofuels sector, livestock and meat trade, and prices (USDA-OCE, 2011). Long-term projections show planted corn retaining its recent gains, maintaining between approximately 90 and 92 million acres a year through 2020 (USDA-OCE, 2011). The projected stability of U.S. planted corn acreage for the period is attributed to increased export competition, leveling of ethanol production based on corn, and continued higher price realization and yields, among other factors (USDA-OCE, 2011). Yields are projected to substantially increase; 2011 yields were 154.3 bushels per acre and are projected to increase to 180.0 bushels per acre by 2020 (USDA-OCE, 2011).

2.1.2 Agronomic Practices

Agronomic practices associated with corn production include several crop management systems that are available to producers. Conventional farming in this document refers to any farming system where synthetic pesticides or fertilizers may be used. This type of farming broadly includes occasional use of pesticides and fertilizers to those that depend on regular inputs for successful crop production. This definition of 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 Protection Act. Organic systems exclude certain production methods, such as synthetic agricultural inputs and GE crops, and are discussed in more detail below. Although specific crop production practices vary according to geographic area and end-use market, they commonly include tillage, irrigation, agricultural inputs such as fertilizers and pesticides, and crop rotation systems. The following introduces the basic cultivation requirements of corn and the agronomic practices commonly employed to produce corn in the U.S. More detailed information regarding the biology of corn may be obtained by consulting Stine's Request for Extension of Determination of Nonregulated Status to the Additional Regulated Article: Maize Line HCEM485 (APHIS Number 09-063-01p) or APHIS's Plant Pest Risk Assessment for Maize Line HCEM485 (Stine, 2010; USDA-APHIS, 2011b).

Cultivation

Corn (*Zea mays* ssp. *mays* L.) is a member of the *Poaceae* grass family (OECD, 2003). Corn was originally domesticated from various wild relatives in the teosinte taxa (*Z. Mexicana*) in South Mexico and Central America approximately 10,000 years ago (Matsuoka et al., 2002). Cultivated corn is sexually compatible with other members of the genus *Zea*, and to a much lesser degree with members of the genus *Tripsacum* grasses, the closest wild relative with which corn can interbreed. Teosinte grows in the tropical regions of Mexico, Guatemala, and Nicaragua. (USDA-APHIS, 2011b). Three species of *Tripsacum* (*T. dactyloides, T. floridatum*, and *T. lanceolatum*) are found in the continental U.S. (OECD, 2003), and two (*T. fasciculatum* and *T. latifolium*) also occur in Puerto Rico (USDA-NRCS, 2011b). Corn is an annual plant with male tassels and female silks (i.e., it is monoecious) and is fertilized by windborne pollen, afterwards developing seeds on the cob that requires the assistance of humans to disperse (OECD, 2003). It freely hybridizes among its many races, as well as with wild annual teosinte and a few *Tripsacum* grass species, although the latter has not been documented outside of experimental breeding (OECD, 2003).

The primary types of corn include dent, flint, flour, pop, and sweet corn, cultivars differing in their quantity, quality, and seed (endosperm) composition (Brown et al., 1985). Corn production in the U.S. is dominated by dent corn. Producers can choose from a large variety of corn lines developed from traditional breeding or GE systems; in 2010 it was estimated there were over 6,000 traited[2] and 1,000 conventional varieties from which to choose (Monsanto, 2011c).

Corn is highly adaptable, tolerating widely divergent altitudes, sunlight, humidity, and temperature regimes (OECD, 2003). Corn is a warm weather crop grown in temperate latitudes due to the number of frost free days (110-115 days) and moisture needed for its production (OECD, 2003). The crop requires over 20 inches of rainfall to produce, but yields greatly increase in areas receiving over 30 inches of rainfall (Brown et al., 1985). Moisture availability within the week after silking is critical, as even one day of drought stress can reduce yields by 8% (Duncan et al., 2007). Farmers in areas that predictably have high temperature stress and rainfall deficiencies during critical corn growth stages plant earlier and typically use earlier maturing varieties (Brown et al., 1985). Corn hybrids in the U.S. are traditionally classified into

[2] Traited seeds are hybrid crop seeds that contain transgenic traits.

15 maturity groups, but actual maturation of a given hybrid can vary primarily based upon temperature and available moisture (Brown et al., 1985)

Corn produces best on deep loamy soils, but can be grown in sandy to heavy clay settings (OECD, 2003; Ross et al., 2006). Optimal soil acidity (pH) for corn cultivation ranges from 5.8 to 7.0, and key soil nutrients are nitrogen, phosphorous, potassium, calcium, magnesium, sulfur, and micronutrients such as iron, manganese, zinc, and copper (Espinoza and Ross, 2006). Good drainage is also an important element, as areas with inadequate drainage limit yield (Ross et al., 2006). Overall, adequate drainage is achieved when there is no standing water in a field 24 hours following rainfall or irrigation (Tacker et al., 2006).

Depending upon the specific location, corn is typically planted from mid-March to the beginning of July; corn grown in more southern regions is planted earlier in the year than corn grown in northern regions (USDA-NASS, 1997). However, planting dates have moved earlier given the development of new maize cultivars that are better adapted to cooler soil conditions, although planting time fluctuates with wet springs (Kucharik, 2006). Planting date is important (especially for full season varieties); however, the critical factor for deciding when to plant is soil condition (i.e., temperature and moisture level), provided planting is accomplished within the timeframe for adequate maturation (Farnham, 2001a). If later planting is necessary, earlier maturing hybrids should be used to lower the potential of reduced yields.

Planting rates are determined by the germination percentage of the seed used, soil conditions, and anticipated pest problems; producers usually plant more seed than the intended plant population goal (Farnham, 2001a). Plant populations are established based on a number of decisions and factors, including but not limited to soil properties, fertility, row spacing, yield goals, and corn cultivar. Carefully planned planting strategies and selection of corn cultivars that thrive in high populations and closer spacing may increase yields (Leidy, 2009; Stine, 2010). In a study in Illinois, Widdicombe and Thelen (2002) found that average corn yield increased as row width narrowed from 76 centimeters to 56 and 38 centimeters (approximately 2 feet 6 inches to 1 foot 10 inches and 1 foot 3 inches), and that the highest plant density evaluated (90,000 plants per hectare) had the highest grain yield. However, in a study that compared row spacing in Iowa, Farnham (2001b) found that there was no statistical difference in yields between corn planted with 76 centimeter row spacing and that planted in 38 centimeter row spacing, although it was found that some hybrids tested had greater yield when planted in the decreased row spacing width, while other hybrids had greater yields in rows with wider spacing.

The determination of when is the best time to harvest includes considerations such as the price of corn, potential yield, the length of the harvest period, weather, and equipment and labor costs, all of which can change during the course of the harvest season (Bitzer et al., No Date). Harvesting corn is done mechanically and varies based on the region. For example, harvest in Kansas typically occurs from early September to mid-November, depending on the weather conditions, while harvest in North Dakota begins in late September and ends in late November (Olson and Sander, 1988; USDA-NASS, 1997). The extent of kernel damage to field corn while mechanically harvesting is dependent on its moisture content (Huitink, 2006); hence, corn ear moisture is factored into the determination of when to harvest. Field corn must be dried to 12% moisture content for storage extending longer than a few months (Gardisser, 2006); thus, economical harvest timing is dependent upon drying cost, any high moisture discounts levied upon sale, field loss, and damage penalties (Huitink, 2006). Corn harvested for silage is accomplished earlier than for grain, when standing plants still contain 65% to 70% moisture, just before physical maturity at the R7 growth stage (Lee et al., 2005).

Crop Rotation

Crop rotations are used to optimize soil nutrition and fertility, and reduce weeds, insects, and disease problems (Olson and Sander, 1988; Hoeft et al., 2000; Cartwright et al., 2006; McLeod and Studebaker, 2006; Leikam and Megel, 2007; Green and Owen, 2011). Crop rotation is the successive planting of different crops in the same field over a particular period of years. Crop rotation has two primary goals: 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". Crops in the legume family fix nitrogen in soil, improving the yield of following crops such as corn or wheat (Berglund and Helms, 2003). Moreover, the rotation of crops can effectively reduce disease, pest incidence, weediness, and selection pressure for weed resistance to herbicides (USDA-ERS, 1997b; Berglund and Helms, 2003). 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 choice of crop rotation system to use, ranging from soil type present in an individual field to 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 (Hoeft et al., 2000; Langemeier, 2007; Duffy, 2011).

Crops used in rotation with corn vary regionally and include oats, peanut, soybean, wheat, rye, and forage (USDA-APHIS, 2011b). In 2010, 71% of corn acreage in 19 surveyed states was under some form of rotation (USDA-NASS, 2011c). Cropland used for corn and soybean production is nearly identical in many areas, such as Illinois, where over 90% of the cropped area is planted in a two-year corn-soybean rotation (Hoeft et al., 2000). Returns for producers from corn-soybean-corn are variable, dependent upon the price and projected yield of both corn and soybean for an individual operator (Stockton, 2007).

Recently, there has been an increase in continuous corn rotations given the profitability of corn production (USDA-ERS, 2011d) and the strong demand for grain (USDA-OCE, 2011). Continuous corn rotations require more fertilizer treatments to replace diminished soil nitrogen levels and more pesticide applications (Bernick, 2007; Laws, 2007; Erickson and Alexander, 2008). Producers planting continuous corn are more likely to rely on GE varieties to compensate for the increased risk of corn pests and limited options of herbicides that come with growing corn over several consecutive years (Erickson and Alexander, 2008). Since more crop residue is produced, additional tillage prior to planting is necessary to prevent interference with mechanical planters or the application of fertilizer, and facilitate springtime warming of the soil (Bernick, 2007; Laws, 2007; Erickson and Alexander, 2008). More corn residue accumulation also contributes to higher potential for disease and insect infestation in continuous corn rotations (Laws, 2007; Nafziger, 2011). 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).

Corn seed left in a field after harvest can grow in a subsequent crop rotation and is known as "volunteer" corn (USDA-APHIS, 2011b). Subsection 2.3.2, Plants Communities, has a more detailed discussion of this issue and corresponding impacts analysis is found in Subsection 4.4.2, Plants Communities.

Tillage

Tillage is used to prepare a seedbed, address soil compaction, incorporate fertilizers and herbicides, manage water movement both within and out of a production field, control weeds, and reduce the incidence of insect pests and plant disease (Hoeft et al., 2000; Christensen, 2002; Fawcett and Towery, 2002; Tacker et al., 2006; Givens et al., 2009; NRC, 2010). A variety of tillage systems accomplishes these goals, with each system defined by the remaining plant residue left on the field. These residues aid in conserving soil moisture and reduce wind and water-induced soil erosion (USDA-ERS, 1997a; USDA-NRCS, 2005; Heatherly et al., 2009). Conventional tillage employs moldboard plows, heavy disks, and chisel plows that disturb soil and leaves less than 15% of crop residue on the surface (Heatherly et al., 2009; Towery and Werblow, 2010). Conservation tillage employs tools that disturb soil less and leaves more crop residues on the surface (at least 30%), whereas no-till farming only disturbs the soil for planting seed (USDA-NRCS, 2005; Towery and Werblow, 2010). The choice to till is dependent upon a variety of factors (Hoeft et al., 2000), such as:

- desired yields;
- soil type and moisture storage capacity;
- crop rotation pattern;
- prevalence of insect and weed pests;
- risk of soil compaction and erosion;
- the need for crop residue or animal waste disposal; and
- management and time constraints.

Tillage may increase yields in some cropping systems and soils, and not in others. For example, if a tillage system increases moisture infiltration, production potentially increases in response, but if it also increases denitrification or the incidence of plant diseases, crop yield would likely decrease (Hoeft et al., 2000). Tillage can impact the amount of agronomic inputs needed to maintain soil fertility and moisture and the amount of agricultural chemicals needed to control insect and weed pests (Olson and Sander, 1988; Hoeft et al., 2000; Cerdeira and Duke, 2006).

According to USDA Agricultural Resource Management Survey (ARMS) 2010 data, the average residue remaining on the soil surface after planting corn was 34% and an average of 1.4 tillage operations per corn crop were conducted (USDA-ERS, 2011f). The plant residue coverage of the soil after planting increased dramatically to 65% for no-till corn production in 2005; however, no-till corn production represented only 24% of all corn acres planted in the U.S. (USDA-ERS, 2011f). In 2010, 62% of planted corn acreage in 19 surveyed states was dedicated to no-till or minimum till systems (USDA-NASS, 2011c). Increases in total acres dedicated to conservation tillage have been attributed to increased use of GE crops, reducing the need for mechanical weed control, although the change in tillage practices in corn was less dramatic than other crops such as soybean or cotton, as many growers of corn had already changed to conservation tillage systems as a means to reduce soil erosion (Fawcett and Towery, 2002; Givens et al., 2009).

Agricultural Inputs

Depending on the region and practices used, corn production includes inputs such as irrigation, fertilizer (e.g., synthetic fertilizers, manures, and composts containing nitrogen, phosphorus and potassium), pesticides (e.g., insecticides, herbicides), and fungicides (Olson and Sander, 1988; Hoeft et al., 2000; McLeod and Studebaker, 2006). Irrigation provides essential water for growth where rainfall is insufficient or erratic. This issue is discussed in detail in Subsection 2.2.2, Water Resources, and the corresponding impacts analysis in Subsection 4.3.2. While most of the corn produced in the U.S. is grown without irrigation, approximately 14.2% of the harvested grain and silage corn acres were irrigated in 2008, the latest year with available national statistics reported (USDA-NASS, 2011e; USDA-NASS, 2011b).

Soil and foliar macronutrient applications to corn primarily include nitrogen, phosphorous (phosphate), potassium (potash), calcium, and sulfur, with other micronutrient supplements such as zinc, iron, and magnesium applied as needed (Espinoza and Ross, 2006). A 2010 survey of 19 corn producing states conducted by National Agricultural Statistics Service (NASS) found nitrogen was the most widely used fertilizer on corn, applied to 97% of planted acres at an average rate of 140 pounds per acre (lb/Ac) (USDA-NASS, 2011c). Macronutrient phosphate was applied at an average rate of 60 lb/Ac to 78% of planted corn and potash was applied to 61% of planted acres at the rate of 79 lb/Ac. The survey found sulfur was applied less extensively at a rate of 13 lb/Ac to 15% of acres planted to corn (USDA-NASS, 2011c).

A wide variety of pests can hinder corn production and many require agricultural pesticidal inputs for their control. Several groups and types of insects can feed on the seeds, roots, stalk, leaf, and ear of the corn plant, and can reduce yield if not adequately controlled. Major corn insect pests are the seed corn maggot (*Hylemya platura)*, European (*Ostrinia nubilalis* Hübner) and Southwestern (*Diatraea grandiosella*) corn stalk borer, the Western (*Diabrotica virgifera virgifera* LeConte), Northern (*Diabrotica barberi* Smith and Lawrence), and Southern (*Diabrotica undecimpunctata howardi* Barber) rootworm, and earworms (*Helicoverpa zea)* (Flanders et al., 2009). Additionally, there are soil nematodes (microscopic worms) of which the majority are beneficial; however, the few that are parasitic can constitute a significant management issue (SWCS, 2000) and are discussed in more detail in Subsection 2.3.4, Microorganisms, and corresponding impact analysis in Subsection 4.4.4.

Before deciding to apply insecticides, producers should be relatively sure that yield increases will justify paying for the application cost (Higgins, 1997). Insect infestation thresholds for the most damaging pests have been established to indicate when control measures 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 (for example, see the Field Corn Pest Management Strategic Plan, North Central Region at http://www.ipmcenters.org/cropprofiles/index.cfm) (NSF Center for IPM, 2002). In 2010, insecticide active ingredients were applied to 12% of acres planted to corn in 19 surveyed states (USDA-NASS, 2011c). Tefluthrin was applied on average to the most planted corn acreage at 3% to control corn rootworm, followed by bifenthrin (corn earworm, thrips), cyfluthrin (corn rootworm, earworm, European corn borer), lambda-cyhalothrin (corn earworm, European corn borer), and tebupirimphos (corn rootworm, seed corn maggot), each equally treating an average 2% of planted corn acreage (USDA-NASS, 2011a). Producers can minimize the need to apply pesticides by choosing resistant cultivars (including GE varieties designed to kill particular pests), introducing beneficial pests that prey on targeted insects, and implementing crop rotation and tillage best management practices (BMPs) as discussed above.

Several plant diseases can also reduce corn yield (Cartwright et al., 2006), many of which are addressed with planting disease-resistant cultivars, and relatively few that may be treated with fungicides. The most common corn pathogens are fungi, viruses, bacteria, and nematodes. Factors contributing to crop disease include the susceptibility of the plant host, and a favorable air and soil environment (Stuckey et al., 1993). Diseases that afflict corn with significant potential for economic loss include fungal corn rusts, cornleaf blights, ear smuts, ear and kernel rot fungi, and maize mosaic viruses (Cartwright et al., 2006). In 2010, fungicides were applied to 8.0% of acres planted to corn in 19 survey states (USDA-NASS, 2011c).

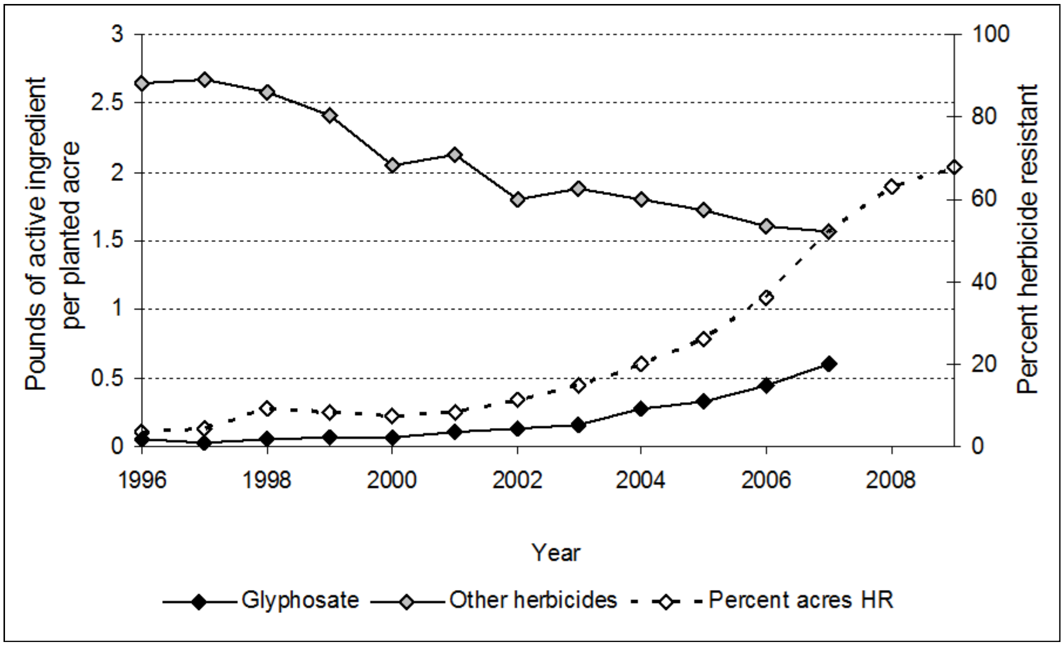
Weeds are the most important pest complex that interferes with maximum yield and profitability in U.S. agriculture; therefore, effective weed management is critically important to sustainable production (Owen et al., 2011). Weeds have the most impact on potential corn yields in the first six weeks after planting and can reduce yields by as much as 50% if they are uncontrolled (Smith and Scott, 2006). Practices to reduce the incidence of weeds include tillage, crop rotation, intercropping, the use of ground covers and mulches, flame weeding, and the application of herbicides (Gunsolus, 2006; Hedtke et al., 2006; Smith and Scott, 2006; CropsReview, 2011; USDA-NASS, 2011c). In addition, no-till practices also reduce weed occurrence by minimizing soil disturbance that promotes weed seed germination (University of California, 2009).

Although cultivation controls weeds, it prunes corn roots in later growth stages, potentially reducing yields. This fact and the availability of better herbicide technology have driven producers to turn to more chemical weed control than cultivation in corn production (Smith and Scott, 2006). Herbicides have different ways of acting on plant physiology (i.e., modes of action) to affect the health of a given plant. Some common modes of herbicide action include amino acid inhibitors such as glyphosate and imazethapyr, chlorophyll pigment inhibitors like atrazine, auxin growth regulators including dicamba and 2,4-D, long chain fatty acid inhibitors such as acetochlor and s-metolachlor, and glutamine synthase inhibitors such as glufosinate (University of Wisconsin, No Date). Herbicides are applied pre-emergence to a crop (i.e., "preplant burndown") and post-emergence. If herbicides were not available, it is estimated that approximately 20% of yields would be lost to weeds, assuming only tillage and hand weeding remain as the weed management tactic (Gianessi and Reigner, 2007). Hand and mechanical tillage methods to control weeds damage crops, prune roots, and increase plant susceptibility to some diseases, which decrease yield; furthermore, any delays in mechanical weed control due to events such as weather increases the chance for crop damage when tillage can resume, or may cause the loss of crops in sections or an entire field (Gianessi and Reigner, 2007).

In 2010, more than 98% of corn acres in 19 surveyed states (Arkansas, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Michigan, Minnesota, Mississippi, Missouri, Nebraska, North Carolina, North Dakota, Ohio, South Dakota, Tennessee, Virginia, and Wisconsin) were treated with herbicides and more than two-thirds of the total pesticides applied to corn in those states were herbicides (USDA-NASS, 2011c). Of the latter, 66% of the 2010 corn acreage in the surveyed states was treated with glyphosate, 61% with atrazine, and 25% with acetochlor (USDA-NASS, 2011c). Compared to data collected in a 2005 survey from the same 19 states, glyphosate-treated planted corn acres increased 35%, atrazine was applied to 5% fewer acres, and acetochlor treatments of planted acres increased 2% (USDA-NASS, 2007a; USDA-NASS, 2011c). The dramatic increase in the use of glyphosate as a consequence of expanded adoption of the GE trait in corn production is primarily attributed to the herbicide's effective and efficient weed control as a non-selective herbicide (Owen et al., 2011). Its relatively low cost and simplicity of use, coupled with minimal animal toxicological and environmental impact, as well as its support of conservation tillage practices makes it a desirable weed management tool and reduces overall production costs (Duke and Powles, 2009; NRC, 2010; Green and Owen, 2011).

Herbicide usage trends since the adoption of GE technologies are the subject of much debate, with initial assessments indicating a decline in herbicide use in the early years of herbicide-resistant crop production (Carpenter et al., 2002), while some argue that an increase in the volume of herbicide usage followed as the technology spread (Benbrook, 2009). Others report a continuing decline in herbicide use with the adoption of GE crops (Fernandez-Cornejo and Caswell, 2006) and in the amount of herbicide active ingredients applied to corn (Brookes and Barfoot, 2010). The contradictory findings have been attributed to the different measurement approaches used by researchers, the manner in which different factors affecting pesticide use such as weather or cropping patterns are controlled for, and how collected data is statistically analyzed (NRC, 2010).

Another observed herbicide trend since the adoption of GE corn has been a substantial reduction in the diversity of herbicides used in corn production (Young, 2006). The use of other herbicides has declined significantly and it is estimated that 34% of corn acres receive only glyphosate for weed management (NRC, 2010; Owen, 2011) (Figure 5). Weed management is herbicide-based in both GE and conventional corn production; however, due to the effectiveness of glyphosate and the ease of its use, the adoption of GE glyphosate-resistant crops for weed management was the most rapid implementation of a crop technology in the history of agriculture (Duke, 2011). This trend and its potential impacts to herbicide-resistant weed development are discussed in Subsection 2.3.2, Plants Communities.



Source: (NRC, 2010)

Figure 5. Application to corn from 1996 to 2008 of glyphosate and other herbicides in terms of pounds per active ingredient per acre, and the percentage of herbicide-resistant planted corn.

Maize Line HCEM485 was developed to provide growers another alternative in glyphosate-resistant corn cultivars (Stine, 2011). The following presents a summary of the current use and registration of the herbicide glyphosate.

Glyphosate is a non-selective herbicide and plant growth regulator approved for use on a wide variety of food and non-food field crops and wherever total vegetation control is desired (US-EPA, 1993b). First registered for use in 1974, glyphosate has been subsequently reregistered in the 1993 Glyphosate Registration Eligibility Decision (US-EPA, 1993b). Glyphosate is currently under registration review with a decision expected in 2015 (US-EPA, 2009a). The chemical is formulated in several salt, acid, and ammonium compounds and is registered for use on fruit, vegetables, field crops, lawns and residential settings, industrial rights of way, and for aquatic weed control (US-EPA, 2009a).

Glyphosate, which is in the glycine herbicide category, inhibits EPSPS production in plants (Senseman, 2007). Inhibition of EPSPS reduces the presence of key amino acids required for protein synthesis or necessary for certain metabolic pathways required for plant growth. It absorbs directly through plant leaves and rapidly spreads throughout the plant. Surfactants are used in the herbicide formulation to enable greater glyphosate penetration into the leaves (Senseman, 2007). The environmental risk of the surfactant polyethoxylated tallow amine (POEA) in certain glyphosate products will be assessed by the EPA in their current registration review for glyphosate (US-EPA, 2009a). Glyphosate can be tank mixed with other herbicides to minimize the potential for selection of herbicide-resistant weeds and provide control over a diversity of weed pests (Thompson and Peterson, 2005; Boerboom and Owen, 2006; Gunsolus, 2006; Owen, 2010).

2.1.3 Corn Seed Production

Cornfields in the U.S. are generally planted with hybrid seed because hybrid vigor results in higher and more consistent grain yields. Approximately 50 to 60 million bushels (1.3 to 1.5 million metric tons) of seed corn are needed annually, which seed companies generally exceed by producing 30 to 40% more than is needed (Wych, 1988).

Seed corn production occurs regionally with the seed for hybrids adapted to the conditions in the southern U.S. grown in the South and similarly, hybrids adapted to the northern U.S. grown in the North (Stefferud, 2007). Iowa, Nebraska, Indiana, and Illinois represent the region where the most seed corn is produced (Bennett, 2011). Seed corn is also grown during the winter in nurseries in Hawaii, Puerto Rico, Chile, and Argentina (Leidy, 2009; Alfaro, 2011), where growing conditions maximize corn growth and productivity. Corn is grown in these nurseries to supplement low seed supplies or provide enough seed of the elite hybrids in greatest demand for planting the next season in the mainland U.S. (Beckman, 2011). Acreage devoted to corn seed production in winter nurseries is comparatively small. For example, only approximately 7,100 acres were under cultivation for all crop seed production in Hawaii in the 2010/2011 crop year, compared to 91.9 million acres of U.S. planted corn in 2011 (USDA-NASS, 2011h).

The U.S. Federal Seed Act of 1939 recognizes seed certification and official certifying agencies. Implementing regulations further recognize land history, field isolation, and varietal purity standards for seed. Seed certification is important to ensure the high quality of corn seed and is accomplished by a wide range of programs which include field inspections and laboratory testing (Bradford, 2006; AOSCA, 2011). Various seed associations have standards to help maintain the quality of corn seed. New seed varieties are evaluated by review boards to determine if the varieties meet the eligibility requirements for certification. The Association of Official Seed Certifying Agencies (AOSCA, No Date) defines the classes of seed as follows:

- *Breeder* seed is directly controlled by the plant breeder that developed the variety.
- *Foundation* seed is the progeny of Breeder or Foundation seed that is handled to most nearly maintain specific genetic identity and purity.
- *Registered* seed is a progeny of Breeder or Foundation seed that is so handled as to maintain satisfactory genetic identity and purity.
- *Certified* seed is the progeny of Breeder, Foundation, or Registered seed that is so handled as to maintain satisfactory genetic identity and purity.

Identity preservation (IP) is distinguished from seed certification as its focus is a rigorous process to maintain the genetic purity of seed stocks (Sundstrom et al., 2002; Bradford, 2006; Bennett, 2011). IP is accomplished by following a strict regime of management practices such as seed purity standards, recognizing field history to insure eligibility of the field for seed corn production, meeting field isolation standards to protect from the introgression of pollen from other corn varieties, seed sampling and testing, and record maintenance and labeling (Sundstrom et al., 2002).

Both certification programs and IP have been extremely successful in maintaining the purity and high quality of seed corn product and have provided oversight during the entire process from planting to bagging of the seed corn.

2.1.4 Organic Corn Production

In the U.S., only products produced using specific methods and certified under the USDA's Agricultural Marketing Service (AMS) National Organic Program (NOP) definition of organic farming can be marketed and labeled as "organic" (USDA-AMS, 2008). Organic certification is a process-based certification, not a certification of the end product; the certification process specifies and audits the methods and procedures by which the product is produced.

In accordance with NOP, an accredited organic certifying agent conducts an annual review of the certified operation's organic system plan and makes on-site inspections of the certified operation and its records. Organic growers must maintain records to show that production and handling procedures comply with USDA organic standards.

The NOP regulations preclude the use of excluded methods. The NOP provides the following guidance under 7 CFR Section 205.105:

> …to be sold or labeled as "100 percent organic", "organic" or "made with organic (specified ingredients or group(s))," the product must be produced and handled without the use of:…
>
> (a) Synthetic substances and ingredients,…
>
> (e) Excluded methods,…

Excluded methods are then defined at 7 CFR Section 205.2 as:

> A variety of methods used to genetically modify organisms or influence their growth and development by means that are not possible under natural conditions or processes and are not considered compatible with organic production. Such methods include cell fusion, microencapsulation and macroencapsulation, and recombinant deoxyribonucleic acid (DNA) technology (including gene deletion, gene doubling, introducing a foreign gene, and changing the positions of genes when achieved by recombinant DNA technology). Such methods do not include the use of traditional breeding, conjugation, fermentation, hybridization, in vitro fertilization, or tissue culture.

Organic farming operations, as described by the NOP, are required to have distinct, defined boundaries and buffer zones to prevent unintended contact with excluded methods from adjoining land that is not under organic management. Organic production operations must also develop and maintain an organic production system plan approved by their accredited certifying agent. This plan enables the production operation to achieve and document compliance with the National Organic Standards, including the prohibition on the use of excluded methods (USDA-AMS, 2008).

Common practices organic growers may use to exclude GE products include planting only organic seed, planting earlier or later than neighboring farmers who may be using GE crops so that the crops will flower at different times, and employing adequate isolation distances between the organic fields and the fields of neighbors to minimize the chance that pollen will be carried between the fields (NCAT, 2003). Although the National Organic Standards prohibit the use of excluded methods, they do not require testing of inputs or products for the presence of excluded methods. The presence of a detectable residue of a product of excluded methods alone does not necessarily constitute a violation of the National Organic Standards (USDA-AMS, 2008). The current NOP regulations do not specify an acceptable threshold level for the adventitious presence of GE materials in an organic-labeled product. The unintentional presence of the products of excluded methods will not affect the status of an organic product or operation when the operation has not used excluded methods and has taken reasonable steps to avoid contact with the products of excluded methods as detailed in their approved organic system plan (Ronald and Fouche, 2006; USDA-AMS, 2008).

Organic corn production practices include crop rotation, use of cover crops and green manures, animal manures, application of rock minerals such as lime, other soil additives, mechanical weed control, and biological control of pests (Kuepper, 2002). Weed control can be accomplished with delayed seeding to avoid spring weeds, applying fertilizer to growing plants to outcompete weeds, increasing seeding rates, sowing cover crops, crop rotation, intercropping, flame weeding, hand weeding, and mechanical means (e.g., tillage) (Halford et al., 2001; Kuepper, 2002; Heverton et al., 2008; Green and Owen, 2011). Other pest control is accomplished with application of natural pesticides, integrated pest management techniques such as introduction of beneficial organisms in the form of soil predator and parasitic organisms, and practices such as those described for weed control (NCAT, 2003). Organic crop production historically has also utilized mulch and ridge tillage practices (NCAT, 2003). However, while no-till organic corn production has been generally difficult and possibly unsustainable due to weed pests, broadcast flame weeding may be a viable alternative to chemical weed control (Heverton et al., 2008).

NASS and ERS recently reported the organic crop production data collected in 2008 (USDA-ERS, 2010a; USDA-NASS, 2010a). In that year, 143,432 acres of organic corn on 2,146 farms in 39 states were harvested for grain or seed; furthermore, 24,871 acres of organic corn on 664 farms in 27 states were harvested as silage or greenchop; greenchop is the harvest of a crop without allowing it to dry in the field. Iowa, Michigan, Minnesota, New York, and Wisconsin were the only states with more than 10,000 acres of organic corn harvested for grain or seed while only Wisconsin had more than 6,000 acres of organic corn grown for silage or greenchop. In contrast, Iowa, Michigan, Minnesota, New York, and Wisconsin combined had approximately 29 million acres of corn harvested in 2008 (USDA-NASS, 2008a). In 2008, organic corn harvested for grain or seed consisted of about 0.2% of total U.S. corn production (USDA-NASS, 2010a; USDA-NASS, 2011e).

2.2 Physical Environment

2.2.1 Soil Quality

Soil consists of solids (minerals and organic matter), liquid, and gases. This body of inorganic and organic matter is home to a wide variety of fungi, bacteria, and arthropods, as well as the growth medium for terrestrial plant life (USDA-NRCS, 2004). Soil is characterized by its layers that can be distinguished from the initial parent material due to additions, losses, transfers, and transformations of energy and matter (USDA-NRCS, 1999b). It is further distinguished by its ability to support rooted plants in a natural environment. Soil plays a key role in determining the capacity of a site for biomass vigor and production in terms of physical support, air, water, temperature moderation, protection from toxins, and nutrient availability. Soils also determine a site's susceptibility to erosion by wind and water, and a site's flood attenuation capacity.

Soil properties change over time: temperature, acidity or alkalinity (pH), soluble salts, amount of organic matter, the carbon-nitrogen ratio, and numbers of microorganisms and soil fauna all change seasonally as well as over extended periods of time (USDA-NRCS, 1999b). Soil texture and organic matter levels directly influence soil shear strength, nutrient holding capacity, and permeability. Soil taxonomy was established to classify soils according to the relationship between soils and the factors responsible for their character (USDA-NRCS, 1999b). Soils are organized into four levels of classification, the highest being the soil order. Soils are differentiated based on characteristics such as particle size, texture, and color, and classified taxonomically into soil orders based on observable properties such as organic matter content and degree of soil profile development (USDA-NRCS, 2010c). The Natural Resources Conservation Service (NRCS) maintains soil maps on a county level for the entire U.S. and its territories.

Corn is able to grow in a wide variety of soils with irrigation, but grows best in deep, well-drained, medium- to coarse-textured soils (Ross et al., 2006; Wright et al., 2009). Corn needs a variety of nutrients: primarily nitrogen, phosphorus, and potassium, as well as secondary nutrients such as calcium, magnesium, and sulfur at various levels (Espinoza and Ross, 2006). Corn also requires smaller amounts of micronutrients such as iron, zinc, copper, boron, manganese, molybdenum, and cobalt. The availability of nutrients is influenced by the soil pH, with the desirable range for corn of 5.8 to 7.0. Soil with a pH below 5.7 generally requires amendment with lime (Espinoza and Ross, 2006).

Land management practices for corn cultivation can affect soil quality. While management 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 agricultural practices include increased erosion, soil compaction, degradation of soil structure, nutrient loss, increased salinity, change in pH, and reduced biological activity (USDA-NRCS, 2001).

As discussed in Subsection 2.1.2, Agronomic Practices, conventional and conservation tillage are practiced in the cultivation of corn. 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. Management of the residue is one of the most effective conservation methods to reduce wind and water soil erosion, and also benefits air and water quality and wildlife (USDA-NRCS, 2006a).

Residue management that uses intensive tillage and leaves low amounts of crop residue on the surface results in greater losses of soil organic matter (SOM). Intensive tillage turns the soil over and buries the majority of the residue, stimulating microbial activity and increasing the rate of residue breakdown (USDA-NRCS, 1996). The residues left after conservation tillage increases organic matter and improves infiltration, soil stability and structure, and soil microorganism habitat (Fawcett and Caruana, 2001; USDA-NRCS, 2006b). Organic matter is probably the most vital component in maintaining soil quality (USDA-NRCS, 1996):

- it maintains soil stability and structure;
- reduces the potential for erosion;
- provides energy for microorganisms;
- improves infiltration and water holding capacity;

- is important in nutrient cycling;
- increases cation exchange capacity[3]; and
- breaks down pesticides.

The increased residue from conservation tillage increases SOM in the top three inches of the soil and protects the surface from erosion while maintaining water-conducting pores. Soil aggregates in conservation tillage systems are more stable than that of conventional tillage due to the products of SOM decomposition and the presence of soil bacteria and fungal hyphae (filamentous structures that compose the main growth) that bind aggregates and soil particles together (USDA-NRCS, 1996). Although soil erosion rates in crop production are dependent on numerous local conditions such as soil texture and crop, a comparison of 39 studies contrasting conventional and no-till practices found that, on average, no-till practices were 20 to 488 times more effective in reducing erosion than conventional tillage (Montgomery, 2007). This reduction enables soil production to nearly replace soil losses from erosion. From 1982 through 2003, erosion on U.S. cropland dropped from 3.1 billion tons per year to 1.7 billion tons per year (USDA-NRCS, 2006a). This can partially be attributed to the increased effectiveness of weed control through the use of herbicides and corresponding reduction in the need for mechanical weed control that facilitates no-till crop production (Carpenter et al., 2002).

Conservation tillage also minimizes soil compaction due to the reduced number of tillage trips. Other methods to improve soil quality includes 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).

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 as tillage is useful for breaking up compacted areas (USDA-NRCS, 1996). Likewise, not all soils (such as wet and heavy clay soils) are suited for no-till. Also, no-till practices may lead to increased pest occurrences that conventional tillage is better suited to managing (NRC, 2010).

There are a multitude of organisms associated with soils ranging from microorganisms to larger organisms such as worms and insects. The microorganisms that make up the soil community include bacteria, fungi, protozoa, and nematodes that are responsible for a wide range of activities that impact soil health and plant growth. Decomposers such as bacteria, actinomycetes (filamentous bacteria), and saprophytic fungi degrade plant and animal remains, organic materials, and some pesticides (USDA-NRCS, 2004). Other organisms, such as protozoa, mites, and nematodes, consume decomposer microbes and release macro- and micronutrients, making them available for plant usage. Another important group of soil microorganisms are the mutualists. These are the 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). Plants also have both direct and indirect impacts on the

[3] A cation is an element ion with a positive charge (missing electrons) such as iron (Fe^{2+}), manganese (Mn^{2+}), calcium (Ca^{2+}), potassium (K^{+}) and sodium (Na^{+}). Cation Exchange Capacity is a term used to describe 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 (such as potassium, calcium and ammonium).

chemical, physical, and biological characteristics of soil. Plant root exudates play a major role in the microbial community structure and resource availability in the rhizosphere (Bais et al., 2006). Because of the close association with bacteria, fungi, actinomycetes, and other soil microbes, corn roots play a key role in influencing nutrient cycling and availability necessary for plant growth (OECD, 2003).

Pesticide use has the potential to affect soil quality due to impacts to the microbial community, and is discussed further in Subsection 2.3.4, Microorganisms. Glyphosate is rapidly and tightly adsorbed in soil; its adsorption rate is minimally influenced by organic matter, the amount of clay, silt, or sand, and pH, although soil high in phosphate decreases its adsorption (Senseman, 2007), making it more available for plant uptake, microbial degradation, and leaching (Kremer and Means, 2009)[4]. Glyphosate is microbially degraded in soil and water and the rate of decomposition varies with the microbial structure and population, having an average soil residual half-life of 47 days (Senseman, 2007). It has been reported that glyphosate appears to interact with manganese by forming insoluble, stable complexes that either immobilize this element, reducing plant uptake, or preventing reduction in the plant, making it unavailable (Eker et al., 2006; Neumann et al., 2006; Ozturk et al., 2008; Cakmak et al., 2009; Huber, 2010). Huber (2010) and Cakmak (2009) also reported that glyphosate is a broad-spectrum chelate of several other nutrients (e.g., iron, calcium, magnesium, copper, iron, nickel, and zinc); however, these assertions are not without debate. Hartzler (2010) agrees that glyphosate could immobilize essential elements temporarily, but offers that it does not specifically target manganese or any other particular element, but instead targets those cations that are most prevalent in the soil. Hartzler (2010) also reports that areas in which glyphosate interactions with manganese nutrition are reported are also areas with known soil manganese deficiencies. Camberato (2010) points out that manganese deficiency is not a new phenomenon and is also associated with high pH, low moisture, or high levels of organic matter; furthermore, manganese deficiency is easily recognizable and can usually be resolved through foliar application(s) of manganese fertilizers.

2.2.2 Water Resources

The principal law governing pollution of the nation's water resources is the Federal Water Pollution Control Act of 1972, better known as the Clean Water Act (CWA). The Act utilizes water quality standards, permitting requirements, and monitoring to protect water quality. The EPA sets the standards for water pollution abatement for all waters of the U.S. under the programs contained in the CWA, but, in most cases, gives qualified States the authority to issue and enforce permits. Drinking water is protected under the Safe Drinking Water Act (SDWA) of 1974 (Public Law 93-523, 42 U.S.C. 300 *et seq.*).

Surface water in rivers, streams, creeks, lakes, and reservoirs supports everyday life by providing water for drinking and other public uses, irrigation, and industry (USGS, 2011). In 2005, about 77% of the freshwater used in the U.S. came from surface-water sources, whereas the other 23% came from groundwater (USGS, 2011). Groundwater is the water that fills cracks and other openings in beds of rocks and sand (USGS, 2009). Each drop of rain that soaks into the soils moves downward to the water table, which is the water level in the groundwater reservoir.

[4] Adsorption is a scientific term used to describe the "adhesion" of atoms, ions, or molecules onto a surface, whereas absorption refers to the transfer of a substance into another substance or medium.

The CWA (33 U.S.C. 1251 *et seq.*) establishes the basic structure for regulating discharges of pollutants into the waters of the U.S. and regulating quality standards for surface waters. It is the cornerstone of surface water quality protection in the U.S.; however, it does not deal directly with groundwater or with water quantity issues. Surface water is an important natural resource used for many purposes, especially irrigation and public supply of drinking water and for everyday uses. The CWA employs a variety of regulatory and nonregulatory tools to sharply reduce direct pollutant discharges into waterways, finance municipal wastewater treatment facilities, and manage polluted runoff (US-EPA, 2008a). It also provides resources to help manage nonpoint source pollution (NPS). NPS is caused by rainfall, snowmelt, or irrigation moving over and through the ground that picks up and carries with it natural and human-made pollutants, depositing them into lakes, rivers, wetlands, coastal waters, and groundwater (US-EPA, 2011f).

The SDWA is the main Federal law that ensures the quality of U.S. drinking water. Under the SDWA, the EPA sets national health-based standards for drinking water quality to protect against both naturally-occurring and man-made contaminants that may be found in drinking water. The EPA also oversees the states, localities, and water suppliers who implement those standards (US-EPA, 2011g). The Sole Source Aquifer (SSA) designation under the SDWA is used to protect drinking water supplies in areas with few or no alternative groundwater resources, and where if contamination occurred, using an alternative source would be extremely expensive (US-EPA, 2011h). The EPA defines SSA as an aquifer that supplies at least 50% of the drinking water consumed in the area overlying the aquifer. There are 77 designated SSAs in the U.S. and its territories (US-EPA, 2011h) .

Agriculture is one of the largest users of water in the U.S. Approximately 40% of the water withdrawn from U.S. surface and groundwater sources is used for agricultural irrigation (CAST, 2009). Although the proportion of available freshwater used in agriculture varies widely among geographic areas, it is a major proportion of water use in every area. Corn requires water for germination, photosynthesis, cell structure and fullness, and transpiration (i.e., water movement to the atmosphere via movement through the growing plant) (McClaren, 2009). According to the National Corn Growers' Association (NCGA) and ARMS data for corn production practices, corn is not as water-intensive as many other crops; with only about 11 to 11.5% of corn acreage irrigated in 2010 (NCGA, 2011). The estimated average amount of water applied per irrigated acre was 10.7 inches (USDA-ERS, 2011e). The crop yield per irrigated acre in 2010 was estimated to be 174 bushels (USDA-ERS, 2011e) compared to the average for all corn for grain, which in 2010 was approximately 153 bushels per year (USDA-NASS, 2011e). The ERS estimates did not separate corn yield by corn produced for grain versus silage. In 2008, nearly 14 million acres of harvested corn were irrigated (USDA-NASS, 2010c). Also in 2008, the four Water Resources Regions that irrigated corn the most included 6.54 million acres in Region 10 (Missouri), 1.84 million acres in Region 11 (Arkansas White-Red), 1.16 million acres in Region 08 (Lower Mississippi), and 0.73 million acres in Region 07 (Upper Mississippi) (USDA-NASS, 2010c).

Agricultural NPS pollution is the primary source of pollutants discharged to rivers and lakes and a major contributor to groundwater contamination (US-EPA, 2005). Agricultural activities that cause NPS pollution include poorly located or managed animal feeding operations; overgrazing leading to soil erosion; plowing too often or at the wrong time; and improper, excessive, or poorly timed application of pesticides, irrigation water, and fertilizer. The pollutants that result from agricultural practices include sediment, nutrients, pathogens, pesticides, metals, and salts (US-EPA, 2005).

Weed management is a critical component to maximize corn yields and maintain a high-quality harvest free of weed seeds (Smith and Scott, 2006). As discussed in Subsection 2.1.2, Agronomic Practices, weed management strategies include using a combination of tillage practices, chemical herbicides, and herbicide-resistant trait breeding in crops (Dill et al., 2008).

Tillage is an important tool for managing weeds before the planting of crops and after their emergence, but before full crop canopy (Givens et al., 2009). Reducing tillage and conserving crop residue can produce many water quality benefits, such as less sediment and chemical runoff entering surface water, reduced usage of pesticides, improved moisture content in soil, and reduced potential for flooding (Fawcett and Towery, 2002). The increased amount of plant residue on the soil surface serves as a physical barrier to erosion and runoff, allowing more time for water absorption into the soil (Locke et al., 2008). There is a strong association between the cultivation of herbicide-resistant crops and recent improvements in tillage reduction (Fawcett and Towery, 2002). Dill et al. (2008) noted for the period of 2002 to 2006, rates of conventional tillage slightly declined in glyphosate-resistant corn production compared to non-GE corn cultivation, while conservation tillage in glyphosate-resistant corn production increased slightly over that time frame. Use of no-till practices declined during the same period; however, the rates of no-till cultivation were similar between glyphosate-resistant and conventional corn production (Dill et al., 2008).

If resistance to glyphosate occurred, farmers preferred to treat weeds with herbicide mixes or rotations (Foresman and Glasgow, 2008; Johnson et al., 2009). The USDA has documented that 66% of U.S. herbicide-treated corn acreage in 2010 was treated with glyphosate isopropylamine salt (USDA-NASS, 2011c). Glyphosate may be applied terrestrially and in aquatic settings (US-EPA, 2009b). Glyphosate has several formulations including acid and a variety of salts (US-EPA, 2009b). The environmental fate of glyphosate salts is not well studied, but the EPA assumes glyphosate salts dissociate rapidly to form glyphosate and its counter ion (US-EPA, 2009e). Glyphosate is highly adsorbed to most soils, although the amount of organic matter, clay, silt, or sand content or pH has minimal effects (Senseman, 2007). It has a typical soil residual half-life of 47 days (Senseman, 2007), although reported field half-lives range from 2.4 to 160 days (US-EPA, 2009e). Because glyphosate is so tightly bound to soil, little is transported by rain or irrigation runoff, except as adsorbed to soil particles.

Microbes are primarily responsible for the breakdown of glyphosate, rather than by volatilization or photo-degradation. The main metabolite of glyphosate microbial degradation is aminomethyl-phosphonic acid (AMPA) (Rueppel et al., 1977; WHO, 2005). It has also been reported that *Pseudomonas* spp. bacteria degrade glyphosate, producing the metabolites sarcosine and phosphates (Shinabarger and Braymer, 1986; Borggaard and Gimsing, 2008). AMPA has a similar half-life in water as glyphosate (Giesy et al., 2000) and is ultimately degraded into carbon dioxide (CO_2) and ammonium (NH_4^+) (Borggaard and Gimsing, 2008). Because of its low mobility in soil, the potential for glyphosate leaching to groundwater is low and its potential movement to surface waters at high levels is considered low (US-EPA, 2009e); however, glyphosate can enter surface and subsurface waters if used in close proximity to water bodies or by runoff from terrestrial applications (WHO, 2005).

In water, glyphosate adsorbs to suspended organic and mineral matter and is broken down primarily by microorganisms. In aerobic water, sediment glyphosate has a residual half-life of 7 days, but in anaerobic aquatic sediment settings its residual half-life is approximately 208 days (US-EPA, 2009e). Surfactants may be used with glyphosate because the latter is highly soluble in water and will easily slide off plant surfaces (US-EPA, 2009e).

Coupe et al. (2011) recently evaluated the fate of glyphosate and its AMPA degradate on a watershed scale in three Mississippi River basin watersheds and compared results to a watershed in France. They found from 0.06 to 0.86% of glyphosate was transported to surface water, although their samples frequently detected both glyphosate and AMPA (Coupe et al., 2011). Variability was correlated to differences in source strength, rainfall runoff, and flow route. The study concluded the watersheds most at risk for transport of glyphosate have high application rates, rainfall events resulting in overland runoff, and flow routes unfiltered by soil. Glyphosate has not been identified as the cause of impairment to any water bodies classified as such under Section 303(d) of the CWA[5] (US-EPA, 2011i).

2.2.3 Air Quality

The Clean Air Act (CAA) requires the maintenance of National Ambient Air Quality Standards (NAAQS). The NAAQS, developed by the EPA to protect public health, establishes limits for six criteria pollutants: ozone (O_3), nitrogen dioxide (NO_2), carbon monoxide (CO), sulfur dioxide (SO_2), lead (Pb), and inhalable particulates (coarse particulate matter (PM) greater than 2.5 micrometers and less than 10 micrometers in diameter (PM_{10}) and fine particles less than 2.5 micrometers in diameter ($PM_{2.5}$)). The CAA requires states to achieve and maintain the NAAQS within their borders. Each state may adopt requirements stricter than those of the national standard and each is required by the EPA to develop a State Implementation Plan (SIP) that contains strategies to achieve and maintain the national standard of air quality within the state. Areas that violate air quality standards are designated as non-attainment areas for the relevant pollutants, whereas areas that comply with air quality standards are designated as attainment areas. Primary sources of emissions associated with crop production include exhaust from motorized equipment such as tractors and irrigation equipment, soil particulates from tillage and wind induced erosion, particulates from burning of fields, and spraying of herbicides and pesticides. Emissions contributing to greenhouse gases (GHG) associated with global warming are discussed in Subsection 2.2.4, Climate Change.

Since corn is the most widely produced feed grain in the U.S., its production practices can substantially impact air quality. Tillage exposes soil to wind erosion and utilizes motorized equipment that produces emissions. The use of herbicide-resistant crops has facilitated the

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[5] Glyphosate is classified as an organophosphorus pesticide. One waterbody, Smith Canal in the California Central Valley Region, has been identified as being impaired by organophorphorus pesticides, principally diazinon and chlorpyrifos California RWQCB, Requirement for Technical Report Pursuant to California Water Code Section 13267 (Sacramento: California Regional Water Quality Control Board, 2007), "Specific State Causes for Impairment That Make up the National Pesticides Causes of Impairment Group," 2011i, U.S. Environmental Protection Agency, October 10, <http://iaspub.epa.gov/tmdl_waters10/attains_nation_cy.cause_detail_303d?p_cause_group_id=885>.7.

adoption of conservation tillage (Towery and Werblow, 2010). According to ARMS data, in 2010 conservation tillage ranging from no-till to reduced-till conserving about 22 to 65% of residues was utilized on 74.5% of planted corn acres in 2010 (USDA-ERS, 2011f). Reduced tillage generates fewer particulates (dust) and potentially contributes to lower rates of wind erosion releasing soil particulates into the air, benefitting air quality (Fawcett and Towery, 2002). Conservation tillage also reduces equipment emissions due to decreased usage. This is illustrated in Table 1 utilizing the NRCS Energy Estimator: Tillage tool (USDA-NRCS, 2011a). The tool estimates potential fuel savings of 2,269 gallons or 42% savings per year based upon producing 1,000 acres of no-till corn compared to conventional till corn in the Urbana, Illinois postal code[6]; however, NRCS is careful to note that this estimate is only approximate, as many variables could affect an individual operation's actual savings.

Table 1. Total farm diesel fuel consumption estimate (in gallons per year) for no-till versus conventional till corn production in the Urbana, Illinois postal code.

Estimate for 1,000 acre corn crop	Tillage method			
	conventional tillage	mulch-till	ridge-till	no-till
Total fuel use	5,399	4,529	4,490	3,130
Potential fuel savings over conventional tillage	--	870	909	2,269
Total savings	--	16%	17%	42%

Source: (USDA-NRCS, 2011a)

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 determined that volatilization is highly dependent upon 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). Glyphosate has a low vapor pressure and volatilization from soils is not considered an important dissipation mechanism (US-EPA, 1993b).

Pesticide and herbicide spraying introduce air quality impacts from drift and diffusion. Drift is defined by the 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" (US-EPA, 2000). Diffusion is gaseous transformation to the atmosphere (FOCUS, 2008). Factors affecting drift and diffusion include application equipment and method, weather conditions, topography, and the type of crop being sprayed (US-EPA, 2000). The EPA is currently evaluating new regulations for pesticide

[6] 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.

drift labeling and the identification of BMPs to control such drift (US-EPA, 2009d), as well as identifying scientific issues surrounding field volatility of conventional pesticides (US-EPA, 2010).

Chang et al. (2011) recently evaluated the occurrence and fate of glyphosate and its degradate AMPA in the atmosphere and rainfall in the Mississippi River basin. They found the frequency of glyphosate in the air and rain was similar to that of other commonly applied herbicides such as atrazine and metolachlor, but its concentration in rain was higher, primarily due to the widespread use of glyphosate for crop production in the region (Chang et al., 2011). AMPA in air was sampled at a range of <0.01 to 0.97 nanograms per cubic meter, initially lower in the application season and increasing as glyphosate degraded in soil to produce the metabolite; its incidence in rain was similar to that of glyphosate. The study also investigated the source of glyphosate in the air and found most occurred from spray application rather than volatilization or transport from windborne soil. Chang et al. (2011) conclude up to 97% of glyphosate may be removed from the atmosphere by weekly rainfall greater than 30 millimeters (1.18 inches).

2.2.4 Climate Change

Climate change represents a significant and lasting statistical change in climate conditions that may be measured across both time and space. As scientists and the public became more concerned with climate change and the impact that human-derived air pollutants were having on global temperature, the EPA identified CO_2, methane (CH_4), and nitrous oxide (N_2O) as the key GHG affecting warming temperatures. While each of these gases occurs naturally in the atmosphere, human activity has significantly increased the concentration of these gases since the beginning of the industrial revolution. The level of human-produced gases accelerated even more so after the end of the Second World War, when industrial and consumer consumption flourished. With the advent of the industrial age, there has been a 36% increase in the concentration of CO_2, 148% in CH_4, and 18% in N_2O (US-EPA, 2011c).

U.S. agriculture may influence climate change through various facets of the production process (Horowitz and Gottlieb, 2010) and conversion of land to agriculture. The major sources of GHG emissions associated with crop production are soil N_2O emissions, soil CO_2 and CH_4 fluxes, and CO_2 emissions associated with agricultural inputs and farm equipment operation (Adler et al., 2007; US-EPA, 2011c). Over the 20-year period of 1990 to 2009, total emissions in the agriculture sector grew by 9.3%, and in 2009, this sector was responsible for 6.3% of total U.S. GHG emissions (US-EPA, 2011c). CH_4 and N_2O were the primary GHG emitted by agricultural activities. Emissions from intestinal (enteric) fermentation and manure management represent about 20% and 7% of total CH_4 emissions from anthropogenic activities, respectively (US-EPA, 2011c). Agricultural soil management activities including fertilizer application and cropping practices were the largest source of N_2O emissions, accounting for 69% of all U.S. N_2O emissions (US-EPA, 2011c).

Agricultural practices that produce CO_2 emissions include liming and the application of urea fertilization to agricultural soils. In 2009, the use of lime and urea fertilizers resulted in an increase of 9.9% of CO_2 relative to 1990 emissions, mostly attributable to increased urea applications (US-EPA, 2011c). The agricultural sector is also responsible for CO_2 emissions from fossil fuel combustion by farm equipment such as tractors as discussed in Subsection 2.2.3, Air Quality. In addition, soil disturbing practices such as tillage can result in the release of soil organic carbon (SOC), which occurs in the bodies of microorganisms (i.e., fungi, bacteria, etc.), in non-living organic matter, and attached to inorganic minerals in the soil.

From 1991 to 2010, harvested corn acreage increased from approximately 75 million acres to over 87 million acres (USDA-NASS, 2011e), and as of 2011, approximately 72% of all corn planted in the U.S. were GE herbicide-resistant varieties (USDA-ERS, 2011a). As discussed in Subsection 2.2.1, Soil Quality, the introduction of herbicide-resistant crop varieties may be correlated to the increase in usage of no-till or conservation tillage agriculture (Fawcett and Towery, 2002; Givens et al., 2009). In 1990, prior to the introduction of herbicide-resistant corn varieties, approximately 8% of corn acreage in the U.S. was treated using the no-till systems and 43% was treated using conventional tillage practices (CTIC, 2011); whereas, in 2008, no-till systems increased to nearly 21% and conventional tillage decreased to about 35% of U.S. corn production acreage (CTIC, 2011). While some conserving tillage practices (i.e., ridge till and mulch till) decreased about 1% and 3% respectively from 1990 to 2008 and reduced tillage rates remained relatively constant at 24% over the same period, overall soil conserving tillage practices increased from about 57% in 1990 to 65% in 2008 (CTIC, 2011). Increased conservation tillage operations reduce GHG emissions directly through reductions in fossil fuel consumption and accumulation of crop residue (Brookes and Barfoot, 2006). The relative contribution of conservation tillage to carbon sequestration in soil is variable, dependent upon soil and climate characteristics (Lal, 2004), as well as cropping systems and the amount of crop residue generated; further, under certain conditions, full inversion tillage may sequester carbon at similar rates as conservation tillage, only at a greater depth in the soil profile (Angers and Ericksen-Hamel, 2008; Varvel and Wilhelm, 2011).

The impacts of herbicide-resistant crop varieties on climate change are dependent on many variables including cropping systems, production practices, geographic distribution of activities, and individual grower decisions. Agricultural practices produce emissions that may contribute to climate change, and impacts from climate change potentially impact agriculture. Field et al. (2007) reports that most studies project likely climate-related yield increases of 5 to 20% for corn, rice, sorghum, soybean, wheat, common forages, cotton, some fruits, and irrigated grains; however, they go on to report that positive impacts would not be observed evenly across all regions, as certain areas of the U.S. that are currently near climate thresholds are expected to be negatively impacted by such impacts as substantially reduced water resources. In addition, the current range of weeds and pests of agriculture is expected to change in response to climate change (USGCRP, 2009).

2.3 Biological Resources

This section provides a summary of the biological environment and includes an overview of animals, plants, gene transfer, weeds and weediness, microorganisms, and biodiversity. This summary provides the foundation to assess the potential impact to plant and animal communities, and the potential for gene movement.

2.3.1 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 species use a wide range of strategies to meet their needs from highly adaptable generalists to specialists that require a narrow set of conditions to survive (Bolen and Robinson, 2003). Wildlife may also occupy a wide array of habitats, including agricultural lands. Agriculture dominates human uses of land (Robertson and Swinton, 2005). In 2010, 920 million acres (47%) of the contiguous 48 states were devoted to farming, including: crop production, pasture, rangeland, Conservation Reserve Program, Wetlands Reserve Program, or other government program uses (USDA-NASS, 2011g). How these lands are maintained influences the function and integrity of ecosystems and the wildlife populations that they support.

For the purposes of this analysis, discussion is limited to vertebrates and invertebrates that feed on corn and live in and adjacent to cornfields. Corn is commercially produced in all continental U.S. states except for Alaska and is grown in winter nurseries in Hawaii and the Puerto Rico territory (Leidy, 2009; Alfaro, 2011). As a result, a wide array of wildlife species occupy habitats that are within or adjacent to cornfields, although few species directly utilize corn for food or shelter. Corn is, however, a nutrient-rich source for many waterfowl species for fat synthesis prior to migration (Krapu et al., 2004). Additionally, during the spring, summer, and fall months, cornfields provide browse for rabbits (*Sylvilagus floridana*); deer (*Odocoileus virginianus*); bears (Ursidae); squirrels (*Sciurus* spp., *Spermophilus tridecemlineatus*); raccoons (*Procyon lotor*); a variety of rodents and small mammals; wild turkey (*Meleagris gallopavo*); pheasants (*Phasianus colchicus*); quail (*Colinus virginianus*); and some songbirds while also providing a forage base for insects (Mattson, 1990; Miller and Hazzard, 1996; Krapu et al., 2004; MacGowan et al., 2006; Ohio Division of Wildlife, 2011; Palmer et al., 2011). Cornfields also attract species that prey on those animals directly using the field as a food source or habitat, such as predatory birds and insects feeding on other insects that infest corn (Quiring and Timmons, 1987; Clark et al., 1994; Tremblay et al., 2001). During the winter, waste corn provides a food source for wildlife, and if not fall plowed or harvested for silage, cornfields provide winter cover (Ohio Division of Wildlife, 2011; Palmer et al., 2011).

Cornfields are intensively cultivated lands that provide less suitable habitat for wildlife than adjacent pasture, fallow fields, or windbreaks and shelterbelts. As discussed in Subsection 2.1.2, Agronomic Practices, no-till corn production that may provide better habitat for some wildlife is practiced in the U.S., but not extensively, with only approximately 24% of planted corn produced under the no-till system (USDA-ERS, 2011f). Conservation tillage practices can benefit 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 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, as they provide a protein-rich diet to fast growing young, as well as a nutrient-rich diet for migratory birds (USDA-NRCS, 2003).

Insects such as the lady beetle (Coccinellidae), big-eyed bug (Lygaeidae), ground beetle (Carabidae), lacewing (Chrysopidae), damsel bug (Nabidae), insidious flower bug/minute pirate bug (Anthocoridae), assassin bug (Triatominae), spined soldier bug (Pentatomidae), and parasitoid wasps (e.g., Braconidae, Ichneumonidae), as well as a multitude of spiders (Order: Araneae) may benefit corn production by preying on plant pests (Stewart et al., 2007; Iowa State

University, No Date). Other, soil dwelling fauna such as earthworms and arthropods play critical roles in the aeration and turn-over of soil, processing of wastes and detritus, and nutrient cycling (ATTRA, 1999; USDA-NRCS, 2004). Conversely, there are many insects and invertebrates that are detrimental to corn crops, such as the corn earworm (*Helicoverpa zea*), corn rootworm (*Diabrotica* spp.), and European corn borer (*Ostrina nubilalis*) (University of Illinois, 2003; University of Illinois, 2004a; University of Illinois, 2004b).

Herbicide use for the control of weeds in corn production has the potential to affect wildlife. The environmental effects associated with glyphosate use are summarized in the most recent Glyphosate Reregistration Eligibility Decision (RED) Facts (US-EPA, 1993a). Since 2009, glyphosate has been under review by the EPA for continued registration of the herbicide, with a reregistration decision expected in 2015 (US-EPA, 2009a). Assessments of the toxicity of glyphosate to animal species indicate registered uses pose a minimal risk to animals, but the herbicide may cause adverse effects to plants providing animal habitat. Glyphosate is moderately toxic to mammals, no more than slightly toxic to birds, and practically nontoxic to fish, aquatic invertebrates, and honeybees (US-EPA, 1993a). Non-target exposure for animal habitats typically results from runoff or spray drift (US-EPA, 1993b). EPA-approved labels governing use that includes measures such as appropriate droplet size settings and assessment of wind, weather, and temperature inversion conditions (Monsanto, 2010). The EPA is also currently evaluating new regulations for pesticide drift labeling and the identification of BMPs to control such drift (US-EPA, 2009d), as well as identifying scientific issues surrounding field volatility of conventional pesticides (US-EPA, 2010). While animals can also be affected from runoff and drift, ingestion is often the primary cause of exposure. The final work plan for the reregistration review of glyphosate has identified additional data needs concerning potential impacts to terrestrial animals and certain aquatic species (US-EPA, 2009a). Part of the EPA reregistration assessment will include an acute avian oral toxicity study for passerine species.

The glyphosate degradate, AMPA, has not been fully evaluated for ecological risk, which will be undertaken in the current EPA review (US-EPA, 2009a). Additionally, some inert ingredients used as surfactants applied with glyphosate that increase its absorption are more toxic than glyphosate to aquatic organisms, and will be evaluated for acute toxicity to estuarine and marine mollusks, invertebrates, and fish (US-EPA, 2009a).

2.3.2 Plants Communities

Corn production in the U.S. encompasses a wide range of physiographic regions, ecosystems, and climatic zones since it is grown in every U.S. state except Alaska (USDA-NASS, 2011b; USDA-NASS, 2011h). Plants communities are varied and adapted to local climate and soil, as well as the frequency of natural or human-induced disturbance (Smith and Smith, 2003). Non-crop vegetation in cornfields is limited by cultivation and weed control practices used by producers. Plants communities adjacent to cornfields may be other crops, pasturelands, rangelands, grasslands, forest, or conservation covers designed to control soil erosion and wind. Areas adjacent to cornfields are often highly managed to minimize sources of weed and insect invasion, and reduce cover or perches from which other pests may easily feed on the crop (Pierce II et al., 2008).

Weeds are simply plants growing in areas undesired by humans (Baucom and Holt, 2009). Weeds are the most important pest complex in agriculture and are represented by plants with specific characteristics that make these species uniquely adapted to agriculture (Gibson et al., 2005; Baucom and Holt, 2009). Plants that colonize frequently disturbed environments exhibit early germination and rapid growth from seedling to sexual maturity, have the ability to reproduce sexually and asexually and are well-adapted to agricultural fields (Baucom and Holt, 2009). Weeds compete with crops for light, nutrients, and water, and therefore, have the potential to significantly affect yields. Their ability to compete with crops depends on the specific weed (e.g., woolly cupgrass (*Eriochloa villosa*) is more competitive than giant foxtail (*Setaria faberi*)), population density, the diversity of the weed community, and the length of time the weed community has been established in the crop field (Bosnic and Swanton, 1997; Fausey et al., 1997; Owen, 1999). Types of weeds encountered in corn production vary by region, but common weeds include common waterhemp (*Amaranthus rudis*), giant ragweed (*Ambrosia trifida*), common lambsquarters (*Chenopodium alum*), velvetleaf (*Abutilon theophrasti*), giant foxtail, and horseweed (*Conyza canadensis*) (Moore, 2012).

Loss of corn yield attributable to weeds varies. Smith and Scott (2006) estimate that light infestation may reduce yields 10 to 15%, and heavier infestations potentially reducing yields up to 50%. Bosnic and Swanton (1997) report a 26 to 35% loss from early emerging barnyardgrass, yet this loss drops to less than 6% from barnyardgrass emergence after corn has reached the four-leaf growth stage. Johnson et al. (2007) found that corn yield was not reduced by early season giant ragweed, yet yield dropped by 19% from season-long interference. Yield reductions depend on weed prevalence at critical growth stages (Halford et al., 2001; Knezevic et al., 2002). Generally, weeds must be controlled early in the development of corn in order to protect potential corn yields (Smith and Scott, 2006).

Collectively, the practices used in crop production will ultimately impart selection pressures upon the weed community, resulting in shifts in the relative importance of specific weeds. Agricultural practices with the most impact on weed composition and prevalence are tillage and herbicide regime (Owen, 2008). Weed shifts are illustrated by a previously unimportant weed achieving ecological dominance due to changes in production practices (e.g., Asiatic dayflower) or the evolution of an herbicide-resistant weed biotype due to herbicide-use practices (e.g., common waterhemp) (Owen, 2008; Ulloa and Owen, 2009). In aggressive tillage systems, weed diversity tends to decline and annual grasses and broadleaf plants are the dominant weeds, whereas, in no-till fields, greater diversity of annual and perennial weed species may occur (Baucom and Holt, 2009).

As described in Subsection 2.1.2, Agronomic Practices, while there are numerous tactics that will provide weed management, herbicides have been the dominant approach in corn production (Gianessi and Reigner, 2007; Green and Owen, 2011). Herbicide resistance naturally evolves when a plant survives and reproduces after exposure to a dose of herbicide usually lethal to the wild type, passing this ability down to its future generations (WSSA, 2008). With repeated use of the herbicide, the herbicide-resistant plants can quickly reproduce and spread to dominate the plant (weed) population and seed bank (WSSA, 2011).

Currently, there are 370 herbicide-resistant weed biotypes that have been reported representing 200 species and infesting an estimated 570,000 fields globally (Heap, 2011). Weeds with evolved resistance to glyphosate have increased since the commercial introduction of the Roundup Ready® glyphosate-resistant crops in 1996 (Heap, 2011; Owen et al., 2011). It should be noted, however, that the GE crop in this case, namely corn, did not directly cause the resistance to evolve as a result of introgression; there are no near-relative weeds that are compatible with corn (Ellstrand et al., 1999). As of December 2011, there are 21 weed species with evolved resistance to glyphosate world-wide and 13 in the U.S. (Table 2) (Heap, 2011; Owen et al., 2011). In the U.S., it is estimated that 11 of the 13 glyphosate-resistant weed species were identified in glyphosate-resistant crop systems and are widely distributed in regions where agriculture predominates. For example, 15 states have from 2 to 7 weed species with evolved resistance to glyphosate (Table 3) (Heap, 2011). Table 3 illustrates how widespread herbicide-resistant weeds are in the U.S., as the same 15 states with glyphosate-resistant weeds have also identified at least 1 weed species with resistance to 3 to 8 herbicide modes of action.

Table 2. U.S. glyphosate-resistant weeds as of December 2011.

System	Species	Year Identified
Weeds identified outside of Roundup Ready® Systems	Rigid Ryegrass (*Lolium rigidum*)	1998
	Hairy Fleabane (*Conyza bonariensis*)	2003
Weeds identified in Roundup Ready® Systems	Annual Bluegrass (*Poa annua*)	2010
	Common Ragweed (*Ambrosia artemisiifolia*)	2004
	Common Waterhemp (*Amaranthus rudis*)	2005
	Giant Ragweed (*Ambrosia trifida*)	2004
	Goosesgrass (*Eleusene indica*)	2010
	Horseweed, Marestail (*Conyza canadensis*)	2000
	Italian Ryegrass (*Lolium multiflorum*)	2001
	Johnsongrass (*Sorghum halepense*)	2005
	Junglerice (*Echinochloa colona*)	2008
	Kochia (*Kochia scoparia*)	2007
	Palmer Amaranth (*Amaranthus palmeri*)	2005

Source: (Heap, 2011)

Many of the glyphosate-resistant weeds are agronomically important and dominant members of weed communities. For example, glyphosate-resistant Palmer pigweed (amaranth) is a major economic problem in the Southeast U.S., while glyphosate-resistant waterhemp is an economically important weed in Midwestern states (Culpepper et al., 2006; Owen, 2008). Other glyphosate-resistant weeds of importance include giant ragweed, common lambsquarters, and horseweed (Owen, 2008; Owen et al., 2011).

As described in Subsection 2.1.2, Agronomic Practices, the most effective weed management programs focus on the inclusion of diverse control tactics in addition to herbicides (Beckie, 2006; Owen, 2011; Owen et al., 2011). Given that many weeds have evolved multiple resistances to several herbicide mechanisms of action, it is important that herbicide diversity of mechanisms of action also be a factor in herbicide selection. The key consideration to managing herbicide-resistant weeds is to ensure that the herbicides used continue to have efficacy on the target weeds. Managing weed species that have evolved multiple resistances can be challenging.

In corn production where sufficient herbicide mechanisms of action typically are available, Beckie and Reboud (2009) recommend the use of herbicides in tank mixtures rather than to simply rotate herbicide modes of action. However, in a study of the efficacy of acetolactate synthase (ALS)-inhibitor mixtures, Wrubel and Gressel (1994) note that not all mixtures meet all the criteria for resistance management, and the use of mixtures for short-term economic benefit risks increasing widespread resistance to herbicides. Weed scientists recommend the use of an integrated systems approach of including science-based crop improvement and farm management tools developed over the last 60 years, and providing producers reasonable and attractive alternatives for effective weed management (Gunsolus, 2002; Beckie, 2006; Owen et al., 2011; Sellers et al., 2011).

Table 3. U.S. states with more than one weed species with glyphosate resistance.

State	Number of weed species with glyphosate resistance	Number of herbicide modes of action with at least one resistant weed species
Arkansas	6	8
California	4	8
Illinois	3	5
Indiana	4	3
Iowa	3	6
Kansas	5	5
Louisiana	2	5
Michigan	2	5
Minnesota	3	4
Mississippi	7	7
Missouri	6	5
North Carolina	2	6
Ohio	3	5
Tennessee	4	6
Virginia	2	4

Source: (Heap, 2011)

Corn seeds that overwinter and germinate in subsequent crops are “volunteers” and are also considered weeds. Domesticated corn needs human intervention to disperse its seeds, as they are tightly bound to the cob and protected within husks (OECD, 2003). Harvesting and transporting corn from the field can release individual kernels that survive and germinate the following year, but corn is incapable of sustained reproduction outside of agriculture (OECD, 2003); thus, has little potential to become a weed outside of cultivated fields (see Subsection 2.3.3, Gene Flow and Weediness, for an in depth discussion of feral corn weediness).

Volunteer corn frequently occurs in soybean, cotton, and other crops such as sugar beets, other dry beans, and the following year’s corn crop (Bernards et al., 2010; Monsanto, No Date; Wilson et al., No Date). Volunteer corn can be quite extensive in fields, competing with the desired crop for light, nutrients, and moisture (Wilson et al., No Date) and is particularly problematic with short crops such as soybeans and sugar beets. As a result of transgene pollen movement, some volunteer glyphosate-resistant corn plants occur in fields even if glyphosate-resistant corn was not planted the previous year (Beckie and Owen, 2007). While pollen mediated gene transfer can occur in corn, as discussed in Subsection 2.3.3, Gene Flow and Weediness, gene flow in the crop decreases rapidly with separation distance. Controlling volunteer corn early is the key to preserving yields in these desired crops. Prevention of volunteer corn is achievable by selecting cultivars with adequate stalk strength and ear retention qualities; minimizing disease and insect infestations that result in pre-harvest ear losses; harvesting corn on time and with equipment having correct settings; and, operating harvest equipment at appropriate speeds (Beckie and Owen, 2007; Bernards et al., 2010; Monsanto, No Date). Management could also be accomplished by applying post-emergence grass herbicides in subsequent broadleaf crops, planting a corn variety resistant to a different mode of action than the previous corn crop, or performing spring tillage (Wilson et al., No Date).

Volunteer corn may be managed and crop damage minimized by early and diligent scouting, mechanical inter-row cultivation or flame weeding, and the application of herbicides. The most effective herbicides for eliminating volunteer corn are those with efficacy in grasses (i.e., graminicides), including glyphosate application to conventional corn volunteers in glyphosate-resistant corn. Controlling glyphosate-resistant corn in subsequent glyphosate-resistant broad-leaf crops such as soybean may be achieved by application of acetyl-CoA synthase (ACCase)-inhibitors and ALS herbicides such as Assure II®, Fusilade®, Select®, Poast®, Raptor®, and Wolverine® (Hager, 2007; Zollinger et al., 2011). The use of paraquat or an ALS inhibitor such as Finesse® is effective for controlling glyphosate-resistant corn in wheat (Martin, 2010). Controlling volunteer glyphosate-resistant corn in cornfields may be achieved by alternating the glyphosate-resistant corn with non-GE corn or with GE corn cultivars having resistance to herbicides with different modes of action, and then application of that herbicide post-emergence, such as LibertyLink® and glufosinate (Beckie and Owen, 2007; Wilson et al., No Date). Beckie and Owen (2007) suggest that the most effective method of controlling volunteer crops is to utilize a combination of these techniques.

The application of an herbicide in corn production has the potential to impact non-target plants communities through spray drift, volatilization (evaporation), its adsorption to soils incorporated in runoff, leaching, and cleaning and disposal of the equipment used to dispense it. Factors affecting drift and diffusion include application equipment and method, weather conditions, topography, and the type of crop being sprayed (US-EPA, 2000). The EPA is currently evaluating new regulations for pesticide drift labeling and the identification of BMPs to control such drift (US-EPA, 2009d), as well as identifying scientific issues surrounding field volatility of conventional pesticides (US-EPA, 2010).

The environmental effects associated with glyphosate use are summarized in the most recent Glyphosate RED Facts (US-EPA, 1993a). As mentioned previously, glyphosate is currently under review by EPA for continued registration of the herbicide, with a reregistration decision expected in 2015 (US-EPA, 2009a). Glyphosate is toxic to most terrestrial and aquatic plants, inducing plant death. The leaching potential of glyphosate is minimal as it tightly adsorbs to soil particles (Senseman, 2007). It also has a low vapor pressure and volatility from soils (US-EPA, 1993b). In its 1993 glyphosate reregistration decision, the EPA required additional studies concerning vegetative vigor, droplet size spectrum, and a drift field evaluation that did not affect the reregistration eligibility of the herbicide (US-EPA, 1993a). EPA-approved labels provide detailed measures to manage spray drift including optimal wind conditions, temperature inversions, humidity, spray droplet size, sprayer boom heights, aerial spraying by aircraft measures, and inclusion of drift reduction additives (Monsanto, 2010).

2.3.3 Gene Flow and Weediness

Gene flow is a biological process that facilitates the production of hybrid plants, introgression of novel alleles (i.e., versions of a gene) into a population, and evolution of new plant genotypes. Gene flow to and from an agro-ecosystem can occur on both spatial and temporal scales. In general, plant pollen tends to represent the major reproductive method for moving across space, while both seed and vegetative propagation tend to promote the movement of genes across time and space.

The rate and success of gene flow is dependent on numerous external factors in addition to the intrinsic reproductive biology of donor/recipient plants (Chandler and Dunwell, 2008; Zapiola et al., 2008). External factors important to pollen-mediated gene flow include the presence/ abundance/distance of sexually-compatible plant species; overlap of flowering phenology between populations; wind versus insect pollination; the amount and duration of pollen production; and weather conditions such as temperature, wind, and humidity. Seed-mediated gene flow also depends on many factors, including the absence/presence/magnitude of seed dormancy, contribution and participation in various dispersal pathways, and environmental conditions and events.

Corn plants do not produce clonal structures (shoots) that then develop into plants (vegetative propagules); therefore, asexual reproduction and gene flow as a result of dispersal of vegetative tissues does not occur with corn. Corn is self-compatible and primarily pollinated by wind or gravity with minimal contribution from insect pollination (McGregor, 1976; Thomison, 2009). There are no extant populations of sexually compatible species related to *Z. mays* within the continental U.S., its territories, or possessions; therefore, APHIS (2011b) has concluded that there is not a significant risk of gene movement between corn and its wild or weedy maize relatives.

Molecular evidence of gene flow among corn, *Z. mexicana* and *Z. mays* ssp. *parviglumis,* has been documented to occur at low frequencies among extant populations of these species in Mexico and likely due to historical admixture among native populations in the same geographic area rather than recent introgression (Ross-Ibarra et al., 2009). Complex mechanisms of incompatibility have been described that are barriers to gene flow (Kermicle and Evans, 2010). While corn and various teosinte species are culturally and biologically similar, and gene exchange between these groups has been documented, no successful weedy species has evolved (US-EPA, 2011b).

<u>Pollen-mediated Gene Flow and Mitigation</u>

Many varieties of corn are cultivated in the U.S. For gene flow to occur between corn varieties, flowering of the source and sink populations must overlap, pollen transfer must occur, embryo/ seeds must develop, and hybrid seed must disperse and establish. Corn is a monoecious (having both male and female reproductive units), out-crossing, wind-pollinated crop that produces abundant, large, and heavy pollen. The reproductive morphology of corn encourages cross-pollination between corn plants and there is no evidence (genetic or biological barriers) to indicate that gene flow is restricted between genetically modified, conventional, and organic corn.

A number of studies have investigated pollen dispersal, cross-fertilization, and gene flow involving corn grain production fields. Sanvido et al. (2008) reviewed these studies and found that pollen-mediated gene flow typically decreases to less than 0.5% beyond 50 meters (approximately 164 feet) and proposes this as an adequate isolation distance for GE cornfields in areas with dense corn production. In comparisons of outcrossing relating to both distance and temporal separation in California and Washington, Halsey et al. (2005), found that temporal separation reduced the occurrence of outcrossing, yet the difference was only statistically significant in California due to the rate of crop growth. At both study locations, 200 meters (approximately 656 feet) was found to reduce outcrossing to <0.1%. Spatial and temporal isolation can be one of the most effective barriers to gene exchange between corn crop cultivars. Current practices for maintaining the purity of hybrid seed production in corn are typically successful for maintaining 99% genetic purity, though higher instances of out-crossing can occur (Ireland et al., 2006). Requirements and methods to ensure seed and crop purity are discussed in more detail in Subsections 2.1.3, Corn Seed Production, and 2.1.4, Organic Corn Production.

Seed-mediated Gene Flow and Mitigation

For gene flow to occur via seeds and result in feral populations of corn, seeds must disperse and establish in new habitats. Generally, gene flow by seed is dependent on natural dispersal mechanisms, such as water, wind, animals, or by human actions and is favored by characteristics such as small and lightweight seed size, prolific production, seed longevity and dormancy, and long distance seed transport (Mallory-Smith and Zapiola, 2008). Corn does not possess the characteristics for efficient seed-mediated gene flow. Through thousands of years of selective breeding by humans, corn has been extensively modified to depend on human cultivation for survival (Doebley, 2004). As a result of its domestication, corn is not able to survive in the wild, and also has several traits that greatly reduce its ability to disperse via seeds (OECD, 2003). Humans have selected corn to produce seeds that do not shatter and cannot disperse from the cob, and corn seeds are tightly bound within a protective sheath of leaves or husk (Doebley, 2004). Corn seeds lack dormancy and will not produce a persistent seed bank; additionally, corn seeds are large and heavy and not easily dispersed by wind or water (Mallory-Smith and Zapiola, 2008). Any crop seeds that remain on the field after harvest and are viable to germinate the following year in rotation crops are termed volunteers (Carpenter et al., 2002) and considered weeds since they are out of place (see Subsection 2.3.2, Plants Communities, for a more detailed discussion on volunteer corn). Fortunately, volunteer corn in subsequent crops is relatively easily managed by a combination of agronomic practices and mechanical means, and the application of herbicides.

Global dispersal of seed leading to adventitious presence in seed or grain stocks has been documented (Marvier and Van Acker, 2005; Mercer and Wainwright, 2008; Dyer et al., 2009; Piñeyro-Nelson et al., 2009; Gamarra et al., 2011). Its presence can be mitigated by effective quality control analysis of seed prior to sale, coupled with best practices of product stewardship by seed companies and growers. Moreover, compliance with identity preservation protocols outlined by organizations such as AOSCA (2003) would minimize the potential for inadvertent inclusion of GE crops.

Horizontal Gene Flow

The potential for horizontal gene flow from a plant species to bacteria or fungi is unlikely to occur (Keese, 2008). There are several bacteria and fungi associated with plants such as commensals, symbionts, parasites, pathogens, decomposers, and those found in herbivore guts; however, there are very few evolutionary examples of horizontal gene transfer from plants to bacteria or fungi (Keese, 2008). Many bacteria (or parts thereof) that are closely associated with plants have been sequenced including *Agrobacterium* and *Rhizobium* (Kaneko et al., 2000; Wood et al., 2001; Kaneko et al., 2002). There is no evidence that these organisms contain genes derived from plants. In cases where the review of sequence data implied that horizontal gene transfer occurred, these events were inferred to occur on an evolutionary time scale in the order of millions of years (Koonin et al., 2001; Brown, 2003). The FDA has also evaluated horizontal gene transfer from the use of antibiotic resistance marker genes, and concluded that the likelihood of transfer of antibiotic resistance genes from plant genomes to microorganisms in the gastrointestinal tract of humans or animals or in the environment is remote (US-FDA, 1998b). The probability of gene flow from corn to other organisms is, therefore, considered to be unlikely.

2.3.4 Microorganisms

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). 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 soil type (texture, structure, organic matter, aggregate stability, pH, and nutrient content), plant type (providers of specific carbon and energy sources into the soil), and agricultural management practices (crop rotation, tillage, herbicide and fertilizer application, and irrigation) (Garbeva et al., 2004). Plant roots, including those of corn, release a variety of compounds into the soil creating a unique environment for microorganisms in the rhizosphere. Microbial diversity in the rhizosphere may be extensive and differs from the microbial community in the bulk soil (Garbeva et al., 2004).

The structure of soil microbial communities is highly dependent on plant type, the physical and chemical characteristics of the soil, and climate (Garbeva et al., 2004; Marschner et al., 2004; Gupta et al., 2007). As such, potential changes to the soil microbial community as a result of cultivating genetically modified crops has been of research interest (O'Callaghan and Glare, 2001; Kowalchuk et al., 2003; Dunfield and Germida, 2004). There are potential direct and indirect impacts from the large-scale use of GE crops to soil- and plant-associated microbial communities, both in the rhizosphere and bulk soil (Lynch et al., 2004; Motavalli et al., 2004). Direct impacts include changes to the structural and functional community near the roots due to altered root exudation or the transfer of GE material, or a change in microbial populations due to the changes in agronomic practices used to produce GE crops (e.g., use of agricultural chemicals and fertilizers and tillage). Indirect impacts may arise from changes in the amount and composition of residue from the GE crops.

Studies to determine the impact of GE crops on soil microbial communities are mixed. A review of those investigating the impact of transgenic plants on microbial soil communities completed by Kowalchuk et al. (2003) found that much of the research examining distinctive microbial traits concluded there were minor or no non-target effects; only a few found induced targeted alterations to the composition of the microbial community that usually resulted in the inhibition of plant pathogenic organisms. A similar review by Motavalli et al. (2004) did not find any conclusive evidence that released transgenic plants were causing significant direct impacts on microbe-mediated soil nutrient transformations and studies of potential indirect impacts were lacking.

Crop rotations influence microorganisms as the chemical and nutrient composition of plants and their residues can promote or suppress diseases, affect levels of organic matter, and diversify nutrient sources for soil biota (Gupta et al., 2007). Tillage systems can alter the physiological and chemical properties and biological composition of soils. No-till promotes retention of soil organic matter and concentrates soil microorganism activity at the soil surface, while increasing populations of both disease suppressing and disease promoting fungi, in turn increasing species that feed on fungi (Gupta et al., 2007). Conventional tillage distributes organisms deeper into the soil, while promoting bacteria and bactivorous fauna and increasing residue breakdown accompanied by rapid nutrient mineralization (Gupta et al., 2007). Water is one of the important factors influencing microbial population structure and activity in soil; thus irrigation can have a substantial impact. Soil moisture carries nutrients to microorganisms and supplies hydrogen and oxygen (AgriInfo, 2011). Microbes are most active and populous in the moisture range of 20% to 60%, while excess moisture conditions can create a low oxygen environment beneficial to anaerobic microflora, and too little will not support soil microbia (Stark and Firestone, 1995; AgriInfo, 2011).

Fertilizers may support soil microorganisms as increased crop growth can lead to increased residues, building soil organic matter. But fertilizers may change the relative acidity of soils that can be detrimental to some microorganisms, and may reduce the beneficial symbiosis of some microorganisms with particular plant species (Gupta et al., 2007). Pesticides such as fungicides potentially impact fungal microbia.

In a comparison of fields planted with glyphosate-resistant and conventional corn and cotton, Locke et al. (2008) found that crops treated with glyphosate had subtle and dynamic differences in soil microbial populations when compared to non-glyphosate-resistant crops. The authors surmise that the decreased disturbance of the soil and increased level of residue as a result of reduced tillage on the glyphosate-treated crops allowed for a more diverse microbial population. A 10-year comparison study of GE glyphosate-resistant and non-GE corn and soybean by Kremer and Means (2009) found that glyphosate-resistant soybeans, even when not treated with glyphosate, had a lower number and mass of root nodules than that of non-GE soybean, indicating that root exudates from GE crops influence the rhizosphere microbial community.

Glyphosate is readily metabolized by soil microbes, yet its strong adsorption capacity to soil slows this function (Tu et al., 2001). The average half-life of glyphosate is 47 days, yet this rate varies depending on soil structure and microbial population (Senseman, 2007). The primary metabolite from microbial degradation is AMPA, which is further degraded to CO_2 (US-EPA, 1993a; Senseman, 2007). Results of research investigating the impact of glyphosate on the microbial community are mixed (Weaver et al., 2007). For example, Haney et al. (2002) and Araujo et al. (2003) report that glyphosate is mineralized by microorganisms that leads to an increase in their population and activity, while Busse et al. (2001) and Weaver et al. (2007) found little evidence of changes to soil microorganism's population and activity, and any declines recorded were small and not consistent throughout the season. It also has been reported that the use of glyphosate increases the colonization of soil-borne fungal pathogens such as *Fusarium* (Kremer and Means, 2009; Huber, 2010). Similarly, research by Camberato (2011) found that some weeds treated with glyphosate and other herbicides had increased incidence of fungal infection, suggesting that some soil fungi are more able to infect a weed after it has been weakened by glyphosate. They point out, however, that plant pathologists have not observed widespread increases in plant diseases in glyphosate-resistant corn and soybean. In a review of recent studies investigating a potential link between the use of glyphosate and outbreaks of fungal disease, Powell and Swanton (2008) did not find sufficient evidence from field trials demonstrating whether a causative relationship exists. Additionally, they found that observed links may be context dependent, as they were found only under controlled laboratory conditions. The authors suggest that to adequately address the effect glyphosate has on fungal diseases, future investigations should consider additional interactive factors, such as inoculum level, weed abundance and community composition, fertility, cultural practices, climate, and soil properties.

2.3.5 Biodiversity

Biodiversity refers to all plants, animals, and microorganisms interacting in an ecosystem (Wilson, 1988). Biodiversity provides valuable genetic resources for crop improvement (Harlan, 1975) and also provides other functions beyond food, fiber, fuel, and income. These include pollination, genetic introgression, biological control, nutrient recycling, competition against natural enemies, soil structure, soil and water conservation, disease suppression, control of local microclimate, control of local hydrological processes, and detoxification of noxious chemicals (Altieri, 1999). The loss of biodiversity results in a need for costly management practices in order to provide these functions to the crop (Altieri, 1999).

The degree of biodiversity in an agroecosystem depends on four primary characteristics: (1) diversity of vegetation within and around the agroecosystem; (2) permanence of various crops within the system; (3) intensity of management; and (4) extent of isolation of the agroecosystem from natural vegetation (Southwood and Way, 1970).

Agricultural land subject to intensive farming practices, such as that used in crop production, generally has low levels of biodiversity compared with adjacent natural areas. Tillage, seed bed preparation, planting of a monoculture crop, pesticide use, fertilizer use, and harvest result limit the diversity of plants and animals (Lovett et al., 2003). Biodiversity can be maintained or reintroduced into agroecosystems through the use of woodlots, fencerows, hedgerows, and wetlands. Agronomic practices include intercropping (the planting of two or more crops simultaneously to occupy the same field), agroforestry, crop rotations, cover crops, no-tillage, composting, green manuring (growing a crop specifically for the purpose of incorporating it into the soil in order to provide nutrients and organic matter), addition of organic matter (e.g., compost, green manure, animal manure), and hedgerows and windbreaks (Altieri, 1999).

The potential impact to biodiversity associated with agriculture, including the cultivation of GE crops, is the loss of diversity, which can occur at the crop, farm, and/or landscape scale (Visser, 1998; Ammann, 2005; Carpenter, 2011). In this analysis, crop diversity refers to the genetic uniformity within crops, farm-scale diversity refers to the level of complexity of organisms within the boundaries of a farm, and landscape-scale diversity refers to potential changes in land use and the impacts of area-wide weed suppression beyond the farm boundaries (Carpenter, 2011).

Crop Diversity

As indicated in reviews conducted by Carpenter (2011), Krishna et al. (2009), van de Wouw et al. (2010), and Visser (1998), it is widely accepted that genetic diversity in crops is beneficial as it may improve yields, pest and disease resistance, and quality in agricultural systems, and that greater varietal and species diversity enable growers to maintain productivity over a wide range of conditions. There is concern that the adoption of GE technology potentially reduces grower-demand for crop genetic diversity because breeding programs could concentrate on a smaller number of high value cultivars, which could reduce the availability of, and demand for, non-GE varieties (Krishna et al., 2009; Carpenter, 2011). The establishment of large monocultures of genetically homogeneous crops increases the vulnerability of crops to potentially catastrophic damage from pest and disease outbreaks (Garcia and Altieri, 2005), but this potential is not limited to GE crops. Several summary reviews of relevant research evaluating GE herbicide-resistant soybeans and cotton, however, have provided evidence that the introduction of GE crops has not decreased crop diversity because of widespread use of the traits in multiple breeding programs and the technology enables the introduction of novel genes in crops (Ammann, 2005; Carpenter, 2011). Concern for the loss of genetic variability has led to the establishment of an extensive network of genebanks (van de Wouw et al., 2010). The National Plant Germplasm System manages an active collection of more than 14,000 accessions of corn at the USDA-ARS North Central Regional Plant Introduction Station at Iowa State University, Ames, Iowa (USDA-ARS, 2005). Managing the active collection involves acquiring, maintaining, evaluating, characterizing, and distributing this germplasm to researchers worldwide, which helps ensure a continuous reservoir of genetic diversity for future crop development.

Farm-scale Diversity

Adoption of GE technology has the potential to impact diversity at the farm scale by affecting a farm's biota, including birds, wildlife, invertebrates, soil microorganisms, and weed populations. For example, an increase in adoption of conservation tillage practices is associated with the use of GE herbicide-resistant crops (Givens et al., 2009). Less tillage provides more wildlife habitat by allowing other plants to establish between crop rows. Conservation tillage leaves a higher rate of plant residue and increases soil organic matter (Hussain et al., 1999; Towery and Werblow, 2010), which benefit soil biota by providing additional food sources (energy) (USDA-NRCS, 1996). In addition, invertebrates that feed on plant detritus and their predators as well as the birds and other wildlife that feed on them, may benefit from increases in conservation tillage practices (Towery and Werblow, 2010; Carpenter, 2011). Ground-nesting and seed-eating birds, in particular, have been found to benefit from greater food and cover associated with conservation tillage (SOWAP, 2007).

In addition to conservation tillage, habitat can be maintained on agricultural lands by managing field edges for wildlife and using several cultural practices such as crop rotations, planting grassed terraces, and contour strip planting. Field edges are often not productive, and the cost for cultivation can exceed the crop value (Sharpe, 2010). Field edges that are allowed to return to volunteer plants such as ragweed (*Ambrosia*), goldenrod (*Solidago*), and aster (*Aster* L.) can quickly become suitable habitat for game birds and songbirds (Sharpe, 2010). Rotating crops with small grains or meadow crops not only serves to reduce erosion and enhance soil properties, this practice also increases plant diversity and provides forage and cover for several wildlife species (Brady, 1985; Sharpe, 2010). Similarly, planting crops in strips along the natural contour of the slope and along grass or fallow strips, otherwise known as contour strip cropping, also increases plant diversity and provide beneficial wildlife habitat (Brady, 1985; Sharpe, 2010).

Herbicide use in agricultural fields may impact biodiversity by decreasing weed quantities or causing a shift in weed species present in the field, which may affect those insects, birds, and mammals that utilize these weeds. The quantity and type of herbicide use associated with GE crops, however, is dependent on many variables, including cropping systems, type and abundance of weeds, production practices, and individual grower decisions.

Landscape-scale Diversity

The greatest direct impact of agriculture on biodiversity on the landscape scale results from the loss of natural habitats caused by the conversion of natural ecosystems into agricultural land (Ammann, 2005). A literature review by Carpenter (2011) revealed that increases in crop yields, such as may be attained with GE crops (including herbicide-resistant corn) have the potential to reduce impacts to biodiversity by allowing less land to be converted to agriculture than would otherwise be necessary; however, substantial gains in yields have generally not been obtained by herbicide-resistant cultivars unless higher yielding cultivars are modified with an herbicide-resistant trait (NRC, 2010).

As with farm-scale diversity, use of herbicides at the landscape scale also has the potential to impact biodiversity. Area-wide herbicide application may increase certain populations of invertebrates and wildlife that benefit from conservation tillage, whereas species that are dependent on the targeted weeds may be negatively impacted.

Further, potential impacts to landscape-scale diversity can be related to the effects of herbicides on non-target animal and plant species. Assessments of the toxicity of glyphosate to animal species indicate a minimal risk to animals, but it may cause adverse effects to plants composing the animals' habitat. As discussed in Subsection 2.3.1, Animal Communities, glyphosate was found by the EPA to be no more than slightly toxic to birds, moderately toxic to practically nontoxic to fish, and practically nontoxic to aquatic invertebrates and honeybees (US-EPA, 1993b). Spraying herbicides onto crops has the potential for inadvertent contact and damage to non-target plants; the EPA is currently evaluating additional labeling requirements concerning BMPs for controlling pesticide spray drift (see Subsection 2.3.2, Plants Communities). While herbicide use potentially affects biodiversity, the application of pesticides in accordance with registered uses and label instructions, and careful management of chemical spray drift, minimizes the potential impacts from their use.

In 2009, the EPA initiated reregistration of glyphosate and has identified additional data needs. Part of the risk assessment will include an acute avian oral toxicity study for passerine species. Additionally, some inert ingredients used as surfactants are more toxic than glyphosate to aquatic organisms, and will be evaluated for acute toxicity to estuarine and marine mollusk, invertebrates, and fish (US-EPA, 2009b).

2.4 Human Health

Corn is used for food, feed, and various other products to which people are exposed. One component of the affected environment is the direct human consumption of products derived from corn, as described below. This section also addresses exposure to pesticides used on corn.

The majority of corn produced in the U.S. is field or "dent" corn (named for the dent at the crown of the mature kernel) (USGC, 2010). Field corn is used in a multitude of products which are also either directly or indirectly consumed by humans. Directly consumed corn products include corn syrup and sweeteners, starches, oil, cereal, beverage and industrial alcohol, and cosmetics and other personal hygiene products containing corn ingredients (USGC, 2010). In the 2010/2011 market year, these products totaled 12.2% of domestic field corn consumption (USDA-ERS, 2011g). In 2010, the average per capita consumption of corn food products was 102.2 pounds, 69.2 pounds of which was corn sweeteners (USCB, 2011). The major use of corn indirectly consumed by humans is in the form of livestock feed; in the 2010/11 market year, approximately 42.8% of domestic corn consumption was for feed and residual use (USDA-ERS, 2011g). Also in the 2010/11 market year, the U.S. produced about 12.4 billion bushels (315 million metric tons) of corn, 88% of which (10.9 billion bushels or 277 million metric tons) were GE varieties and 72% (8.9 billion bushels or 226 million metric tons) that was genetically engineered for herbicide resistance (USDA-ERS, 2011a; USDA-ERS, 2011g). Starch and oil fractions obtained from wet or dry milling processes produce products such as corn syrup and corn oil for direct human consumption (CERA, 2010).

Some of the commonly raised human health concerns associated with GE crops include the potential toxicity of the introduced genes and their products, the expression of new antigenic proteins, or altered levels of existing allergens (Malarkey, 2003; Dona and Arvanitoyannis, 2009). All forms of genetic modification, including natural and human-mediated, have the potential for unexpected and unintentional compositional changes (NRC, 2004). The potential for compositional changes to impact human health is dependent on the nature of the altered substances and biological effects of the compounds. Previous studies of the EPSPS protein, which confers glyphosate resistance, found that the EPSPS proteins expressed through genetic engineering pose no potential for toxicity or allergenicity (Harrison et al., 1996; Ridley et al., 2002; Batista et al., 2005; Hoff et al., 2007; Herouet-Guicheney et al., 2009). For example, in a study to evaluate the safety of the 2mEPSPS[7] protein in corn, Herouet-Guicheney et al. (2009) found that the 2mEPSPS protein is highly similar, both structurally and functionally, to the wild-type[8] EPSPS protein found in nature, and does not have an amino acid sequence similar to any known allergenic or toxic protein. Similarly, in a study of the allergenicity of the CP4 EPSPS[9] protein in GE corn and soybean to potentially sensitive humans, Batista et al. (2005) found that none of the individuals tested reacted differently to either the transgenic or wild-type maize samples.

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[7] The 2mEPSPS protein differs from the wild-type corn EPSPS protein as a result of the substitution of two amino acids in the genetic sequence.
[8] The natural state, or non-mutated gene that encodes the normal genetic function.
[9] The CP4 EPSPS protein is derived from the *Agrobacterium* sp. strain CP4.

An additional concern with GE food crops is the potential for increased levels of anti-nutrients, the compounds that interfere with the digestion of proteins, fats, and carbohydrates or the absorption of essential elements in the digestive tract (Dona and Arvanitoyannis, 2009). There are several naturally occurring anti-nutrients found in corn, including phytic acid, DIMBOA[10], raffinose, and low levels of trypsin and chymotrypsin inhibitors (OECD, 2002). In a comparison of the nutritional profile of the glyphosate-resistant corn variety NK603, which expresses the CP4 EPSPS protein for glyphosate resistance, and non-GE corn, Ridley et al. (2002) found that the genetic modification to confer glyphosate resistance did not significantly change any of the 51 biologically and nutritionally important components evaluated.

Under the 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 GE corn 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. Although a voluntary process, thus far all applicants who wish to commercialize a GE variety that will be included in the food supply have completed a consultation with the FDA. In a consultation, a developer who intends to commercialize a bioengineered food meets with the agency 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. The FDA evaluates the submission and responds to the developer by letter (US-FDA, 2012b).

Stine has provided the FDA with information on the identity, function, and characterization of the genes for Maize Line HCEM485, including the expression of gene products. A biotechnology consultation of the EPSPS protein was completed by the FDA on the GA21 corn variety (Biotechnology Notification File (BNF) No. 000051) on February 10, 1998 (US-FDA, 1998a). According to the consultation note,

> "Monsanto has concluded that corn containing transformation event GA21 is not materially different in composition, nutrition, and safety from corn currently grown, processed, marketed, and consumed for animal feed or human food. At this time, based on Monsanto's description of its data and analyses, the Agency considers Monsanto's consultation on corn from varieties containing transformation event GA21 to be complete."

Stine submitted a safety and nutritional assessment of food and feed derived from Maize Line HCEM485 to the FDA in December 2010 in support of the consultation process with the FDA for the commercial distribution of Maize Line HCEM485 (Stine, 2011).

The allergy potential of a GE food crop is also part of the safety evaluation conducted by FDA. Food allergies are caused by parts of the food or ingredients, usually proteins, which are recognized by the body's immune cells causing a reaction. There have been reported cases of corn allergies; however, the protein(s) that may be responsible has not been identified (CERA,

[10] 2,4-Dihydroxy-7-methoxy-2H-1,4-benzoxazin-3(4H)-one (DIMBOA) belongs to a group of metabolites, hydroxamic acids and benzoxazinoids that are frequently found in cereal crops.

2010). Some foods only cause an allergic reaction when eaten raw, while others such as corn may or may not be allergenic, depending on how they are processed (i.e. corn oil versus corn grain) (NIAID, 2011). The Food Allergen Labeling and Consumer Protection Act of 2004 (FALCPA) identified the eight most-common allergenic foods which account for 90% of food allergic reactions; however, corn is not included on this list (US-FDA, 2012a). The EPSPS protein expressed in Maize Line HCEM485 has the same molecular weight and immunochemical cross-reactivity as that of GA21 corn (Stine, 2011), and was determined:

- not to be a known allergen;
- not to have a gene sequence homology (similarity in structure) to known allergens or toxins;
- to have a gene sequence homology 99.3% the same as the wild-type corn enzyme and other EPSPS proteins found in food crops;
- to be rapidly degraded in the gut; and
- dietary exposure to the protein is very low (US-FDA, 1998a; CERA, 2010).

Corn allergies are, therefore, not very common, but because corn starch, syrup, and oil are used in so many products not readily identifiable as potentially containing corn, those with corn food allergies must carefully read all food labels (More, 211).

In 2010, pesticides were applied to 98% of planted corn acres, and of that, approximately 66% of all active ingredients applied were herbicides (USDA-NASS, 2011c). Insecticides and fungicides made up approximately 8% and 12% of active ingredients, respectively. The herbicides most widely used on corn in 2010 in order of prevalence were glyphosate applied to 66% of treated acres, followed by atrazine (61%) and acetochlor (25%) (USDA-NASS, 2011c).

Under the FIFRA, all pesticides (which is inclusive of herbicides, insecticides and fungicides) sold or distributed in the U.S. must be registered by the EPA (US-EPA, 2011a). 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 glyphosate, must also be reregistered to ensure that they meet the current, more stringent standards and have a reregistration review every 15 years (US-EPA, 2011a). Glyphosate was first registered in the U.S. in 1974; the latest reregistration decision for glyphosate was issued in 1993 (US-EPA, 1993b; US-EPA, 2009b; US-EPA, 2009a). It is currently under reregistration review, which began in July 2009 and is scheduled for completion in 2015 (US-EPA, 2009a).

Pursuant to the FFDCA, before a pesticide can be used on a food crop the EPA must establish the tolerance value, which is the maximum amount of pesticide residue that can remain on the crop or in foods processed from that crop (US-EPA, 2011j). The USDA has implemented the Pesticide Data Program (PDP) in order to collect data on pesticides residues on food (USDA-AMS, 2010). The EPA uses PDP data to prepare pesticide dietary exposure assessments pursuant to the 1996 Food Quality Protection Act. Pesticide tolerance levels for glyphosate have been established for a wide variety of commodities, including field corn for grain and forage, and are published in the *Federal Register*, 40 CFR §180.364, and the *Indexes to Part 180 Tolerance*

Information for Pesticide Chemicals in Food and Feed Commodities (US-EPA, 2011e). Glyphosate tolerance for corn grain is 5.0 parts per million (ppm) (40 CFR §180.364).

Glyphosate is registered under a variety of trade names (e.g., Roundup®, Roundup Ultra®, Glyphomax Plus®, and Abundit Extra®) by several companies. There are currently over 400 active glyphosate products registered under FIFRA Section 3, and over 100 registered for use on terrestrial food crops (US-EPA, 2009b). As mentioned above, it was the most widely-used herbicide on corn in 2010, applied to 66% of herbicide-treated acres in the U.S. (USDA-NASS, 2011c). In that year, the average application rate was approximately 1.07 lb/Ac, with a total of over 57.5 million pounds applied (USDA-NASS, 2011c). When corn treated with glyphosate may be harvested for food varies by particular formulation. Glyphosate is classified as Toxicity Category III or IV[11], having been found to have low toxicity via the oral, dermal, and inhalation routes (US-EPA, 2009c). Similarly, glyphosate is not classified as a carcinogen or teratogen (US-EPA, 2009c) While neurotoxicity has not been observed in previous studies, new data requirements established under 40 CFR part 158 require acute and subchronic neurotoxicity studies, and an immunotoxicity study to take place for reregistration. The next RED for glyphosate is scheduled to be complete in 2015 (US-EPA, 2009a). Based on toxicological considerations, the EPA Health Effects Division (HED) determined that the main metabolite of glyphosate, AMPA, did not need regulation despite levels observed in foods or feed (US-EPA, 2009c).

The EPA published the Worker Protection Standard (WPS) pursuant to 40 CFR part 170 in 1992 for the purpose of reducing the risk of pesticide poisonings and injuries among agricultural workers and pesticide handlers (US-EPA, 2011k). The WPS offers protections to about 2.5 million agricultural workers who work with pesticides at more than 600,000 agricultural workplaces (e.g., farms, forests, nurseries, greenhouses). The WPS contains requirements for pesticide safety training, notification of pesticide applications, use of personal protective equipment (PPE), restricted entry intervals following pesticide application, decontamination supplies, and emergency medical assistance.

Growers are required to use pesticides consistent with the application instructions provided on the EPA-approved pesticide labels. For example, pesticide labels specify the appropriate worker safety practices that must be followed, including the necessary PPE to be worn by mixers, loaders, other applicators and handlers. These label restrictions carry the weight of law and are enforced by the EPA and the states (FIFRA 7 U.S.C. 136j (a)(2)(G) Unlawful Acts); therefore, it is expected that glyphosate use on Maize Line HCEM485 would be consistent with the EPA-approved labels.

2.5 Animal Feed

U.S. animal agriculture consumed approximately 44% of U.S. corn usage and approximately 127 million metric tons of corn in 2010 (USDA-ERS, 2011g; USDA-ERS, 2011d). As with human consumption of corn, the majority of corn used for animal feed in the U.S. is herbicide resistant (USDA-ERS, 2011a). Corn typically accounts for approximately 96% of the total feed grain produced for use in the U.S. (USDA-ERS, 2011d). According to the National Corn Growers Association, beef cattle consume the largest volume of U.S. corn feed, followed by poultry,

[11] Category I indicates the highest degree of acute toxicity and Category IV the lowest.

swine, and dairy cattle (NCGA, 2011). Corn is used as livestock feed in the form of forage, silage, feed-grain, and refined feed products. The amount of corn that is used for feed is dependent on the number of animals (livestock and poultry) that are fed corn and the supply and price of the crop (USDA-ERS, 2011d). Also taken into account is the amount of supplemental ingredients added to feed and the supply and price of competing ingredients.

Corn silage is commonly used as livestock feed. In 2010, corn was grown for silage in the U.S. on approximately 5.5 million acres and produced approximately 0.97 million metric tons (USDA-NASS, 2011e). Corn silage is consumed primarily by beef and dairy cattle (Staples, 2003; Sewell and Wheaton, 2011), swine (Kephart et al., 2012), sheep, and goats (Schoenian, 2009; OMAFRA, 2011). More than half of all corn feed consists of grain corn. Corn grain is further refined into feed by dry milling, wet milling, and as by-products from distilleries (CRA, 2006). Corn refiners produce five major animal feed products in the form of gluten meal, gluten feed, corn germ meal, condensed fermented corn extractives (steepwater), and amino acids (CRA, No Date). Dairy and beef cattle, poultry, swine, sheep, pets, and fish are fed refined corn products that are good sources of protein, fiber, minerals, and vitamins (CRA, 2006). Amino acids such as lysine, threonine, and tryptophan are produced from corn dextrose, providing nutrient supplements in animal feed; lysine is particularly valued for poultry and swine (CRA, 2006). Corn may also be grown solely for grazing by cattle, goats, sheep, and swine (Hoorman et al., 2002). While annuals, such as corn, make excellent pasture crops and have the compositional value to meet many of the nutritional needs of livestock, they are generally more expensive than perennials typically used in pastures (Hoorman et al., 2002; Aasen, 2010). In some states, such as Illinois and Kentucky, grazing corn is recommended as a viable option for extending the grazing season, especially for producers with limited land area (USDA-NRCS, 2000; Ditsch et al., 2004). Corn varieties recommended for grazing include hybrids recommended for silage (Aasen, 2010). Glyphosate-resistant varieties may be used, but herbicide application restrictions apply and are dependent on the type and timing of application (Bradley et al., 2010).

Similar to the regulatory control for direct human consumption of corn under the FFDCA, it is the responsibility of feed manufacturers to ensure that the products they market are safe and properly labeled. Feed derived from GE corn, like all corn, must comply with all applicable legal and regulatory requirements, which in turn protects human health. To help ensure compliance, GE organisms used for feed may undergo a voluntary consultation process with the FDA before release onto the market, which provides the applicant with any needed direction regarding the need for additional data or analysis, and allows for interagency discussions regarding possible issues.

Although a voluntary process, thus far all applicants who wish to commercialize a GE variety that will be included in the food supply have completed a consultation with the FDA. In a consultation, a developer who intends to commercialize a bioengineered food meets with the agency 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 (US-FDA, 2012b). The FDA evaluates the submission and responds to the developer by letter. Stine submitted their final food consultation regarding Maize Line HCEM485 in December 2010 and is pending review by the FDA. It will be posted on the FDA website Final Biotechnology Consultations http://www.fda.gov/Food/Biotechnology

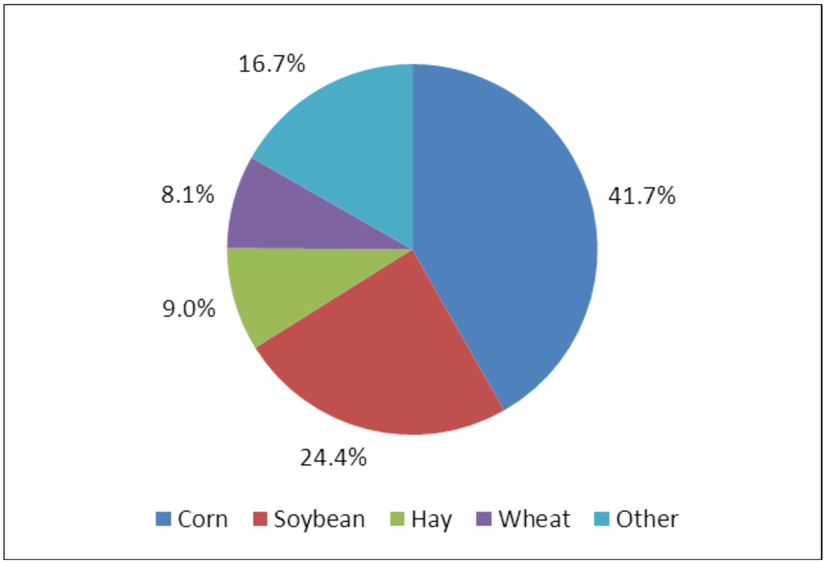
/Submissions/ucm225108.htm when completed. A biotechnology consultation of the EPSPS protein was completed by the FDA on the GA21 corn variety (BNF No. 000051) on February 10, 1998 (US-FDA, 1998a). No food safety issues were found by the FDA in their review of Monsanto's safety and nutritional assessment of GA21 corn and the modified EPSPS protein.

As described in Subsection 2.4, Human Health, under FIFRA, all pesticides (including herbicides) sold or distributed in the U.S. must be registered by the EPA (US-EPA, 2011a). All pesticides registered prior to November 1, 1984, such as glyphosate, must also be reregistered to ensure that they meet the current, more stringent standards and should have a reregistration review every 15 years (US-EPA, 2011a). The latest reregistration decision for glyphosate was issued in 1993 and the reregistration review was started in July 2009 (US-EPA, 2009b; US-EPA, 2009a). Before a pesticide can be used on a food or feed crop, the EPA must establish the tolerance value, which is the maximum amount of pesticide residue that can remain on the crop or in foods or feed processed from that crop (US-EPA, 2011j; US-EPA, 2011e). Pesticide tolerance levels for glyphosate have been established for corn and are published in the *Federal Register,* CFR, and the *Indexes to Part 180 Tolerance Information for Pesticide Chemicals in Food and Feed Commodities* (US-EPA, 2011e). The glyphosate tolerance level established for field corn intended for forage is 6.0 ppm and for grain corn is 5.0 ppm (40 CFR §180.364).

2.6 Socioeconomic

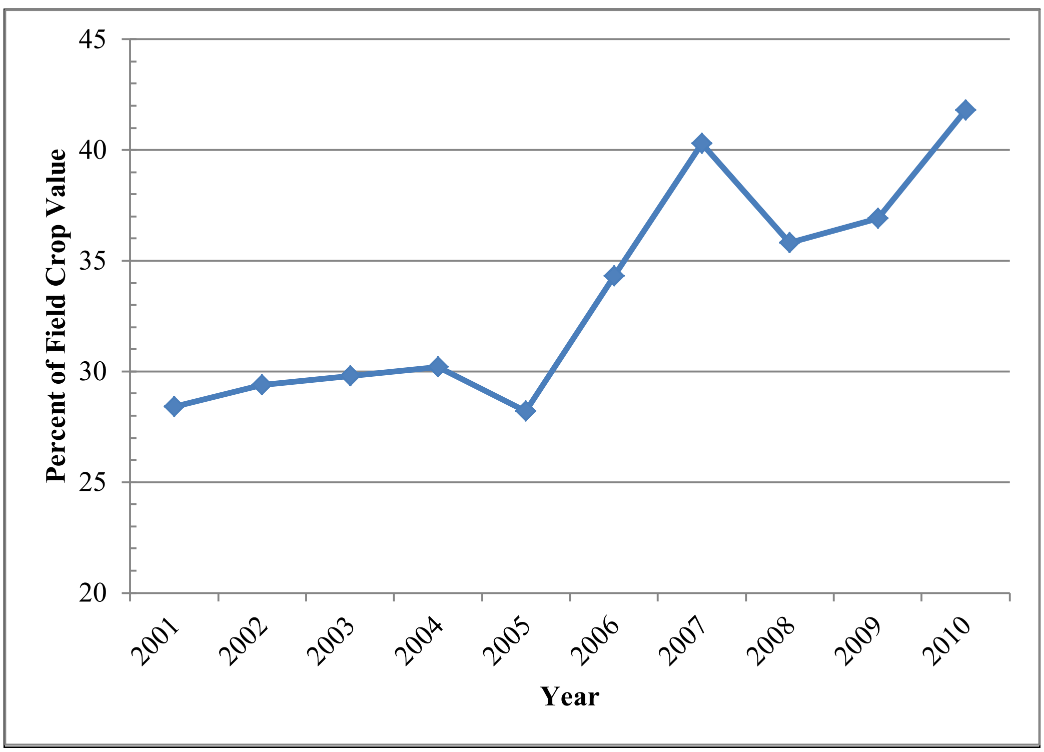
2.6.1 Domestic Economic Environment

The value of U.S. corn production exceeded $66.7 billion in 2010 (USDA-NASS, 2011f) which was 41.7% of the total value of field crops (Figure 6). Corn is among the most important field crops in the U.S. and has been increasing in importance over the past decade (Figure 7). Thirteen states (Iowa, Illinois, Nebraska, Minnesota, Indiana, Kansas, Ohio, South Dakota, Wisconsin, Missouri, Michigan, Texas, and North Dakota) that produced at least one billion dollars' worth of corn in 2010 also accounted for more than 90% of U.S. production (USDA-NASS, 2011f). These states are widely distributed across resource regions defined by the ERS as the Heartland (Illinois, Indiana, Iowa, Minnesota, Missouri, Nebraska, Ohio, and South Dakota), Northern Crescent (Michigan, Minnesota, Ohio, and Wisconsin), Northern Great Plains (Minnesota, Nebraska, North Dakota, and South Dakota), Prairie Gateway (Kansas, Nebraska, and Texas), Eastern Uplands (Missouri and Ohio), Fruitful Rim (Texas), and Southern Seaboard (Texas) resource regions (Fernandez-Cornejo and McBride, 2002). These regions vary in terms of land productivity and cost of production (Figure 8). The most productive of these regions are the Heartland and Northern Crescent. The two most profitable regions, the Heartland and Northern Great Plains, are most profitable for different reasons. The Heartland benefits from greater productivity, while the Northern Great Plains benefits from lower production costs.



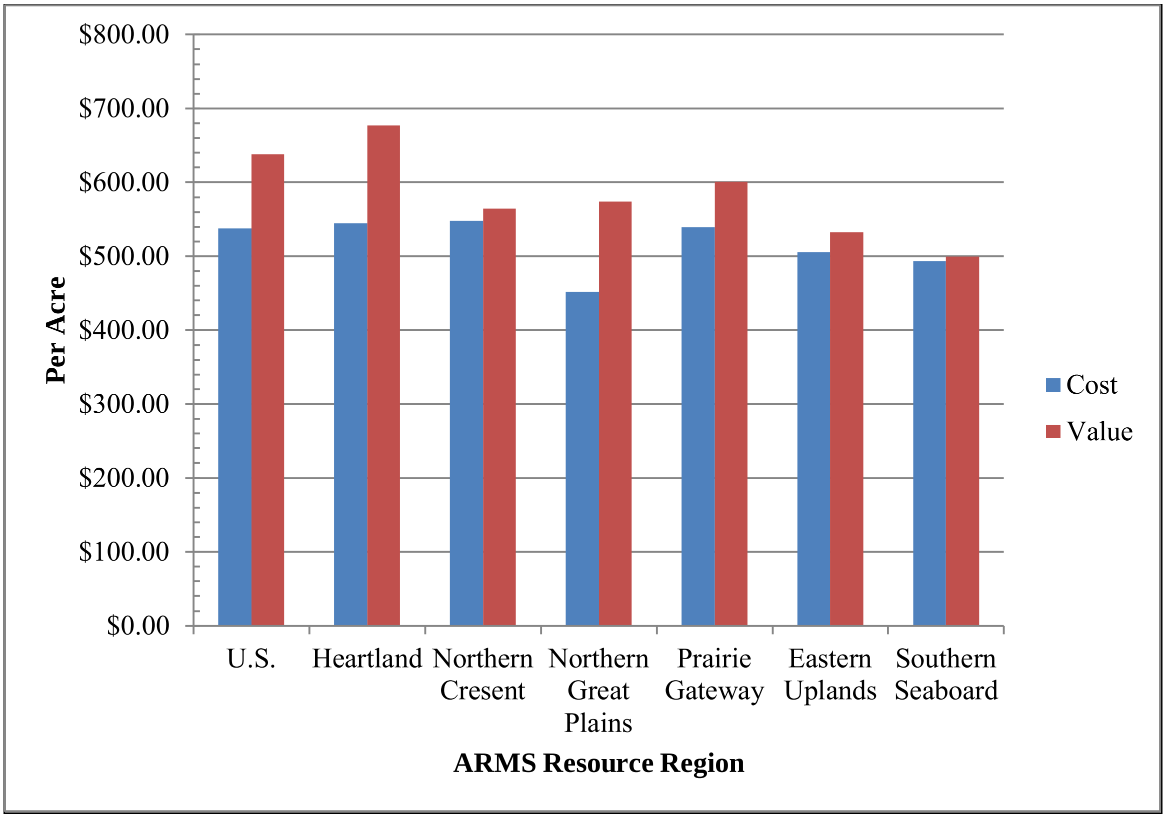
Source: (USDA-NASS, 2011f)

Figure 6. Percentage distribution of 2010 U.S. crop value among corn, soybean, hay, wheat, and other crops. Corn is among the most important field crops in the U.S. as its value of production was 41.7% of the total value of field crops in 2010.



Source: (USDA-NASS, 2004; USDA-NASS, 2005; USDA-NASS, 2006; USDA-NASS, 2007b; USDA-NASS, 2008b; USDA-NASS, 2009b; USDA-NASS, 2010b; USDA-NASS, 2011f)

Figure 7. Value of U.S. corn crop as a percent of all U.S. field crops from 2001 to 2010. Note the value of corn has increased since 2001, indicating its growing importance in U.S. agriculture.



Source: (USDA-ERS, 2011c)

Figure 8. U.S. corn per acre cost and value of production estimates in major ARMS corn- producing regions and the entire U.S. in 2010. Values presented exclude government payments. States comprising the regions include: Heartland (Illinois, Indiana, Iowa, Minnesota, Missouri, Nebraska, Ohio, and South Dakota), Northern Crescent (Michigan, Minnesota, Ohio, and Wisconsin), Northern Great Plains (Minnesota, Nebraska, North Dakota, and South Dakota), Prairie Gateway (Kansas, Nebraska, and Texas), Eastern Uplands (Missouri and Ohio), Fruitful Rim (Texas), and Southern Seaboard (Texas) resource regions (Fernandez-Cornejo and McBride, 2002). These regions vary in terms of land productivity and cost of production.

Production cost data are provided by the ERS and collected in surveys conducted every four to eight years for each commodity as part of the annual ARMS (USDA-ERS, 2011b). In 2010, typical corn production operating costs were reported in dollars per planted acre, and included primarily purchased seed ($83.22), fertilizer and soil amendments ($101.03), other chemicals ($26.86), and irrigation water ($0.15) (USDA-ERS, 2011c). In 2010, total-operating costs for U.S. corn production were $275.58 per planted acre (USDA-ERS, 2011c).

Almost all of the U.S. corn supply (99.8% in 2010/11) comes from new annual domestic production (USDA-ERS, 2011g). Over the past decade this production has increased 25.5%

from 2001 to 2010. In 2010/11, 86.2% of this supply was consumed domestically. Consumption patterns have changed substantially over the past decade. In the 2000/01 marketing year, approximately 75% of the domestic use was for animal feed, whereas only about 8.1% was used for ethanol production. In the 2010/11 marketing year, less than half (42.8%) of domestic usage was for feed, while approximately 44.7% of domestic use was for the production of ethanol, which has been supported by government policies designed to promote domestic renewable energy sources. Similarly, the percentage of corn used for food products (e.g., corn syrup, starch, alcohol for beverages, cereals and other products) decreased between the 2000/01 and 2010/11 marketing years from 19.3% to 12.2% (USDA-ERS, 2011g). Corn use for seed over this period has remained steady at approximately 0.2% (USDA-ERS, 2011g).

The first commercial herbicide-resistant variety of corn was released in 1996 that had conferred resistance to glufosinate, followed in 1998 by glyphosate-resistant corn (Green and Owen, 2011). Herbicide-resistant corn varieties have been more slowly adopted than other such crops, but now account for 72% of U.S. corn acreage in 2011(Brookes and Barfoot, 2010; USDA-ERS, 2011a). As discussed in Subsection 2.1.1, Acreage and Area of Corn Production, herbicide-resistant corn adoption has varied regionally in the U.S., with South Dakota leading the planting of herbicide-resistant-only and herbicide-resistant stacked GE varieties since 2000, and Ohio planting the least (USDA-ERS, 2011a) (see Subsection 2.1.1, Acreage and Area of Production, Figure 4). In 2005, 31% of U.S. corn was glyphosate-resistant and 4% was glufosinate-resistant (Sankula, 2006).

Estimates of the benefits of herbicide-resistant corn to farmers are limited (NRC, 2010). For specialized corn farmers, each time farmers increase herbicide-resistant corn production 10%, Fernandez-Cornejo and McBride (2002) found a 2.7% increase in whole farm net returns, while McBride and El-Osta (2002) found a 2.7% increase in crop operating margin. McBride and El-Osta (2002) did not find higher crop operating margins for herbicide-resistant corn farmers in general, which includes those that rotate corn with other crops. In an examination of research into U.S. farm-level economic impacts of GE crops, the National Research Council (NRC) (2010) found studies indicate in the early years of the adoption, GE cultivars exerted downward pressure on crop prices while the earnings of adopting farmers increased, and barriers to access of GE crops reduced grower income. Now that the adoption of GE cultivars is more widespread globally, the NRC recommends further assessment of the farm-level economic impacts of GE crops (NRC, 2010).

Costs of Herbicide-resistant Weeds

An important concern currently facing U.S. farmers, including corn farmers, is the emergence of glyphosate-resistant weeds (Johnson and Gibson, 2006; Foresman and Glasgow, 2008; Hurley et al., 2009a; Johnson et al., 2009), a result of the repeated, wide spread, and sometimes exclusive use of glyphosate on corn, cotton, and soybean crops resistant to the pesticide (Beckie, 2006; Duke and Powles, 2009). As of the 2010 growing season, there were 13 different weed species with glyphosate-resistant populations ranging across 25 different U.S. states (Heap, 2011) (see Subsection 2.3.2, Plants Communities, Table 2). Glyphosate-resistant weed populations have been found in all but 3 (South Dakota, Wisconsin, and Texas) of the 13 major corn producing states. Comparing the typical glyphosate-resistant weed management programs to a typical nonherbicide-resistant weed management program, Sankula and Blumenthal (2004) and Sankula

(2006) estimated that farmers saved $9.49 to $10.15 per acre in weed management costs. Based on 2007 survey data, Hurley, Mitchell, and Frisvold (2009b) found that farmers planting more glyphosate-resistant corn reported lower weed management costs.

Surveys indicate that farmers prefer to address glyphosate-resistant weeds by using additional herbicides with different modes of action (Johnson and Gibson, 2006; Foresman and Glasgow, 2008; Johnson et al., 2009). Weirich et al. (2011) investigated the effect of grower adoption of alternative glyphosate weed resistance management programs, finding they increased cost substantially, though they did not statistically significantly decrease net returns due to higher yields. These results suggest that growers may be able to effectively respond to glyphosate resistance using weed BMPs without substantially affecting their returns.

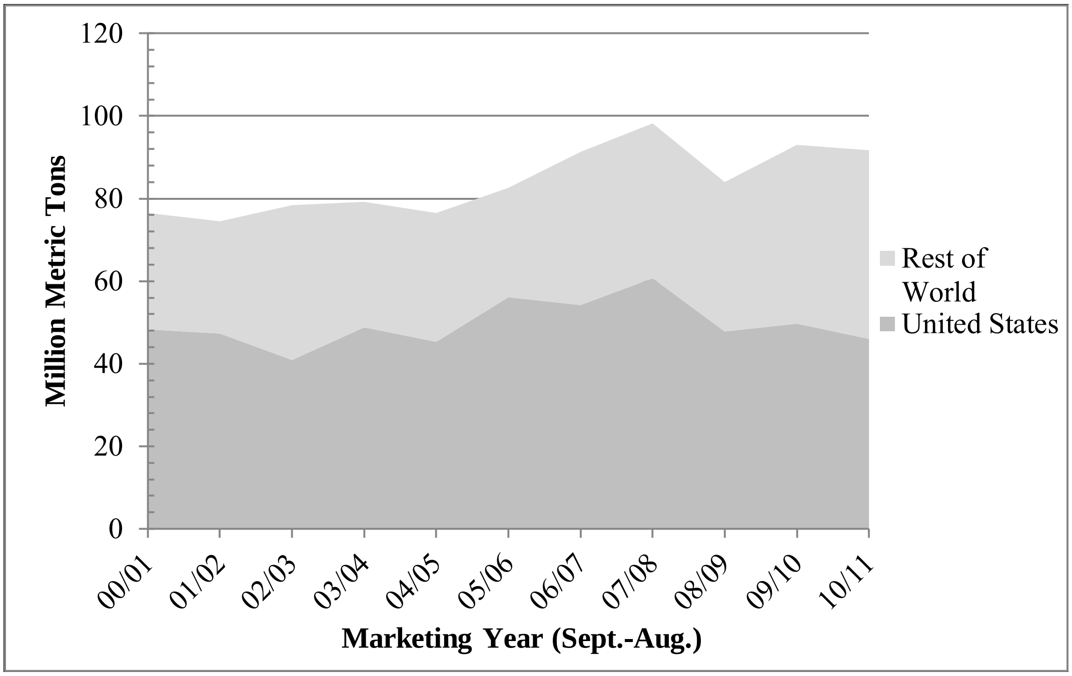
Organic Crop Production

Organic crop production represents an extremely small share of U.S. production. In 2008, there were approximately 2.2 to 2.6 million acres of certified organic cropland representing about 0.70% of the total cropland acres (USDA-ERS, 2010a; USDA-NASS, 2010a). There were only 194,637 acres of organic corn representing 0.05% of total cropland and 0.21% of the total corn acres in 2008 (USDA-ERS, 2010a). More than 80% of this production was concentrated in 10 states (Wisconsin, Minnesota, Iowa, Michigan, New York, Texas, Nebraska, Ohio, Illinois, and Pennsylvania), with the top 2 states (Wisconsin and Minnesota) representing almost a third of these acres (USDA-ERS, 2010b). All but New York and Pennsylvania are among the top 13 corn producing states. The value of corn produced for grain or seed from organic-certified farms in the U.S. in 2008 was nearly $111.4 million (USDA-NASS, 2010a).

2.6.2 Trade Economic Environment

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 Living Modified Organisms (LMOs), including those modified through biotechnology. See Subsection 7.1.2, International Implications, for a more extensive discussion of the *Cartagena Protocol*. Although the U.S. is not a party to the CBD, Parties to the *Protocol* have developed regulations to comply with it which U.S. exporters must adhere.

Agricultural exports represented $137.4 billion or 10% of the total value of U.S. exports in the 2011 fiscal year (USDA-ERS, 2010d). Approximately 15% of U.S. corn production is destined for export (USDA-ERS, 2009). Corn exports worth $9.1 billion ranked second only to bulk soybean exports, and accounted for 8.4% of all U.S. agricultural exports (USDA-ERS, 2010c). In the 2010/11 marketing year (extending from September to August), the U.S. accounted for more than half of all global corn exports (46.0 million metric tons), while Argentina and Brazil accounted for another 25%, exporting 15.0 and 11.0 million metric tons, respectively (USDA-FAS, 2011a). Over the past decade, U.S. corn exports have remained relatively stable, while global exports have increased by almost 20%, eroding the U.S. export share (Figure 9). This is attributed to greater domestic use of U.S. corn, smaller corn crops, and increased competition from other major corn exporters such as Argentina, Brazil, and Ukraine (USDA-FAS, 2011a). U.S. exports tend to increase when there is a large domestic supply, prices are competitive, and foreign demand increases (USDA-ERS, 2009), illustrated by record exports in 2007/2008 (Figure 9).



Source: (USDA-FAS, 2004; USDA-FAS, 2005; USDA-FAS, 2006; USDA-FAS, 2007; USDA-FAS, 2008a; USDA-FAS, 2009; USDA-FAS, 2010a; USDA-FAS, 2011a)

Figure 9. U.S. and world corn exports in million metric tons for marketing years 2000/01 to 2010/11. Market years extend from September to August. The rest of the world major exporters include Argentina, Brazil, Canada, China, EU-27, India, Paraguay, Romania, Serbia, South Africa, Thailand, Ukraine, and Zambia as well as other smaller exporting countries. Note that U.S. percentage of corn exports in relation to overall world exports declined at the end of the last decade.

Table 4 includes the quantities of U.S.-produced corn imported by the 10 largest importing countries spanning 2010 and 2011. Japan, Mexico, and South Korea were the top three importers of U.S. corn for those periods (USDA-ERS, 2011h), consuming approximately 31%, 17%, and 13% of total U.S. corn exports, respectively. Where U.S. corn will be exported is subject to global market conditions shaped by many factors such as the value of the U.S. dollar and other currencies, oil prices, U.S. and international agricultural policy, the U.S. and international biofuels sector, livestock and meat trade, prices, and population growth (USDA-ERS, 2009; USDA-OCE, 2011). In the case of GE crops and derived food and feed, consumer perception of GE products can create trade barriers (Fernandez-Cornejo and Caswell, 2006). The primary U.S. corn export destinations are also the largest world importers of corn and do not seem to have major barriers for importing GE products. For example, as of 2006, Japan has approved 75 biotech modifications for food, 59 for feed and 55 for planting (Hamamoto, 2006). Commercialization of domestic and imported biotech plant products requires environmental, food and feed approvals in Japan, and strict labeling on all biotech food products is required. In addition to national regulations, there are also local requirements in some areas of Japan (Hamamoto, 2006). Mexico imports and consumes existing varieties of GE corn and has passed legislation that would enable experimental releases of GE corn crops, and, potentially, commercial production (USDA-FAS, 2008b; USDA-FAS, 2010b). South Korea has adopted the *Cartagena Protocols on Biosafety*, thus has processes requiring environmental, food and feed safety approvals for imported GE crops for cultivation, food, and feed, but has not produced

Table 4. Largest importers of U.S. corn in the 2010/11 Season.

Location	October 2009-August 2010	October 2009-August 2011	August 2010	August 2011
	(Million Metric Tons)			
Japan	13.76	13.16	1.32	0.85
Mexico	7.63	6.86	0.62	0.67
South Korea	6.20	5.54	0.74	0.57
Taiwan	2.88	2.65	0.32	0.11
Egypt	2.30	2.74	0.28	0.44
Canada	1.81	0.80	0.11	0.16
China	1.20	0.67	0.49	0.18
Venezuela	1.05	0.79	0.15	0.16
Dominican Republic	0.88	0.68	0.06	0.03
Colombia	0.85	0.48	0.03	0.01
World Total	45.23	42.11	4.72	3.82

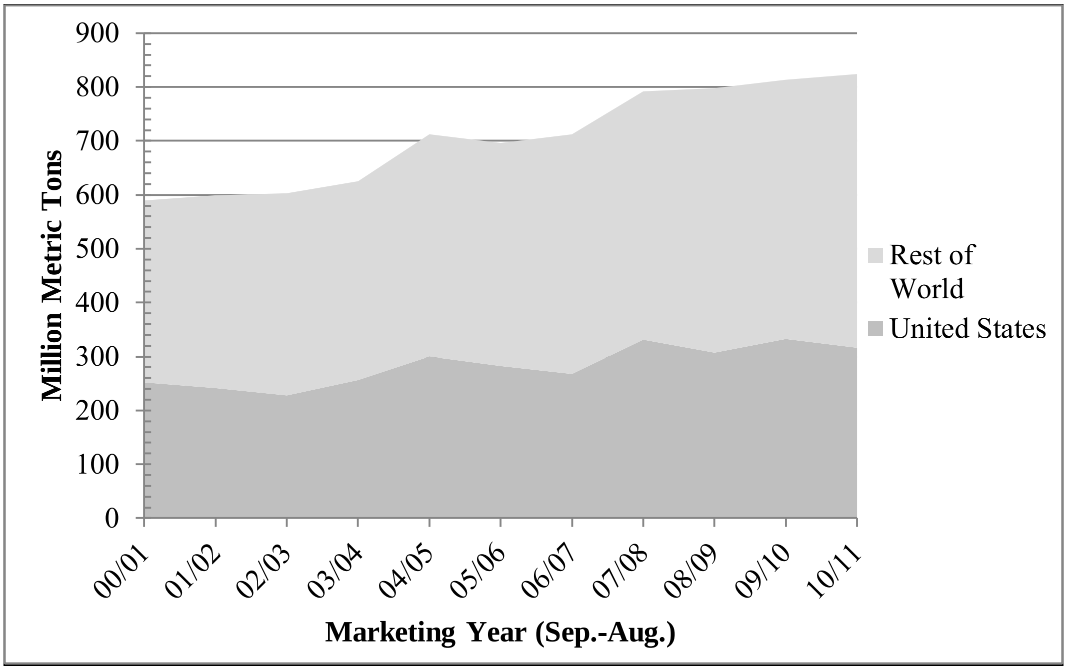
Source: (USDA-ERS, 2011h)

biotechnology crops (USDA-FAS, 2011b); they have, however, approved field trials of certain biotech crops. The majority of GE corn imported to South Korea is used for animal feed, which is nearly all GE in that country (USDA-FAS, 2011b). Processed corn products such as corn syrup or corn oil are exempt from labeling there because they contain miniscule amounts of biotech protein (USDA-FAS, 2011b), but other food and animal feed require labeling. Surveys consistently find that consumers around the world have concerns about food derived from GE crops (Fernandez-Cornejo and Caswell, 2006) that has led to labeling requirements in many countries, and some retailers are reluctant to stock GE-labeled food, creating a barrier to trade.

The U.S. produced 316.2 million metric tons of corn in the 2010/11 marketing year, which represented 38.6% of world production (USDA-FAS, 2011a). U.S. corn production has remained relatively stable over the last decade, but the U.S. share of world production has declined even as total world production increased by 39.8% (Figure 10). The other major producers of corn are China and Brazil, producing respectively 21.0% (173.0 million metric tons) and 7.0% (57.5 million metric tons) of global production in 2010/11.

The U.S. and China are also the top 2 consumers of corn at 290.3 and 172.0 million metric tons, respectively, in the 2010/11 marketing year, comprising more than half of world consumption (Table 5) (USDA-FAS, 2011a). The European Union is the next largest consumer, accounting for 7.4% (62.3 million metric tons) of global consumption. Over the past decade, U.S. corn consumption has increased by 46.5%, primarily due to increased ethanol production, while world corn consumption increased by 38.6% (Figure 11) (USDA-FAS, 2004; USDA-FAS, 2005;

USDA-FAS, 2006; USDA-FAS, 2007; USDA-FAS, 2008a; USDA-FAS, 2009; USDA-FAS, 2010a; USDA-FAS, 2011a).



Source: (USDA-FAS, 2004; USDA-FAS, 2005; USDA-FAS, 2006; USDA-FAS, 2007; USDA-FAS, 2008a; USDA-FAS, 2009; USDA-FAS, 2010a; USDA-FAS, 2011a)

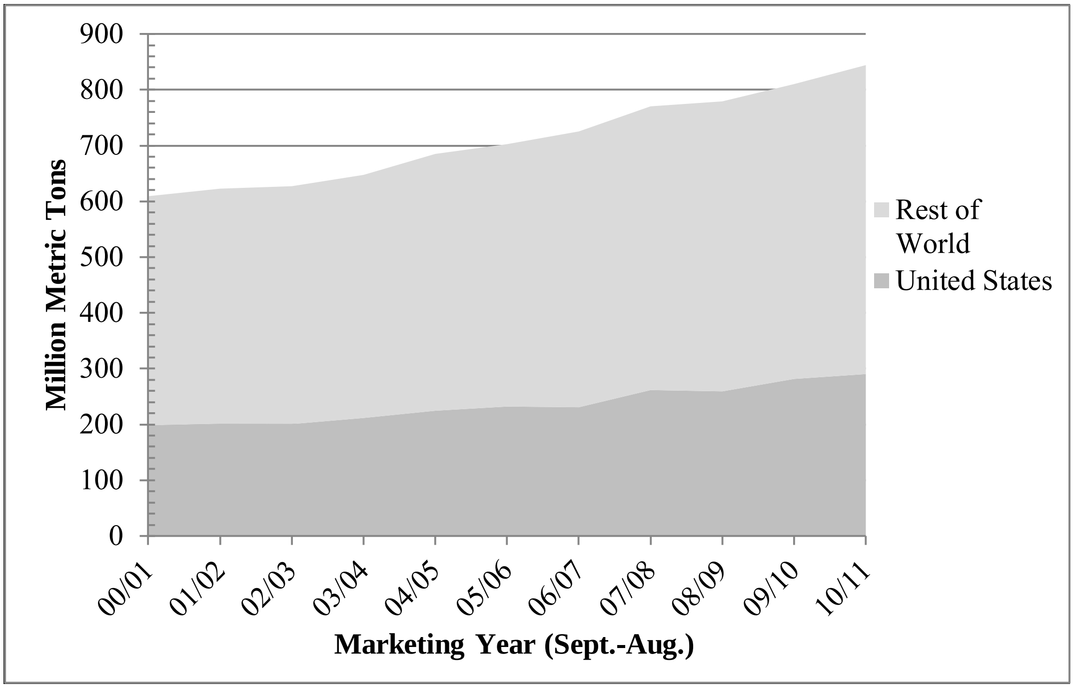
Figure 10. U.S. and world corn production in million metric tons for marketing years 2000/01 to 2010/11. Market years extend from September to August. The rest of the world major producing countries include Argentina, Brazil, Canada, China, Egypt, EU-27, India, Indonesia, Mexico, Nigeria, Philippines, Romania, Serbia, South Africa, Thailand, Turkey, and the Ukraine. Note that U.S. production increased slightly while its percentage of overall world corn production declined in the last decade.

Table 5. World corn consumption for marketing years (August to September) 2008/2009 to 2010/2011.

Location	2008/09	2009/10 (Million Metric Tons)	2010/11
Brazil	45.5	47.0	49.5
Canada	11.7	11.6	11.3
China	153.0	159.0	172.0
Egypt	11.1	12.0	12.1
EU-27[1]	61.6	59.5	62.3
India	17.0	15.1	18.3
Japan	16.7	16.3	15.6
Mexico	32.4	30.2	28.5
South Africa	9.9	10.3	10.6
United States	259.3	281.6	290.3

Others	165.5	174.1	173.0
World Total	783.7	816.7	843.6

Source (USDA-FAS, 2011a)
[1] European Union 27 member countries



Source (USDA-FAS, 2004; USDA-FAS, 2005; USDA-FAS, 2006; USDA-FAS, 2007; USDA-FAS, 2008a; USDA-FAS, 2009; USDA-FAS, 2010a; USDA-FAS, 2011a)

Figure 11. U.S. and world corn consumption in million metric tons for marketing years 2000/01 to 2010/11. Marketing years extend from September to August. The rest of the world major comsumers of corn include Brazil, Canada, China, Egypt, EU-27, India, Japan, Mexico, and South Africa. Note both U.S. and world corn consumption has increased over the last decade, although the U.S. percentage of overll world corn consumption has decreased.

3 ALTERNATIVES

This document analyzes the potential environmental consequences of APHIS' response to Stine's extension request for a determination of nonregulated status to Maize Line HCEM485. To respond favorably to a request for an extension of nonregulated status, APHIS must determine that Maize Line HCEM485 is similar to the antecedent organism, GA21 and is, therefore, unlikely to pose a plant pest risk. Based on its PPRA (USDA-APHIS, 2011b), APHIS has concluded that Maize Line HCEM485 is similar to GA21 and is unlikely to pose a plant pest risk. Therefore APHIS must determine that Maize Line HCEM485 is no longer subject to 7 CFR part 340 or the plant pest provisions of the Plant Protection Act.

Two alternatives are evaluated in this EA: (1) no action and (2) extension of a determination of nonregulated status to Maize Line HCEM485. APHIS has assessed the potential for environmental impacts for each alternative in the Environmental Consequences section.

3.1 No Action Alternative: Continuation as a Regulated Article

Under the No Action Alternative, APHIS would deny the extension request. Maize Line HCEM485 corn and progeny derived from Maize Line HCEM485 corn would continue to be regulated articles under the regulations at 7 CFR part 340. Permits issued or notifications acknowledged by APHIS would still be required for introductions of Maize Line HCEM485 corn and measures to ensure physical and reproductive confinement would continue to be implemented. APHIS might choose this alternative if there were insufficient evidence to demonstrate that Maize Line HCEM485 is similar to the antecedent organism, GA21.

This alternative is not the Preferred Alternative because APHIS has concluded through a Plant Pest Risk Assessment that Maize Line HCEM485 corn is similar to the antecedent organism, GA21 and is unlikely to pose a plant pest risk (USDA-APHIS, 2011b). Choosing this alternative would not satisfy the purpose and need of making a determination of plant pest risk status and responding to the extension request for nonregulated status.

3.2 Preferred Alternative: Approve the Request for an Extension of a Determination of Nonregulated Status to Maize Line HCEM485 from Corn Event GA21

Under this alternative, Maize Line HCEM485 corn and progeny derived from them would no longer be regulated articles under the regulations at 7 CFR part 340. Maize Line HCEM485 is unlikely to pose a plant pest risk (USDA-APHIS, 2011b). Permits issued or notifications acknowledged by APHIS would no longer be required for introductions of Maize Line HCEM485 corn and progeny derived from this event. This alternative best meets the purpose and need to respond appropriately to a request for an extension of a determination of nonregulated status based on the requirements in 7 CFR part 340 and the agency's authority under the plant pest provisions of the Plant Protection Act. Because the agency has concluded that Maize Line HCEM485 corn is similar to the antecedent organism, GA21 and is unlikely to pose a plant pest risk, an extension of a determination of nonregulated status to Maize Line HCEM485 corn is a response that is consistent with the plant pest provisions of the Plant Protection Act, the regulations codified in 7 CFR part 340, and the biotechnology regulatory policies in the Coordinated Framework.

Under this alternative, growers may have future access to Maize Line HCEM485 and progeny derived from this event if the developer decides to commercialize Maize Line HCEM485.

3.3 Alternatives Considered But Rejected from Further Consideration

APHIS assembled a list of alternatives that might be considered for Maize Line HCEM485. The agency evaluated these alternatives, in light of the agency's authority under the plant pest provisions of the Plant Protection Act, and the regulations at 7 CFR part 340, with respect to environmental safety, efficacy, and practicality to identify which alternatives would be further considered for Maize Line HCEM485. Based on this evaluation, APHIS rejected several alternatives. These alternatives are discussed briefly below along with the specific reasons for rejecting each.

3.3.1 Prohibit Any Maize Line HCEM485 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 Maize Line HCEM485 corn, including denying any permits associated with the field testing. APHIS determined that this alternative is not appropriate given that APHIS has concluded that Maize Line HCEM485 is similar to the antecedent organism, GA21 and is unlikely to pose a plant pest risk (USDA-APHIS, 2011b).

In enacting the Plant Protection Act, Congress found that

> [D]ecisions affecting imports, exports, and interstate movement of products regulated under [the Plant Protection Act] shall be based on sound science…§402(4).

On March 11, 2011, in a Memorandum for the Heads of Executive Departments and Agencies, the White House Emerging Technologies Interagency Policy Coordination Committee developed broad principles, consistent with Executive Order (EO) 13563, to guide the development and implementation of policies for oversight of emerging technologies (such as genetic engineering) at the agency level. In accordance with this memorandum, agencies should adhere to EO 13563 and, consistent with that EO, the following principle, among others, to the extent permitted by law, when regulating emerging technologies:

> "[D]ecisions 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"

Based on the PPRA (USDA-APHIS, 2011b) and the scientific data evaluated therein, APHIS concluded that Maize Line HCEM485 is unlikely to pose a plant pest risk. Accordingly, there is no basis in science for prohibiting the release of Maize Line HCEM485.

3.3.2 Isolation Distance between Maize Line HCEM485 and Non-GE Corn Production and Geographical Restrictions

In response to public concerns of gene movement between GE and non-GE plants, APHIS considered requiring an isolation distance separating Maize Line HCEM485 from conventional or specialty corn production. However, because APHIS has concluded that Maize Line HCEM485 is unlikely to pose a plant pest risk (USDA-APHIS, 2011b), an alternative based on requiring isolation distances would be inconsistent with the statutory authority under the plant pest provisions of the Plant Protection Act and regulations in 7 CFR part 340.

APHIS also considered geographically restricting the production of Maize Line HCEM485 based on the location of production of non-GE corn in organic production systems 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 APHIS' PPRA for Maize Line HCEM485, there are no geographic differences associated with any identifiable plant pest risks for Maize Line HCEM485 (USDA-APHIS, 2011b). This alternative was rejected and not analyzed in detail because APHIS has concluded that Maize Line HCEM485 does not pose a plant pest risk and will not exhibit a greater plant pest risk in any geographically restricted area. Therefore, such an alternative would not be consistent with APHIS' statutory authority under the plant pest provisions of the Plant Protection Act and regulations in Part 340 and the biotechnology regulatory policies embodied in the Coordinated Framework.

Based on the foregoing, the imposition of isolation distances or geographic restrictions would not meet APHIS' purpose and need to respond appropriately to an extension request for nonregulated status based on the requirements in 7 CFR part 340 and the agency's authority under the plant pest provisions of the Plant Protection Act. However, individuals might choose on their own to geographically isolate their non-GE corn production systems from Maize Line HCEM485 or to use isolation distances and other management practices to minimize gene movement between cornfields. Information to assist growers in making informed management decisions for Maize Line HCEM485 is available from AOSCA(AOSCA, 2010).

3.3.3 Requirement of Testing for Maize Line HCEM485

During the comment periods for other petitions for nonregulated status, some commenters requested USDA to require and provide testing for GE products in non-GE production systems. APHIS notes there are no nationally-established regulations involving testing, criteria, or limits of GE material in non-GE systems. Such a requirement would be extremely difficult to implement and maintain. Additionally, because Maize Line HCEM485 does not pose a plant pest risk (USDA-APHIS, 2011b), the imposition of any type of testing requirements is inconsistent with the plant pest provisions of the Plant Protection Act, the regulations at 7 CFR part 340 and biotechnology regulatory policies embodied in the Coordinated Framework. Therefore, imposing such a requirement for Maize Line HCEM485 would not meet APHIS' purpose and need to respond appropriately to the request in accordance with its regulatory authorities.

3.4 Comparison of Alternatives

Table 6 presents a summary of the potential impacts associated with selection of either of the alternatives evaluated in this EA. The impact assessment is presented in Section 4, Environmental Consequences of this EA.

Table 6. Summary of issues of potential impacts and consequences of alternatives.

Attribute/Measure	Alternative A: No Action	Alternative B: Extend a Determination of Nonregulated Status
Meets Purpose and Need and Objectives	**No**	**Yes**
Unlikely to pose a plant pest risk	Satisfied through use of regulated field trials	Satisfied – risk assessment (USDA-APHIS, 2011b)
Management Practices		
Acreage and Areas of Corn Production	Unchanged	Unchanged
Agronomic Practices	Unchanged	Unchanged
Pesticide Use	Unchanged	Unchanged
Corn Seed Production	Unchanged	Unchanged
Organic Corn Production	Unchanged	Unchanged
Environment		
Land Use	Unchanged	Unchanged
Water Resources	Unchanged	Unchanged
Soil Quality	Unchanged	Unchanged
Air Quality	Unchanged	Unchanged
Climate Change	Unchanged	Unchanged
Animal Communities	Unchanged	Unchanged

Table 6. Summary of issues of potential impacts and consequences of alternatives (continued).

Attribute/Measure	Alternative A: No Action	Alternative B: Extend a Determination of Nonregulated Status
Plant Communities	Unchanged	Unchanged
Gene Movement	Unchanged	Unchanged
Soil Microorganisms	Unchanged	Unchanged
Biological Diversity	Unchanged	Unchanged
Human and Animal Health		
Risk to Human Health	Unchanged	Unchanged
Risk to Animal Feed	Unchanged	Unchanged
Socioeconomic		
Domestic Economic Environment	Unchanged	Unchanged
Trade Economic Environment	Unchanged	Unchanged
Other Regulatory Approvals		
U.S.	Unchanged for existing nonregulated GE organisms	FDA consultation pending
Other countries	Unchanged	Canada
Compliance with Other Laws		
CWA, CAA, Eos	Fully compliant	Fully compliant

4 ENVIRONMENTAL CONSEQUENCES

4.1 Scope of Analysis

Potential environmental impacts from the No Action Alternative and the Preferred Alternative for Maize Line HCEM485 corn are described in detail throughout this section. An impact would be any change, positive or negative, from the existing (baseline) conditions of the affected environment (described for each resource area in Section 2.0, Affected Environment). Impacts may be categorized as direct, indirect, or cumulative. A direct impact is an effect that results solely from a proposed action without intermediate steps or processes. Examples include soil disturbance, air emissions, and water use. An indirect impact may be an effect that is related to but removed from a proposed action by an intermediate step or process. Examples include surface water quality changes resulting from soil erosion due to increased tillage, and worker safety impacts resulting from an increase in herbicide use.

A cumulative effects analysis is also included for each environmental issue. A cumulative impact may be an effect on the environment which results from the incremental impact of the proposed action when added to other past, present, and reasonably foreseeable future actions. An example includes breeding Maize Line HCEM485 with other nonregulated events. If there are no direct or indirect impacts identified for a resource area, then there can be no cumulative impacts. Cumulative impacts are discussed in Section 5.

Where it is not possible to quantify impacts, APHIS provides a qualitative assessment of potential impacts. Certain aspects of this product and its cultivation may be no different between the alternatives; those are described below.

APHIS considered the potential for Maize Line HCEM485 to extend the range of corn production and affect the conversion of land to agricultural purposes. Stine's studies demonstrate Maize Line HCEM485 is similar in its growth habit, agronomic properties, disease susceptibility, and composition to its antecedent GA21, its control group cultivars, other nonregulated varieties of glyphosate-resistant corn, and other GE and non-GE corn (Stine, 2011; USDA-APHIS, 2011b). As such, its cultural requirements would be no different than those of other corn or provided by the areas in which corn is currently cultivated. As presented in Subsection 2.1.1, Acreage and Area of Corn Production, the majority of corn cultivated in the U.S. is herbicide-resistant, most of which is glyphosate-resistant (Duke and Powles, 2009; USDA-ERS, 2011a). Nonregulated Maize Line HCEM485 could replace other commercially available glyphosate-resistant corn varieties without requiring cultivation of new, natural lands. As such, land use changes associated with extending a determination of nonregulated status to Maize Line HCEM485 are not expected to be any different than those associated with the cultivation of other corn cultivars. Accordingly, although the preferred alternative would allow for new plantings of Maize Line HCEM485 to occur anywhere in the U.S., APHIS will focus the environmental analysis to those areas that currently support corn production. To determine areas of corn production, APHIS consulted the NASS Census of Agriculture crop statistics to identify corn producing states in the U.S.; all states except Alaska produce corn (USDA-NASS, 2009a). Additionally, winter nurseries for maize seed are found in the territory of Puerto Rico.

The environmental consequences of the different alternatives described above will be analyzed under the assumption that farmers, who produce conventional corn, Maize Line HCEM485, or produce corn using organic methods, are using reasonable, commonly accepted BMPs for their chosen system and varieties during agricultural corn production. However, APHIS recognizes that not all farmers follow these BMPs for corn. Thus, the analyses of potential environmental affects will also include the assumption that some farmers do not follow these BMPs. Stine has indicated there is no need to change the use pattern of glyphosate for the glyphosate-resistant Maize Line HCEM485 variety; hence, APHIS will use current glyphosate labels as the basis for its potential effects analysis.

4.2 Agricultural Production of Corn

4.2.1 Acreage and Area of Corn Production

<u>No Action Alternative: Acreage and Area of Corn Production</u>

Under the No Action Alternative, the total acres used for the production of corn in the U.S. is predicted to remain between 90 and 92 million acres through 2020 (USDA-OCE, 2011) (see Subsection 2.1.1, Acreage and Area of Corn Production).

Both GE and non-GE varieties of corn would be produced under this alternative. The adoption of GE hybrids are likely to dominate U.S. corn production because GE hybrids comprised 88% of the planted corn acres in 2011 (USDA-ERS, 2011a), the bulk of which contain multiple (stacked) traits such as insect resistance (Bt) and herbicide resistance (see Subsection 2.1.1, Acreage and Area of Corn Production, Figure 3,) (Fernandez-Cornejo and Caswell, 2006; USDA-ERS, 2011a). From 2007 to 2011, the production of herbicide-resistant-only varieties leveled off at about 23%, insect-resistant-only varieties declined to 16% of all planted corn, while those varieties with stacked traits (with both insect and herbicide resistance) have continued to increase to 49% of all planted corn acreage in 2011 (USDA-ERS, 2011a) (see Subsection 2.1.1, Acreage and Area of Corn Production, Figure 3).

<u>Preferred Alternative: Acreage and Area of Corn Production</u>

An extension of a determination of nonregulated status to Maize Line HCEM485 under the Preferred Alternative would allow the planting and movement of Maize Line HCEM485 without APHIS-acknowledged notification. Maize Line HCEM485 is the same with regard to its growth habit and agronomic properties, disease susceptibility, and composition as its control cultivars, its antecedent GA21, other nonregulated varieties of glyphosate-resistant corn, and other GE and non-GE corn (Stine, 2011; USDA-APHIS, 2011b). Because it is similar to varieties that are currently available, Maize Line HCEM485 is expected to replace some of the currently available glyphosate-resistant varieties. Therefore the Preferred Alternative would not change corn production area and acreage when compared to the No Action Alternative.

4.2.2 Agronomic Practices

<u>No Acton Alternative: Agronomic Practices</u>

As discussed in Subsection 2.1.2, Agronomic Practices, the cultivation of corn requires certain agronomic considerations such as soil and moisture regimes, planting schedules and rates, harvesting schedules, rotation strategy, tillage, and agricultural inputs. Planting schedules and rates are determined by factors such as regional climate, soil conditions, seed germination, anticipated pest problems, and weather (Farnham, 2001a). Similarly, the determination of the best harvest time is influenced by factors such as the price of corn, potential yield, weather, length of harvest period, and equipment and labor availability and cost (Bitzer et al., No Date). Crop rotations and tillage strategy would be accomplished in order to optimize soil nutrition, fertility and moisture, and control weeds, insects, and pests.

The cultivation of corn requires several agricultural inputs such as irrigation, fertilizer (e.g., synthetic fertilizers, manures, and composts containing nitrogen, phosphorus, and potassium), pesticides (e.g., insecticides, herbicides), and fungicides (Olson and Sander, 1988; Hoeft et al., 2000; McLeod and Studebaker, 2006). As discussed in Subsection 2.1.2, Agronomic Practices, these inputs are dependent on such factors as the region, climate, soil conditions, and pests present. Grower decisions regarding the type and extent of agricultural inputs needed to produce conventional or organic corn would continue to be based on the ease and flexibility of production systems and individual needs that may vary from year to year, responding to variation in weather, weed, insect pest, disease pressures, and targeted production returns (USDA-ERS, 1997c).

Weeds are the most important pests that interfere with yield and profitability (Gibson et al., 2005; Baucom and Holt, 2009). Practices to reduce the incidence of weeds include tillage, crop rotation, intercropping, the use of ground covers and mulches, flame weeding, and the application of herbicides (Gunsolus, 2006; Hedtke et al., 2006; Smith and Scott, 2006; CropsReview, 2011; USDA-NASS, 2011c). In addition, no-till practices also reduce weed occurrence by minimizing soil disturbance that promotes weed seed germination (University of California, 2009).

Due to the potential damage caused to crops from mechanical weed control and the availability of better herbicide technology, producers have turned more to chemical control in corn production (Smith and Scott, 2006). The proportion of herbicide-resistant corn cultivars in the U.S. has steadily grown since the approval of the request for nonregulated status of the first variety of herbicide-resistant corn in 1995 (USDA-APHIS, 2012). Recent estimates indicate the majority of corn planted in the U.S. is herbicide resistant, comprising 72% of corn planted in 2011 (USDA-ERS, 2011a), and most herbicide-resistant corn is glyphosate-resistant (Duke and Powles, 2009). The increased use of glyphosate as a consequence of expanded adoption of the glyphosate-resistant trait in corn production is primarily attributed to the herbicide's effective and efficient weed control as a non-selective herbicide (Owen et al., 2011), its lower cost and simplicity of use, its minimal toxicity to animals and the environment, and its support of conservation tillage practices (Duke and Powles, 2009; NRC, 2010; Green and Owen, 2011). Another observed herbicide trend since the adoption of GE corn has been a substantial reduction in the diversity of herbicides used in corn production (Young, 2006). The use of other herbicides has declined significantly, and it is estimated that 34% of corn acres receive only glyphosate for weed management (NRC, 2010; Owen, 2011).

In 2010, over 98% of corn acres in 19 survey states were treated with herbicides, and of that acreage, 66% were treated with glyphosate (USDA-NASS, 2011c). Farmers have recently begun to broaden weed management strategies in response to the development of herbicide-resistant weeds, addressed in Subsection 2.3.2, Plants Communities.

Preferred Alternative: Agronomic Practices

The continued use of herbicides, including glyphosate, would be unaffected by the extension of a determination of nonregulated status to Maize Line HCEM485. Like under the No Action Alternative, the amount of herbicides other than glyphosate applied to corn would likely continue to decline as it has for the last decade (NRC, 2010). The use rate of glyphosate and other herbicides is not expected to change as a result of extending a determination of nonregulated status to Maize Line HCEM485, because Maize Line HCEM485 is anticipated to replace other glyphosate-resistant corn cultivars, and no change in the registered use of glyphosate is proposed. In the longer term, like under the No Action Alternative, the use of non-glyphosate herbicides may increase and more emphasis may be placed on best management agronomic practices to address the issue of glyphosate-resistant weeds (Green, 2011; Owen, 2011; Owen et al., 2011); (see Subsection 4.4.2, Plants Communities). Glyphosate would likely continue to be a major component of weed management in corn production because of its flexibility in application, its efficacy against a broad spectrum of weeds, and its relatively low cost (Powles, 2008; Duke and Powles, 2009; Green and Owen, 2011; Owen et al., 2011). No changes in agronomic practices would occur as a consequence of extending a determination of nonregulated status to Maize Line HCEM485 when compared to the No Action Alternative.

4.2.3 Corn Seed Production

No Acton Alternative: Corn Seed Production

Commercially available corn seed is produced in those regions of the U.S. where the specific hybrid is best adapted for growth, as well as in winter nurseries in Hawaii, Puerto Rico, Chile, and Argentina (see Subsection 2.1.3, Corn Seed Production). Corn is a major U.S. crop, and planted acreage in USDA projections is expected to remain at current levels to 2020 (USDA-OCE, 2011); therefore, seed production is likely to remain at current levels. Because 72% of the corn acreage is planted in herbicide-resistant varieties, a comparable amount of the corn seed acreage planted is likely to be of herbicide-resistant varieties.

Corn seed production adheres to seed certification standards such as land history, field isolation, and varietal purity, as discussed in Subsection 2.1.3, Corn Seed Production, to ensure the quality of corn seed remains high. Corn producers implement measures to preserve the identity of their seed varieties in accordance with seed certifying standards.

Preferred Alternative: Corn Seed Production

Stine's field trials have not demonstrated any agronomic or phenotypic differences between Maize Line HCEM485 and its control corn cultivars (Stine, 2011; USDA-APHIS, 2011b). As described in Subsection 4.2.1, Acreage and Area of Corn Production, an extension of a determination of nonregulated status to Maize Line HCEM485 would likely replace some of the acreage planted in other commercially available glyphosate-resistant corn cultivars on current production acres because of its similarity to these other cultivars. The extent to which Maize Line HCEM485 is planted for seed is dependent upon how much it is adopted in the market, but it would likely replace acres planted to other glyphosate-resistant varieties.

4.2.4 Organic Corn Production

No Action Alternative: Organic Corn Production

Acreage devoted to organic corn production is small relative to that of GE varieties. Measurable acreages of organic corn is produced in 39 states, with the largest amount produced in Iowa, Michigan, Minnesota, New York, and Wisconsin, which also produced a combined amount of about 29 million acres of non-organic conventional and GE corn in 2010 (USDA-NASS, 2010a; USDA-ERS, 2011a; USDA-NASS, 2011b). While the amount of organic corn production has steadily increased between 1995 and 2008, the latest year with available statistics, organic corn production remained at around 0.2% of the total U.S. corn acreage from 2005 through 2008 (USDA-ERS, 2010a).

It is important to note that the current NOP regulations do not specify an acceptable threshold level for the adventitious presence of GE materials in an organic-labeled product. The unintentional presence of the products of excluded methods will not affect the status of an organic product or operation when the operation has not used excluded methods and has taken reasonable steps to avoid contact with the products of excluded methods as detailed in their approved organic system plan (Ronald and Fouche, 2006; USDA-AMS, 2008). However, certain markets or contracts may have defined thresholds (Non-GMO-Project, 2010). Under the No Action Alternative, 88% of the corn grown in the U.S. is GE. Growers with contracts that specify defined thresholds for GE materials incorporate production practices to meet their thresholds.

Preferred Alternative: Organic Corn Production

As described in Subsection 4.2.1, Acreage and Area of Corn Production, extending a determination of nonregulated status to Maize Line HCEM485 is not expected to change the acreage or area of corn production that could potentially impact organic corn production. Because of its similarity to other corn growth and reproductive habits, the current availability and extent of other nonregulated glyphosate-resistant corn, and the relative stability of acreage devoted to herbicide-resistant-only corn production in the U.S., Maize Line HCEM485 is expected to replace other glyphosate-resistant corn in the areas that corn is currently produced. Maize Line HCEM485 would not influence the overall adoption rate of herbicide-resistant corn. Extension of a determination of nonregulated status to Maize Line HCEM485 under the Preferred Alternative would not change agronomic production practices used by organic or other corn producers. There are no discernible differences in pollen size and morphology between Maize Line HCEM485 and control corn comparators, and, while Maize Line HCEM485 pollen viability was significantly greater than the control, it was within the ranges reported for other corn reference samples (Stine, 2011; USDA-APHIS, 2011b). As such, an organic corn producer may utilize existing separation practices as used for all other commercially available glyphosate-resistant corn varieties to meet National Organic Standards and NOP eligibility.

The production of organic corn would not be expected to change under the Preferred Alternative; hence, the potential impacts of extending a determination of nonregulated status to Maize Line HCEM485 would be similar to the No Action Alternative.

4.3 Physical Environment

4.3.1 Soil Quality

No Action Alternative: Soil Quality

Agronomic practices associated with GE and non-GE corn crop production that benefit soil quality include contouring, use of cover crops to limit the time soil is exposed to wind and rain and introduce certain soil nutrients, crop rotation, and windbreaks. Other agronomic practices utilized in non-GE and GE corn production that potentially impact soil quality include tillage for crop establishment, fertilizer, weed control, and pesticide application.

The production of nonregulated herbicide-resistant corn utilizes EPA-registered pesticides for insect and plant pest management, including glyphosate. In 2010, herbicides were applied to 98% of cropland planted to corn (USDA-NASS, 2011c). Pesticides (including herbicide, insecticide, and fungicide) consist of active ingredients that control pests and inert ingredients to facilitate their application. In 2010, 66% of all active ingredients applied to corn treated with pesticides were herbicidal (USDA-NASS, 2011c), indicating their widespread use and potential to affect the environment The amount of herbicides other than glyphosate applied to corn has declined over the last decade (NRC, 2010) (see Subsection 4.2.2, Agronomic Practices). The environmental risks of pesticide use are assessed by the EPA in the pesticide registration process and are regularly re-evaluated by the EPA to maintain their registered status under FIFRA. In this process, steps to reduce pesticide residuals and persistence in soil are included on a pesticide's label and approved by the EPA.

As discussed in Subsection 2.2.1, Soil Quality, there have been several reports of the long-term use of glyphosate immobilizing manganese and potentially reducing plant uptake or ability to utilize this nutrient (Eker et al., 2006; Neumann et al., 2006; Ozturk et al., 2008; Cakmak et al., 2009; Huber, 2010). Additional investigations are required to determine the scope and characterization of glyphosate interactions with nutrients. The current understanding is manganese-glyphosate interaction resulting in manganese problems appears to occur in areas where manganese deficiency already exists (Hartzler, 2010), and producers should be prepared to address it with agronomic practices designed to augment manganese (Camberato et al., 2010).

The development of glyphosate-resistant weeds or weed management tillage practices potentially impact soil quality. A variety of strategies should be utilized in addressing glyphosate-resistant weeds, including applying the right strength of herbicide, rotating herbicide modes of action, crop rotation, spot treatments, vigilant scouting, and hand weeding (Gunsolus, 2002; Sellers et al., 2011). In the long term, more diverse weed management tactics potentially including more aggressive tillage practices that can affect soil quality may be needed to address the increasing emergence of glyphosate-resistant weeds (Beckie, 2006; Owen, 2011; Owen et al., 2011). The particular mix of weed management tactics selected by an individual producer is dependent upon many factors, including the agroecological setting, the problem weed type, and agronomic and socioeconomic factors important to farmers (Beckie, 2006).

Preferred Alternative: Soil Quality

Extending a determination of nonregulated status to Maize Line HCEM485 would not affect soil quality. With nonregulated status, Maize Line HCEM485 would likely replace other commercially available glyphosate-resistant corn cultivars because most corn acreage is currently planted to either glyphosate-resistant-only corn or herbicide-resistant corn varieties stacked with other GE traits (Duke and Powles, 2009; USDA-ERS, 2011a). The area and acreage of corn production potentially impacting soil quality would not change as a result of the Preferred Alternative.

Maize Line HCEM485 is agronomically and compositionally equivalent to its antecedent GA21, its control cultivars, and other GE and non-GE corn varieties currently in commercial production (Stine, 2011; USDA-APHIS, 2011b). Agronomic practices such as tillage and the application of agricultural chemicals that could impact soil quality or its community structure and function would not change from those currently used for production of other nonregulated glyphosate-resistant corn varieties.

Since it is expected to replace other glyphosate-resistant cultivars, the nonregulated status of Maize Line HCEM485 would not affect weed management practices or their effects on soil quality. As discussed above, more diverse weed management tactics potentially including more aggressive tillage practices that can affect soil quality may be needed to address the increasing emergence of glyphosate-resistant weeds (Beckie, 2006; Owen, 2011; Owen et al., 2011). As described under the No Action Alternative discussion, the weed management tactics selected by an individual producer would be dependent upon many factors (Beckie, 2006). Weed management practices needed for the production of Maize Line HCEM485 would be no different than those used in other commercially available glyphosate-resistant corn cultivars.

Under the Preferred Alternative, the amount of herbicides other than glyphosate applied to corn would likely continue to decline as they have for the last decade (NRC, 2010) (see Subsection 4.2.2, Agronomic Practices). The application of glyphosate is not expected to change as a result of extending a determination of nonregulated status to Maize Line HCEM485, as no change in the registered use or label of this herbicide is proposed and, as discussed in Subsection 4.2.1, Acreage and Area of Corn Production, the cultivar is anticipated to replace other glyphosate-resistant corn varieties. As discussed above, the impact of glyphosate on manganese availability for uptake by crops after its application is an issue that may be addressed with common practices utilized to augment deficient soil nutrients. Since Maize Line HCEM485 is agronomically similar to other GE and non-GE corn varieties and would most likely replace other glyphosate-resistant varieties, the same methods used to address manganese deficiency in current corn production would also be used with Maize Line HCEM485; therefore, impacts to soil quality under the Preferred Alternative would be the same as the No Action Alternative.

4.3.2 Water Resources

No Action Alternative: Water Resources

As discussed in Subsection 4.2.1, Acreage and Area of Corn Production, corn is expected to continue to be a major crop in the U.S., with a predicted increase in production from approximately 88 million acres of land in 2010 to between 90 and 92 million acres through 2020 (USDA-OCE, 2011). Current agronomic practices associated with corn production that have potential to impact water quality or quantity include tillage, agricultural inputs such as fertilizer and pesticide use, and irrigation. The majority of herbicide-resistant corn grown in the U.S. is glyphosate-resistant (Duke and Powles, 2009).

As discussed above in Subsection 4.3.1, Soil Quality, more diverse weed management tactics potentially including more aggressive tillage practices that can affect soil erosion may be needed to address the increasing emergence of glyphosate-resistant weeds (Beckie, 2006; Owen, 2011; Owen et al., 2011). Increased tillage could result in more soil erosion that could consequently increase sedimentation and residual pollutant loading of nearby waters. The particular mix of weed management tactics selected by an individual producer, however, are dependent upon many factors such as the agroecological setting, the problem weed type, and agronomic and socioeconomic factors important to farmers (Beckie, 2006). As discussed in Subsection 2.2.2, Water Resources, fertilizer and pesticide use has the potential to impact water quality. In 2010, fertilizer (primarily nitrogen) was applied to the majority of corn acres, and herbicides applied to 98% of planted corn (USDA-NASS, 2011c). Of the treated acres, glyphosate was the most commonly applied herbicide active ingredient that year (USDA-NASS, 2011c). When used consistent with registered uses and EPA-approved labels, glyphosate presents minimal risk to surface and groundwater. Irrigation from surface and subsurface sources can reduce water quantity and impact water quality by the used water acquiring increased sediment, nutrients, and chemicals adsorbed to soil that is subsequently leached to groundwater, or returned to surface water. Recent estimates indicate only 11.0 to 11.5% of corn acreage is irrigated in the U.S. (NCGA, 2011).

<u>Preferred Alternative: Water Resources</u>

An extension of a determination of nonregulated status to Maize Line HCEM485 under the Preferred Alternative would present another glyphosate-resistant corn and weed management option to farmers. It is expected Maize Line HCEM485 would replace other glyphosate-resistant corn varieties and, therefore, not change the overall acreage or area of corn production in the U.S. that potentially impacts water resources through sedimentation and residual pollutant loading from runoff. As discussed in Subsection 4.2.1, Acreage and Area of Corn Production, herbicide-resistant corn comprised 72% of all planted corn acreage in 2011 and the majority of herbicide-resistant corn is glyphosate resistant (Duke and Powles, 2009; USDA-ERS, 2011a). As Maize Line HCEM485 is similar in its growth and agronomic characteristics to its control cultivars and antecedent GA21, and other nonregulated glyphosate-resistant maize lines (USDA-APHIS, 2011b), no changes to irrigation and other agronomic practices such as fertilizer and pesticide applications, including herbicides, that have the potential to affect water quality or quantity, would occur as a result of this alternative.

Since Maize Line HCEM485 is expected to replace other glyphosate-resistant corn acreage, its nonregulated status would not affect the recent trend to broaden weed management practices, including more tillage that may increase erosion, and thereby sediment loading to surface waters. The impacts of the Preferred Alternative to water resources, therefore, would be the same as the No Action Alternative.

4.3.3 Air Quality

<u>No Action: Air Quality</u>

Corn is the most widely produced feed grain in the U.S., so its production practices can substantially impact air quality. Tillage is utilized to prepare the ground for planting, to control weeds, incorporate nutrients and herbicides into soil, and is useful for other functions such as controlling water flow through a field (see Subsection 2.1.2, Agronomic Practices). Tillage exposes soil to wind erosion and utilizes motorized equipment that produces emissions. The use of herbicide-resistant crops has facilitated the adoption of conservation tillage (Towery and Werblow, 2010). The USDA reports that in 2010, up to 74.5% of planted corn acres were produced under conservation tillage practices ranging from no-till to reduced till (USDA-ERS, 2011f). Reduced tillage generates fewer particulates (dust) and potentially contributes to lower rates of wind erosion releasing soil particulates into the air, benefitting air quality (Fawcett and Towery, 2002). Conservation tillage also reduces equipment emissions due to decreased usage. More recently, these benefits may be eroding by employing more aggressive tillage to control the increasing resistance of weeds to herbicides, including glyphosate-resistant weeds (Beckie, 2006; Owen, 2011; Owen et al., 2011). Weed management methods, however, vary from farm to farm, dependent upon the agroecological setting, the problem weed type, and agronomic and socioeconomic factors important to farmers (Beckie, 2006).

Pesticide application in corn production has the potential to impact air quality while actively applied through spray drift, afterward by volatilization off of plant and soil surfaces, and by windborne soil containing residuals in areas where a pesticide has been dispensed (see Subsection 2.2.3, Air Quality, for detailed discussion). Glyphosate is the most common herbicide active ingredient applied to herbicide-treated corn in the U.S. (USDA-NASS, 2011c). The EPA is currently evaluating new regulations for pesticide drift labeling and the identification of BMPs to control such drift (US-EPA, 2009d), as well as identifying scientific issues surrounding field volatility of conventional pesticides (US-EPA, 2010). Agricultural production of existing nonregulated GE and conventional corn utilize EPA-registered pesticides for insect and plant pest management, including glyphosate. Glyphosate has a low vapor pressure and volatility from soils (US-EPA, 1993b). Glyphosate's EPA-approved label provides measures for minimizing the potential air quality impacts from its use. When used in accordance with registered uses and EPA-approved labels, glyphosate poses minimal risks to air quality. Increasing or decreasing the amount of corn production acreage and its associated agronomic practices with emissions potentially impact air quality. As discussed in Subsection 4.2.1, Acreage and Area of Corn Production, corn is a major crop in the U.S., expected to maintain current production levels through 2020 (USDA-OCE, 2011). Global market forces determine the price of corn, which in turn affects grower decisions on how much to plant (USDA-OCE, 2011).

Preferred Alternative: Air Quality

Maize Line HCEM485 is agronomically and compositionally equivalent to its antecedent GA21, its control cultivars, and other GE and conventional corn varieties currently in commercial production (Stine, 2011; USDA-APHIS, 2011b). No changes to agronomic practices that are sources of emissions or positively contribute to air quality such as the amount, type and timing of tillage, equipment use, irrigation, and the application of fertilizers or pesticides would result from extending a determination of nonregulated status to Maize Line HCEM485 under the preferred alternative. The commercial use of glyphosate is expected to remain the same if Maize Line HCEM485 were determined nonregulated, since the cultivar would replace other glyphosate-resistant corn varieties, and no changes to glyphosate's registered use or label are proposed. Approximately 72% of planted corn in the U.S. is herbicide resistant, and of that, most is glyphosate resistant (Duke and Powles, 2009; USDA-ERS, 2011a) (see Subsection 4.2.1, Acreage and Area of Corn Production, for detailed discussion).

Maize Line HCEM485 would not likely change the development of glyphosate-resistant weeds or the methods used for their control that may impact air quality, since it is expected to replace other glyphosate-resistant corn cultivars. In summary, there are no new impacts to air quality posed by an extension of determination of nonregulated status to Maize Line HCEM485. The potential impacts to air quality under the Preferred Alternative are, therefore, similar to the No Action Alternative.

4.3.4 Climate Change

No Action Alternative: Climate Change

The major sources of GHG emissions associated with crop production are soil N_2O emissions, soil CO_2 and CH_4 fluxes, and CO_2 emissions associated with agricultural inputs and farm equipment operation (US-EPA, 2011c). Agricultural practices that produce CO_2 emissions include liming and the application of urea (i.e., nitrogen) fertilization to agricultural soils, and CH_4 produced by enteric fermentation and animal manure management. Agricultural soil management activities including fertilizer application and cropping practices are the largest source of N_2O emissions in the U.S. (US-EPA, 2011c). Corn crop production primarily affects climate-changing emissions through: (1) fossil fuel burning equipment used for production and nitrogen fertilization producing $CO_{2;}$ and, (2) cropping production practices including residue management and tillage (see Subsection 2.2.4, Climate Change, for detailed discussion). Conservation tillage practices increase crop residue on the surface, promoting the production of SOC and protecting the soil from erosive forces that would release SOC back to the air. These practices also reduce the use of emissions-producing equipment normally used in tilling. The USDA has estimated approximately 74.5% of planted corn acres in 2010 were produced under conservation tillage practices ranging from no-till to reduced till (USDA-ERS, 2011f). Recent increases in the incidence of herbicide-resistant weeds, including glyphosate, may require increased tillage to affect control (Beckie, 2006; Owen, 2011; Owen et al., 2011). This could potentially release more SOC sequestered in upper soil layers; however, the particular weed management methods employed by individual farmers would be dependent on many factors unique to characteristics of the individual farm, including its agroecological setting, the particular problem weed type, and on-farm economics (Beckie, 2006).

Nitrogen is also the most-used fertilizer in U.S. corn production (USDA-NASS, 2011c). Nitrogen in the form of urea is commonly applied to cornfields and contributes CO_2 emissions from the volatilization of ammonia. Recommended BMPs to reduce volatilization include incorporating urea with equipment, accompanied with irrigation or rainfall; topdressing urea when temperatures and soil moisture levels are low; and avoiding topdressing urea in higher risk conditions, except if there is an opportunity to incorporate the urea within a few days of application (Jones et al., 2007).

Preferred Alternative: Climate Change

Because Maize Line HCEM485 is similar to other GE and non-GE corn cultivars in terms of its growth habit, agronomic properties, disease susceptibility, and composition (USDA-APHIS, 2011b), the agronomic practices required to cultivate Maize Line HCEM485 would be no different than those utilized in the production of other herbicide-resistant corn cultivars.

Therefore, no changes to agricultural practices that could affect GHG emissions would be expected from extending a determination of nonregulated status to Maize Line HCEM485.

Because Maize Line HCEM485 is another glyphosate-resistant cultivar similar to other commercially available glyphosate-resistant corn varieties, and the majority of planted corn in the U.S. is herbicide resistant (72% in 2011) primarily consisting of glyphosate-resistant cultivars (Duke and Powles, 2009; USDA-ERS, 2011a), Maize Line HCEM485 would likely replace other glyphosate-resistant cultivars rather than expand the production of glyphosate-resistant cultivars. An extension of a determination of nonregulated status to Maize Line HCEM485 would not likely change the development of glyphosate-resistant weeds, since it is expected to replace other glyphosate-resistant maize acreage; thus, no change to GHG emissions would occur from use of fossil fuels, release of SOC, or carbon sequestration in plant residue and soils under the Preferred Alternative. As discussed under the No Action Alternative above, more diverse weed management tactics, potentially those including more aggressive tillage practices that can affect GHG emissions, may be needed in the long term to address the increasing emergence of glyphosate-resistant weeds (Beckie, 2006; Owen, 2011; Owen et al., 2011). Since Maize Line HCEM485 is expected to replace other glyphosate-resistant cultivars, its nonregulated status would not alter weed management practices and their effects on GHG contributing to climate change; therefore, the potential impacts to climate change under the Preferred Alternative would be similar to the No Action Alternative.

4.4 Biological Resources

4.4.1 Animal Communities

No Action Alternative: Animal Communities

Corn production potentially impacts animal communities through the conversion of wildlife habitat to agricultural purposes. As discussed in Subsection 2.2., Acreage and Area of Corn Production, corn was produced on approximately 92.3 million acres in 2011, an increase of approximately 4.1 million acres over 2010 (USDA-NASS, 2011b). Corn is expected to continue to be a major crop in the U.S. through 2020 (USDA-OCE, 2011). A wide array of wildlife occupy and/or utilize habitats that are within or adjacent to cornfields (see Subsection 2.3.1, Animal Communities). While cornfields are less suitable for wildlife than adjacent pasture, fallow fields, windbreaks, or shelterbelts, those in conservation tillage management provide greater benefit for wildlife than those in more intensive tillage. This is because greater diversity in plants would occur that provides more habitat and potential food sources, soil would be less disturbed, and potentially sediment and agricultural pollutant loading of nearby surface waters would be reduced, improving water quality (Brady, 2007; Sharpe, 2010).

Glyphosate-resistant corn varieties have been nonregulated since 1997 (USDA-APHIS, 2012), and the majority of corn cultivated today is herbicide resistant (USDA-ERS, 2011a), primarily glyphosate-resistant (Duke and Powles, 2009). All glyphosate-resistant corn varieties currently available on the market have been evaluated for their food and feed safety impacts by the FDA. The EPSPS protein that confers glyphosate resistance in GA21 (the antecedent of Maize Line HCEM485) is corn-derived, and 99.3% identical to its non-herbicide-resistant corn comparators (Monsanto, 1997). It has been previously evaluated by the FDA;according to the consultation note,

> "Monsanto has concluded that corn containing transformation event GA21 is not materially different in composition, nutrition, and safety from corn currently grown, processed, marketed, and consumed for animal feed or human food. At this time, based on Monsanto's description of its data and analyses, the Agency considers Monsanto's consultation on corn from varieties containing transformation event GA21 to be complete."

(US-FDA, 1998a). Consumption of nonregulated glyphosate-resistant corn presents minimal risk to animal communities.

Current corn agronomic practices potentially impacting animal communities include application of agricultural inputs, such as fertilizer, herbicides, and pesticides. Both fertilizer and pesticides are applied to the majority of corn acres in the U.S. (USDA-NASS, 2011c) and potentially impact non-target wildlife from ingestion or spray drift. Glyphosate is the primary herbicide applied to herbicide-treated corn acreage in the U.S. (USDA-NASS, 2011c). As discussed in Subsection 2.1.2, Agronomic Practices, there are several glyphosate formulations (US-EPA, 2009b) that differ in the timing and amount of application to field corn. The environmental risks of glyphosate herbicides are assessed by the EPA in the pesticide registration process. The glyphosate RED was last accomplished in 1993, and the herbicide is currently undergoing registration review scheduled for the final decision in 2015 (US-EPA, 2009a). As discussed in Subsection 2.3.1, Animal Communities, the registered uses for glyphosate pose minimal risk to animals, but spray drift may adversely impact non-target plants that provide habitat. The EPA is evaluating new regulations for labeling and BMPs to control drift (US-EPA, 2009d). When used consistent with the EPA-registered uses and labels, glyphosate application in corn presents minimal risk to animal communities. In 2010, 66% of all active ingredients applied to corn treated with pesticides were herbicidal (USDA-NASS, 2011c).

More diverse weed management tactics potentially including more aggressive tillage practices that can affect animal communities may be needed to address the increasing emergence of glyphosate-resistant and other herbicide-resistant weeds (Beckie, 2006; Owen, 2011; Owen et al., 2011). As discussed above, more intensive tillage can reduce wildlife habitat and contribute to increased sedimentation and pollutants in runoff to nearby surface waters, affecting water quality that could impact wildlife. The particular mix of weed management tactics selected by an individual producer would be dependent upon many factors, including the agroecological setting, the problem weed type, and agronomic and socioeconomic factors important to farmers (Beckie, 2006).

<u>Preferred Alternative: Animal Communities</u>

As part of the assessment for the proposed action, APHIS has evaluated the potential effects of each alternative on a wide array of wildlife species and their habitats occurring in the U.S. Under the Preferred Alternative, a determination of nonregulated status would be extended to Maize Line HCEM485, and it would be available as another glyphosate-resistant corn and weed management option for farmers. As stated above, the majority of corn planted in the U.S. today is herbicide and glyphosate resistant (Duke and Powles, 2009; USDA-ERS, 2011a). As such, it is expected Maize Line HCEM485 as another option to other currently available glyphosate-resistant corn varieties would replace these varieties and not change the acreage or area of corn production in the U.S. (see Subsection 4.2.1, Acreage and Areas of Corn Production). Maize Line HCEM485 is similar in its growth and agronomic characteristics to its control comparators, its antecedent GA21, and other nonregulated glyphosate-resistant corn lines (Stine, 2011; USDA-APHIS, 2011b); hence, no changes to agronomic practices such as cultivation, crop rotation, irrigation, tillage, or agricultural inputs with potential impacts to wildlife and their habitat would likely occur under this alternative.

As discussed in Subsection 2.5, Animal Feed, a final food consultation with the FDA for Maize Line HCEM485 was submitted by Stine in December 2010 and is still pending. As discussed in the No Action Alternative, the food safety of the EPSPS protein conveying glyphosate resistance was previously established by an FDA evaluation. Because the composition of Maize Line HCEM485 is similar to its antecedent GA21 and other nonregulated glyphosate-resistant corn lines (Stine, 2011), with no expected hazards associated with its consumption, the risk of Maize Line HCEM485 affecting wildlife species is also unlikely, regardless of exposure.

Commercial use of glyphosate is not expected to change as a result of an extension of a determination of nonregulated status to Maize Line HCEM485. Based upon information provided by Stine (2011), Maize Line HCEM485 is similar in its growth characteristics to its antecedent GA21 and other nonregulated glyphosate-resistant corn. No changes to the registered uses or labels of glyphosate products would be required to apply it to Maize Line HCEM485. Consequently, there would be no difference in the potential of Maize Line HCEM485 cultivation to impact wildlife or habitat from that of other nonregulated glyphosate-resistant corn varieties. As discussed above, the EPA is currently evaluating new regulations for labeling and BMPs to control drift. When used consistent with the EPA-registered uses and labels, glyphosate application in Maize Line HCEM485 fields presents minimal risk to animal communities.

An extension of a determination of nonregulated status to Maize Line HCEM485 would not change the development of glyphosate-resistant weeds or the methods used for their control that may impact animal communities, such as increased tillage. As discussed above, Maize Line HCEM485 would likely replace other glyphosate-resistant corn cultivars that currently comprise the majority of the 72% of corn acres planted with herbicide-resistant cultivars.

Based on the above, the impacts of extending a determination of nonregulated status to Maize Line HCEM485 to animal communities would be similar to those of the No Action Alternative.

4.4.2 Plants Communities

<u>No Action Alternative: Plants Communities</u>

The majority of U.S. corn acres are planted with GE herbicide-resistant corn cultivars. Plants communities are varied and adapted to local climate and soil, as well as the frequency of natural or human-induced disturbance (Smith and Smith, 2003). Non-crop vegetation in cornfields is limited by farmers' cultivation and weed control practices. Plants communities adjacent to cornfields commonly include other crops, borders, hedgerows, windbreaks, pastures, and other natural vegetation.

Agricultural practices affect plants communities by exerting selection pressures that influence the type and composition of plants present in a community. Preparation of fields for planting of crops removes other plants that compete for light and nutrients. Natural selection in frequently disturbed environments enables colonization by plants exhibiting early germination and rapid growth from seedling to sexual maturity, and the ability to reproduce sexually and asexually (Baucom and Holt, 2009). These weedy characteristics enable such plants to spread rapidly into areas undesired by humans.

Weeds are the most important pest in agriculture, competing for light, nutrients, and water and can significantly affect yields (Gibson et al., 2005; Baucom and Holt, 2009). Weeds commonly encountered in corn production include water hemp, giant ragweed, common lambsquarters, and others as described in Subsection 2.3.2, Plants Communities. Agronomic practices common in corn production, such as tillage and herbicide use, impart selection pressures on the weed community that can result in shifts in the relative importance of specific weeds (Owen, 2008). In aggressive tillage systems, weed diversity tends to decline and annual grasses and broadleaf plants are the dominant weeds; whereas, in no-till fields, greater diversity of annual and perennial weed species may occur (Baucom and Holt, 2009). The most common weed management tactic in U.S. corn production is to use herbicides. Recent estimates indicate herbicides are applied to 98% of planted corn acreage, and on that acreage, the most applied herbicide is glyphosate (USDA-NASS, 2011c).

Herbicide resistance occurs when a plant survives the application of an herbicide and reproduces, passing on its resistance to new generations. Herbicide-resistant weeds can become agronomically important as they out-compete crops and require additional resources to affect control. As discussed in Subsection 2.3.2, Plants Communities, weed species resistant to glyphosate are becoming more agronomically important in crop production. For example, glyphosate-resistant Palmer pigweed (amaranth) is a major economic problem in the Southeast U.S. while glyphosate-resistant waterhemp is an economically important weed in Midwestern states (Culpepper et al., 2006; Owen, 2008). In response, producers are diversifying weed management tactics in corn production to include alternating crops resistant to different herbicide modes of action grown in a field, alternating the herbicide modes of action used, practicing more crop rotation, and increasing tillage to affect control of herbicide-resistant weeds (Owen et al., 2011). Weeds are also developing resistance to multiple herbicides as well, but are also controlled with adjustments to practices such as crop rotation and tillage (Owen et al., 2011).

As discussed in Subsection 2.3.3, Gene Flow and Weediness, there are no extant populations of sexually compatible species related to *Z. mays* within the continental U.S., its territories, or possessions; therefore, APHIS (2011b) has concluded there is no significant risk of gene flow between cultivated corn and its weedy relatives that may impact plants communities.

Volunteer herbicide-resistant corn pose an additional management challenge when they appear in subsequent crops with the same resistance and can be extensive and problematic (see Subsection 2.3.2, Plants Communities). Typical agronomic practices, however, are effective in the management of volunteer corn. Glyphosate-resistant volunteer corn is being controlled by the application of effective herbicides (e.g., ACCase and ALS inhibitors), mechanical means, and rotation of crops with resistance to different herbicide modes of action (Beckie and Owen, 2007; Zollinger et al., 2011). The incidence of glyphosate-resistant volunteer corn in cornfields where it was not planted the year before as a result of pollen-mediated gene flow can be controlled by maintaining adequate spatial or temporal isolation distances between corn crops. See Subsection 2.3.3, Gene Flow and Weediness, for a description of pollen-mediated gene flow in corn.

The application of an herbicide in corn production has the potential to impact non-target plants communities through spray drift, volatilization (evaporation), its adsorption to soils incorporated in runoff, leaching, and cleaning and disposal of the equipment used to dispense it. The EPA is currently evaluating new regulations for pesticide drift labeling and the identification of BMPs to control such drift (US-EPA, 2009d), as well as identifying scientific issues surrounding field volatility of conventional pesticides (US-EPA, 2010). Glyphosate is currently under review by EPA for continued registration of the herbicide, with a reregistration decision expected in 2015 (US-EPA, 2009a). Glyphosate is toxic to most terrestrial and aquatic plants, inducing plant death. The herbicide has low leaching potential, low vapor pressure, and low volatility from soils (US-EPA, 1993b; Senseman, 2007). In its 1993 glyphosate reregistration decision, the EPA required additional studies concerning vegetative vigor, droplet size spectrum, and a drift field evaluation that did not affect the reregistration eligibility of the herbicide (US-EPA, 1993a). The potential effects of glyphosate spray drift are minimized by EPA-approved labels that provide detailed measures to manage spray drift, including optimal wind conditions, temperature inversions, humidity, spray droplet size, sprayer boom heights, aerial spraying by aircraft measures, and inclusion of drift reduction additives (Monsanto, 2010).

In summary, under the No Action Alternative, natural selection, and the selection pressure exerted through the use of herbicides and other agronomic practices, impact plants communities by either inducing plant death, selecting for weedy characteristics, inducing shifts in the composition of the plant community, through gene flow to other related plants, and in some cases, contributing to the development of herbicide-resistant weeds.

<u>Preferred Alternative: Plants Communities</u>

Impacts of Maize Line HCEM485 to plants communities adjacent to or within agroecosystems would not be different from currently available glyphosate-resistant corn cultivars. As discussed in Subsection 4.2.2, Agronomic Practices, the agronomic and phenotypic characteristics of Maize Line HCEM485 have been evaluated in field trials (Stine, 2011) and determined by APHIS to be similar to its comparator corn cultivars, and its antecedent GA21 (USDA-APHIS, 2011b). Maize Line HCEM485 would, therefore, be cultivated similar to other glyphosate-resistant corn, and have impacts to plants communities similar to those described under the No Action Alternative.

An extension of a determination of nonregulated status to Maize Line HCEM485 would not be expected to increase or decrease the development of glyphosate-resistant weeds. As another glyphosate-resistant corn cultivar option, Maize Line HCEM485 would likely replace other glyphosate-resistant corn cultivars without changing the application of glyphosate to corn. No changes to glyphosate's registered uses or labels for use on Maize Line HCEM485 are proposed by Stine, and no increase in glyphosate-resistant corn production acres is anticipated.

As discussed above, corn has few sexually compatible relatives in the U.S., and there is little risk of its cultivation contributing to weediness that may impact plants communities; further, APHIS has determined that there are no phenotypic differences between Maize Line HCEM485 and control lines that would contribute to enhanced weediness (USDA-APHIS, 2011b). Herbicide-resistant corn such as Maize Line HCEM485 has the potential to impact other crops in the same fields or adjacent fields in later seasons as volunteers. As Maize Line HCEM485 is similar to other nonregulated corn cultivars, its volunteers would be controlled by common agronomic practices as discussed under the No Action Alternative.

Based on these findings, the potential impact to other vegetation in corn and the landscapes surrounding cornfields from extending a determination of nonregulated status to Maize Line HCEM485 is not expected to differ from the No Action Alternative.

4.4.3 Gene Flow and Weediness

No Action Alternative: Gene Flow and Weediness

As described in Subsection 2.1.2, Agronomic Practices, corn is the largest crop grown in the U.S. in terms of value (USGC, 2010), acreage planted, and geographic area of production, and is predicted to remain an important crop in USDA projections to 2020 (USDA-OCE, 2011). Gene flow may occur through dispersal of vegetative tissues, pollen, or seed. Asexual reproduction and gene flow as a result of dispersal of vegetative tissues does not occur with corn. Corn is self-compatible and primarily pollinated by wind or gravity, with minimal contribution from insect pollination (McGregor, 1976; Thomison, 2009), and is propagated by seed.

As discussed in Subsection 2.3.3, Gene Flow and Weediness, although some teosinte species are culturally and biologically similar to corn, no successful weedy species have been documented (US-EPA, 2011b). There are no extant populations of sexually compatible species related to domesticated *Z. mays* within the continental U.S., its territories, or possessions; therefore, APHIS (2011b) has concluded that there is not a significant risk of gene movement between corn and its wild or weedy maize relatives.

The reproductive morphology of corn encourages cross-pollination between corn plants and there is no evidence (genetic or biological barriers) to indicate that gene flow is restricted between genetically modified, conventional, and organic corn. Spatial and temporal isolation can be the most effective barriers to gene exchange between corn crop cultivars. Requirements and methods to ensure seed and crop purity are discussed in more detail in Subsections 2.1.3, Corn Seed Production, and 2.1.4, Organic Corn Production.

Corn does not possess the characteristics for efficient seed-mediated gene flow. Through thousands of years of selective breeding by humans, corn has been extensively modified to depend on human cultivation for survival (Doebley, 2004). As a result of its domestication, corn is not able to survive in the wild and also has several traits that greatly reduce its ability to disperse via seeds (OECD, 2003). Corn seed lost after harvest may survive in fields and develop into volunteer plants, but such volunteers are controlled with common agronomic practices (see Subsection 2.3.2, Plants Communities).

Horizontal gene flow or gene flow to unrelated species in any currently cultivated corn is unlikely, and its potential occurrence in any crop is discussed more theoretically than practically. It has never been documented under realistic conditions (Stewart, 2008) (see Subsection 2.3.3, Gene Flow and Weediness). The horizontal transfer of entire transgenes, including portions of the DNA that code for the production of specific proteins, has never been shown to occur in nature (Stewart, 2008), and the risk of its occurrence in corn cultivation is considered low.

Preferred Alternative: Gene Flow and Weediness

Under the Preferred Alternative, Maize Line HCEM485 would be commercially available as an additional glyphosate-resistant corn option for use by producers. APHIS evaluated the potential for gene flow between Maize Line HCEM485 and its wild relatives, other corn cultivars, and other unrelated species. Phenotypic testing of Maize Line HCEM485 and agronomic trials have demonstrated the cultivar is similar to other glyphosate-resistant corn varieties and its antecedent GA21 corn (USDA-APHIS, 2011b). Therefore, its potential for gene flow and weediness would be no different than other corn varieties currently on the market as described under the No Action Alternative.

4.4.4 Microorganisms

No Action Alternative: Microorganisms

Soil microorganisms are important in soil structure formation, decomposition of organic matter, toxin removal, nutrient cycling, and most biochemical soil processes (Garbeva et al., 2004). They may also suppress soil-borne plant diseases and promote plant growth (Doran et al., 1996). As described in Subsection 2.3.4, Microorganisms, the main factors affecting microbial population size and diversity include soil and plant type, and agricultural management practices (crop rotation, tillage, herbicide and fertilizer application, and irrigation) (Garbeva et al., 2004). Plant roots, including those of corn, release a variety of compounds into the soil creating a unique environment for microorganisms in the rhizosphere.

GE plants potentially impact soil microbes directly from the transfer of introduced genetic material, exposure to expressed proteins through root exudation and crop residue incorporated into soil, or changes in agronomic practices used to produce crops. Indirect impacts may arise from changes in the amount and composition of residue from crops.

Gene transfer between microorganisms is common (Keese, 2008; McDaniel et al., 2010). Yet, biodegradation of plant materials tilled into soils generally results in fragmentation of DNA strands into small pieces (Lerat et al., 2007; Levy-Booth et al., 2008; Hart et al., 2009), which would be unlikely to represent an intact entire *cp4 epsps* gene. Cleaves et al. (2011) have evaluated the ability of shorter DNA strands to adsorb to soil aggregates, potentially affecting their persistence in soil; however, these were likely unable to convey functional genes. However unlikely, if a microorganism incorporated an intact *cp4 epsps* gene, it might transfer the gene to other microorganisms, resulting in a greater presence of the gene in the environment. As described in Subsection 2.3.3, Gene Flow and Weediness, gene transfers between plants and microorganisms are thought to occur on an evolutionary timescale. The *cp4 epsps* gene in the form of herbicide-resistant crops has been approved for release under 7 CFR part 340 and the plant pest provisions of the Plant Protection Act since 1994 (USDA-APHIS, 2012). An incremental increase in gene transfer among microorganisms under the No Action Alternative is unlikely.

The potential for intact CP4 EPSPS protein conveying glyphosate resistance to remain functional in soils is remote, because the protein degrades once it is released from cells, decaying in soils (Australian Government, 2006). If some molecules did persist in soils, there is no reason to anticipate toxicity of the CP4 EPSPS protein to soil microbes. Studies of the impact of GE crops on soil microbial communities have indicated there have been minor to no non-target effects, but induced targeted alterations to the composition of the microbial community have usually resulted in the inhibition of plant pathogenic organisms (Kowalchuk et al., 2003).

Root exudates have been found to promote certain microbial populations, such as soybeans symbiotic relationship with nitrogen-fixing bacteria, and other free-living microbes that have co-evolved with plants that supply nutrients to and obtain food from their plant hosts (USDA-NRCS, 2004; Bais et al., 2006). Management practices used in corn production can affect soil microorganisms by altering microbial populations and activity through modification of the soil environment. As presented in Subsection 2.3.4, Microorganisms, crop rotation, irrigation, tillage, and agricultural chemicals such as fertilizers and pesticides affect microbial community structure and functions such as nutrient cycling, disease promotion or suppression, and presence in soil. As discussed in Subsection 2.1.2, Agronomic Practices, the adoption of glyphosate-resistant corn (and other herbicide-resistant crops) has enabled the use of conservation tillage, creating less soil disturbance and retaining more crop residue which has been found to increase soil microbe population diversity (Locke et al., 2008). An agronomic practice may be beneficial for one microorganism but detrimental to another. For example, the primary agents degrading glyphosate in soil and water are microorganisms feeding on the herbicide (Senseman, 2007). As discussed in Subsection 2.3.4, Microorganisms, results from investigations into the toxicity of glyphosate to microorganisms are varied. Reviews of studies investigating the impact of glyphosate on soil microorganisms found that numerous studies did not detect adverse effects under field use conditions, others found minor effects that could not be separated from changes in habitat, and still others reported effects at or near normal glyphosate use rates, but in most cases, the effects were minor and temporary (Giesy et al., 2000). Other studies have implicated glyphosate in an increase in the population and virulence of certain plant diseases, as well as the increased susceptibility to some diseases in glyphosate-resistant crop varieties (as reviewed in Johal and Huber, 2009). The authors suggest measures to minimize this potential include using the minimum amount of glyphosate necessary for weed management, amending soils with micronutrients, detoxifying meristematic (i.e., growth) tissues by adding chelating agents to the soil, and detoxifying root exudates through the regular inoculation of nitrogen-fixing organisms (Johal and Huber, 2009).

APHIS has previously examined in detail the potential impacts of glyphosate to microorganisms in the cultivation of glyphosate-resistant alfalfa and sugar beets (USDA-APHIS, 2010; USDA-APHIS, 2011a). Based on extensive review of the literature, they conclude glyphosate application might favor development of detrimental microbial species (or harm some beneficial microbes); however, to date, there is no conclusive evidence linking applications of glyphosate to changes in soil microbial communities that have adverse effects on plants grown in those soils.

Corn cultivation, including the production of glyphosate-resistant corn and its potential impacts to soil microorganisms, is expected to continue under the No Action Alternative. The majority of corn grown in the U.S. is herbicide resistant, and glyphosate is the most applied herbicide to corn (USDA-ERS, 2011a; USDA-NASS, 2011c). Farmers have access to non-glyphosate-resistant corn varieties, and manage their crops by implementing practices to control pests and weeds, including the use of glyphosate.

Preferred Alternative: Microorganisms

Extension of a determination of nonregulated status to Maize Line HCEM485 is not expected to result in any new impacts to microbial communities. Maize Line HCEM485 is genetically equivalent to its GA21 antecedent for expression of the EPSPS protein (Stine, 2011; USDA-APHIS, 2011b). All the sequences inserted into Maize Lane HCEM485 are the same as those associated with the native EPSPS-encoding gene in corn (USDA-APHIS, 2011b). As such, nothing new or unique would be introduced into the environment that may impact the microbial community under the Preferred Alternative.

Maize Line HCEM485 has been determined to be agronomically and compositionally similar to its antecedent GA21, as well as other nonregulated glyphosate-resistant corn varieties (USDA-APHIS, 2011b). It is not expected to change the acreage or area of glyphosate-resistant corn production that potentially would expand the use of glyphosate herbicide with potential impacts to soil microorganisms. Maize Line HCEM485 is another glyphosate-resistant corn cultivar likely to replace other nonregulated glyphosate-resistant corn varieties. Approximately 72% of corn cultivated in the U.S. today is herbicide-resistant and the majority of herbicide-resistant corn is glyphosate-resistant (Duke and Powles, 2009; USDA-ERS, 2011a). Because Maize Line HCEM485 is agronomically similar to its antecedent GA21 and other glyphosate-resistant and conventional corn, its cultivation would not change the agronomic practices needed for its cultivation, such as amount and rate of glyphosate application. Since the use of glyphosate for corn production is not expected to change under the Preferred Alternative, there would be no change to potential impacts to microorganisms from those of the No Action Alternative.

4.4.5 Biodiversity

No Action Alternative: Biodiversity

All the plants, animals, and microorganisms interacting in an ecosystem contribute to biodiversity (Wilson, 1988) that provides valuable life functions. In agriculture, biodiversity contributes to critical functions such as pollination, genetic introgression, biological control, nutrient recycling, and other processes the loss of which requires costly management (Altieri, 1999). Concerns regarding the potential impacts to biodiversity associated with the introduction of GE crops (and crops in general) include the loss of diversity, which can occur at the crop, farm, and/or landscape scale (Visser, 1998; Ammann, 2005; Carpenter, 2011) (see Subsection 2.3.5, Biodiversity).

At the crop scale, research suggests that developing GE crops has introduced novel genes that has not decreased crop diversity because of widespread use of the traits in multiple breeding programs, and the technology enables the introduction of novel genes in crops (Ammann, 2005; Carpenter, 2011). Additionally, the concern for the loss of genetic variability has led to the establishment of an extensive network of genebanks (van de Wouw et al., 2010), including an active collection of more than 14,000 accessions of corn at the ARS North Central Regional Plant Introduction Station at Iowa State University, Ames, Iowa (USDA-ARS, 2005). These collections are shared with researchers worldwide, which helps ensure a continuous reservoir of genetic diversity for future crop development. Under this alternative, growers have access to existing nonregulated herbicide-resistant and other GE corn varieties, as well as other non-GE corn varieties, while Maize Line HCEM485 would remain a regulated article.

At the farm scale, agronomic practices that can impact biodiversity include cropping practices (e.g., strip or contour cropping, crop rotation), soil conservation practices that maintain grass strips, windbreaks and shelterbelts and the like, tillage, and the application of agrochemicals. The rotation of crops and strip contour cropping provide varied habitat that can benefit biodiversity. Recently, there has been an increase in corn-to-corn rotation given the profitability of corn production (USDA-ERS, 2011d). As discussed in Subsection 2.1.2., Agronomic Practices, continuous corn production must be highly managed to maintain productivity, which can be less beneficial to biodiversity; however, the practice does accumulate more crop residue that benefits some species. The establishment of soil conserving grass and other vegetative borders stabilize soil that maintains additional wildlife habitat, and improves the quality of existing habitat (such as surface water quality) that contributes to biodiversity. Allowing unproductive field edges to become managed wildlife habitat promotes diversity in both plants and animal species (Sharpe, 2010).

Herbicides are used to control plants in areas where humans do not want them. As described in Subsection 2.1.2, Agronomic Practices, weeds compete with crops for light and nutrients, reducing yields. Glyphosate effectively kills grass and broadleaf plants when applied at the recommended rates. At the farm scale, herbicide use in agricultural fields may impact biodiversity by decreasing weed quantities or causing a shift in weed species present in the field, which may affect those insects, birds, and mammals that utilize these weeds. The quantity and type of herbicide use associated with herbicide-resistant corn crops, however, is dependent on many variables, including cropping systems, type and abundance of weeds, production practices, and individual grower decisions. See Subsection 2.1.2, Agronomic Practices, for a detailed discussion of pesticide use in corn production. The effects of glyphosate on plants and animals are presented in the following discussion of landscape-scale biodiversity.

Use of herbicide-resistant crops such as corn has been linked to increased rates of conservation tillage in U.S. crop production (Givens et al., 2009). This promotes biodiversity by allowing the establishment of other plants between crop rows and the accumulation of more plant residue that creates more soil organic matter, food, and cover for wildlife. In a review of literature that assessed the impacts of GE crops on biodiversity, Carpenter (2011) found that, for the most part, impacts to biodiversity have been positive due to increased yields, decreased usage of insecticides, use of more environmentally friendly herbicides, and facilitation of conservation tillage. In 2010, 62% of planted corn acreage in 19 surveyed states was dedicated to no-till or minimum till systems (USDA-NASS, 2011c). As described in Subsection 2.3.2, Plants Communities, the increasing incidence of herbicide-resistant weeds is also causing farmers to turn to more diversified weed management strategies, including increased tillage that potentially reduces biodiversity.

Crop production in general impacts biodiversity at the landscape scale by potentially converting natural lands that have greater animal and plant species diversity to more monocultural landscapes. Corn is the largest crop grown in the U.S. in terms of acreage planted and geographic area of production with over 92 million planted acres in 2011 (USDA-NASS, 2011b). USDA projections to 2020 indicate the acreage devoted to corn production in the U.S. will remain relatively stable at this level (USDA-OCE, 2011).

Area-wide herbicide application may negatively impact species that are dependent on the targeted weeds, reducing diversity. As stated above, the majority of corn cultivated in the U.S. is treated with herbicides and glyphosate is the most-applied herbicide to corn (USDA-NASS, 2011c). Potential impacts to landscape-scale diversity can be related to the effects of herbicides on non-target animal and plant species. Assessments of the toxicity of glyphosate to animal species indicate a minimal risk to animals, but it is toxic to targeted plants and may affect non-targeted plants and animals through spray drift, volatilization (i.e., evaporation) and runoff. Inadvertent exposure may cause adverse effects to plants composing animals' habitat that could lead to a decrease in biodiversity. As discussed in Subsection 2.3.1, Animal Communities, glyphosate was found by the EPA to be no more than slightly toxic to birds, moderately toxic to practically nontoxic to fish, and practically nontoxic to aquatic invertebrates and honeybees (US-EPA, 1993b). The EPA is currently evaluating additional labeling requirements concerning BMPs for controlling pesticide spray drift (see Subsection 2.3.2, Plants Communities). While herbicide use potentially affects biodiversity, the application of pesticides in accordance with registered uses and label instructions, and careful management of chemical spray drift, minimizes the potential impacts from their use.

In 2009, the EPA initiated reregistration of glyphosate and has identified additional data needs. Part of the risk assessment will include an acute avian oral toxicity study for passerine species. Additionally, some inert ingredients used as surfactants are more toxic than glyphosate to aquatic organisms, and will be evaluated for acute toxicity to estuarine and marine mollusk, invertebrates, and fish (US-EPA, 2009b).

Preferred Alternative: Biodiversity

Under the Preferred Alternative, an extension of a determination of nonregulated status to Maize Line HCEM485 would provide growers an additional glyphosate-resistant corn variety. Maize Line HCEM485 is functionally the same as its antecedent GA21 and other GE and non-GE corn with regard to agronomic characteristics, growth, reproductive habit, utilization of resources, and production practices (Stine, 2011; USDA-APHIS, 2011b). Extending a determination of nonregulated status to Maize Line HCEM485 is unlikely to have any direct effects on non-target organisms associated with exposure to its gene products and the modified EPSPS protein expressed by the cultivar. The genetic material in and proteins produced by Maize Line HCEM485 are similar to those of the nonregulated antecedent GA21 and other corn varieties in commercial production (USDA-APHIS, 2011b). An extension of a determination of nonregulated status to Maize Line HCEM485 would, therefore, have no impact on biodiversity at the crop-, farm- or landscape scales.

Because Maize Line HCEM485 is another glyphosate-resistant cultivar option, it would likely replace other glyphosate-resistant corn varieties without expanding the acreage or area of corn production that could impact farm- and landscape-scale biodiversity. Approximately 72% of corn planted in the U.S. in 2011 was herbicide resistant, and the majority of herbicide-resistant corn is glyphosate-resistant (Duke and Powles, 2009; USDA-ERS, 2011a). Also, based on its similarity to other corn as described above, Maize Line HCEM485 would not result in changes to agronomic practices such as crop rotation, soil conservation, tillage, weed management, or pesticide use that potentially impact farm- or landscape-scale biodiversity.

Based on the above information, APHIS has concluded the extension of a determination of nonregulated status to Maize Line HCEM485 under the Preferred Alternative would not have impacts to crop-, farm-, or landscape-scale biodiversity any different than other currently available glyphosate-resistant corn cultivars. As such, the impacts to biodiversity under this alternative would be similar to the No Action Alternative.

4.5 Human Health

4.5.1 No Action Alternative: Human Health

As discussed in Subsection 2.1.1, Acreage and Area of Corn Production, 88% of corn grown in the U.S. in 2011 was GE (USDA-ERS, 2011a). The majority of GE herbicide-resistant corn grown in the U.S. is glyphosate resistant (Duke and Powles, 2009). Human health concerns 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 (Malarkey, 2003; Dona and Arvanitoyannis, 2009). Previous studies of the EPSPS protein, which confers glyphosate resistance, found that the EPSPS protein expressed through genetic engineering poses no potential for toxicity or allergenicity (Harrison et al., 1996; Ridley et al., 2002; Batista et al., 2005; Hoff et al., 2007; Herouet-Guicheney et al., 2009). Some people are allergic to corn, but corn is not included in the FALCPA as one of the most common food allergens (see Subsection 2.4, Human Health). An additional concern with GE food crops is the potential for increased levels of anti-nutrients (Dona and Arvanitoyannis, 2009). As discussed in Subsection 2.4, Human Health, there are several naturally occurring anti-nutrients found in corn, including phytic acid, DIMBOA, raffinose, and low levels of trypsin and chymotrypsin inhibitors (OECD, 2002). In a study of the CP4 EPSPS protein conferring glyphosate resistance, Ridley et al. (2002) found the genetic modification to confer glyphosate resistance did not significantly change any of the 51 biologically and nutritionally important components evaluated.

Under the FFDCA, it is the responsibility of food and feed manufacturers to ensure that the products they market are safe and properly labeled. The food safety evaluation of the EPSPS protein imparting glyphosate resistance was completed by the FDA on the GA21 corn variety (BNF No. 000051) on February 10, 1998 (US-FDA, 1998a). According to the consultation note,

> "Monsanto has concluded that corn containing transformation event GA21 is not materially different in composition, nutrition, and safety from corn currently grown, processed, marketed, and consumed for animal feed or human food. At this time, based on Monsanto's description of its data and analyses, the Agency considers Monsanto's consultation on corn from varieties containing transformation event GA21 to be complete."

No food safety issues were found by the FDA in previous consultations regarding the EPSPS protein in corn or any other GE corn cultivars (See the FDA website Final Biotechnology Consultations http://www.fda.gov/Food /Biotechnology/Submissions/ucm225108.htm).

Agricultural production of nonregulated GE and non-GE corn utilize EPA-registered pesticides for insect and plant pest management under the No Action Alternative, including glyphosate. Glyphosate may also be applied to regulated Maize Line HCEM485 cultivated under confined conditions. The environmental risks of pesticide use are assessed by the EPA in the pesticide registration process and a pesticide is regularly reevaluated by the EPA to maintain its registered status under FIFRA. The human health effects from exposure to glyphosate have been evaluated by the EPA. The 1993 glyphosate RED presents the data used by the EPA for chemical reregistration (see US-EPA, 1993b). As previously discussed in Subsection 2.4, Human Health, the review for reregistration began in July 2009; the EPA is currently conducting a comprehensive human health assessment for all uses of glyphosate and its salts (US-EPA, 2009b). The glyphosate RED presents the EPA's analysis of the toxicity, carcinogenicity, and developmental toxicity of this herbicide. Glyphosate is classified as having low toxicity via the oral, dermal, and inhalation routes and is not classified as a carcinogen or teratogen (US-EPA, 2009b; US-EPA, 2009c). Moreover, neurotoxicity has not been reported in any acute, subchronic, chronic, developmental, or reproductive studies, although additional studies will occur as part of the current review process (US-EPA, 2009c). Based on additional toxicity tests, the EPA determined the main glyphosate metabolite AMPA does not require regulation (US-EPA, 2009c).

As presented in Subsection 2.4, Human Health, pesticide tolerance levels for glyphosate on field corn such as Maize Line HCEM485 have been established (US-EPA, 2011e). Tolerances are the limits on the amount of pesticide that may remain on or in foods marketed in the U.S., that are established for every pesticide based on its potential risks to human health. The maximum tolerance level for glyphosate in field corn is 5.0 ppm for grain (40 CFR §180.364).

It has been suggested that the importance producers place on worker safety, perceived increased simplicity and flexibility of farm management, and decreased risk in production can be partially attributed to the high rate of adoption of GE crops (NRC, 2004). Producers and farm workers experience reduced exposure to potentially harmful pesticides compared to before adoption of GE crops and are also able to spend less time applying pesticides with greater flexibility in determining when pesticides are applied. There are no data indicating that workers exposed to herbicide-resistant corn (raw or byproducts), such as that could occur during production, transportation, and milling, have experienced adverse reactions. While a small portion of the population does suffer from corn allergies, the EPSPS protein that confers glyphosate resistance in Maize Line HCEM485 has been determined not to be an allergen (see Subsection 2.4, Human Health).

Agricultural workers that routinely handle glyphosate (mixers, loaders, and applicators) may be exposed during and after use. Due to glyphosate's low acute toxicity and lack of carcinogenicity and other toxicological concerns, occupational exposure data is not required for reregistration (US-EPA, 1993b); however, the glyphosate RED does classify some end-use glyphosate products as eye and skin irritants and recommends PPE be worn by mixers, loaders, and applicators (US-EPA, 1993b). Additionally, due to the potential for skin and eye irritation, the EPA has set the restricted entry interval for glyphosate to 12 hours after products have been applied. Due to the expected short-term dermal and inhalation exposures of occupational handlers and growers, no endpoints were identified by the HED, and as such, no occupational handler or occupational post-application assessments are required for reregistration (US-EPA, 2009c). Current EPA-approved labels for glyphosate include precautions and measures to protect human health. When used consistent with the label, pesticides present minimal risk to human health and safety.

4.5.2 Preferred Alternative: Human Health

Maize Line HCEM485 is a GE variety of corn that has been modified to add resistance to the herbicide glyphosate (Stine, 2011). This resistance was conferred using an altered sequence of DNA derived from the corn genome accomplished by the removal and modification of the *epsps* gene from an inbred corn line so that it encodes a double mutated 2mEPSPS enzyme, which was subsequently reintroduced back into the corn DNA. The 2mEPSPS enzyme product is identical to that produced by the antecedent GA21 corn (USDA-APHIS, 2011b). In addition, all promoter, intron, and terminator sequences inserted into HCEM485 are the same as those already associated with the native EPSPS-encoding gene in corn. As discussed above, studies have found that the EPSPS protein expressed in glyphosate-resistant crops is compositionally similar to, and is as safe and nutritional as, the same non-GE crops (Ridley et al., 2002; Batista et al., 2005; Herouet-Guicheney et al., 2009). APHIS considers the FDA regulatory assessment in making its determination of the potential impacts of removing a new agricultural product from regulated status. As discussed in Subsection 2.4, Human Health, a biotechnology consultation of the EPSPS protein that confers glyphosate resistance was completed by the FDA on the GA21 corn variety (BNF No. 000051) on February 10, 1998 (US-FDA, 1998a). According to the consultation note,

> "Monsanto has concluded that corn containing transformation event GA21 is not materially different in composition, nutrition, and safety from corn currently grown, processed, marketed, and consumed for animal feed or human food. At this time, based on Monsanto's description of its data and analyses, the Agency considers Monsanto's consultation on corn from varieties containing transformation event GA21 to be complete."

Stine submitted a safety and nutritional assessment of food and feed derived from Maize Line HCEM485 to the FDA in December 2010 in support of the consultation process with the FDA for the commercial distribution of Maize Line HCEM485. Based on the above information and its similarity to the antecedent GA21 corn, potential impacts to food safety from production of Maize Line HCEM485 would be similar to the No Action Alternative.

Under the Preferred Alternative, pesticide tolerance levels for glyphosate on field corn would not change. Tolerances are the limits on the amount of pesticide that may remain on or in foods marketed in the U.S. established for every pesticide based on its potential risks to human health. As specified in 40 CFR §180.364, the glyphosate tolerance level for field corn grain is 5.0 ppm. As discussed in Subsection 4.2.2, Agronomic Practices, the use of glyphosate in corn production would be unaffected by an extension of a determination of nonregulated status to Maize Line HCEM485. The application rate of glyphosate in corn would not likely change as a result of the Preferred Alternative since Maize Line HCEM485 is expected to replace other glyphosate-resistant corn cultivars (see Subsection 4.2.1, Acreage and Area of Corn Production), is similar to other nonregulated glyphosate-resistant cultivars in its cultural requirements, and no change to the registered use of glyphosate is proposed.

Potential risks to occupational handlers and growers during glyphosate application to Maize Line HCEM485 would be the same as those presented under the No Action Alternative. There would be no increased risk to workers' health or safety from exposure to Maize Line HCEM485 corn or byproducts during typical agricultural-related activities. Moreover, as discussed above, the application rate of glyphosate would not likely change and no change to the registered use of glyphosate is proposed under the Preferred Alternative. Potential risks to farm workers from the use of glyphosate would be the same as the No Action Alternative.

APHIS concludes impacts to human health or worker safety from an extension of nonregulated status to Maize Line HCEM485 under the Preferred Alternative would be similar to the No Action Alternative

4.6 Animal Feed

4.6.1 No Action Alternative: Animal Feed

As described in Subsection 2.5, Animal Feed, most of the corn produced in the U.S. is for animal feed that is consumed primarily by cattle, poultry, and swine (NCGA, 2011; USDA-ERS, 2011d). Corn comprises approximately 96% of the total feed grain produced in the U.S. (USDA-ERS, 2011d). In 2011, corn was grown on 92.3 million acres (USDA-NASS, 2011b) and measurably produced in all states but Alaska (USDA-NASS, 2009a). As discussed in Subsection 2.5, Animal Feed, 44% of the corn consumed in the U.S. in 2010 was used for animal feed (USDA-ERS, 2011d). In 2011, 72% of the corn produced in the U.S. was genetically engineered to be resistant to herbicides, consisting primarily of glyphosate-resistant cultivars (Duke and Powles, 2009; USDA-ERS, 2011a). The amount of corn that is used for feed is dependent on a number of factors such as the number of animals that are fed corn, its supply and price, the amount of supplemental ingredients added, and the supply and price of competing ingredients (USDA-ERS, 2011d). Corn forage, silage, grain, and refined corn feed products from currently cultivated GE herbicide-resistant and conventional corn varieties are utilized by livestock producers.

It is the responsibility of feed manufacturers to ensure that the products they market are safe and properly labeled and feed derived from GE corn must comply with all applicable legal and regulatory requirements, which in turn protect human health (see Subsection 2.5, Animal Feed). All applicants who wish to commercialize a GE variety that will be included in the food supply complete a consultation with the FDA to identify and discuss relevant safety, nutritional, or other regulatory issues regarding the bioengineered food and submits a summary of its scientific and regulatory assessment of the food to FDA (US-FDA, 2012b). The FDA evaluates the submission and responds to the developer by letter. Stine submitted their final food consultation regarding Maize Line HCEM485 in December 2010 which is pending review by the FDA. It will be posted on the FDA website Final Biotechnology Consultations http://www.fda.gov/Food/ Biotechnology/Submissions/ucm225108.htm when completed. In addition, a biotechnology consultation of the EPSPS protein was completed by the FDA on the antecedent GA21 corn variety (BNF No. 000051) on February 10, 1998 (US-FDA, 1998a). No food safety issues were found by the FDA in their review of Monsanto's safety and nutritional assessment of GA21 corn and the modified EPSPS protein (see the FDA website Final Biotechnology Consultations http://www.fda.gov/Food/Biotechnology/Submissions /ucm225108.htm).

Agricultural production of existing commercially available glyphosate-resistant corn varieties uses EPA-registered pesticides, including glyphosate. The interval between when corn is treated with glyphosate and the grain may be subsequently harvested is seven days (Bradley et al., 2010). The interval between post-harvest application of glyphosate after corn grain has been harvested and when the corn vegetation may be harvested or used as feed varies with product labels, for example the Roundup Power Max® interval is seven days while the Glyphosate 41 Plus ® interval is eight weeks (CropSmart, 2009; Monsanto, 2010). Tolerances are the limits on the amount of pesticide that may remain on or in foods marketed in the U.S. that are established for every pesticide based on its potential risks to human health. The maximum tolerance level for glyphosate in field corn is 5.0 ppm for grain and is 6.0 ppm for forage (40 CFR §180.364).

4.6.2 Preferred Alternative: Animal Feed

As described in Subsection 4.2.1, Acreage and Area of Corn Production, no change to the area or acreage of corn production is expected to occur as the result of extending a determination of nonregulated status to Maize Line HCEM485. Also, as described in Subsection 4.2.2, Agronomic Practices, the cultural requirements and agronomic practices for corn production that could impact the supply of corn-based animal feed would not change under this alternative because agronomic and growth characteristics of Maize Line HCEM485 are similar to other commercially available glyphosate-resistant corn. As described for the No Action Alternative, the amount of corn that is used for feed is dependent on several factors, including price, supply, and the number of animals that are fed corn (USDA-ERS, 2011d). Because herbicide-resistant corn is the majority of corn produced in the U.S. today, and most of that is glyphosate resistant (USDA-ERS, 2011a), Maize Line HCEM485 would likely replace other glyphosate-resistant cultivars without impacting the supply of corn for animal feed.

Stine has submitted compositional and nutritional characteristics of Maize Line HCEM485 grain and forage to APHIS (Stine, 2011). Samples of Maize Line HCEM485 and its comparators that were sprayed with glyphosate were collected from six different field trial locations (four for grain samples and two for forage samples) and analyzed for comparable nutritional components in accordance with Organisation for Economic Co-operation and Development (OECD) guidelines (OECD, 2002). Tested parameters include proximates (protein, fat, carbohydrates, fiber, ash, and moisture), minerals, amino acids, fatty acids, vitamins, isoflavones, and antinutrients (i.e., ferulic acid, phytic acid, trypsin inhibitor, raffinose, furfural, inositol, and ρ-coumaric acid) (Stine, 2011). Maize Line HCEM485 is similar in compositional and nutritional characteristics to other varieties of GE and non-GE corn (Stine, 2011; USDA-APHIS, 2011b).

A biotechnology consultation of the EPSPS protein that confers glyphosate resistance in the GA21 corn variety has previously been completed. (See Subsection 4.5, Human Health). Stine submitted a safety and nutritional assessment of food and feed derived from Maize Line HCEM485 to the FDA in December 2010 in support of the consultation process with the FDA for the commercial distribution of Maize Line HCEM485 (Stine, 2011). Based on the above information and its similiarity to the antecedent GA21 corn, potential impacts on the safety of Maize Line HCEM485 is expected to be similar to the No Action Alternative.

As discussed above, label restrictions for glyphosate's application to corn prohibits harvesting the grain prior to seven days after application and the interval for harvesting or feeding the vegetation is dependent on the individual glyphosate product label. As discussed in Subsection 4.2.2, Agronomic Practices, the registered uses of glyphosate on Maize Line HCEM485 or other corn would not change as a result of the Preferred Alternative, nor would herbicide label restrictions for feeding corn after treatment. Similarly, no change to the EPA-established tolerances of glyphosate in treated corn intended for forage or grain harvested for animal feed that could impact animal health would be required for the use of glyphosate on Maize Line HCEM485 .

Based on a review of field and laboratory data and scientific literature provided by Stine (2011), as well as safety data available on other glyphosate-resistant corn in commercial production, APHIS has concluded that a determination of nonregulated status to Maize Line HCEM485 would not adversely impact the safety of animal feed and animal health. Overall impacts of the Preferred Alternative would be similar to the No Action Alternative.

4.7 Socioeconomic Impacts

4.7.1 Domestic Economic Environment

No Action Alternative: Domestic Economic Environment

Under the No Action Alternative, Maize Line HCEM485 corn would continue to be a regulated article under 7 CFR part 340, cultivated only in limited test fields. Farmers and other parties who are involved in production, handling, processing, or consumption of corn would not have access to Maize Line HCEM485 corn, but would have access to existing nonregulated herbicide-resistant, conventional, GE, and organic corn varieties. In terms of value, corn is the primary U.S. crop exceeding $66.7 billion in 2010 (USDA-NASS, 2011f), and it is expected corn would retain current planted acreage levels at least until 2020 (USDA-OCE, 2011). Almost all of the U.S. corn supply (99.8% in 2010/11) comes from new annual domestic production (USDA-ERS, 2011g). In the 2010/11 marketing year, less than half (42.8%) of domestic corn usage was for feed, while approximately 44.7% of domestic use was for the production of ethanol (USDA-ERS, 2011g). Total operating costs for U.S. corn production were $275.58 per planted acre (USDA-ERS, 2011c). Corn is widely produced in the U.S. (see Subsection 2.1.1, Acreage and Area of Corn Production, Figure 1). The most productive regions are the Heartland and Northern Crescent, and the two most profitable are the Heartland and Northern Great Plains (USDA-ERS, 2011c). As discussed in Subsections 2.1.4, Organic Corn Production, and 2.6.1, Domestic Economic Environment, organic corn production is a small portion of the U.S. corn market. The value of corn produced for grain or seed from organic-certified farms in the U.S. in 2008 was nearly $111.4 million (USDA-NASS, 2010a).

Most corn planted in the U.S. today are stacked GE varieties with both herbicide and insect resistance (USDA-ERS, 2011a). The widespread adoption of herbicide-resistant corn has been attributed to the cost savings for production, among other non-monetary benefits as described in Subsection 2.1.2, Agronomic Practices (Duke and Powles, 2009; NRC, 2010; Green and Owen, 2011). Of the herbicide-resistant corn varieties on the market today, growers may choose from glyphosate, glufosinate, glyphosate stacked with immidazolinone resistance traits (USDA-APHIS, 2012), and glufosinate (Monsanto, 2011b).

GE technology is patented and GE seeds are proprietary in the U.S. (NRC, 2010). The costs for GE seed are higher than that for conventional seed, as GE seed includes technology fees (NRC, 2010). The higher seed costs, however, may be offset by other premiums offered by companies, such as discounts for herbicides to use on the resistant crop, and reductions in crop insurance

(NRC, 2010). As discussed in Subsection 2.6.1, Domestic Economic Environment, estimates of the economic benefits of herbicide-resistant crops to farmers are limited (NRC, 2010), and studies that have been conducted have had mixed results. Overall, these studies indicate in the early years of the adoption, GE cultivars exerted downward pressure on crop prices while the earnings of adopting farmers increased, and barriers to market access for GE crops reduced grower income (NRC, 2010).

Farmers have recently broadened weed management to treat herbicide-resistant weeds which may be impacting yields, leading to more variety in herbicide application and increased tillage, potentially incurring higher production costs. Weirich et al. (2011), however, investigated the economic effects of alternative glyphosate weed resistance management programs, finding that although they increased cost substantially, higher yields offset these costs such that no statistically significant decrease in net returns occurred. Their study suggests growers may be able to effectively respond to glyphosate resistance using weed BMPs without substantially affecting their returns.

As indicated in Subsection 2.1.1, Acreage and Area of Corn Production, the trend over the last several years in the U.S. has been to stack herbicide resistance with primarily insect-resistant traits. Developers have recently sought approvals for corn varieties that have multiple herbicide and insect resistance, as well as other value added traits (USDA-APHIS, 2012). Herbicide-resistant-only corn has consistently comprised approximately 22 to 23% of planted corn in the U.S. since 2007 (USDA-ERS, 2011a). Two companies hold the licenses for the majority of herbicide-resistant corn in the U.S.: Monsanto patented glyphosate-resistant corn technology and offers varieties in their Roundup Ready® corn lines, and Bayer CropScience licenses glufosinate-resistant corn in their LibertyLink® corn lines. Growers have perceived a lack of competition in the U.S. herbicide- and insect-resistant seed corn market based on substantial increases in the price of GE seed in the last several years (Neuman, 2010); although, concentration of the U.S. seed market has been ongoing since passage of the Plant Variety Protection Act in the 1970s established proprietary rights for certain plant varieties (Fernandez-Cornejo, 2004). In 2010, corn seed comprised 30% of total per acre operating costs for farmers (USDA-ERS, 2011c). Industry has responded that the quality of seed offered has improved, and new GE traits have been added that lower costs associated with improved insect and weed control, among other production costs (Neuman, 2010).

<u>Preferred Alternative: Domestic Economic Environment</u>

Under the Preferred Alternative, farmers and other parties who are involved in the production, handling, processing, or consumption of corn would have access to Maize Line HCEM485.

Maize Line HCEM485 is similar in its composition, growth habits, and cultural requirements to the antecedent GA21, its comparators and other nonregulated glyphosate-resistant corn (Stine, 2011; USDA-APHIS, 2011b). Since this new cultivar is glyphosate-resistant, Maize Line HCEM485 would directly compete with the market share of other glyphosate-resistant corn varieties. As discussed above, herbicide-resistant corn dominates U.S. corn production, either as herbicide-resistant-only varieties or stacked with other traits; therefore, Maize Line HCEM485 would likely replace other glyphosate-resistant corn cultivars without impacting corn acreage or production area that may affect domestic markets. As another glyphosate-resistant corn cultivar in the market, nonregulated Maize Line HCEM485 may increase competition, the extent of which is dependent upon growers finding value in it. As discussed above, growers may currently choose from glyphosate, glufosinate, and glyphosate stacked with immidazolinone resistance traits. It is reasonable to assume Maize Line HCEM485 may be stacked with other traits, similar to other glyphosate-resistant corn cultivars. APHIS assumes that the technology fees for Maize Line HCEM485 seed would be similar to those charged by developers for other GE crop varieties already in the marketplace.

Since Maize Line HCEM485 is similar in growth habits and cultural requirements to other nonregulated herbicide-resistant, GE and non-GE corn varieties (Stine, 2011), no changes to agronomic inputs or practices would be anticipated that may impact on-farm costs for corn producers or the U.S. domestic corn market. As discussed above, farmers are broadening their weed control tactics in response to developing herbicide-resistant weeds, including glyphosate-resistant weeds (see Subsection 2.3.2, Plants Communities, Table 2). These BMPs increase costs of production; however, the costs appear to be offset by increases in yields, having little negative impact to net returns (Weirich et al., 2011). As discussed above, Maize Line HCEM485 is similar to and expected to replace other glyphosate-resistant cultivars, and would, therefore, have similar impacts on the development of herbicide-resistant weeds and weed management practices as the No Action Alternative.

As discussed under the No Action Alternative, the organic corn market serves a smaller consumer niche for corn in the U.S. corn market. Because of Maize Line HCEM485's similarity to other currently available GE corn varities in its reproductive characteristics, it is expected that impacts on organic corn production would be similar to the No Action Alternative. U.S. organic producers would continue to to be able to meet organic certification requirements as outlined in Subsection 2.1.4, Organic Corn Production, by implementing standard practices to preserve the identity of their organic corn crop.

Based upon the above, an extension of a determination of nonregulated status to Maize Line HCEM485 would have potential domestic economic impacts no different than those currently observed under the No Action Alternative .

4.7.2 Trade Economic Environment

<u>No Action Alternative: Trade Economic Environment</u>

Under the No Action Alternative, Maize Line HCEM485 would continue to be a regulated article. Farmers, processors, and consumers in the U.S. would not have access to Maize Line HCEM485, but do have access to existing nonregulated herbicide-resistant and non-GE corn varieties, as do the major U.S. corn export competitors.

The U.S. is the leading exporter of corn in the world market (see Subsection 2.6.2, Trade Economic Environment, Figure 9), while other important exporters are Argentina, Brazil, and Ukraine. In the 2010/2011 marketing year (August to September), the U.S. exported more than half of the world's corn with Japan, Mexico, and South Korea the major importers (USDA-FAS, 2011a). In 2010, corn exports were worth approximately $9.1 billion (USDA-ERS, 2010c). U.S. corn supply, the value of the U.S. dollar and other currencies, oil prices, U.S. and international agricultural policy, the U.S. and international biofuels sector, livestock and meat trade, prices, and population growth are all factors affecting where and how much of U.S. corn is exported (USDA-ERS, 2009; USDA-OCE, 2011). In addition, consumer perception of GE crop production and products derived from GE crops may present barriers to trade. Over the past decade, U.S. corn export share has eroded as exports have remained relatively stable while global exports have increased by almost 20% (See Subsection 2.6.2, Trade Economic Environment, Figure 9). U.S. share of world corn production has declined as well, even as total world production increased (Figure 10). This is attributed to greater domestic use of U.S. corn, smaller corn crops, and increased competition from other major corn exporters such as Argentina, Brazil, and Ukraine (USDA-FAS, 2011a), countries with increasing GE herbicide- and insect-resistant corn production acreage (Brookes and Barfoot, 2011).

Farmers in the U.S. and abroad have begun to utilize BMPs to control glyphosate or other herbicide-resistant weeds, but these BMPs have not necessarily increased costs (Weirich et al., 2011) such that the competitiveness of U.S. corn and trade economic environment would be affected. Increasing herbicide weed resistance is also occuring in other countries producing herbicide-resistant crops, including U.S. corn export competitors (for example, Argentina and Brazil (Heap, 2011)) that would likely incur increases in production cost to mitigate the incidence of glyphosate-resistant weeds, similar to the U.S. experience.

Stine has submited applications for regulatory approval of Maize Line HCEM485 to Canada for cultivation and use as food and feed. In the 2010/2011 market year, Canada imported approximately 58.7% of the amount of corn they exported, and imported more corn than they exported in the prior three years (USDA-FAS, 2012). Canada is not a major corn export competitor of the U.S.; in the 2010/2011 market year, Canadian corn exports equated to only about 3.7% of the U.S. corn exports that year (USDA-FAS, 2012).

Preferred Alternative: Trade Economic Environment

Maize Line HCEM485 is compositionally and agronomically similar to the antecedent GA21, its comparators and other nonregulated glyphosate-resistant corn (Stine, 2011; USDA-APHIS, 2011b). As such, it is not expected to affect the seed, feed, or food trade any differently than other nonregulated glyphosate-resistant corn varieties (see Subsections 4.7.1, Domestic Economic Environment). As another glyphosate-resistant corn cultivar, Maize Line HCEM485 is expected to replace other glyphosate-resistant cultivars to the extent growers find value. Approval of the extension request for a determination of nonregulated status of Maize Line HCEM485 would, therefore, not likely increase the U.S. supply of corn that may affect trade. As discussed above, other countries are increasing their production of herbicide-resistant corn, including glyphosate-resistant cultivars, and are becoming significant export competitors to U.S. corn trade. Because the U.S. and other countries already have access to other glyphosate-resistant corn cultivars, and Maize Line HCEM485 presents another option of glyphosate-resistant corn, its availability only to U.S. producers would not likely significantly impact the economic trade environment. As noted above, Stine has submitted applications to Canada for import clearance and production approval of Maize Line HCEM485 (Potter, 2011a, personal communication); however, Canada is not a major U.S. corn export competitor.

As discussed in Subsection 4.4.2, Plants Communities, the cultivation of Maize Line HCEM485 would not change the development of glyphosate-resistant weeds nor affect the BMPs to control glyphosate-resistant weeds any differently than other nonregulated glyphosate-resistant corn. These BMPs would not necessarily increase costs such that the competitiveness of U.S. corn and trade economic environment would be affected, as the increased costs may be offset by increased yields (Weirich et al., 2011).

As discussed under the No Action Alternative, global corn export markets respond to many factors, including consumer perception of GE crops and derived products. As another glyphosate-resistant corn cultivar, the availability of Maize Line HCEM485 for production in the U.S. would not likely affect foreign consumer perception of GE corn products or those global forces shaping the U.S. corn trade economic environment.

Impacts to the trade economic environment from an extension of a determination of nonregulated status to Maize Line HCEM485 would be similar to the No Action Alternative.

5 CUMULATIVE IMPACTS

5.1 Assumptions Used for Cumulative Impacts Analysis

Cumulative effects have been analyzed for each environmental issue assessed in Section 4, Environmental Consequences. The cumulative effects analysis is focused on the incremental impacts of the Preferred Alternative taken in consideration with related activities including past, present, and reasonably foreseeable future actions. Certain aspects of this product and its cultivation would be no different between the alternatives; those instances are described below. In this analysis, if there are no direct or indirect impacts identified for a resource area, then APHIS assumes there can be no cumulative impacts. Where it is not possible to quantify impacts, APHIS provides a qualitative assessment of potential cumulative impacts. APHIS considered the potential for Maize Line HCEM485 to extend the range of corn production and affect the conversion of land to agricultural purposes. Stine's studies demonstrate Maize Line HCEM485 is similar in its growth habit, agronomic properties, disease susceptibility, and composition to its antecedent GA21, its control group cultivars, other nonregulated varieties of glyphosate-resistant corn, and other GE and non-GE corn (Stine, 2011; USDA-APHIS, 2011b). As such, its cultural requirements would be no different than those of other corn or provided by the areas in which corn is currently cultivated. As presented in Subsection 2.1.1, Acreage and Area of Corn Production, the majority of corn cultivated in the U.S. is herbicide-resistant, most of which is glyphosate-resistant (Duke and Powles, 2009; USDA-ERS, 2011a). Nonregulated Maize Line HCEM485 could replace other commercially available glyphosate-resistant corn varieties without requiring cultivation of new, natural lands. As such, land use changes associated with extending a determination of nonregulated status to Maize Line HCEM485 are not expected to be any different than those associated with the cultivation of other corn cultivars. Accordingly, although the preferred alternative would allow for new plantings of Maize Line HCEM485 to occur anywhere in the U.S., APHIS will focus the analysis of cumulative impacts to the areas in the U.S. that currently support corn production.

Potential reasonably foreseeable cumulative effects are analyzed under the assumption that farmers have used in the past and would continue to use reasonable, commonly accepted BMPs for their chosen system and varieties during agricultural corn production. APHIS recognizes, however, that not all farmers will use such BMPs; thus, the cumulative impact analysis will also make the assumption that not all farmers would do so. Stine has indicated it is not necessary to change the use pattern of glyphosate on the glyphosate-resistant Maize Line HCEM485 variety; hence, APHIS will use current glyphosate labels as the basis for its potential past, present, and reasonably foreseeable impacts from the use of and exposure to glyphosate assessment. APHIS assumes growers of Maize Line HCEM485 will adhere to the EPA-registered uses and EPA-approved labels for all pesticides applied to this crop.

As part of the cumulative impacts analysis, APHIS will assume that Maize Line HCEM485 would likely be combined with commercially available herbicide- and insect-resistant varieties of corn as a reasonably foreseeable future action. Crop varieties that contain more than one GE trait, known as a "stacked" hybrid, are currently found in agricultural production and in the marketplace. Maize Line HCEM485 would likely be combined with non-GE and GE corn varieties through traditional breeding techniques (Potter, 2011b). Stacking of nonregulated GE crop varieties using traditional breeding techniques is common practice and is not regulated by APHIS. Stacking could involve combining Maize Line HCEM485 with other corn varieties having GE traits such as herbicide, insect, and/or drought resistance, which are no longer subject to the regulatory requirements of 7 CFR part 340 or the plant pest provisions of the Plant Protection Act. Such stacked varieties could provide growers with several options such as combining several herbicides with different modes of action for control of weeds.

5.2 Cumulative Effects

5.2.1 Past and Present Actions

In the preceding analysis, the potential impacts from an extension of a determination of nonregulated status to Maize Line HCEM485 were assessed. The agronomic characteristics evaluated for Maize Line HCEM485 encompassed the entire life cycle of the corn plant and included germination, seedling emergence, growth habit, vegetative vigor, days to pollen shed, days to maturity, and yield parameters. The compositional analysis included the major constituents (carbohydrates, protein, fat, and ash), minerals, vitamins, amino acids, fatty acids, secondary metabolites, antinutrients, phytosterols, and nutritional impact. Maize Line HCEM485 is agronomically and compositionally similar to its previously nonregulated antecedent GA21, as well as other GE and non-GE corn varieties (Stine, 2011; USDA-APHIS, 2011b). As a result, the potential impacts under the Preferred Alternative for all the resource areas analyzed would be the same as those described for the No Action Alternative.

The Preferred Alternative is not expected to directly cause a measurable change in agricultural acreage or area devoted to conventional or GE corn cultivation or corn grown for seed in the U.S. (see Subsections 4.2.1, Acreage and Area of Corn Production, and 4.2.3, Corn Seed Production). The majority of corn grown in the U.S. is GE and herbicide resistant (USDA-ERS, 2011a). Long-term projections show planted corn maintaining between approximately 90 and 92 million acres a year through 2020, about the same as the 92.3 million acres planted to corn in 2011 (USDA-NASS, 2011b; USDA-OCE, 2011). Because Maize Line HCEM485 is another glyphosate-resistant corn cultivar agronomically and compositionally similar to other commercially available glyphosate-resistant corn cultivars, and herbicide-resistant corn is currently approximately 72% of all planted corn and most U.S. corn is glyphosate-resistant, it is expected Maize Line HCEM485 would replace other similar cultivars without expanding the acreage or area of corn production. Additionally, no anticipated changes to the availability of GE and non-GE corn varieties on the market are anticipated.

Based upon recent trends, adding GE varieties to the market is not related to the ability of organic production systems to maintain their market share (see Subsection 4.2.4, Organic Corn Production). As described above, the majority of corn in 2011 was GE and herbicide resistant (USDA-ERS, 2011a). Since 1994, 27 GE corn events or lines have been determined by APHIS to be no longer subject to the regulatory requirements of 7 CFR part 340 or the plant pest provisions of the Plant Protection Act (USDA-APHIS, 2012). U.S. organic corn production acreage grew 83% from 32,650 acres in 1995 to 194,637 acres in 2008, and remained at about 0.2% of total U.S. corn acreage from 2005 to 2008 (USDA-ERS, 2010a). Availability of another GE glyphosate-resistant corn variety, such as Maize Line HCEM485 under the Preferred Alternative, is not expected to impact the organic production of corn any differently than other GE varieties currently being grown.

Extending a determination of nonregulated status to Maize Line HCEM485 is not expected to result in changes to current corn cropping practices. Studies conducted by Stine demonstrate that, in terms of agronomic characteristics and cultivation practices, Maize Line HCEM485 is similar to other corn varieties currently grown (Stine, 2011; USDA-APHIS, 2011b). Consequently, no changes to current corn cropping practices such as tillage, crop rotation, or agricultural inputs associated with the adoption of Maize Line HCEM485 are expected (see Subsection 4.2.2, Agronomic Practices).

Extending a determination of nonregulated status to Maize Line HCEM485 would have the same impacts to water, soil, air quality, and climate change as that of nonregulated glyphosate-resistant corn varieties presently available. Agronomic practices that have the potential to impact soil, water and air quality, and climate change such as tillage, agricultural inputs (fertilizers and pesticides), and irrigation would not change because Maize Line HCEM485 is agronomically similar to other glyphosate-resistant corn and other GE and non-GE corn. Other practices that benefit these resources, such as contouring, use of cover crops to limit the time soil is exposed to wind and rain, crop rotation, and windbreaks would also be the same. Because of its similarity to other nonregulated glyphosate-resistant corn and the fact that most cultivated corn in the U.S. is glyphosate resistant, adoption of Maize Line HCEM485 is expected to replace other similar cultivars without changing the acreage or area of corn production that could impact water, soil, air quality, and climate change.

The impacts of the Preferred Alternative to animal and plants communities, microorganisms, and biodiversity would be no different than that experienced under the No Action Alternative. Maize Line HCEM485 is both agronomically and compositionally similar to its antecedent GA21 and other nonregulated glyphosate-resistant corn; thus, it would not require any different agronomic practices to cultivate, and does not represent a safety or increased weediness risk any differently than other currently available glyphosate-resistant corn. Availability of Maize Line HCEM485 would not impact the development of glyphosate-resistant weeds or the trend to broaden weed management tactics to affect control over herbicide-resistant weeds, as it is expected to replace other glyphosate-resistant cultivars without expanding the acreage or area of corn production or changing the application rates of glyphosate.

The potential impacts from the use of herbicides under the Preferred Alternative would be the same as those of the No Action Alternative. The methods of application and use rate for herbicides to be applied to Maize Line HCEM485 would not change from those already approved for use on other nonregulated glyphosate-resistant corn cultivars. The total amount of the mix of herbicides that could be applied to Maize Line HCEM485 would be limited by the authorized EPA-registered uses and the total application amount allowed by law. Glyphosate and other pesticides are registered by the EPA under FIFRA and are reviewed and reregistered every 15 years to assess potential toxicity and environmental impact. In order to be registered for use, a pesticide must be able to be used without unreasonable risks to people or the environment. Pesticide residue tolerances for glyphosate and other herbicides and pesticides are listed in 40 CFR §180.364 and include acceptable concentrations for corn grain and forage. In addition, the safety precautions and EPA-labeled instructions for the application of pesticides would not change under the Preferred Alternative, ensuring continued human health and worker safety.

There are no differences in the potential for gene flow and weediness under the Preferred Action Alternative. Only limited populations of sexually compatible relatives of domesticated corn are found within the U.S.; hence, there is not a significant risk of gene movement between corn and its wild or weedy maize relatives (US-EPA, 2011b). Additionally, corn seed does not possess the characteristics for efficient seed-mediated gene flow, does not establish wild or feral populations, and is dependent on human cultivation for survival (OECD, 2003; Doebley, 2004). Maize Line HCEM485 is similar to other glyphosate-resistant corn varieties. The risk of gene flow and weediness of Maize Line HCEM485 is no greater than that of other nonregulated glyphosate-resistant corn varieties.

Food and feed derived from GE corn must be in compliance with all applicable legal and regulatory requirements and may undergo a voluntary consultation process with the FDA prior to release onto the market to identify and discuss relevant safety, nutritional, or other regulatory issues regarding the bioengineered food. Maize Line HCEM485 is expected to have no toxic effect to human health or livestock. Stine submitted a safety and nutritional assessment of food and feed derived from Maize Line HCEM485 to the FDA in December 2010 and their decision is pending. It will be posted on the FDA website Final Biotechnology Consultations http://www.fda.gov/Food /Biotechnology/Submissions/ucm225108.htm when completed. A food safety evaluation of the EPSPS protein for the GA21 corn variety was completed by the FDA (BNF No. 000051) on February 10, 1998, which found no safety concerns (US-FDA, 1998a). In addition, the potential environmental impacts from the cultivation of glyphosate-resistant corn varieties have been thoroughly evaluated by APHIS (see http://www.aphis.usda.gov/biotechnology /not_reg.html). APHIS has determined there would be no significant risk to biological resources from the presence of the EPSPS protein that confers glyphosate resistance in Maize Line HCEM485, which is the same protein found in nonregulated glyphosate-resistant corn cultivars in commerce today. No change in food and feed safety is expected to occur under the Preferred Alternative.

SinceMaize Line HCEM485 is glyphosate-resistant, it would directly compete with the market share of other glyphosate-resistant corn varieties. Based on its similarity to other nonregulated corn cultivars, Maize Line HCEM485 would likely replace other glyphosate-resistant corn cultivars without impacting corn acreage or production area that may affect domestic markets. Additionally, since Maize Line HCEM485 is agronomically and compositionally similar to other commercially available corn, there would be no changes to agronomic inputs or practices that may impact on-farm costs for corn producers or the domestic economic environment, including the organic corn market. As mentioned above, Maize Line HCEM485 would not likely impact the development or treatment of herbicide-resistant weeds or their associated costs in crop losses or methods to affect control. No changes to the domestic economic environment are expected to occur under the Preferred Alternative.

Similarly, Maize Line HCEM485 is not expected to affect the seed, feed, or food trade any differently than other nonregulated glyphosate-resistant corn varieties. Other countries already have access to and are increasing their production of glyphosate-resistant corn varieties and are becoming significant export competitors to U.S. corn trade. Maize Line HCEM485 is compositionally and agronomically similar to other glyphosate-resistant cultivars in the marketplace. In summary, the potential cumulative effects regarding past and present actions combined with the Preferred Alternative have been analyzed, and no changes from the current baseline under the No Action Alternative would occur.

5.2.2 Reasonably Foreseeable Actions

If a determination of nonregulated status is extended to Maize Line HCEM485, the cultivar would likely be combined (stacked) with non-GE and GE corn varieties using traditional breeding techniques. Stacking of nonregulated GE crop varieties using traditional breeding techniques is common practice. As of 2011, corn with only herbicide-resistant traits comprised 23% of the U.S. corn grown, but a greater proportion was stacked with both herbicide- and insect-resistant traits (49%) (USDA-ERS, 2011a).

Potential future stacking of Maize Line HCEM485 might include development of hybrids using other currently available nonregulated corn varieties expressing resistance to other herbicides, or resistance to select insect pests by stacking with one of the biopesticidal Bt genes. For example, a new cultivar combining glyphosate and glufosinate resistance with insect resistance is available for the 2012 planting season (Monsanto, 2011b; Monsanto, 2011a). APHIS regulations under 7 CFR part 340 do not provide for Agency oversight of stacked varieties combining GE varieties that are no longer regulated under 7 CFR 340 or the plant pest provisions of the Plant Protection Act, unless it can be positively shown that such stacked varieties are likely to pose a plant pest risk. Whether Maize Line HCEM485 would be stacked with any particular nonregulated GE or non-GE variety is unknown, as company plans and market demands play a significant role in those business decisions. In addition, the adoption level of Maize Line HCEM485 would depend on the extent producers value the traits offered by stacked versions of Maize Line HCEM485 over other available stacked corn varieties.

The potential future development and cultivation of Maize Line HCEM485 glyphosate-resistant corn stacked with other herbicide-resistant, insect-resistant, and/or other GE traits is not likely to change the area or acreage of corn production. Despite the availability of these cultivars, corn production acreage is expected to remain relatively stable until 2020 (USDA-OCE, 2011).

If Maize Line HCEM485 is stacked with other transgenic herbicide-resistant traits, depending on the extent of its adoption, it may contribute to sustaining conservation tillage in U.S. corn production that both directly and indirectly impacts water, soil, and air quality. Stacking Maize Line HCEM485 with other herbicide-resistant traits would enable use of a combination of different herbicide modes of action to be applied to corn, an approach recommended by Dill et al. (2008) to preserve the utility of glyphosate resistance technology. This approach has been proposed to mitigate the future development of herbicide-resistant weeds (Duke and Powles, 2009), which may reduce the need for tillage for weed management (Owen, 2011), thus, benefiting soil, water, and air quality. This could also reduce GHG emissions from soil and emissions from associated fuel-burning equipment that can contribute to climate change. Reduced tillage improves habitat value through increased water quality, availability of waste grain, retention of cover in fields, and increased populations of invertebrates (Brady, 2007; Sharpe, 2010). Similarly, stacking multiple herbicide resistance into a single cultivar may sustain conservation tillage rates that promote greater plant diversity in fields while retaining crop yields which subsequently would improve soil quality and reduce soil erosion, sustaining both crop and non-crop plants.

Similar to other stacked varities of herbicide resistant corn, Maize Line HCEM485 stacked with other herbicide-resistant traits would, however, narrow the options for herbicidal management of volunteer corn. In crop rotations where soybean or some other broadleaf cultivar is rotated with corn, an approved grass herbicide could be used to control volunteer corn (Sandell et al., 2011). In continuous corn cropping systems with the same herbicide resistances, control becomes more complicated and must be accomplished through other means such as tillage (Sandell et al., 2011). Loux et al. (2011) recommend careful rotation planning to eliminate this potential problem. Maize Line HCEM485 stacked with insect-resistant traits would be no more likely to exhibit increased weediness characteristics than other currently available glyphosate- and insect-resistant stacked transgenic corn cultivars. Similarly, stacked Maize Line HCEM485 is not expected to exhibit any gene flow characteristics different from the parent transformation events (i.e., crop lines) that would pose a plant pest risk.

The total amount of the mix of pesticides that may be applied to stacked varieties of Maize Line HCEM485 would be limited by the total application amount authorized by law, and would be no different than the application rate already approved for use on other stacked glyphosate-resistant corn cultivars. When used consistently with the label, the potential risks from the application of pesticides to stacked Maize Line HCEM485 varieties to physical and biological resources, as well as human health and safety, would not increase. In addition, there would be no changes to currently authorized pesticide tolerance levels for stacked varieties of Maize Line HCEM485.

Maize Line HCEM485 would likely be stacked with insect-resistant corn varieties that express the Bt endotoxin. In accordance with 40 CFR part 174, all the currently nonregulated insect-resistant corn varieties that contain the Bt endotoxin are exempt from the requirement of tolerance in feed commodities. Based on studies undertaken to assess the potential impacts of the Bt endotoxin to the monarch and other non-target butterflies, as well as factors such as the location of corn production and the characteristics of corn pollen, the EPA determined that the potential risk to non-target butterflies is low (US-EPA, 2002). Maize Line HCEM485 stacked with insect-resistant (Bt) traits would likely replace other currently nonregulated stacked transgenic corn varieties with herbicide and insect resistance. The adoption of stacked Maize Line HCEM485 would be contingent on the extent growers see value in the traits expressed in comparison to other commercially available corn cultivars with similar herbicide- and insect-resistant traits.

No cumulative impacts on biological resources, human health, or animal feed are anticipated from the stacking of Maize Line HCEM485 with additional GE traits. Food and feed derived from GE corn must be in compliance with all applicable legal and regulatory requirements and may undergo a voluntary consultation process with the FDA prior to release onto the market. All varieties of GE corn with which Maize Line HCEM485 may be stacked with would have undergone, or are expected to undergo, this process to ensure their safety as food and feed products.

Corn varieties with single and multiple herbicide resistance or insect resistance are already widely available, representing almost 72% of U.S. corn acreage in 2011. While the adoption of herbicide-resistant-only corn has remained relatively level and the production of insect-resistant-only corn has decreased since 2007, the adoption of stacked varieties that confer resistance to herbicides and insects has steadily increased from 1% of planted corn acres in 2000 to 49% in

2011 (USDA-ERS, 2011a). As such, it is expected that Maize Line HCEM485 corn would likely be stacked with insect-resistant traits and would have impacts similar to other such stacked corn cultivars already on the market. Agronomic practices, including inputs for production of Maize Line HCEM485 stacked with insect resistance, would be no different than those needed to cultivate other commercially available corn with the same resistances; thus, changes to on-farm costs for corn producers or to the U.S. domestic corn market would be unlikely. Maize Line HCEM485 may also be stacked with other nonregulated GE traits; however, predicting these potential combinations would be speculative. Overall, it is unlikely that any cumulative impact to the domestic economic environment would result from a stacked product consisting of Maize Line HCEM485 and other readily-available GE traits.

U.S. corn exports have remained relatively stable over the last decade, a period in which other corn varieties with stacked glyphosate and other traits have been brought to market. Global export markets respond to many factors and are unlikely to change with the commercial availability of another glyphosate-resistant corn cultivar such as Maize Line HCEM485 alone, or stacked with other currently available traits.

In summary, the potential for impacts as a result of Maize Line HCEM485 alone or stacked with other nonregulated GE or non-GE corn varieties would not result in any changes to the resources areas when compared to the No Action Alternative. No cumulative effects are expected from an extension of a determination of nonregulated status to Maize Line HCEM485, when taken in consideration with related activities, including past, present, and reasonably foreseeable future actions.

6 THREATENED AND ENDANGERED SPECIES

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 and 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 the USFWS and/or NMFS determined it 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.

In accordance with the ESA, 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 a Federal agency, in consultation with the USFWS or NMFS, ensures that any action the agency authorizes, funds, or carries out is not likely to jeopardize the continued existence of a listed species or result in the destruction or adverse modification of designated critical habitat. It is the responsibility of the Federal agency taking the action to assess the effects of the agency's action and to consult with the USFWS or NMFS if it is determined that the action "may affect" listed species or critical habitat. To facilitate APHIS' ESA consultation process, the agency 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 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' regulatory authority over GE organisms under the Plant Protection Act is limited to those GE organisms for which it has reason to believe might be a plant pest or those for which APHIS does not have sufficient information to determine that the GE organism is unlikely to pose a plant pest risk (Title 7, part 340.1 of the CFR). APHIS does not have authority to regulate the use of any herbicide, including glyphosate. After completing a plant pest risk analysis, if APHIS determines that Maize Line HCEM485 does not pose a plant pest risk, then Maize Line HCEM485 would no longer be subject to the plant pest provisions of the Plant Protection Act or to the regulatory requirements of 7 CFR part 340 and, therefore, APHIS must approve the extension request for a determination of nonregulated status. As part of its EA analysis, APHIS is analyzing the potential effects of Maize Line HCEM485 on the environment, including any potential effects to threatened and endangered species (TES) and critical habitat. As part of this process, APHIS thoroughly reviews GE product information and data related to the organism (generally a plant species, but may also be other GE organisms). For each transgene(s)/transgenic plant, APHIS considers the following information, data, and questions:

- A review of the biology, taxonomy, and weediness potential of the crop plant and its sexually compatible relatives;
- Characterization of each transgene with respect to its structure and function and the nature of the organism from which it was obtained;
- A determination of where the new transgene and its products (if any) are produced in the plant and their quantity;
- A review of the agronomic performance of the plant including disease and pest susceptibilities, weediness potential, and agronomic and environmental impact;
- Determination of the concentrations of known plant toxicants (if any are known in the plant); and
- Analysis to determine if the transgenic plant is sexually compatible with any TES or a host of any TES.
- Any other information that may inform the potential for an organism to pose a plant pest risk.

In following this review process, APHIS has evaluated the potential effects that approving an extension request for a determination of nonregulated status to Maize Line HCEM485 would have on federally-listed TES, proposed species, critical habitat, and proposed critical habitat occurring within the 49 corn-producing U.S. states and Puerto Rico. APHIS has reviewed USFWS-listed and proposed TES species for each state in which corn is commercially produced using the Environmental Conservation Online System (ECOS) (Accessed May 17, 2012 from http://ecos.fws.gov/tess_public). Appendix A lists TES found in 49 corn-producing U.S. states and Puerto Rico. Prior to this review, APHIS considered the potential for Maize Line HCEM485 to extend the range of corn production and affect the conversion of land to agricultural purposes. Stine's studies demonstrate Maize Line HCEM485 is similar in its growth habit, agronomic properties, disease susceptibility, and composition to its antecedent GA21, its control group cultivars, other nonregulated varieties of glyphosate-resistant corn, and other GE and non-GE corn (Stine, 2011; USDA-APHIS, 2011b). As such, its cultural requirements would be no different than those of other corn or provided by the areas in which corn is currently cultivated. As presented in Subsection 2.1.1, Acreage and Area of Corn Production, the majority of corn cultivated in the U.S. is herbicide-resistant, most of which is glyphosate-resistant (Duke and Powles, 2009; USDA-ERS, 2011a). Nonregulated Maize Line HCEM485 could replace other commercially available glyphosate-resistant corn varieties without requiring cultivation of new, natural lands. As such, land use changes that could decrease TES habitat from an extension of a determination of nonregulated status to Maize Line HCEM485 are not expected to be any different than those associated with the cultivation of other corn cultivars. Accordingly, this analysis focuses on potential TES impacts where corn is currently grown.

6.1 Potential Effects of Maize Line HCEM485 on TES

This section considers the potential effects of the interaction of TES and Maize Line HCEM485, including: (1) its potential as a host for TES species; (2) potential gene flow to TES; (3) consumption effects of Maize Line HCEM485 seeds and vegetation; and, (4) potential non-target impacts to TES, their habitat, and critical habitat from glyphosate use associated with the production of Maize Line HCEM485.

A review of the listed and proposed TES indicates no members of the corn genus *Zea* serve as a host plant for any Federally-protected species. There are also no listed or proposed TES plant species that are sexually compatible or could cross-pollinate with the *Zea* genus in the U.S. As discussed above in the analysis of gene flow and weediness, commercially grown corn varieties in the U.S. are not considered weeds because corn does not possess characteristics to easily disperse and survive without human intervention (OECD, 2003). As presented in Subsections 4.4.2, Plants Communities, and 4.4.3, Gene Flow and Weediness, the potential for gene flow between Maize Line HCEM485 and sexually compatible wild teosinte relatives is low. While corn and various teosinte species are culturally and biologically similar, and gene exchange between these groups has been documented at low frequencies in Mexico, there has been no evidence of successful weedy species developing (US-EPA, 2011b). Based on the agronomic studies conducted by Stine and verified by APHIS, extending determination of nonregulated status to Maize Line HCEM485 does not present a plant pest risk, a risk of increased potential for weediness, nor an increased risk of gene flow, when compared to other currently cultivated corn varieties (USDA-APHIS, 2011b).

Stine has presented information on the animal feed safety characteristics of Maize Line HCEM485 that could impact wildlife that may use cornfields as a food source, consuming the plant or insects that live on the plants. Few TES are likely to use cornfields because they do not provide suitable habitat; however, some species may visit agricultural fields for incidental feeding. Midwestern TES species that occasionally feed in farmed sites include: whooping crane (*Grus americana*), sandhill crane (*Grus canadensis pulla*), piping plover (*Charadrius melodus*), and interior least tern (*Sterna antillarum*) (USFWS, 2011a). These and other bird species may visit cornfields during migratory periods, but would not be present during normal farming operations (Krapu et al., 2004; USFWS, 2011a). 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 Delmarva fox squirrel feeds primarily on acorns, nuts, and pine seeds, but also utilizes corn in adjacent agricultural fields (USFWS, 2011b). The Louisiana black bear (*Ursus americanus luteolus*), occurring in Louisiana, Mississippi, and Texas (USFWS, 2011c), may occasionally forage on corn (Mississippi State University, No Date).

Maize Line HCEM485 presents minimal risk to TES consuming this crop. As discussed in Subsection 4.6, Animal Feed, there is no difference in the composition and nutritional quality of Maize Line HCEM485 compared with conventional corn (Stine, 2011); no expected hazards are associated with its consumption. The FDA has previously evaluated the safety of GE corn cultivars containing the EPSPS protein, which included toxicity and allergenicity assessments, finding no safety concern (US-FDA, 1998a). Pending results of the final biotechnology consultation with the FDA, effects on TES consuming Maize Line HCEM485 would be unlikely, regardless of exposure.

After reviewing the possible effects of allowing the unregulated environmental release of Maize Line HCEM485, 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 extending a determination of nonregulated status to Maize Line HCEM485 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, 2011b). Corn is not sexually compatible with, or serves as a host species for, any listed species or species proposed for listing. Consumption of Maize Line HCEM485 by any listed species or species proposed for listing would not result in a toxic or allergic reaction. Based on these factors, APHIS has concluded that extending a determination of nonregulated status to Maize Line HCEM485 and the corresponding environmental release of this corn variety would 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.

6.2 Potential Effects of the Use of Glyphosate

APHIS met with USFWS officials on June 15, 2011 to discuss whether APHIS has any obligations under the ESA regarding analyzing the impacts of herbicide use associated with all GE crops on TES. As a result of these joint discussions, the USFWS and APHIS have agreed that it is not necessary for APHIS to perform an ESA effects analysis on herbicide use associated either with Maize Line HCEM485 or with all GE crops currently planted because the EPA has both complete 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 glyphosate, or any other herbicide, by corn growers. Under Part 340 regulations, APHIS only has authority to regulate Maize Line HCEM485 or any GE organism as long as the agency believes it may pose a plant pest risk. APHIS has no regulatory jurisdiction over any other risks associated with GE organisms including risks resulting from the use of herbicides or other pesticides on those organisms. Nevertheless, APHIS is aware that there may be potential environmental impacts resulting from the use of glyphosate on Maize Line HCEM485, including potential impacts on TES and critical habitat, based on assessments provided by the EPA, and in peer reviewed scientific literature. APHIS is providing the available information of potential environmental impacts resulting from glyphosate use on Maize Line HCEM485 below.

6.2.1 EPA Endangered Species Protection Program (ESPP)

On October 7, 1988, Congress enacted Public Law 100-478 to in part address the relationship between the ESA and EPA's pesticide labeling program (Section 1010) by requiring EPA to conduct a study, and report to Congress, on ways to implement EPA's endangered species pesticide labeling program in a manner that both complies with the ESA and allows people to continue production of agricultural food and fiber. This law provided a clear sense that Congress wanted EPA to fulfill its obligation to conserve listed species, while at the same time consider the needs of agriculture and other pesticide users (70 FR 66392).

In 1988, EPA established the ESPP to meet its obligations under the ESA. The EPA's Endangered Species Protection Program website (http://www.epa.gov/espp/) describes the EPA assessment process for endangered species. Some of the elements of that process are summarized below. The goal of EPA's ESPP is to carry out its responsibilities under FIFRA in compliance with the ESA without placing unnecessary burden on agriculture and other pesticide users consistent with Congress's intent. EPA is responsible for reviewing pesticide information and data to determine whether a pesticide product may be registered for a particular use, including those uses associated with the approval of biotechnology products. As part of that determination, the Agency assesses whether listed endangered or threatened species or their designated critical habitat may be affected by use of the pesticide product. All pesticide products that EPA determines "may affect" a listed species or its designated critical habitat may be subject to the ESPP. If limitations on pesticide use are necessary to protect listed species in areas where a pesticide may be used, the information is related through Endangered Species Protection Bulletins. Bulletins identify the species of concern and the pesticide active ingredient that may affect the listed species. They also provide a description of the protection measures necessary to protect the species, and contain a county-level map showing the geographic area(s) associated with the protection measures, depending on the susceptibility of the species. Bulletins are enforceable as part of the product label (http://www.epa.gov/oppfead1/endanger/basic-info.htm).

6.2.2 EPA TES Evaluation Process

The EPA evaluates listed species and their critical habitat concerns within the context of pesticide registration and registration review so that when a decision is made, it fully addresses issues relative to listed species protection. If a risk assessment determines that use limitations are necessary to ensure that legal use of a pesticide will not harm listed species or their critical habitat, EPA may either change the terms of the pesticide registration or establish geographically specific pesticide use limitations (http://www.epa.gov/oppfead1/endanger/basic-info.htm).

The EPA's review of the pesticide and its registration decision is independent of APHIS' review and regulatory decisions under 7 CFR part 340. EPA does not require data or analyses conducted by APHIS to complete its reviews. The EPA evaluates extensive toxicity, ecological effects data, environmental fate, and transport and behavior data, most of which is required under FIFRA data requirements, to assess and determine how a pesticide will move through and break down in the environment. Risks to various taxa, e.g., birds, fish, invertebrates, plants and mammals are routinely assessed and used in EPA's determinations of whether a pesticide may be licensed for use in the U.S.

The EPA's core pesticide risk assessment and regulatory processes ensure that protections are in place for all populations of non-target species, not just TES. The EPA has developed a comprehensive risk assessment process modeled after, and consistent with, EPA's numerous guidelines for environmental assessments (http://www.epa.gov/oppfead1/endanger/consultation/ecorisk-overview.pdf). The result of an assessment, which may go through several refinements, is to determine whether the potential effects of a pesticide's registration to a listed species will result in either a "no effect" or "may affect" determination. The EPA consults on determinations that "may affect" a listed species or adversely modify its critical habitat (http://www.epa.gov/oppfead1/endanger). As a result of either an assessment or consultation, EPA may require changes to the use conditions specified on the label of the product. When such changes are necessary only in specific geographic areas rather than nationwide to ensure protection of the listed species, EPA implements these changes through geographically-specific Endangered Species Protection Bulletins; otherwise, these changes are applied to the label for all uses of the pesticide.

6.2.3 Ecological Risks of Glyphosate

The ecological risks associated with use of glyphosate as an herbicide have been assessed several times since 1974 when it was first registered for use in the U.S. In addition, EPA has consulted with the USFWS on the effects of glyphosate on listed species and critical habitat. Findings from relevant ecological risk assessments and the results and status of consultations are summarized below.

In the June 1986 Registration Standard for glyphosate, the EPA discussed consultations with the USFWS on hazards to crops, rangeland, silvicultural sites, and the Houston toad which may result from the use of glyphosate. Because a jeopardy opinion resulted from these consultations, the agency imposed endangered species labeling requirements in the Registration Standard to mitigate the risk to endangered species.

In 1993, glyphosate was assessed by the EPA for the RED (US-EPA, 1993b). The RED concluded that direct risks to birds, mammals, invertebrates, and fish would be minimal. Under certain conditions, aquatic plants were expected to be at risk from glyphosate use. Additional data were needed for non-target terrestrial plants, including incident data and vegetative vigor testing on non-target terrestrial plants. The assessment stated that many endangered plants may be at risk from use of glyphosate with the registered use patterns. In addition, it was determined that the Houston toad may be at risk from use of glyphosate on alfalfa. The RED resulted in label changes to provide protection of aquatic organisms.

In 2003, the USDA's Forest Service had a risk assessment conducted for glyphosate uses in Forest Service vegetation management programs (USDA-FS, 2003). For forestry uses, all commercial formulations of glyphosate contained the isopropylamine salt of glyphosate. Application rates ranged from 0.5 pounds acid equivalent per acre (lb ae/Ac) to 7 lb ae/Ac with the most typical at 2 lb ae/Ac. Based on the available data, the USDA concluded that the risks were minimal to mammals, birds, fish, amphibians, invertebrates, and aquatic plants. Risks to fish following application of the more toxic formulations were not considered to be high; however, the assessment did state that at an application rate of 7 lb ae/Ac, the acute exposures slightly exceeded the acute LC_{50}[12] for a more tolerant freshwater fish and exceeded it by a factor of 2 for the less tolerant fish. These values were estimated from a worst-case scenario where there was a severe rainfall of about 7 inches over a 24-hour period in an area where runoff is favored. USDA did not conduct a separate assessment for amphibians. The document concluded the amphibian data indicated glyphosate is no more toxic to amphibians than it is to fish. For terrestrial plants, the assessment concluded that for relatively tolerant plants, when a low-boom spray is utilized as the method of application, there is no indication glyphosate would

[12] The concentration of a toxicant in the air or water that is lethal to 50% of the test organisms within a designated period. The lower the LC_{50} value, the more lethal the compound.

result in damage from spray drift at distances from the application site of 25 feet or greater. For more sensitive plants, the distance increased to approximately 100 feet. For applications requiring the use of backpack-directed spray, the distances would be less. No risks to terrestrial plants from runoff were expected.

In 2004, the EPA issued a report, "Glyphosate Analysis of Risks to Endangered and Threatened Salmon and Steelhead". The analysis included 11 Evolutionary Significant Units (ESU) - a population that is considered distinct for purposes of conservation - in California with one unit extending into southern Oregon. Much of the quantitative information presented and used was derived from the 1993 RED Ecological Risk Assessment. Testing was performed with formulated products, in addition to glyphosate alone, and included acute and chronic toxicity. Testing of the pure product indicate that pure glyphosate is practically non-toxic to the species examined. Glyphosate was moderately toxic to practically non-toxic in formulated products. Since this is somewhat increased over results with the pure chemical, the report concluded that it appears likely due to the added agents, generally surfactants. The EPA uses a variety of chemical fate and transport data to develop "estimated environmental concentrations" (EECs) from a suite of established models. The EECs were used with toxicity for the most sensitive species from technical grade testing of the active ingredient to develop acute risk quotients (RQs). The RQ analysis indicates that glyphosate applied at 5.062 pounds active ingredient per acre (lb ai/Ac) does not present an acute risk to endangered and threatened salmonids from direct effects because the calculated RQ is less than the level of concern (LOC). The primary indirect effect of concern would be for the food source for listed fish. The report concluded that this rate of application does not present indirect effects from loss of food or loss of cover, as the RQs for invertebrates and plants is less than the LOC. However, the assessment determined that use of glyphosate "may affect, but is not likely to adversely affect" the species based on acute toxicity to fish for uses with application rates above 5 lb ai/Ac. For uses with application rates below 5 lb ai/Ac, the Agency determined glyphosate would have no effect on the 11 ESUs.

In 2006, the EPA assessed glyphosate for a new use on bentgrass (US-EPA, 2006a) (0.74 lb ai/Ac) and for new uses on Indian mulberry (noni), dry peas, lentils, garbanzo (US-EPA, 2006b), safflower, and sunflower (US-EPA, 2006c), with the highest proposed ground application rate of 3.73 lb ae/Ac. For all proposed new uses, the EPA concluded that there was minimal risk of direct acute effects to terrestrial animals (birds and mammals) and aquatic animals (fish, amphibians, and invertebrates) and minimal risk to terrestrial plants (both non-target and endangered plant species), aquatic non-vascular (algae and diatoms) and vascular (duckweed) plants from off-target spray drift and runoff from ground-based applications. In addition, there were no chronic risks to animals.

In 2008, as a part of EPA's TES effects assessment for the California red-legged frog (CRLF), EPA evaluated the effect of glyphosate use at rates up to 7.95 lb ae/Ac on fish, amphibians, aquatic invertebrates, aquatic plants, birds, mammals, and terrestrial invertebrates (US-EPA, 2008b). This assessment determined that at the maximum application rate for in-crop applications of glyphosate to glyphosate-resistant corn (8 aerial applications of 0.75 lb ae/Ac and 2 ground applications of 3.75 and 2.25 lb ae/Ac), there would be no effects of glyphosate use on the following taxa of TES: fish, amphibians, birds, and mammals. The EPA assessment was uncertain of the effects on terrestrial invertebrates, citing the potential to affect small insects at all application rates and large insects at the 7.95 lb ae/Ac acre rate which is above the maximum rate for glyphosate-resistant corn.

In 2010, EPA issued the memorandum Assessment of Ecological Risk for Glyphosate, potassium salt (Pesticide Chemical Code 103613; Chemical Abstract Service Number (CAS#) 70901-12-1) for Label Supplement to Add Uses on Roundup Ready Sweet Corn. Because of the potential risk from surfactants, a conservative estimation of risk to aquatic organisms was conducted on a formulation basis as well as on a glyphosate acid equivalent basis. The names and CAS numbers of the surfactant are proprietary and are not provided in the assessment. Instead the surfactant POEA mixture (CAS # 61791-26-2) was used because it has been used in glyphosate products and is known to be considerably more toxic to aquatic organisms than technical glyphosate. The assessment was completed with the assumption that the proposed surfactants are similar to POEA. Based on the proposed labels, the maximum application rate on a glyphosate acid equivalent basis is 3.71 lb ae/Ac glyphosate and on a formulation basis is 9.35 lb formulation/Ac.

The risk to fish, aquatic phase amphibians, aquatic invertebrates, aquatic plants, birds, reptiles, terrestrial phase amphibians, mammals, terrestrial invertebrates, and terrestrial plants was analyzed. The assessment concluded that there was no risk to fish, aquatic phase amphibians, aquatic invertebrates, aquatic plants, and mammals because the RQs did not exceed the LOCs for any of these groups. Because of the lack of toxicity studies for reptiles and terrestrial phase amphibians, birds are used as a surrogate. None of the available acute and subacute avian studies showed mortality so RQs were not calculated for birds. All of the terrestrial EEC values are lower than the highest dose/concentration tested (3.71 lb ae/Ac glyphosate), but many of the EECs for 20-gram birds were greater than 1/10th of that dose. For 100-gram birds, several EECs were greater than 1/10th of the highest dose and with the 1.15 lb ae/Ac dose applied 4 times per season; therefore, there is uncertainty associated with the effect to listed birds, reptiles, and terrestrial phase amphibians. The chronic LOC for birds (LOC = 1) was exceeded for application to short grasses at the highest dose (3.71 lb ae/Ac glyphosate) (RQ = 1.07). However, because there were no effects at the highest concentrations in the bird studies and the RQ was only slightly greater than the LOC, the risk following chronic exposure is expected to be minimal. The assessment concluded that the risk to terrestrial invertebrates is negligible based on glyphosate's classification as practically non-toxic to honeybees. Lastly, for listed terrestrial plants, the RQ is lower than the LOC at the highest application rate when applied via ground applications, but are exceeded for listed and non-listed monocots and dicots when aerially applied at this 3.71 lb ae/Ac glyphosate rate.

The EPA is currently conducting a registration review for glyphosate (US-EPA, 2009b). EPA plans to conduct comprehensive human health and ecological risk assessments, including an endangered species assessment for uses and formulations of glyphosate, including risks due to surfactants included in formulations designated only for terrestrial applications. The EPA estimates completing the registration review in 2015. The ecological risk assessment planned during the registration review will allow EPA to determine whether glyphosate's use has "no effect" on or "may affect" federally listed TES or their designated critical habitat. When an assessment concludes that a pesticide's use "may affect" a listed species or its designated critical habitat, EPA will consult with the USFWS and/or NMFS, as appropriate, and may develop labels that restrict the pesticide's use or specify certain conditions, e.g., minimum separation distances between areas sprayed with glyphosate-based herbicides and habitats of TES.

6.2.4 Potential Impacts of Glyphosate Use in the Production of Corn

Under the Preferred Alternative, Stine does not propose any change in the currently permitted uses of glyphosate (Stine, 2011). As discussed in Subsection 4.2.1, Acreage and Area, Maize Line HCEM485 would not require new natural lands to be converted to agricultural use. Corn is widely produced throughout 49 states; in 2011, 72% of planted corn was herbicide-resistant. As described in Subsection 4.2.2, Agronomic Practices, Maize Line HCEM485 also does not have cultural requirements different from other glyphosate-resistant corn varieties that would change glyphosate application rates to corn. Of the 98% of planted corn that received herbicide applications in 19 survey states in 2010, 66% were treated with glyphosate (USDA-NASS, 2011c) (see Subsection 2.1.2, Agronomic Practices). As discussed in Subsection 4.2.2, Agronomic Practices, Maize Line HCEM485 is anticipated to replace other glyphosate-resistant corn cultivars and no change to the registered use of glyphosate is proposed; as such, no change to the use rate of glyphosate is expected as a result of extending Maize Line HCEM485 nonregulated status.

As discussed above, the goal of EPA's ESPP is to carry out its responsibilities under FIFRA in compliance with the ESA. As part of the registration and reregistration process, EPA reviews pesticide products to ensure they meet the requirements of FIFRA and ESA, and to assess whether listed endangered or threatened species or their designated critical habitat may be affected by use of the pesticide product. An assessment and subsequent consultation in which a "may affect" determination is made may require changes to the use conditions specified on the label of the product. States have primary authority for compliance monitoring and enforcing use of pesticides by the label requirements. Violators of the regulations are liable for all negative consequences of their actions (FIFRA 7 U.S.C. 136j (a)(2)(G) Unlawful Acts); therefore, growers that use glyphosate are very likely to follow its label restrictions.

In summary, glyphosate would likely continue to be a major component of weed management in corn production and no changes in agronomic practices are expected as a consequence of extending a nonregulated determination to Maize Line HCEM485. In addition, pesticide labels require precautions be taken to protect TES. For these reasons, glyphosate use resulting from a nonregulated determination for Maize Line HCEM485 does not present an increase in potential impacts to TES.

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

7.1.1 Executive Orders with Domestic Implications

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

- ***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. Neither alternative is expected to have a disproportionate adverse effect on minorities, low-income populations, or children.

Available mammalian toxicity data associated with the EPSPS protein establish the safety of Maize Line HCEM485 and its 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 Maize Line HCEM485.

Human toxicity has also been thoroughly evaluated by the EPA in its development of pesticide labels for glyphosate (US-EPA, 1993b; US-EPA, 2009b; US-EPA, 2009c). Pesticide labels include use precautions and restrictions intended to protect workers and their families from exposures. APHIS assumes that growers will adhere to herbicide use precautions and restrictions. As discussed in Subsection 4.5, Human Health, the potential use of glyphosate on Maize Line HCEM485 at the proposed application rates would be no more than that currently approved for other nonregulated glyphosate-resistant corn and found by the EPA not to have adverse impacts to human health when used in accordance with label instructions. It is expected that the EPA and ERS would monitor the use of Maize Line HCEM485 to determine impacts on agricultural practices, such as chemical use, as they have done previously for herbicide-resistant products.

Based on these factors, an extension of a determination of nonregulated status to Maize Line HCEM485 is not expected to have a disproportionate adverse effect on minorities, low-income populations, or children.

The following EO 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.

Field corn is not listed in the U.S. as a noxious weed species by the Federal government (USDA-NRCS, 2010b), nor is it listed as an invasive species by major invasive plant data bases (University of Georgia and USDOI-NPS, 2009; GRN, 2012). As discussed in Subsection 2.3.3, Gene Flow and Weediness, cultivated corn seed does not have the ability to survive in the wild and requires human involvement for seed dispersion (OECD, 2003). In addition, corn seed lacks dormancy, will not produce a persistent seed bank, and is large and heavy and not easily dispersed by wind or water (Mallory-Smith and Zapiola, 2008); therefore, the chance of corn becoming invasive as a result of seed dispersion is not likely. As discussed in Subsection 2.3.3, Gene Flow and Weediness, corn and various teosinte species are culturally and biologically similar, and gene exchange between these groups has been documented, no successful weedy species has evolved and the potential for gene flow between *Z. mays* and sexually compatible wild relatives is not considered a significant agricultural or environmental risk (US-EPA, 2011b). As such, the potential for a weedy species of corn to develop as a result of outcrossing with Maize Line HCEM485 is considered to be highly unlikely.

Volunteer corn can become extensive in crop fields, competing with desired crops for light, moisture, and nutrients (Wilson et al., No Date). There have been reports of some volunteer glyphosate-resistant corn occurring in fields, even if glyphosate-resistant corn was not planted the previous year, thought to be a result of transgene pollen movement (Beckie and Owen, 2007). While pollen mediated gene transfer can occur, as discussed in Subsection 2.3.3, Gene Flow and Weediness, gene flow decreases rapidly with separation distance. Recommended methods to control volunteer corn include using a combination of techniques such as alternating the glyphosate-resistant corn with non-GE crops, or with GE crop cultivars having resistance to herbicides with different modes of action, and then application of that herbicide post-emergence. For example, growers could plant LibertyLink® soybean and treat it with glufosinate (Beckie and Owen, 2007). Others successfully utilize graminicides to control glyphosate-resistant corn in crops not susceptible to the herbicide. See Subsection 2.3.2, Plants Communities, for a more extensive discussion on controlling volunteer corn. Non-GE corn, as well as other GE herbicide-resistant corn varieties, is widely grown in the U.S. Based on historical experience with these varieties, and the data submitted by the developer and reviewed by APHIS, Maize Line HCEM485 plants are similar in fitness characteristics to other corn varieties currently grown; hence, they are not expected to become weedy or invasive (USDA-APHIS, 2011b).

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 with the Fish and Wildlife Service that shall promote the conservation of migratory bird populations.

Migratory birds may be found in cornfields as corn is a nutrient-rich food source for fat synthesis prior to migration (Krapu et al., 2004). Several species of birds are also known to forage for insects and seeds found in and adjacent to cornfields (Best et al., 1990; Tremblay et al., 2001; Puckett et al., 2009). As discussed in Subsection 4.4.1, Animal Communities, data submitted by the developer indicates that levels of key nutrients, minerals, antinutrients, and secondary metabolites in Maize Line HCEM485 were similar to the comparators, by extension the antecedent GA21 variety, and other commercial corn varieties (Stine, 2011). The EPSPS protein that confers glyphosate resistance in GA21 (the antecedent of Maize Line HCEM485) is corn-derived, and 99.3% identical to its non-herbicide-resistant corn comparators (Monsanto, 1997). It has been previously evaluated by the FDA, (US-FDA, 1998a). According to the consultation note,

> "Monsanto has concluded that corn containing transformation event GA21 is not materially different in composition, nutrition, and safety from corn currently grown, processed, marketed, and consumed for animal feed or human food. At this time, based on Monsanto's description of its data and analyses, the Agency considers Monsanto's consultation on corn from varieties containing transformation event GA21 to be complete."

The environmental effects associated with glyphosate are summarized in the EPA RED for the herbicide (US-EPA, 1993b). Testing indicates that ecological toxicity of glyphosate is no more than slightly toxic to birds and does not exceed the agency's LOC (US-EPA, 1993b); however, in accordance with new requirements under 40 CFR part 158, acute avian oral toxicity data for a passerine species (perching birds) is required for the current glyphosate registration review. Based on these factors, it is unlikely that extending a determination of nonregulated status to Maize Line HCEM485 would have a negative effect on migratory bird populations.

7.1.2 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. if APHIS extends a determination of nonregulated status to Maize Line HCEM485. All existing national and international regulatory authorities and phytosanitary regimes that currently apply to introductions of new corn cultivars internationally apply equally to those covered by an APHIS determination of nonregulated status under 7 CFR part 340.

Any international trade of Maize Line HCEM485 subsequent to an extension of 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 Plant Risk Analysis (PRA) of LMOs was adopted at a meeting of the governing body of the IPPC as a supplement to an existing standard, International Standard for Phytosanitary Measure 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 genetically engineered 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 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 (AIA) 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 (FFP) are exempt from the AIA 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 FFP 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 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, 2003).

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.

7.1.3 Compliance with Clean Water Act and Clean Air Act

This EA evaluated the potential changes in corn production associated with an extension of a determination of nonregulated status to Maize Line HCEM485 (see Subsections 4.2.1, Acreage and Area, and 4.2.2, Agricultural Production of Corn) and determined that the cultivation of Maize Line HCEM485 would not lead to the increase in, or expand the area of, corn production that could impact water resources or air quality any differently than currently cultivated corn varieties. The herbicide resistance conferred by the genetic modification to Maize Line HCEM485 is not expected to result in any changes in water usage for cultivation compared to current corn production. As discussed in Subsections 4.3.2, Water Resources, and 4.3.3, Air Quality, there are no expected significant negative impacts to water resources or air quality from potential use of glyphosate or other pesticides associated with Maize Line HCEM485 production. Based on these analyses, APHIS concludes that an extension of a determination of nonregulated status to Maize Line HCEM485 would comply with the CWA and the CAA.

7.1.4 Impacts on Unique Characteristics of Geographic Areas

Extension of a determination of nonregulated status to Maize Line HCEM485 is not expected to impact unique characteristics of geographic areas such as parklands, prime farmlands, wetlands, wild and scenic areas, or ecologically critical areas.

Stine has presented results of agronomic field trials for Maize Line HCEM485 that demonstrate there are no differences in agronomic practices, between Maize Line HCEM485 and currently available glyphosate-resistant corn varieties like GA21 (Stine, 2011; USDA-APHIS, 2011b). The common agricultural practices that would be carried out in the cultivation of Maize Line HCEM485 are not expected to deviate from current practices, including the use of EPA-registered pesticides. The product is expected to be cultivated by growers on agricultural land currently suitable for production of corn, and is not anticipated to expand the cultivation of corn to new, natural areas.

The Preferred Alternative does not propose major ground disturbances or new physical destruction or damage to property, or any alterations of property, wildlife habitat, or landscapes; moreover, no prescribed sale, lease, or transfer of ownership of any property is proposed. This action is limited to an extension of a determination of nonregulated status to Maize Line HCEM485. 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 Maize Line HCEM485, including the use of EPA-registered pesticides. The Applicant's adherence to EPA label use restrictions for all pesticides is expected to mitigate potential impacts to the human environment.

With regard to pesticide use, an extension of a determination of nonregulated status to Maize Line HCEM485 is not likely to result in changes to the use of glyphosate on corn, including application timing and rates and annual maximum allowable applications. APHIS assumes that the grower will closely adhere to EPA label use restrictions for glyphosate.

Glyphosate was assessed by the EPA in 1993 and is currently under reregistration review scheduled for completion in 2015 (US-EPA, 2009a). Potential impacts to unique geographic areas have been considered by the EPA in its evaluation of glyphosate. In 1993, the EPA completed a reregistration analysis for glyphosate which considered human health risk and ecological risks associated with potential exposure to glyphosate in multiple pathways (US-EPA, 1993b).

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 CRLF is underway (US-EPA, 2009b). 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, 2009b). The EPA's formal consultation request for the CRLF 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 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 in regards to the potential effects of various pesticides usage 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.

The Agency plans to conduct a comprehensive ecological risk assessment, including an endangered species assessment, for all uses of glyphosate and its salts (US-EPA, 2009b). 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; and
- 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, an extension of a determination of nonregulated status to Maize Line HCEM485 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.

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

The National Historic Preservation Act (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 and 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.

APHIS' proposed action, an extension of a determination of nonregulated status to Maize Line HCEM485 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.

APHIS' Preferred Alternative would have no impact on 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 an extension of a determination of nonregulated status to Maize Line HCEM485.

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. Additionally, these cultivation practices are already being conducted throughout the corn production regions. The cultivation of Maize Line HCEM485 is not expected to change any of these agronomic practices that would result in an adverse impact under the NHPA.

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APPENDIX A
FEDERALLY THREATENED AND ENDANGERED SPECIES IN CORN PRODUCTION U.S. STATES AND PUERTO RICO

Federally Threatened, Endangered, and Proposed Species in Corn Production U.S. States and Puerto Rico (USFWS, 2013)

Common Name	Scientific Name	Current Distribution	Vertebrate (V) Invertebrate (I) Plant (P)	Listing Status
\`Ahinahina	*Argyroxiphium sandwicense ssp. macrocephalum*	HI	P	Threatened
\`Ahinahina	*Argyroxiphium sandwicense ssp. sandwicense*	HI	P	Endangered
\`Aiakeakua, popolo	*Solanum sandwicense*	HI	P	Endangered
\`Aiea	*Nothocestrum breviflorum*	HI	P	Endangered
\`Aiea	*Nothocestrum peltatum*	HI	P	Endangered
\`Akoko	*Chamaesyce celastroides var. kaenana*	HI	P	Endangered
\`Akoko	*Chamaesyce deppeana*	HI	P	Endangered
\`Akoko	*Chamaesyce eleanoriae*	HI	P	Endangered
\`Akoko	*Chamaesyce herbstii*	HI	P	Endangered
\`Akoko	*Chamaesyce kuwaleana*	HI	P	Endangered
\`Akoko	*Chamaesyce remyi var. kauaiensis*	HI	P	Endangered
\`Akoko	*Chamaesyce remyi var. remyi*	HI	P	Endangered
\`Akoko	*Chamaesyce rockii*	HI	P	Endangered
\`Akoko	*Euphorbia haeleeleana*	HI	P	Endangered
\`Anaunau	*Lepidium arbuscula*	HI	P	Endangered
\`Anunu	*Sicyos alba*	HI	P	Endangered
\`Awikiwiki	*Canavalia molokaiensis*	HI	P	Endangered
\`Awikiwiki	*Canavalia napaliensis*	HI	P	Endangered
\`Awikiwiki	*Canavalia pubescens*	HI	P	PE
\`O\`u (honeycreeper)	*Psittirostra psittacea*	HI	V	Endangered
\`Oha wai	*Clermontia drepanomorpha*	HI	P	Endangered
\`Oha wai	*Clermontia lindseyana*	HI	P	Endangered
\`Oha wai	*Clermontia oblongifolia ssp. brevipes*	HI	P	Endangered
\`Oha wai	*Clermontia oblongifolia ssp. mauiensis*	HI	P	Endangered
\`Oha wai	*Clermontia peleana*	HI	P	Endangered
\`Oha wai	*Clermontia pyrularia*	HI	P	Endangered
\`Oha wai	*Clermontia samuelii*	HI	P	Endangered
\`Ohe\`ohe	*Tetraplasandra gymnocarpa*	HI	P	Endangered

Common Name	Scientific Name	Current Distribution	Vertebrate (V) Invertebrate (I) Plant (P)	Listing Status
A`e	*Zanthoxylum dipetalum var. tomentosum*	HI	P	Endangered
A`e	*Zanthoxylum hawaiiense*	HI	P	Endangered
A`e	*Zanthoxylum oahuense*	HI	P	Proposed Endangered
Akekee	*Loxops caeruleirostris*	HI	V	Endangered
Akiapola`au (honeycreeper)	*Hemignathus munroi*	HI	V	Endangered
Akikiki	*Oreomystis bairdi*	HI	V	Endangered
aku	*Cyanea tritomantha*	HI	P	
Ala `ala wai nui	*Peperomia subpetiolata*	HI	P	PE
Alabama (=inflated) heelsplitter	*Potamilus inflatus*	AL, LA, MS	I	Threatened
Alabama beach mouse	*Peromyscus polionotus ammobates*	AL	V	Endangered
Alabama canebrake pitcher-plant	*Sarracenia rubra alabamensis*	AL	P	Endangered
Alabama cave shrimp	*Palaemonias alabamae*	AL	I	Endangered
Alabama cavefish	*Speoplatyrhinus poulsoni*	AL	V	Endangered
Alabama lampmussel	*Lampsilis virescens*	AL, TN	I	Endangered
Alabama leather flower	*Clematis socialis*	AL, GA	P	Endangered
Alabama moccasinshell	*Medionidus acutissimus*	AL, GA, MS	I	Threatened
Alabama pearlshell	*Margaritifera marrianae*	AL	I	Proposed Endangered
Alabama red-belly turtle	*Pseudemys alabamensis*	AL, MS	V	Endangered
Alabama streak-sorus fern	*Thelypteris pilosa var. alabamensis*	AL	P	Threatened
Alabama sturgeon	*Scaphirhynchus suttkusi*	AL	V	Endangered
Alameda whipsnake (=striped racer)	*Masticophis lateralis euryxanthus*	CA	V	Threatened
Alamosa springsnail	*Tryonia alamosae*	NM	I	Endangered
Alani	*Melicope adscendens*	HI	P	Endangered
Alani	*Melicope balloui*	HI	P	Endangered
Alani	*Melicope christophersenii*	HI	P	Proposed Endangered
Alani	*Melicope degeneri*	HI	P	Endangered

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Alani	*Melicope haupuensis*	HI	P	Endangered
Alani	*Melicope hiiakae*	HI	P	Proposed Endangered
Alani	*Melicope knudsenii*	HI	P	Endangered
Alani	*Melicope lydgatei*	HI	P	Endangered
Alani	*Melicope makahae*	HI	P	Proposed Endangered
Alani	*Melicope mucronulata*	HI	P	Endangered
Alani	*Melicope munroi*	HI	P	Endangered
Alani	*Melicope ovalis*	HI	P	Endangered
Alani	*Melicope pallida*	HI	P	Endangered
Alani	*Melicope paniculata*	HI	P	Endangered
Alani	*Melicope puberula*	HI	P	Endangered
Alani	*Melicope quadrangularis*	HI	P	Endangered
Alani	*Melicope reflexa*	HI	P	Endangered
Alani	*Melicope saint-johnii*	HI	P	Endangered
Alani	*Melicope zahlbruckneri*	HI	P	Endangered
Altamaha spinymussel	*Elliptio spinosa*	GA	I	Endangered
Amargosa niterwort	*Nitrophila mohavensis*	CA, NV	P	Endangered
Amargosa vole	*Microtus californicus scirpensis*	CA	V	Endangered
Amber darter	*Percina antesella*	GA, TN	V	Endangered
American burying beetle	*Nicrophorus americanus*	AR, KS, MA, MO, NE, OH, OK, RI, SD, TX	I	Endangered
American chaffseed	*Schwalbea americana*	AL, FL, GA, LA, MS, NC, NJ, SC, VA	P	Endangered
American crocodile	*Crocodylus acutus*	FL	V	Threatened
American hart's-tongue fern	*Asplenium scolopendrium var. americanum*	AL, MI, NY, TN	P	Threatened
Amphipod, diminutive	*Gammarus hyalleloides*	TX	I	PE
Amphipod, Pecos	*Gammarus pecos*	TX	I	PE
Anastasia Island beach mouse	*Peromyscus polionotus phasma*	FL	V	Endangered
Anthony's riversnail	*Athearnia anthonyi*	AL, TN	I	Endangered

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Antioch Dunes evening-primrose	*Oenothera deltoides ssp. howellii*	CA	P	Endangered
Apache trout	*Oncorhynchus apache*	AZ	V	Threatened
Apalachicola rosemary	*Conradina glabra*	FL	P	Endangered
Appalachian elktoe	*Alasmidonta raveneliana*	NC, TN	I	Endangered
Appalachian monkeyface (pearlymussel)	*Quadrula sparsa*	TN, VA	I	Endangered
Applegate's milk-vetch	*Astragalus applegatei*	OR	P	Endangered
Arizona Cliff-rose	*Purshia (=Cowania) subintegra*	AZ	P	Endangered
Arizona hedgehog cactus	*Echinocereus triglochidiatus var. arizonicus*	AZ	P	Endangered
Arkansas fatmucket	*Lampsilis powellii*	AR	I	Threatened
Arkansas River shiner	*Notropis girardi*	AR, KS, NM, OK, TX	V	Threatened
Armored snail	*Pyrgulopsis (=Marstonia) pachyta*	AL	I	Endangered
Arroyo (=arroyo southwestern) toad	*Bufo californicus (=microscaphus)*	CA	V	Endangered
arroyo Toad (=arroyo southwestern)	*Anaxyrus californicus*	CA	V	E
Ash Meadows Amargosa pupfish	*Cyprinodon nevadensis mionectes*	NV	V	Endangered
Ash Meadows blazingstar	*Mentzelia leucophylla*	NV	P	Threatened
Ash Meadows gumplant	*Grindelia fraxino-pratensis*	CA, NV	P	Threatened
Ash Meadows ivesia	*Ivesia kingii var. eremica*	CA, NV	P	Threatened
Ash meadows milk-vetch	*Astragalus phoenix*	CA, NV	P	Threatened
Ash Meadows naucorid	*Ambrysus amargosus*	NV	I	Threatened
Ash Meadows speckled dace	*Rhinichthys osculus nevadensis*	NV	V	Endangered
Ash Meadows sunray	*Enceliopsis nudicaulis var. corrugata*	CA, NV	P	Threatened

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Ash-breasted tit-tyrant	*Anairetes alpinus*	NA[1]	V	Proposed Endangered
Ash-grey paintbrush	*Castilleja cinerea*	CA	P	Threatened
Ashy dogweed	*Thymophylla tephroleuca*	TX	P	Endangered
Asplenium-leaved diellia	*Diellia erecta*	HI	P	Endangered
Atlantic salmon	*Salmo salar*	ME	V	Endangered
Atlantic salt marsh snake	*Nerodia clarkii taeniata*	FL	V	Threatened
Attwater's greater prairie-chicken	*Tympanuchus cupido attwateri*	TX	V	Endangered
Audubon's crested caracara	*Polyborus plancus audubonii*	FL	V	Threatened
Aupaka	*Isodendrion hosakae*	HI	P	Endangered
Aupaka	*Isodendrion laurifolium*	HI	P	Endangered
Aupaka	*Isodendrion longifolium*	HI	P	Threatened
Autumn Buttercup	*Ranunculus aestivalis (=acriformis)*	UT	P	Endangered
Avon Park harebells	*Crotalaria avonensis*	FL	P	Endangered
Awiwi	*Centaurium sebaeoides*	HI	P	Endangered
Awiwi	*Hedyotis cookiana*	HI	P	Endangered
Bachman's warbler (=wood)	*Vermivora bachmanii*	FL, SC	V	Endangered
Baker's larkspur	*Delphinium bakeri*	CA	P	Endangered
Bakersfield cactus	*Opuntia treleasei*	CA	P	Endangered
Banbury Springs limpet	*Lanx sp.*	ID	I	Endangered
Bariaco	*Trichilia triacantha*	PR	P	Endangered
Barneby reed-mustard	*Schoenocrambe barnebyi*	UT	P	Endangered
Barneby ridge-cress	*Lepidium barnebyanum*	UT	P	Endangered
Barton Springs salamander	*Eurycea sosorum*	TX	V	Endangered
bat, Florida bonneted	*Eumops floridanus*	FL	V	PE
Bay checkerspot butterfly	*Euphydryas editha bayensis*	CA	I	Threatened
Bayou darter	*Etheostoma rubrum*	MS	V	Threatened
Beach jacquemontia	*Jacquemontia reclinata*	FL	P	Endangered

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Beach layia	*Layia carnosa*	CA	P	Endangered
bean, sea	*Mucuna sloanei persericea*	HI	P	PE
Bear Valley sandwort	*Arenaria ursina*	CA	P	Threatened
Beautiful goetzea	*Goetzea elegans*	PR	P	Endangered
Beautiful pawpaw	*Deeringothamnus pulchellus*	FL	P	Endangered
Beautiful shiner	*Cyprinella formosa*	AZ, NM	V	Threatened
Bee Creek Cave harvestman	*Texella reddelli*	TX	I	Endangered
Behren's silverspot butterfly	*Speyeria zerene behrensii*	CA	I	Endangered
Beluga whale	*Delphinapterus leucas*	NA[1]	V	Endangered
Ben Lomond spineflower	*Chorizanthe pungens var. hartwegiana*	CA	P	Endangered
Ben Lomond wallflower	*Erysimum teretifolium*	CA	P	Endangered
Big Bend gambusia	*Gambusia gaigei*	TX	V	Endangered
Big Spring spinedace	*Lepidomeda mollispinis pratensis*	NV	V	Threatened
Big-leaved crownbeard	*Verbesina dissita*	CA	P	Threatened
Birdwing pearlymussel	*Conradilla caelata*	TN, VA	I	Endangered
Black abalone	*Haliotis cracherodii*	NA[1]	I	Endangered
Black clubshell	*Pleurobema curtum*	MS	I	Endangered
Black lace cactus	*Echinocereus reichenbachii var. albertii*	TX	P	Endangered
Black spored quillwort	*Isoetes melanospora*	GA, SC	P	Endangered
Blackburn's sphinx moth	*Manduca blackburni*	HI	I	Endangered
Black-capped vireo	*Vireo atricapilla*	OK, TX	V	Endangered
Black-footed ferret	*Mustela nigripes*	AZ, CO, KS, MT, ND, NE, NM, SD, UT, WY	V	Endangered
Blackline Hawaiian damselfly	*Megalagrion nigrohamatum nigrolineatum*	HI	I	Proposed Endangered
Blackside dace	*Phoxinus cumberlandensis*	KY, TN, VA	V	Threatened
Bliss Rapids snail	*Taylorconcha serpenticola*	ID	I	Threatened
Blowout penstemon	*Penstemon haydenii*	NE, WY	P	Endangered

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Blue Ridge goldenrod	*Solidago spithamaea*	NC, TN	P	Threatened
Blue shiner	*Cyprinella caerulea*	AL, GA, TN	V	Threatened
Blue whale	*Balaenoptera musculus*	CA, MA	V	Endangered
Blue-billed curassow	*Crax alberti*	NA[1]	V	Proposed Endangered
Bluemask (=jewel) Darter	*Etheostoma sp.*	TN	V	Endangered
Bluetail mole skink	*Eumeces egregius lividus*	FL	V	Threatened
Blunt-nosed leopard lizard	*Gambelia silus*	CA	V	Endangered
Bocaccio	*Sebastes paucispinis*	NA[1]	V	Endangered
Bog (=Muhlenberg) turtle	*Clemmys muhlenbergii*	CT, DE, MD, NJ, NY, PA	V	Threatened
Bone Cave harvestman	*Texella reyesi*	TX	I	Endangered
Bonytail chub	*Gila elegans*	AZ, CA, CO, NV, UT	V	Endangered
Borax Lake chub	*Gila boraxobius*	OR	V	Endangered
Boulder darter	*Etheostoma wapiti*	AL, TN	V	Endangered
Bradshaw's desert-parsley	*Lomatium bradshawii*	OR, WA	P	Endangered
Brady pincushion cactus	*Pediocactus bradyi*	AZ	P	Endangered
Braken Bat Cave Meshweaver	*Cicurina venii*	TX	I	Endangered
Braun's rock-cress	*Arabis perstellata*	KY, TN	P	Endangered
Braunton's milk-vetch	*Astragalus brauntonii*	CA	P	Endangered
Britton's beargrass	*Nolina brittoniana*	FL	P	Endangered
Brooksville bellflower	*Campanula robinsiae*	FL	P	Endangered
Brown-banded antpitta	*Grallaria milleri*	NA[1]	V	Proposed Endangered
Bruneau Hot springsnail	*Pyrgulopsis bruneauensis*	ID	I	Endangered
Buena Vista Lake ornate shrew	*Sorex ornatus relictus*	CA	V	Endangered
Bull Trout	*Salvelinus confluentus*	ID, MT, NV, OR, WA	V	Threatened
Bunched arrowhead	*Sagittaria fasciculata*	NC, SC	P	Endangered

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Bunched cory cactus	*Coryphantha ramillosa*	TX	P	Threatened
Burke's goldfields	*Lasthenia burkei*	CA	P	Endangered
Butte County meadowfoam	*Limnanthes floccosa ssp. californica*	CA	P	Endangered
Butterfly, Mount Charleston blue	*Plebejus shasta charlestonensis*	CA, NV	I	PE
Cactus, Acuna	*Echinomastus erectocentrus var. acunensis*	AZ	P	PE
Cactus, Fickeisen plains	*Pediocactus peeblesianus fickeiseniae*	AZ	P	PE
Cactus, Florida semaphore	*Consolea corallicola*	FL	P	PE
cactus, Tobusch fishhook	*Sclerocactus brevihamatus ssp. tobuschii*	TX	P	E
Cahaba shiner	*Notropis cahabae*	AL	V	Endangered
California clapper rail	*Rallus longirostris obsoletus*	CA	V	Endangered
California condor	*Gymnogyps californianus*	AZ, CA	V	Endangered
California freshwater shrimp	*Syncaris pacifica*	CA	I	Endangered
California jewelflower	*Caulanthus californicus*	CA	P	Endangered
California least tern	*Sterna antillarum browni*	AZ, CA	V	Endangered
California Orcutt grass	*Orcuttia californica*	CA	P	Endangered
California red-legged frog	*Rana draytonii*	CA	V	Threatened
California seablite	*Suaeda californica*	CA	P	Endangered
California taraxacum	*Taraxacum californicum*	CA	P	Endangered
California tiger Salamander	*Ambystoma californiense*	CA	V	Endangered
California tiger Salamander	*Ambystoma californiense*	CA	V	Threatened
California tiger Salamander (Sonoma)	*Ambystoma californiense*	CA	V	Endangered
Calistoga allocarya	*Plagiobothrys strictus*	CA	P	Endangered
Callippe silverspot butterfly	*Speyeria callippe callippe*	CA	I	Endangered

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Canada Lynx	*Lynx canadensis*	CO, ID, ME, MI, MN, MT, NH, NY, OR, UT, VT, WA, WI, WY	V	Threatened
Canary Rockfish	*Sebastes pinniger*	NA[1]	V	Threatened
Canby's dropwort	*Oxypolis canbyi*	DE, GA, MD, NC, SC	P	Endangered
Canelo Hills ladies'-tresses	*Spiranthes delitescens*	AZ	P	Endangered
Capa rosa	*Callicarpa ampla*	PR	P	Endangered
Cape Fear shiner	*Notropis mekistocholas*	NC	V	Endangered
Cape Sable seaside sparrow	*Ammodramus maritimus mirabilis*	FL	V	Endangered
Carolina heelsplitter	*Lasmigona decorata*	NC, SC	I	Endangered
Carolina northern flying squirrel	*Glaucomys sabrinus coloratus*	NC, TN, VA	V	Endangered
Carson wandering skipper	*Pseudocopaeodes eunus obscurus*	CA, NV	I	Endangered
Carter's mustard	*Warea carteri*	FL	P	Endangered
Carter's panicgrass	*Panicum fauriei var. carteri*	HI	P	Endangered
Caseys june beetle	*Dinacoma caseyi*	CA	I	Endangered
Catalina Island mountain-mahogany	*Cercocarpus traskiae*	CA	P	Endangered
Cave crayfish	*Cambarus aculabrum*	AR	I	Endangered
Cave crayfish	*Cambarus zophonastes*	AR	I	Endangered
Chapman rhododendron	*Rhododendron chapmanii*	FL	P	Endangered
Cheat Mountain salamander	*Plethodon nettingi*	WV	V	Threatened
Checkerspot, Taylor's (=whulge)	*Euphydryas editha taylori*	OR, WA	I	PE
Cherokee darter	*Etheostoma scotti*	GA	V	Threatened
Chihuahua chub	*Gila nigrescens*	NM	V	Threatened
Chinese Camp brodiaea	*Brodiaea pallida*	CA	P	Threatened

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Chinook salmon	*Oncorhynchus (=Salmo) tshawytscha*	CA	V	Endangered
Chinook salmon	*Oncorhynchus (=Salmo) tshawytscha*	CA	V	Threatened
Chinook salmon	*Oncorhynchus (=Salmo) tshawytscha*	OR	V	Threatened
Chinook salmon	*Oncorhynchus (=Salmo) tshawytscha*	OR, WA	V	Threatened
Chinook salmon	*Oncorhynchus (=Salmo) tshawytscha*	WA	V	Endangered
Chinook salmon	*Oncorhynchus (=Salmo) tshawytscha*	WA	V	Threatened
Chipola slabshell	*Elliptio chipolaensis*	AL, FL	I	Threatened
Chiricahua leopard frog	*Rana chiricahuensis*	AZ, NM	V	Threatened
Chisos Mountain hedgehog cactus	*Echinocereus chisoensis var. chisoensis*	TX	P	Threatened
Chittenango ovate amber snail	*Succinea chittenangoensis*	NY	I	Threatened
Choctaw bean	*Villosa choctawensis*	AL, FL	I	Proposed Endangered
Choctawhatchee beach mouse	*Peromyscus polionotus allophrys*	FL	V	Endangered
Chorro Creek bog thistle	*Cirsium fontinale var. obispoense*	CA	P	Endangered
Chucky madtom	*Noturus crypticus*	TN	V	Endangered
Chum salmon	*Oncorhynchus (=Salmo) keta*	OR, WA	V	Threatened
Chum salmon	*Oncorhynchus (=Salmo) keta*	WA	V	Threatened
Chupacallos	*Pleodendron macranthum*	PR	P	Endangered
Chupadera springsnail	*Pyrgulopsis chupaderae*	NM	I	Proposed Endangered
Clara Hunt's milk-vetch	*Astragalus clarianus*	CA	P	Endangered
Clay phacelia	*Phacelia argillacea*	UT	P	Endangered
Clay reed-mustard	*Schoenocrambe argillacea*	UT	P	Threatened
clay-loving wild buckwheat	*Eriogonum pelinophilum*	CO	P	ndangered

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Clay's hibiscus	*Hibiscus clayi*	HI	P	Endangered
Clear Creek gambusia	*Gambusia heterochir*	TX	V	Endangered
Clover lupine	*Lupinus tidestromii*	CA	P	Endangered
Clover Valley speckled dace	*Rhinichthys osculus oligoporus*	NV	V	Endangered
Clubshell	*Pleurobema clava*	IL, IN, KY, MI, NY, OH, PA, TN, WV	I	Endangered
Coachella Valley milk-vetch	*Astragalus lentiginosus var. coachellae*	CA	P	Endangered
Coachella Valley fringe-toed lizard	*Uma inornata*	CA	V	Threatened
Coastal California gnatcatcher	*Polioptila californica californica*	CA	V	Threatened
Coastal dunes milk-vetch	*Astragalus tener var. titi*	CA	P	Endangered
Cobana negra	*Stahlia monosperma*	PR	P	Threatened
Cochise pincushion cactus	*Coryphantha robbinsorum*	AZ	P	Threatened
Coffin Cave mold beetle	*Batrisodes texanus*	TX	I	Endangered
Coho salmon	*Oncorhynchus (=Salmo) kisutch*	CA	V	Endangered
Coho salmon	*Oncorhynchus (=Salmo) kisutch*	CA, OR	V	Threatened
Coho salmon	*Oncorhynchus (=Salmo) kisutch*	NA[1]	V	Threatened
Coho salmon	*Oncorhynchus (=Salmo) kisutch*	OR	V	Threatened
Cokendolpher Cave harvestman	*Texella cokendolpheri*	TX	I	Endangered
Colorado Butterfly plant	*Gaura neomexicana var. coloradensis*	CO, NE, WY	P	Threatened
Colorado hookless Cactus	*Sclerocactus glaucus*	CO	P	Threatened
Colorado pikeminnow (=squawfish)	*Ptychocheilus lucius*	AZ, CA, CO, NM, UT	V	Endangered

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Columbian white-tailed deer	Odocoileus virginianus leucurus	OR, WA	V	Endangered
Colusa grass	Neostapfia colusana	CA	P	Threatened
Comal Springs dryopid beetle	Stygoparnus comalensis	TX	I	Endangered
Comal Springs riffle beetle	Heterelmis comalensis	TX	I	Endangered
Comanche Springs pupfish	Cyprinodon elegans	TX	V	Endangered
Conasauga logperch	Percina jenkinsi	GA, TN	V	Endangered
Conejo dudleya	Dudleya abramsii ssp. parva	CA	P	Threatened
Conservancy fairy shrimp	Branchinecta conservatio	CA	I	Endangered
Contra Costa goldfields	Lasthenia conjugens	CA	P	Endangered
Contra Costa wallflower	Erysimum capitatum var. angustatum	CA	P	Endangered
Cooke's koki`o	Kokia cookei	HI	P	Endangered
Cook's holly	Ilex cookii	PR	P	Endangered
Cook's lomatium	Lomatium cookii	OR	P	Endangered
Cooley's meadowrue	Thalictrum cooleyi	FL, GA, NC	P	Endangered
Cooley's water-willow	Justicia cooleyi	FL	P	Endangered
Coosa moccasinshell	Medionidus parvulus	AL, GA, TN	I	Endangered
Copperbelly water snake	Nerodia erythrogaster neglecta	IN, MI, OH	V	Threatened
coqui, Llanero	Eleutherodactylus juanariveroi	PR	V	Proposed Endangered
Coyote ceanothus	Ceanothus ferrisae	CA	P	Endangered
Cracking pearlymussel	Hemistena lata	AL, KY, PA, TN, VA	I	Endangered
Crenulate lead-plant	Amorpha crenulata	FL	P	Endangered
Crested honeycreeper	Palmeria dolei	HI	V	Endangered
Crimson Hawaiian damselfly	Megalagrion leptodemus	HI	I	Proposed Endangered
Cui-ui	Chasmistes cujus	NV	V	Endangered
Culebra Island giant anole	Anolis roosevelti	PR	V	Endangered

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Cumberland bean (pearlymussel)	*Villosa trabalis*	AL, KY, NC, TN, VA	I	Endangered
Cumberland darter	*Etheostoma susanae*	KY, TN	V	Endangered
Cumberland elktoe	*Alasmidonta atropurpurea*	KY, TN	I	Endangered
Cumberland monkeyface (pearlymussel)	*Quadrula intermedia*	AL, TN, VA	I	Endangered
Cumberland pigtoe	*Pleurobema gibberum*	TN	I	Endangered
Cumberland rosemary	*Conradina verticillata*	KY, TN	P	Threatened
Cumberland sandwort	*Arenaria cumberlandensis*	KY, TN	P	Endangered
Cumberlandian combshell	*Epioblasma brevidens*	AL, KY, MS, TN, VA	I	Endangered
Curtis pearlymussel	*Epioblasma florentina curtisii*	AR, MO	I	Endangered
Cushenbury buckwheat	*Eriogonum ovalifolium var. vineum*	CA	P	Endangered
Cushenbury milk-vetch	*Astragalus albens*	CA	P	Endangered
Cushenbury oxytheca	*Oxytheca parishii var. goodmaniana*	CA	P	Endangered
Cylindrical lioplax (snail)	*Lioplax cyclostomaformis*	AL	I	Endangered
Dark pigtoe	*Pleurobema furvum*	AL	I	Endangered
Darter, diamond	*Crystallaria cincotta*	WV	V	PE
Davis' green pitaya	*Echinocereus viridiflorus var. davisii*	TX	P	Endangered
DeBeque phacelia	*Phacelia submutica*	CO	P	Threatened
Decurrent false aster	*Boltonia decurrens*	IL, MO	P	Threatened
Del Mar manzanita	*Arctostaphylos glandulosa ssp. crassifolia*	CA	P	Endangered
Delhi Sands flower-loving fly	*Rhaphiomidas terminatus abdominalis*	CA	I	Endangered
Delmarva Peninsula fox squirrel	*Sciurus niger cinereus*	DE, MD, VA	V	Endangered
Delta green ground beetle	*Elaphrus viridis*	CA	I	Threatened
Delta smelt	*Hypomesus transpacificus*	CA	V	Threatened

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Deltoid spurge	*Chamaesyce deltoidea ssp. deltoidea*	FL	P	Endangered
Deseret milk-vetch	*Astragalus desereticus*	UT	P	Threatened
Desert dace	*Eremichthys acros*	NV	V	Threatened
Desert pupfish	*Cyprinodon macularius*	AZ, CA	V	Endangered
Desert slender salamander	*Batrachoseps aridus*	CA	V	Endangered
Desert tortoise	*Gopherus agassizii*	AZ, CA, NV, UT	V	Threatened
Desert yellowhead	*Yermo xanthocephalus*	WY	P	Threatened
Devils Hole pupfish	*Cyprinodon diabolis*	NV	V	Endangered
Devils River minnow	*Dionda diaboli*	TX	V	Threatened
Diamond Head schiedea	*Schiedea adamantis*	HI	P	Endangered
Dromedary pearlymussel	*Dromus dromas*	AL, KY, TN, VA	I	Endangered
Dudley Bluffs bladderpod	*Lesquerella congesta*	CO	P	Threatened
Dudley Bluffs twinpod	*Physaria obcordata*	CO	P	Threatened
Dunes sagebrush lizard	*Sceloporus arenicolus*	NM, TX	V	Proposed Endangered
Duskytail darter	*Etheostoma percnurum*	KY, TN, VA	V	Endangered
Dwarf Bear-poppy	*Arctomecon humilis*	UT	P	Endangered
Dwarf iliau	*Wilkesia hobdyi*	HI	P	Endangered
Dwarf lake iris	*Iris lacustris*	MI, WI	P	Threatened
Dwarf naupaka	*Scaevola coriacea*	HI	P	Endangered
Dwarf wedgemussel	*Alasmidonta heterodon*	CT, MA, MD, NC, NH, NJ, NY, PA, VA, VT	I	Endangered
Dwarf-flowered heartleaf	*Hexastylis naniflora*	NC, SC	P	Threatened
Eastern indigo snake	*Drymarchon corais couperi*	AL, FL, GA	V	Threatened
Eastern prairie fringed orchid	*Platanthera leucophaea*	IA, IL, IN, ME, MI, OH, OK, VA, WI	P	Threatened

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Eastern puma (=cougar)	*Puma (=Felis) concolor couguar*	NA[1]	V	Endangered
El Dorado bedstraw	*Galium californicum ssp. sierrae*	CA	P	Endangered
El Segundo blue butterfly	*Euphilotes battoides allyni*	CA	I	Endangered
Elfin tree fern	*Cyathea dryopteroides*	PR	P	Endangered
Elkhorn coral	*Acropora palmata*	FL, PR	I	Threatened
Encinitas baccharis	*Baccharis vanessae*	CA	P	Threatened
Erubia	*Solanum drymophilum*	PR	P	Endangered
Eskimo curlew	*Numenius borealis*	NE, OK, SD, TX	V	Endangered
Etonia rosemary	*Conradina etonia*	FL	P	Endangered
Etowah darter	*Etheostoma etowahae*	GA	V	Endangered
Eureka dune grass	*Swallenia alexandrae*	CA	P	Endangered
Eureka Valley evening-primrose	*Oenothera avita ssp. eurekensis*	CA	P	Endangered
Everglade snail kite	*Rostrhamus sociabilis plumbeus*	FL	V	Endangered
Ewa Plains `akoko	*Chamaesyce skottsbergii var. kalaeloana*	HI	P	Endangered
Fanshell	*Cyprogenia stegaria*	AL, IL, IN, KY, OH, TN, VA, WV	I	Endangered
Fassett's locoweed	*Oxytropis campestris var. chartacea*	WI	P	Threatened
Fat pocketbook	*Potamilus capax*	AR, IL, IN, KY, LA, MO, MS	I	Endangered
Fat three-ridge (mussel)	*Amblema neislerii*	FL, GA	I	Endangered
Fender's blue butterfly	*Icaricia icarioides fenderi*	OR	I	Endangered
Few-flowered navarretia	*Navarretia leucocephala ssp. pauciflora (=N. pauciflora)*	CA	P	Endangered

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Finback whale	*Balaenoptera physalus*	AL, CA, CT, DE, FL, GA, LA, MA, MD, ME, MS, NC, NH, NJ, NY, PR, RI, SC, TX, VA	V	Endangered
Finelined pocketbook	*Lampsilis altilis*	AL, GA, TN	I	Threatened
Finerayed pigtoe	*Fusconaia cuneolus*	AL, TN, VA	I	Endangered
Fish Slough milk-vetch	*Astragalus lentiginosus var. piscinensis*	CA	P	Threatened
Flat pebblesnail	*Lepyrium showalteri*	AL	I	Endangered
Flat pigtoe	*Pleurobema marshalli*	AL, MS	I	Endangered
Flat-spired three-toothed Snail	*Triodopsis platysayoides*	WV	I	Threatened
Flattened musk turtle	*Sternotherus depressus*	AL	V	Threatened
Fleshy owl's-clover	*Castilleja campestris ssp. succulenta*	CA	P	Threatened
Florida bonamia	*Bonamia grandiflora*	FL	P	Threatened
Florida golden aster	*Chrysopsis floridana*	FL	P	Endangered
Florida grasshopper sparrow	*Ammodramus savannarum floridanus*	FL	V	Endangered
Florida panther	*Puma (=Felis) concolor coryi*	FL	V	Endangered
Florida perforate cladonia	*Cladonia perforata*	FL	P	Endangered
Florida salt marsh vole	*Microtus pennsylvanicus dukecampbelli*	FL	V	Endangered
Florida scrub-jay	*Aphelocoma coerulescens*	FL	V	Threatened
Florida skullcap	*Scutellaria floridana*	FL	P	Threatened
Florida torreya	*Torreya taxifolia*	FL, GA	P	Endangered
Florida ziziphus	*Ziziphus celata*	FL	P	Endangered
Fly, Hawaiian picture-wing	*Drosophila digressa*	HI	I	PE
Flying earwig Hawaiian damselfly	*Megalagrion nesiotes*	HI	I	Endangered
Fosberg's love grass	*Eragrostis fosbergii*	HI	P	Endangered
Foskett speckled dace	*Rhinichthys osculus ssp.*	OR	V	Threatened

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Fountain darter	*Etheostoma fonticola*	TX	V	Endangered
Fountain thistle	*Cirsium fontinale var. fontinale*	CA	P	Endangered
Four-petal pawpaw	*Asimina tetramera*	FL	P	Endangered
Fragrant prickly-apple	*Cereus eriophorus var. fragrans*	FL	P	Endangered
Fresno kangaroo rat	*Dipodomys nitratoides exilis*	CA	V	Endangered
Fringed campion	*Silene polypetala*	FL, GA	P	Endangered
Frog, dusky gopher	*Rana sevosa*	MS	V	E
Frosted Flatwoods salamander	*Ambystoma cingulatum*	FL, GA, SC	V	Threatened
Furbish lousewort	*Pedicularis furbishiae*	ME	P	Endangered
Fuzzy pigtoe	*Pleurobema strodeanum*	AL, FL	I	Proposed Threatened
Gambel's watercress	*Rorippa gambellii*	CA	P	Endangered
Garber's spurge	*Chamaesyce garberi*	FL	P	Threatened
Garrett's mint	*Dicerandra christmanii*	FL	P	Endangered
Gaviota tarplant	*Deinandra increscens ssp. villosa*	CA	P	Endangered
Gentian pinkroot	*Spigelia gentianoides*	AL, FL	P	Endangered
Gentner's fritillary	*Fritillaria gentneri*	CA, OR	P	Endangered
Georgia pigtoe	*Pleurobema hanleyianum*	AL, GA, TN	I	Endangered
Giant garter snake	*Thamnophis gigas*	CA	V	Threatened
Giant kangaroo rat	*Dipodomys ingens*	CA	V	Endangered
Gila chub	*Gila intermedia*	AZ, NM	V	Endangered
Gila topminnow (incl. Yaqui)	*Poeciliopsis occidentalis*	AZ, NM	V	Endangered
Gila trout	*Oncorhynchus gilae*	AZ, NM	V	Threatened
Gladecress, Texas golden	*Leavenworthia texana*	TX	P	PE
globe, noonday	*Patera clarki nantahala*	NC	I	T
Godfrey's butterwort	*Pinguicula ionantha*	FL	P	Threatened
Golden coqui	*Eleutherodactylus jasperi*	PR	V	Threatened
Golden Paintbrush	*Castilleja levisecta*	OR, WA	P	Threatened
Golden sedge	*Carex lutea*	NC	P	Endangered

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Golden-cheeked warbler (=wood)	*Dendroica chrysoparia*	TX	V	Endangered
Goldline darter	*Percina aurolineata*	AL, GA	V	Threatened
Gopher tortoise	*Gopherus polyphemus*	AL, LA, MS	V	Threatened
Government Canyon bat cave meshweaver	*Cicurina vespera*	TX	I	Endangered
Government Canyon bat cave spider	*Neoleptoneta microps*	TX	I	Endangered
Gowen cypress	*Cupressus goveniana ssp. goveniana*	CA	P	Threatened
Graham beardtongue	*Penstemon grahamii*	CO, UT	P	Proposed Threatened
Gray bat	*Myotis grisescens*	AL, AR, FL, GA, IL, IN, KS, KY, MO, MS, NC, OK, TN, VA, WV	V	Endangered
Gray wolf	*Canis lupus*	CO, MI, ND, NE, NM, NV, OR, SD, UT, WA, WI	V	Endangered
Green blossom (pearlymussel)	*Epioblasma torulosa gubernaculum*	TN, VA	I	Endangered
Green pitcher-plant	*Sarracenia oreophila*	AL, GA, NC, TN	P	Endangered
Green sea turtle	*Chelonia mydas*	AL, CA, CT, DE, GA, HI, LA, MA, MD, ME, MS, NC, NH, NJ, NY, OR, PR, RI, SC, TX, UM, VA, WA	V	Threatened
Green sea turtle	*Chelonia mydas*	FL	V	Endangered
Greenback cutthroat trout	*Oncorhynchus clarki stomias*	CO, UT	V	Threatened
Greene's tuctoria	*Tuctoria greenei*	CA	P	Endangered

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Grizzly bear	*Ursus arctos horribilis*	ID, MT, WA, WY	V	Threatened
ground beetle [Unnamed]	*Rhadine exilis*	TX	I	Endangered
ground beetle [Unnamed]	*Rhadine infernalis*	TX	I	Endangered
Guadalupe fur seal	*Arctocephalus townsendi*	CA	V	Threatened
Guajon	*Eleutherodactylus cooki*	PR	V	Threatened
Gulf Coast jaguarundi	*Herpailurus (=Felis) yagouaroundi cacomitli*	TX	V	Endangered
Gulf moccasinshell	*Medionidus penicillatus*	AL, FL, GA	I	Endangered
Gulf sturgeon	*Acipenser oxyrinchus desotoi*	AL, FL, LA, MS	V	Threatened
Guthrie's (=Pyne's) ground-plum	*Astragalus bibullatus*	TN	P	Endangered
Gypsum wild-buckwheat	*Eriogonum gypsophilum*	NM	P	Threatened
Ha`iwale	*Cyrtandra crenata*	HI	P	Endangered
Ha`iwale	*Cyrtandra dentata*	HI	P	Endangered
Ha`iwale	*Cyrtandra giffardii*	HI	P	Endangered
Ha`iwale	*Cyrtandra kaulantha*	HI	P	Proposed Endangered
Ha`iwale	*Cyrtandra limahuliensis*	HI	P	Threatened
Ha`iwale	*Cyrtandra munroi*	HI	P	Endangered
Ha`iwale	*Cyrtandra oenobarba*	HI	P	Endangered
Ha`iwale	*Cyrtandra polyantha*	HI	P	Endangered
Ha`iwale	*Cyrtandra sessilis*	HI	P	Proposed Endangered
Ha`iwale	*Cyrtandra subumbellata*	HI	P	Endangered
Ha`iwale	*Cyrtandra tintinnabula*	HI	P	Endangered
Ha`iwale	*Cyrtandra viridiflora*	HI	P	Endangered
Ha`iwale	*Cyrtandra filipes*	HI	P	PE
Ha`iwale	*Cyrtandra oxybapha*	HI	P	PE
Haha	*Cyanea acuminata*	HI	P	Endangered
Haha	*Cyanea asarifolia*	HI	P	Endangered
Haha	*Cyanea calycina*	HI	P	Proposed Endangered

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Haha	*Cyanea copelandii ssp. copelandii*	HI	P	Endangered
Haha	*Cyanea copelandii ssp. haleakalaensis*	HI	P	Endangered
Haha	*Cyanea dolichopoda*	HI	P	Endangered
Haha	*Cyanea dunbarii*	HI	P	Endangered
Haha	*Cyanea eleeleensis*	HI	P	Endangered
Haha	*Cyanea glabra*	HI	P	Endangered
Haha	*Cyanea grimesiana ssp. grimesiana*	HI	P	Endangered
Haha	*Cyanea grimesiana ssp. obatae*	HI	P	Endangered
Haha	*Cyanea hamatiflora ssp. carlsonii*	HI	P	Endangered
Haha	*Cyanea hamatiflora ssp. hamatiflora*	HI	P	Endangered
Haha	*Cyanea humboldtiana*	HI	P	Endangered
Haha	*Cyanea kolekoleensis*	HI	P	Endangered
Haha	*Cyanea koolauensis*	HI	P	Endangered
Haha	*Cyanea kuhihewa*	HI	P	Endangered
Haha	*Cyanea lanceolata*	HI	P	Proposed Endangered
Haha	*Cyanea lobata*	HI	P	Endangered
Haha	*Cyanea longiflora*	HI	P	Endangered
Haha	*Cyanea macrostegia ssp. gibsonii*	HI	P	Endangered
Haha	*Cyanea mannii*	HI	P	Endangered
Haha	*Cyanea mceldowneyi*	HI	P	Endangered
Haha	*Cyanea pinnatifida*	HI	P	Endangered
Haha	*Cyanea platyphylla*	HI	P	Endangered
Haha	*Cyanea procera*	HI	P	Endangered
Haha	*Cyanea recta*	HI	P	Threatened
Haha	*Cyanea remyi*	HI	P	Endangered
Haha	*Cyanea shipmanii*	HI	P	Endangered
Haha	*Cyanea stictophylla*	HI	P	Endangered
Haha	*Cyanea st.-johnii*	HI	P	Endangered
Haha	*Cyanea superba*	HI	P	Endangered

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Haha	*Cyanea truncata*	HI	P	Endangered
Haha	*Cyanea undulata*	HI	P	Endangered
Haha	*Cyanea asplenifolia*	HI	P	PE
haha	*Cyanea duvalliorum*	HI	P	PE
Haha	*Cyanea kunthiana*	HI	P	PE
Haha	*Cyanea magnicalyx*	HI	P	PE
Haha	*Cyanea maritae*	HI	P	PE
Haha	*Cyanea marksii*	HI	P	PE
Haha	*Cyanea mauiensis*	HI	P	PE
Haha	*Cyanea munroi*	HI	P	PE
Haha	*Cyanea obtusa*	HI	P	PE
Hairy Orcutt grass	*Orcuttia pilosa*	CA	P	Endangered
Hairy rattleweed	*Baptisia arachnifera*	GA	P	Endangered
Haiwale	*Cyrtandra paliku*	HI	P	Endangered
haiwale	*Cyrtandra ferripilosa*	HI	P	PE
Hala pepe	*Pleomele forbesii*	HI	P	Proposed Endangered
Hala pepe	*Pleomele hawaiiensis*	HI	P	Endangered
Hala pepe	*Pleomele fernaldii*	HI	P	PE
Harperella	*Ptilimnium nodosum*	AL, AR, GA, MD, NC, SC, VA, WV	P	Endangered
Harper's beauty	*Harperocallis flava*	FL	P	Endangered
Hartweg's golden sunburst	*Pseudobahia bahiifolia*	CA	P	Endangered
Hau kuahiwi	*Hibiscadelphus giffardianus*	HI	P	Endangered
Hau kuahiwi	*Hibiscadelphus hualalaiensis*	HI	P	Endangered
Hau kuahiwi	*Hibiscadelphus woodii*	HI	P	Endangered
Hawaii akepa (honeycreeper)	*Loxops coccineus coccineus*	HI	V	Endangered
Hawaii creeper	*Oreomystis mana*	HI	V	Endangered
Hawaiian (='alala) Crow	*Corvus hawaiiensis*	HI	V	Endangered
Hawaiian (=koloa) Duck	*Anas wyvilliana*	HI	V	Endangered
Hawaiian (='lo) Hawk	*Buteo solitarius*	HI	V	Endangered

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Hawaiian bluegrass	*Poa sandvicensis*	HI	P	Endangered
Hawaiian common moorhen	*Gallinula chloropus sandvicensis*	HI	V	Endangered
Hawaiian coot	*Fulica americana alai*	HI	V	Endangered
Hawaiian dark-rumped petrel	*Pterodroma phaeopygia sandwichensis*	HI	V	Endangered
Hawaiian gardenia (=Na`u)	*Gardenia brighamii*	HI	P	Endangered
Hawaiian goose	*Branta (=Nesochen) sandvicensis*	HI	V	Endangered
Hawaiian hoary bat	*Lasiurus cinereus semotus*	HI	V	Endangered
Hawaiian monk seal	*Monachus schauinslandi*	NA[1]	V	Endangered
Hawaiian picture-wing fly	*Drosophila sharpi*	HI	I	Endangered
Hawaiian red-flowered geranium	*Geranium arboreum*	HI	P	Endangered
Hawaiian stilt	*Himantopus mexicanus knudseni*	HI	V	Endangered
Hawaiian vetch	*Vicia menziesii*	HI	P	Endangered
Hawksbill sea turtle	*Eretmochelys imbricata*	AL, CT, DE, FL, GA, HI, LA, MA, MD, ME, MS, NC, NH, NJ, NY, PR, RI, SC, TX, VA	V	Endangered
Hay's Spring amphipod	*Stygobromus hayi*	DC, MD	I	Endangered
Heau	*Exocarpos luteolus*	HI	P	Endangered
Heavy pigtoe	*Pleurobema taitianum*	AL	I	Endangered
Heinroth's shearwater	*Puffinus heinrothi*	NA[1]	V	Threatened
Heliotrope milk-vetch	*Astragalus montii*	UT	P	Threatened
Heller's blazingstar	*Liatris helleri*	NC	P	Threatened
Helotes mold beetle	*Batrisodes venyivi*	TX	I	Endangered
Hickman's potentilla	*Potentilla hickmanii*	CA	P	Endangered
Hidden Lake bluecurls	*Trichostema austromontanum ssp. compactum*	CA	P	Threatened

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Higgins eye (pearlymussel)	Lampsilis higginsii	IA, IL, MN, MO, SD, WI	I	Endangered
Highlands scrub hypericum	Hypericum cumulicola	FL	P	Endangered
Higo Chumbo	Harrisia portoricensis	PR	P	Threatened
Higuero de sierra	Crescentia portoricensis	PR	P	Endangered
Hiko White River springfish	Crenichthys baileyi grandis	NV	V	Endangered
Hilo ischaemum	Ischaemum byrone	HI	P	Endangered
Hinckley oak	Quercus hinckleyi	TX	P	Threatened
Hine's emerald dragonfly	Somatochlora hineana	IL, MI, MO, WI	I	Endangered
Ho`awa	Pittosporum napaliense	HI	P	Endangered
Hoffmann's rock-cress	Arabis hoffmannii	CA	P	Endangered
Hoffmann's slender-flowered gilia	Gilia tenuiflora ssp. hoffmannii	CA	P	Endangered
Holei	Ochrosia kilaueaensis	HI	P	Endangered
Holmgren milk-vetch	Astragalus holmgreniorum	AZ, UT	P	Endangered
Holy Ghost ipomopsis	Ipomopsis sancti-spiritus	NM	P	Endangered
Honohono	Haplostachys haplostachya	HI	P	Endangered
Hoover's spurge	Chamaesyce hooveri	CA	P	Threatened
Horned lark, streaked	Eremophila alpestris strigata	OR, WA	V	PT
Houghton's goldenrod	Solidago houghtonii	MI, NY	P	Threatened
Houston toad	Bufo houstonensis	TX	V	Endangered
Howell's spectacular thelypody	Thelypodium howellii spectabilis	OR	P	Threatened
Howell's spineflower	Chorizanthe howellii	CA	P	Endangered
Huachuca water-umbel	Lilaeopsis schaffneriana var. recurva	AZ	P	Endangered
Hualapai Mexican vole	Microtus mexicanus hualpaiensis	AZ	V	Endangered
Hulumoa	Korthalsella degeneri	HI	P	Proposed Endangered
Humpback chub	Gila cypha	AZ, CO, UT	V	Endangered

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Humpback whale	Megaptera novaeangliae	AL, CA, DE, FL, GA, LA, MA, MD, ME, MS, NC, NJ, NY, OR, RI, SC, TX, VA, WA	V	Endangered
Hungerford's crawling water Beetle	Brychius hungerfordi	MI	I	Endangered
Hutton tui chub	Gila bicolor ssp.	OR	V	Threatened
Ihi`ihi	Marsilea villosa	HI	P	Endangered
Illinois cave amphipod	Gammarus acherondytes	IL	I	Endangered
Independence Valley speckled dace	Rhinichthys osculus lethoporus	NV	V	ndangered
Indian Knob mountain balm	Eriodictyon altissimum	CA	P	Endangered
Indiana bat	Myotis sodalis	AL, AR, FL, GA, IA, IL, IN, KY, MD, MI, MO, MS, NC, NJ, NY, OH, OK, PA, TN, VA, VT, WV	V	Endangered
Interrupted (=Georgia) Rocksnail	Leptoxis foremani	AL, GA	I	Endangered
Inyo California towhee	Pipilo crissalis eremophilus	CA	V	Threatened
Ione (incl. Irish Hill) buckwheat	Eriogonum apricum (incl. var. prostratum)	CA	P	Endangered
Ione manzanita	Arctostaphylos myrtifolia	CA	P	Threatened
Iowa Pleistocene snail	Discus macclintocki	IA, IL	I	Endangered
Island barberry	Berberis pinnata ssp. insularis	CA	P	Endangered
Island bedstraw	Galium buxifolium	CA	P	Endangered
Island malacothrix	Malacothrix squalida	CA	P	Endangered
Island night lizard	Xantusia riversiana	CA	V	Threatened
Island phacelia	Phacelia insularis ssp. insularis	CA	P	Endangered
Island rush-rose	Helianthemum greenei	CA	P	Threatened
Ivory-billed woodpecker	Campephilus principalis	AR	V	Endangered

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Jaguar	*Panthera onca*	AZ, NM	V	Endangered
James spinymussel	*Pleurobema collina*	NC, VA, WV	I	Endangered
Jesup's milk-vetch	*Astragalus robbinsii var. jesupi*	NH, VT	P	Endangered
Johnson's seagrass	*Halophila johnsonii*	FL	P	Threatened
Johnston's frankenia	*Frankenia johnstonii*	TX	P	Endangered
Jones cycladenia	*Cycladenia jonesii (=humilis)*	AZ, UT	P	Threatened
June sucker	*Chasmistes liorus*	UT	V	Endangered
Kamakahala	*Labordia cyrtandrae*	HI	P	Endangered
Kamakahala	*Labordia helleri*	HI	P	Endangered
Kamakahala	*Labordia lydgatei*	HI	P	Endangered
Kamakahala	*Labordia pumila*	HI	P	Endangered
Kamakahala	*Labordia tinifolia var. lanaiensis*	HI	P	Endangered
Kamakahala	*Labordia tinifolia var. wahiawaensis*	HI	P	Endangered
Kamakahala	*Labordia triflora*	HI	P	Endangered
Kamanomano	*Cenchrus agrimonioides*	HI	P	Endangered
Kanab ambersnail	*Oxyloma haydeni kanabensis*	AZ, UT	I	Endangered
Karner blue butterfly	*Lycaeides melissa samuelis*	IL, IN, MI, MN, NH, NY, OH, WI	I	Endangered
Kauai `o`o (honeyeater)	*Moho braccatus*	HI	V	Endangered
Kauai akialoa (honeycreeper)	*Hemignathus procerus*	HI	V	Endangered
Kauai cave amphipod	*Spelaeorchestia koloana*	HI	I	Endangered
Kauai cave wolf or pe'e pe'e maka 'ole spider	*Adelocosa anops*	HI	I	Endangered
Kauai hau kuahiwi	*Hibiscadelphus distans*	HI	P	Endangered
Kauila	*Colubrina oppositifolia*	HI	P	Endangered
Kaulu	*Pteralyxia kauaiensis*	HI	P	Endangered
Kaulu	*Pteralyxia macrocarpa*	HI	P	Proposed Endangered
Kearney's blue-star	*Amsonia kearneyana*	AZ	P	Endangered

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Keck's Checker-mallow	Sidalcea keckii	CA	P	Endangered
Kemp's ridley sea turtle	Lepidochelys kempii	AL, CT, DE, FL, GA, LA, MA, MD, MS, NC, NJ, NY, RI, SC, TX, VA	V	Endangered
Kendall Warm Springs dace	Rhinichthys osculus thermalis	WY	V	Endangered
Kentucky cave shrimp	Palaemonias ganteri	KY	I	Endangered
Kenwood Marsh checker-mallow	Sidalcea oregana ssp. valida	CA	P	Endangered
Kern mallow	Eremalche kernensis	CA	P	Endangered
Kern primrose sphinx moth	Euproserpinus euterpe	CA	I	Threatened
Key deer	Odocoileus virginianus clavium	FL	V	Endangered
Key Largo cotton mouse	Peromyscus gossypinus allapaticola	FL	V	Endangered
Key Largo woodrat	Neotoma floridana smalli	FL	V	Endangered
Key tree cactus	Pilosocereus robinii	FL	P	Endangered
Kidneyshell, fluted	Ptychobranchus subtentum	KY	I	PE
Killer whale	Orcinus orca	CA, OR, WA	V	Endangered
Kincaid's lupine	Lupinus sulphureus (=oreganus) ssp. kincaidii (=var. kincaidii)	OR, WA	P	Threatened
Kio`ele	Hedyotis coriacea	HI	P	Endangered
Kiponapona	Phyllostegia racemosa	HI	P	Endangered
Kirtland's warbler	Dendroica kirtlandii	FL, MI, SC, WI	V	Endangered
Kneeland Prairie penny-cress	Thlaspi californicum	CA	P	Endangered
Knieskern's beaked-rush	Rhynchospora knieskernii	DE, NJ	P	Threatened
Knowlton's cactus	Pediocactus knowltonii	CO, NM	P	Endangered
Ko`oko`olau	Bidens amplectens	HI	P	Proposed Endangered

Common Name	Scientific Name	Current Distribution	Vertebrate (V) Invertebrate (I) Plant (P)	Listing Status
Ko`oko`olau	Bidens micrantha ssp. kalealaha	HI	P	Endangered
Ko`oko`olau	Bidens wiebkei	HI	P	Endangered
Ko`oko`olau	Bidens campylotheca pentamera	HI	P	PE
Ko`oko`olau	Bidens campylotheca waihoiensis	HI	P	PE
Ko`oko`olau	Bidens conjuncta	HI	P	PE
Ko`oko`olau	Bidens micrantha ctenophylla	HI	P	PE
Ko`oloa`ula	Abutilon menziesii	HI	P	Endangered
Kodachrome bladderpod	Lesquerella tumulosa	UT	P	Endangered
Kohe malama malama o kanaloa	Kanaloa kahoolawensis	HI	P	Endangered
Koki`o	Kokia drynarioides	HI	P	Endangered
Koki`o	Kokia kauaiensis	HI	P	Endangered
Koki`o ke`oke`o	Hibiscus arnottianus ssp. immaculatus	HI	P	Endangered
Koki`o ke`oke`o	Hibiscus waimeae ssp. hannerae	HI	P	Endangered
Kolea	Myrsine juddii	HI	P	Endangered
Kolea	Myrsine knudsenii	HI	P	Endangered
Kolea	Myrsine linearifolia	HI	P	Threatened
Kolea	Myrsine mezii	HI	P	Endangered
Kolea	Myrsine vaccinioides	HI	P	PE
Kopa	Hedyotis schlechtendahliana var. remyi	HI	P	Endangered
Kopiko	Psychotria grandiflora	HI	P	Endangered
Kopiko	Psychotria hobdyi	HI	P	Endangered
Koster's springsnail	Juturnia kosteri	NM	I	Endangered
Kral's water-plantain	Sagittaria secundifolia	AL, GA	P	Threatened
Kretschmarr Cave mold beetle	Texamaurops reddelli	TX	I	Endangered
Kuahiwi laukahi	Plantago hawaiensis	HI	P	Endangered
Kuahiwi laukahi	Plantago princeps	HI	P	Endangered
Kuawawaenohu	Alsinidendron lychnoides	HI	P	Endangered

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Kuenzler hedgehog cactus	*Echinocereus fendleri var. kuenzleri*	NM	P	Endangered
Kula wahine noho	*Isodendrion pyrifolium*	HI	P	Endangered
Kulu`i	*Nototrichium humile*	HI	P	Endangered
La Graciosa thistle	*Cirsium loncholepis*	CA	P	Endangered
Lacy elimia (snail)	*Elimia crenatella*	AL	I	Threatened
Laguna Beach liveforever	*Dudleya stolonifera*	CA	P	Threatened
Laguna Mountains skipper	*Pyrgus ruralis lagunae*	CA	I	Endangered
Lahontan cutthroat trout	*Oncorhynchus clarki henshawi*	CA, NV, OR, UT	V	Threatened
Lake County stonecrop	*Parvisedum leiocarpum*	CA	P	Endangered
Lakela's mint	*Dicerandra immaculata*	FL	P	Endangered
Lakeside daisy	*Hymenoxys herbacea*	IL, MI, OH	P	Threatened
Lanai sandalwood (=`iliahi)	*Santalum freycinetianum var. lanaiense*	HI	P	Endangered
Lane Mountain milk-vetch	*Astragalus jaegerianus*	CA	P	Endangered
Lange's metalmark butterfly	*Apodemia mormo langei*	CA	I	Endangered
Large Kauai (=kamao) thrush	*Myadestes myadestinus*	HI	V	Endangered
Large-flowered fiddleneck	*Amsinckia grandiflora*	CA	P	Endangered
Large-flowered skullcap	*Scutellaria montana*	GA, TN	P	Threatened
Large-flowered woolly meadowfoam	*Limnanthes floccosa ssp. grandiflora*	OR	P	Endangered
Large-fruited sand-verbena	*Abronia macrocarpa*	TX	P	Endangered
Last Chance townsendia	*Townsendia aprica*	UT	P	Threatened
Lau `ehu	*Panicum niihauense*	HI	P	Endangered
Laulihilihi	*Schiedea stellarioides*	HI	P	Endangered
Laurel dace	*Phoxinus saylori*	TN	V	Endangered
Layne's butterweed	*Senecio layneae*	CA	P	Threatened

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Laysan duck	*Anas laysanensis*	HI	V	Endangered
Laysan finch (honeycreeper)	*Telespyza cantans*	HI	V	Endangered
Leafy prairie-clover	*Dalea foliosa*	AL, IL, TN	P	Endangered
Least Bell's vireo	*Vireo bellii pusillus*	CA	V	Endangered
Least tern	*Sterna antillarum*	AR, CO, IA, IL, IN, KS, KY, LA, MO, MS, MT, ND, NE, NM, OK, SD, TN, TX	V	Endangered
Leatherback sea turtle	*Dermochelys coriacea*	AL, CA, CT, DE, FL, GA, HI, LA, MA, MD, ME, MS, NC, NH, NJ, NY, OR, PR, RI, SC, TX, VA, WA	V	Endangered
Lee County cave isopod	*Lirceus usdagalun*	VA	I	Endangered
Lee pincushion cactus	*Coryphantha sneedii var. leei*	NM	P	Threatened
Leedy's roseroot	*Rhodiola integrifolia ssp. leedyi*	MN, NY	P	Threatened
lehua makanoe	*Lysimachia daphnoides*	HI	P	Endangered
Leon Springs pupfish	*Cyprinodon bovinus*	TX	V	Endangered
Leopard darter	*Percina pantherina*	AR, OK	V	Threatened
Lesser long-nosed bat	*Leptonycteris curasoae yerbabuenae*	AZ, NM	V	Endangered
Lewton's polygala	*Polygala lewtonii*	FL	P	Endangered
Light-footed clapper rail	*Rallus longirostris levipes*	CA	V	Endangered
Liliwai	*Acaena exigua*	HI	P	Endangered
Little Aguja (=Creek) pondweed	*Potamogeton clystocarpus*	TX	P	Endangered
Little amphianthus	*Amphianthus pusillus*	AL, GA, SC	P	Threatened
Little Colorado spinedace	*Lepidomeda vittata*	AZ	V	Threatened

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Little Kern golden trout	*Oncorhynchus aguabonita whitei*	CA	V	Threatened
Littlewing pearly-mussel	*Pegias fabula*	AL, KY, NC, TN, VA	I	Endangered
Lloyd's Mariposa cactus	*Echinomastus mariposensis*	TX	P	Threatened
Lo`ulu	*Pritchardia affinis*	HI	P	Endangered
Lo`ulu	*Pritchardia kaalae*	HI	P	Endangered
Lo`ulu	*Pritchardia munroi*	HI	P	Endangered
Lo`ulu	*Pritchardia napaliensis*	HI	P	Endangered
Lo`ulu	*Pritchardia remota*	HI	P	Endangered
Lo`ulu	*Pritchardia schattaueri*	HI	P	Endangered
Lo`ulu	*Pritchardia viscosa*	HI	P	Endangered
lo`ulu (=Na`ena`e)	*Pritchardia hardyi*	HI	P	Endangered
Loach minnow	*Tiaroga cobitis*	AZ, NM	V	Threatened
Loch Lomond coyote thistle	*Eryngium constancei*	CA	P	Endangered
Loggerhead sea turtle	*Caretta caretta*	AL, CA, CT, DE, FL, GA, HI, LA, MA, MD, ME, MS, NC, NH, NJ, NY, OR, PR, RI, SC, TX, VA	V	Threatened
Loggerhead sea turtle	*Caretta caretta*	NA[1]	V	Threatened
Lompoc yerba santa	*Eriodictyon capitatum*	CA	P	Endangered
Longhorn fairy shrimp	*Branchinecta longiantenna*	CA	I	Endangered
Longspurred mint	*Dicerandra cornutissima*	FL	P	Endangered
Lost River sucker	*Deltistes luxatus*	CA, OR	V	Endangered
Lotis blue butterfly	*Lycaeides argyrognomon lotis*	CA	I	Endangered
Louisiana black bear	*Ursus americanus luteolus*	LA, MS, TX	V	Threatened
Louisiana pearlshell	*Margaritifera hembeli*	LA	I	Threatened
Louisiana quillwort	*Isoetes louisianensis*	AL, LA, MS	P	Endangered
Lower Keys marsh rabbit	*Sylvilagus palustris hefneri*	FL	V	Endangered
Lyon's pentachaeta	*Pentachaeta lyonii*	CA	P	Endangered
Lyrate bladderpod	*Lesquerella lyrata*	AL	P	Threatened

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ma`o hau hele (=Native yellow hibiscus)	Hibiscus brackenridgei	HI	P	Endangered
Ma`oli`oli	Schiedea apokremnos	HI	P	Endangered
Ma`oli`oli	Schiedea kealiae	HI	P	Endangered
Ma`oli`oli	Schiedea hawaiiensis	HI	P	PE
MacFarlane's four-o'clock	Mirabilis macfarlanei	ID, OR	P	Threatened
Madison Cave isopod	Antrolana lira	VA, WV	I	Threatened
Madla's Cave meshweaver	Cicurina madla	TX	I	Endangered
Magazine Mountain shagreen	Mesodon magazinensis	AR	I	Threatened
Maguire primrose	Primula maguirei	UT	P	Threatened
Mahoe	Alectryon macrococcus	HI	P	Endangered
Makou	Peucedanum sandwicense	HI	P	Threatened
Malheur wire-lettuce	Stephanomeria malheurensis	OR	P	Endangered
mallow, Gierisch	Sphaeralcea gierischii	AZ, UT	P	PE
Mancos milk-vetch	Astragalus humillimus	CO, NM	P	Endangered
Mann's bluegrass	Poa mannii	HI	P	Endangered
Many-flowered navarretia	Navarretia leucocephala ssp. plieantha	CA	P	Endangered
Mapele	Cyrtandra cyaneoides	HI	P	Endangered
Marbled murrelet	Brachyramphus marmoratus	CA, OR, WA	V	Threatened
Marcescent dudleya	Dudleya cymosa ssp. marcescens	CA	P	Threatened
Marin dwarf-flax	Hesperolinon congestum	CA	P	Threatened
Mariposa pussypaws	Calyptridium pulchellum	CA	P	Threatened
Marsh Sandwort	Arenaria paludicola	CA	P	Endangered
Maryland darter	Etheostoma sellare	MD	V	Endangered
Masked bobwhite (quail)	Colinus virginianus ridgwayi	AZ	V	Endangered
Mat-forming quillwort	Isoetes tegetiformans	GA	P	Endangered
Maui akepa (honeycreeper)	Loxops coccineus ochraceus	HI	V	Endangered
Maui parrotbill (honeycreeper)	Pseudonestor xanthophrys	HI	V	Endangered

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Maui remya	Remya mauiensis	HI	P	Endangered
Mauna Loa (=Ka'u) silversword	Argyroxiphium kauense	HI	P	Endangered
McDonald's rock-cress	Arabis macdonaldiana	CA, OR	P	Endangered
Mead's milkweed	Asclepias meadii	IA, IL, IN, KS, MO, WI	P	Threatened
Mehamehame	Flueggea neowawraea	HI	P	Endangered
Menzies' wallflower	Erysimum menziesii	CA	P	Endangered
Mesa Verde cactus	Sclerocactus mesae-verdae	CO, NM	P	Threatened
Metcalf Canyon jewelflower	Streptanthus albidus ssp. albidus	CA	P	Endangered
Mexican flannelbush	Fremontodendron mexicanum	CA	P	Endangered
Mexican long-nosed bat	Leptonycteris nivalis	NM, TX	V	Endangered
Mexican spotted owl	Strix occidentalis lucida	AZ, CO, NM, TX, UT	V	Threatened
Miami blue butterfly	Cyclargus (=Hemiargus) thomasi bethunebakeri	FL	I	Endangered
Miccosukee gooseberry	Ribes echinellum	FL, SC	P	Threatened
Michaux's sumac	Rhus michauxii	GA, NC, SC, VA	P	Endangered
Michigan monkey-flower	Mimulus michiganensis	MI	P	Endangered
Minnesota dwarf trout lily	Erythronium propullans	MN	P	Endangered
Mission blue butterfly	Icaricia icarioides missionensis	CA	I	Endangered
Mississippi gopher frog	Rana capito sevosa	MS	V	Endangered
Mississippi sandhill crane	Grus canadensis pulla	MS	V	Endangered
Missouri bladderpod	Physaria filiformis	AR, MO	P	Threatened
Mitchell's satyr butterfly	Neonympha mitchellii mitchellii	AL, IN, MI, MS, OH, VA	I	Endangered
Moapa dace	Moapa coriacea	NV	V	Endangered
Modoc sucker	Catostomus microps	CA, OR	V	Endangered

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Mohave tui chub	*Gila bicolor mohavensis*	CA	V	Endangered
Mohr's Barbara button	*Marshallia mohrii*	AL, GA	P	Threatened
Molokai creeper	*Paroreomyza flammea*	HI	V	Endangered
Molokai thrush	*Myadestes lanaiensis rutha*	HI	V	Endangered
Mona boa	*Epicrates monensis monensis*	PR	V	Threatened
Mona ground iguana	*Cyclura cornuta stejnegeri*	PR	V	Threatened
Monito gecko	*Sphaerodactylus micropithecus*	PR	V	Endangered
Monterey clover	*Trifolium trichocalyx*	CA	P	Endangered
Monterey gilia	*Gilia tenuiflora ssp. arenaria*	CA	P	Endangered
Monterey spineflower	*Chorizanthe pungens var. pungens*	CA	P	Threatened
Morefield's leather flower	*Clematis morefieldii*	AL, TN	P	Endangered
Morro Bay kangaroo rat	*Dipodomys heermanni morroensis*	CA	V	Endangered
Morro manzanita	*Arctostaphylos morroensis*	CA	P	Threatened
Morro shoulderband (=Banded dune) snail	*Helminthoglypta walkeriana*	CA	I	Endangered
Mount Graham red squirrel	*Tamiasciurus hudsonicus grahamensis*	AZ	V	Endangered
Mount Hermon june beetle	*Polyphylla barbata*	CA	I	Endangered
Mountain golden heather	*Hudsonia montana*	NC	P	Threatened
Mountain sweet pitcher-plant	*Sarracenia rubra ssp. jonesii*	NC, SC	P	Endangered
Mountain yellow-legged frog	*Rana muscosa*	CA	V	Endangered
Mucket, Neosho	*Lampsilis rafinesqueana*	AR, KS, MO, OK	I	PE
Munz's onion	*Allium munzii*	CA	P	Endangered
Myrtle's silverspot butterfly	*Speyeria zerene myrtleae*	CA	I	Endangered
Na Pali beach hedyotis	*Hedyotis st.-johnii*	HI	P	Endangered
Na`ena`e	*Dubautia herbstobatae*	HI	P	Endangered
Na`ena`e	*Dubautia imbricata imbricata*	HI	P	Endangered
Na`ena`e	*Dubautia latifolia*	HI	P	Endangered

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Na`ena`e	*Dubautia pauciflorula*	HI	P	Endangered
Na`ena`e	*Dubautia plantaginea magnifolia*	HI	P	Endangered
Na`ena`e	*Dubautia plantaginea ssp. humilis*	HI	P	Endangered
Na`ena`e	*Dubautia waialealae*	HI	P	Endangered
Naenae	*Dubautia kalalauensis*	HI	P	Endangered
Naenae	*Dubautia kenwoodii*	HI	P	Endangered
Nani wai`ale`ale	*Viola kauaiensis var. wahiawaensis*	HI	P	Endangered
Nanu	*Gardenia mannii*	HI	P	Endangered
Napa bluegrass	*Poa napensis*	CA	P	Endangered
Narrow pigtoe	*Fusconaia escambia*	AL, FL	I	Proposed Threatened
Nashville crayfish	*Orconectes shoupi*	TN	I	Endangered
Navajo sedge	*Carex specuicola*	AZ, UT	P	Threatened
Navasota ladies'-tresses	*Spiranthes parksii*	TX	P	Endangered
Nehe	*Lipochaeta fauriei*	HI	P	Endangered
Nehe	*Lipochaeta kamolensis*	HI	P	Endangered
Nehe	*Lipochaeta lobata var. leptophylla*	HI	P	Endangered
Nehe	*Lipochaeta micrantha*	HI	P	Endangered
Nehe	*Lipochaeta tenuifolia*	HI	P	Endangered
Nehe	*Lipochaeta waimeaensis*	HI	P	Endangered
Nellie cory cactus	*Coryphantha minima*	TX	P	Endangered
Nelson's checker-mallow	*Sidalcea nelsoniana*	OR, WA	P	Threatened
Neosho madtom	*Noturus placidus*	KS, MO, OK	V	Threatened
Nevin's barberry	*Berberis nevinii*	CA	P	Endangered
New Mexican ridge-nosed rattlesnake	*Crotalus willardi obscurus*	AZ, NM	V	Threatened
Newcomb's snail	*Erinna newcombi*	HI	I	Threatened
Newell's Townsend's shearwater	*Puffinus auricularis newelli*	HI	V	Threatened
Niangua darter	*Etheostoma nianguae*	MO	V	Threatened

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Nichol's Turk's head cactus	*Echinocactus horizonthalonius var. nicholii*	AZ	P	Endangered
Nihoa finch (honeycreeper)	*Telespyza ultima*	HI	V	Endangered
Nihoa millerbird (old world warbler)	*Acrocephalus familiaris kingi*	HI	V	Endangered
Nioi	*Eugenia koolauensis*	HI	P	Endangered
Nipomo Mesa lupine	*Lupinus nipomensis*	CA	P	Endangered
No common name	*Abutilon eremitopetalum*	HI	P	Endangered
No common name	*Abutilon sandwicense*	HI	P	Endangered
No common name	*Achyranthes mutica*	HI	P	Endangered
No common name	*Adiantum vivesii*	PR	P	Endangered
No common name	*Alsinidendron obovatum*	HI	P	Endangered
No common name	*Alsinidendron trinerve*	HI	P	Endangered
No common name	*Alsinidendron viscosum*	HI	P	Endangered
No common name	*Amaranthus brownii*	HI	P	Endangered
No common name	*Aristida chaseae*	PR	P	Endangered
No common name	*Asplenium fragile var. insulare*	HI	P	Endangered
No common name	*Auerodendron pauciflorum*	PR	P	Endangered
No common name	*Bonamia menziesii*	HI	P	Endangered
No common name	*Calyptranthes thomasiana*	PR	P	Endangered
No common name	*Catesbaea melanocarpa*	PR	P	Endangered
No common name	*Chamaecrista glandulosa var. mirabilis*	PR	P	Endangered
No common name	*Chamaesyce halemanui*	HI	P	Endangered
No common name	*Cordia bellonis*	PR	P	Endangered
No common name	*Cranichis ricartii*	PR	P	Endangered
No common name	*Cyanea purpurellifolia*	HI	P	Proposed Endangered
No common name	*Cyanea (=Rollandia) crispa*	HI	P	Endangered
No common name	*Cyrtandra gracilis*	HI	P	Proposed Endangered
No common name	*Cyrtandra waiolani*	HI	P	Proposed Endangered
No common name	*Daphnopsis hellerana*	PR	P	Endangered
No common name	*Delissea rhytidosperma*	HI	P	Endangered

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No common name	*Delissea undulata*	HI	P	Endangered
No common name	*Diellia falcata*	HI	P	Endangered
No common name	*Diellia mannii*	HI	P	Endangered
No common name	*Diellia pallida*	HI	P	Endangered
No common name	*Diellia unisora*	HI	P	Endangered
No common name	*Diplazium molokaiense*	HI	P	Endangered
No common name	*Doryopteris angelica*	HI	P	Endangered
No common name	*Doryopteris takeuchii*	HI	P	Proposed Endangered
No common name	*Elaphoglossum serpens*	PR	P	Endangered
No common name	*Eugenia woodburyana*	PR	P	Endangered
No common name	*Gahnia lanaiensis*	HI	P	Endangered
No common name	*Geocarpon minimum*	AR, LA, MO, TX	P	Threatened
No common name	*Gesneria pauciflora*	PR	P	Threatened
No common name	*Gouania hillebrandii*	HI	P	Endangered
No common name	*Gouania meyenii*	HI	P	Endangered
No common name	*Gouania vitifolia*	HI	P	Endangered
No common name	*Hedyotis degeneri*	HI	P	Endangered
No common name	*Hedyotis parvula*	HI	P	Endangered
No common name	*Hesperomannia arborescens*	HI	P	Endangered
No common name	*Hesperomannia arbuscula*	HI	P	Endangered
No common name	*Hesperomannia lydgatei*	HI	P	Endangered
No common name	*Ilex sintenisii*	PR	P	Endangered
No common name	*Keysseria (=Lagenifera) erici*	HI	P	Endangered
No common name	*Keysseria (=Lagenifera) helenae*	HI	P	Endangered
No common name	*Lepanthes eltoroensis*	PR	P	Endangered
No common name	*Leptocereus grantianus*	PR	P	Endangered
No common name	*Lipochaeta venosa*	HI	P	Endangered
No common name	*Lobelia gaudichaudii ssp. koolauensis*	HI	P	Endangered
No common name	*Lobelia monostachya*	HI	P	Endangered
No common name	*Lobelia niihauensis*	HI	P	Endangered
No common name	*Lobelia oahuensis*	HI	P	Endangered
No common name	*Lyonia truncata var. proctorii*	PR	P	Endangered

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No common name	*Lysimachia filifolia*	HI	P	Endangered
No common name	*Lysimachia iniki*	HI	P	Endangered
No common name	*Lysimachia lydgatei*	HI	P	Endangered
No common name	*Lysimachia maxima*	HI	P	Endangered
No common name	*Lysimachia pendens*	HI	P	Endangered
No common name	*Lysimachia scopulensis*	HI	P	Endangered
No common name	*Lysimachia venosa*	HI	P	Endangered
No common name	*Mariscus fauriei*	HI	P	Endangered
No common name	*Mariscus pennatiformis*	HI	P	Endangered
No common name	*Mitracarpus maxwelliae*	PR	P	Endangered
No common name	*Mitracarpus polycladus*	PR	P	Endangered
No common name	*Munroidendron racemosum*	HI	P	Endangered
No common name	*Myrcia paganii*	PR	P	Endangered
No common name	*Neraudia angulata*	HI	P	Endangered
No common name	*Neraudia ovata*	HI	P	Endangered
No common name	*Neraudia sericea*	HI	P	Endangered
No common name	*Phyllostegia glabra var. lanaiensis*	HI	P	Endangered
No common name	*Phyllostegia hirsuta*	HI	P	Endangered
No common name	*Phyllostegia hispida*	HI	P	Endangered
No common name	*Phyllostegia kaalaensis*	HI	P	Endangered
No common name	*Phyllostegia knudsenii*	HI	P	Endangered
No common name	*Phyllostegia mannii*	HI	P	Endangered
No common name	*Phyllostegia mollis*	HI	P	Endangered
No common name	*Phyllostegia parviflora*	HI	P	Endangered
No common name	*Phyllostegia renovans*	HI	P	Endangered
No common name	*Phyllostegia velutina*	HI	P	Endangered
No common name	*Phyllostegia waimeae*	HI	P	Endangered
No common name	*Phyllostegia warshaueri*	HI	P	Endangered
No common name	*Phyllostegia wawrana*	HI	P	Endangered
No common name	*Platanthera holochila*	HI	P	Endangered
No common name	*Platydesma cornuta cornuta*	HI	P	Proposed Endangered
No common name	*Platydesma cornuta decurrens*	HI	P	Proposed Endangered
No common name	*Poa siphonoglossa*	HI	P	Endangered

Common Name	Scientific Name	Current Distribution	Vertebrate (V) Invertebrate (I) Plant (P)	Listing Status
No common name	*Polystichum calderonense*	PR	P	Endangered
No common name	*Pteris lidgatei*	HI	P	Endangered
No common name	*Remya kauaiensis*	HI	P	Endangered
No common name	*Remya montgomeryi*	HI	P	Endangered
No common name	*Sanicula mariversa*	HI	P	Endangered
No common name	*Sanicula purpurea*	HI	P	Endangered
No common name	*Schiedea attenuata*	HI	P	Endangered
No common name	*Schiedea haleakalensis*	HI	P	Endangered
No common name	*Schiedea helleri*	HI	P	Endangered
No common name	*Schiedea hookeri*	HI	P	Endangered
No common name	*Schiedea kaalae*	HI	P	Endangered
No common name	*Schiedea kauaiensis*	HI	P	Endangered
No common name	*Schiedea lydgatei*	HI	P	Endangered
No common name	*Schiedea membranacea*	HI	P	Endangered
No common name	*Schiedea nuttallii*	HI	P	Endangered
No common name	*Schiedea sarmentosa*	HI	P	Endangered
No common name	*Schiedea spergulina var. leiopoda*	HI	P	Endangered
No common name	*Schiedea spergulina var. spergulina*	HI	P	Threatened
No common name	*Schiedea verticillata*	HI	P	Endangered
No common name	*Schoepfia arenaria*	PR	P	Threatened
No common name	*Silene alexandri*	HI	P	Endangered
No common name	*Silene hawaiiensis*	HI	P	Threatened
No common name	*Silene lanceolata*	HI	P	Endangered
No common name	*Silene perlmanii*	HI	P	Endangered
No common name	*Spermolepis hawaiiensis*	HI	P	Endangered
No common name	*Stenogyne angustifolia angustifolia*	HI	P	Endangered
No common name	*Stenogyne bifida*	HI	P	Endangered
No common name	*Stenogyne campanulata*	HI	P	Endangered
No common name	*Stenogyne kanehoana*	HI	P	Endangered
No common name	*Stenogyne kealiae*	HI	P	Endangered
No common name	*Tectaria estremerana*	PR	P	Endangered
No common name	*Ternstroemia subsessilis*	PR	P	Endangered
No common name	*Tetramolopium arenarium*	HI	P	Endangered

Common Name	Scientific Name	Current Distribution	Vertebrate (V) Invertebrate (I) Plant (P)	Listing Status
No common name	*Tetramolopium filiforme*	HI	P	Endangered
No common name	*Tetramolopium lepidotum ssp. lepidotum*	HI	P	Endangered
No common name	*Tetramolopium remyi*	HI	P	Endangered
No common name	*Tetramolopium rockii*	HI	P	Threatened
No common name	*Tetraplasandra bisattenuata*	HI	P	Endangered
No common name	*Tetraplasandra flynnii*	HI	P	Endangered
No common name	*Tetraplasandra lydgatei*	HI	P	Proposed Endangered
No common name	*Thelypteris inabonensis*	PR	P	Endangered
No common name	*Thelypteris verecunda*	PR	P	Endangered
No common name	*Thelypteris yaucoensis*	PR	P	Endangered
No common name	*Trematolobelia singularis*	HI	P	Endangered
No common name	*Vernonia proctorii*	PR	P	Endangered
No common name	*Vigna o-wahuensis*	HI	P	Endangered
No common name	*Viola helenae*	HI	P	Endangered
No common name	*Viola lanaiensis*	HI	P	Endangered
No common name	*Viola oahuensis*	HI	P	Endangered
No common name	*Xylosma crenatum*	HI	P	Endangered
No common name	*Cyanea profuga*	HI	P	PE
No common name	*Festuca molokaiensis*	HI	P	PE
No common name	*Phyllostegia bracteata*	HI	P	PE
No common name	*Phyllostegia floribunda*	HI	P	PE
No common name	*Phyllostegia haliakalae*	HI	P	PE
No common name	*Phyllostegia pilosa*	HI	P	PE
No common name	*Pittosporum halophilum*	HI	P	PE
No common name	*Pittosporum hawaiiense*	HI	P	PE
No common name	*Platydesma remyi*	HI	P	PE
No common name	*Schiedea jacobii*	HI	P	PE
No common name	*Schiedea laui*	HI	P	PE
No common name	*Schiedea salicaria*	HI	P	PE
No common name	*Stenogyne cranwelliae*	HI	P	PE
No common name	*Stenogyne kauaulaensis*	HI	P	PE
No common name	*Wikstroemia villosa*	HI	P	PE
Noel's amphipod	*Gammarus desperatus*	NM	I	Endangered
Nohoanu	*Geranium kauaiense*	HI	P	Endangered

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Nohoanu	*Geranium multiflorum*	HI	P	Endangered
Nohoanu	*Geranium hanaense*	HI	P	PE
Nohoanu	*Geranium hillebrandii*	HI	P	PE
Noonday snail	*Mesodon clarki nantahala*	NC	I	Threatened
North American green sturgeon	*Acipenser medirostris*	CA, OR, WA	V	Threatened
North Atlantic right whale	*Eubalaena glacialis*	CT, DE, FL, GA, MA, MD, ME, NC, NJ, NY, RI, SC, VA	V	Endangered
North Pacific right whale	*Eubalaena japonica*	NA[1]	V	Endangered
North Park phacelia	*Phacelia formosula*	CO	P	Endangered
Northeastern beach tiger beetle	*Cicindela dorsalis dorsalis*	MA, MD, NJ, VA	I	Threatened
Northeastern bulrush	*Scirpus ancistrochaetus*	MA, MD, NH, NY, PA, VA, VT, WV	P	Endangered
Northern aplomado falcon	*Falco femoralis septentrionalis*	TX	V	Endangered
Northern Idaho ground squirrel	*Spermophilus brunneus brunneus*	ID	V	Threatened
Northern riffleshell	*Epioblasma torulosa rangiana*	IN, KY, MI, OH, PA, WV	I	Endangered
Northern spotted owl	*Strix occidentalis caurina*	CA, OR, WA	V	Threatened
Northern wild monkshood	*Aconitum noveboracense*	IA, NY, OH, WI	P	Threatened
nui, haha	*Cyanea horrida*	HI	P	PE
Nukupu`u (honeycreeper)	*Hemignathus lucidus*	HI	V	Endangered
Oahu creeper	*Paroreomyza maculata*	HI	V	Endangered
Oahu elepaio	*Chasiempis sandwichensis ibidis*	HI	V	Endangered
Oahu tree snails	*Achatinella spp.*	HI	I	Endangered
Oahu wild coffee (=kopiko)	*Psychotria hexandra ssp. oahuensis var. oahuensis*	HI	P	Proposed Endangered

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Oceanic Hawaiian damselfly	*Megalagrion oceanicum*	HI	I	Proposed dangered
Ocelot	*Leopardus (=Felis) pardalis*	AZ, TX	V	Endangered
Ochlockonee moccasinshell	*Medionidus simpsonianus*	FL, GA	I	Endangered
Oha	*Delissea rivularis*	HI	P	Endangered
Oha	*Delissea subcordata*	HI	P	Endangered
Ohai	*Sesbania tomentosa*	HI	P	Endangered
Ohlone tiger beetle	*Cicindela ohlone*	CA	I	Endangered
Okaloosa darter	*Etheostoma okaloosae*	FL	V	Threatened
Okeechobee gourd	*Cucurbita okeechobeensis ssp. okeechobeensis*	FL	P	Endangered
Olive ridley sea turtle	*Lepidochelys olivacea*	CA, HI	V	Threatened
Olulu	*Brighamia insignis*	HI	P	Endangered
Opuhe	*Urera kaalae*	HI	P	Endangered
Orangefoot pimpleback (pearlymussel)	*Plethobasus cooperianus*	AL, IL, IN, KY, PA, TN	I	Endangered
Orangenacre mucket	*Lampsilis perovalis*	AL, MS	I	Threatened
Orcutt's spineflower	*Chorizanthe orcuttiana*	CA	P	Endangered
Oregon chub	*Oregonichthys crameri*	OR	V	Threatened
Oregon silverspot butterfly	*Speyeria zerene hippolyta*	CA, OR	I	Threatened
Osterhout milk-vetch	*Astragalus osterhoutii*	CO	P	Endangered
Otay mesa-mint	*Pogogyne nudiuscula*	CA	P	Endangered
Otay tarplant	*Deinandra (=Hemizonia) conjugens*	CA	P	Threatened
Ouachita rock pocketbook	*Arkansia wheeleri*	AR, OK	I	Endangered
Oval pigtoe	*Pleurobema pyriforme*	AL, FL, GA	I	Endangered
Ovate clubshell	*Pleurobema perovatum*	AL, MS, TN	I	Endangered
Owens pupfish	*Cyprinodon radiosus*	CA	V	Endangered
Owens tui chub	*Gila bicolor ssp. snyderi*	CA	V	Endangered
Oyster mussel	*Epioblasma capsaeformis*	AL, KY, TN, VA	I	Endangered
Ozark big-eared bat	*Corynorhinus (=Plecotus) townsendii ingens*	AR, MO, OK	V	Endangered

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Ozark cavefish	Amblyopsis rosae	AR, MO, OK	V	Threatened
Ozark hellbender	Cryptobranchus alleganiensis bishopi	AR, MO	V	Endangered
Pa`iniu	Astelia waialealae	HI	P	Endangered
Pacific eulachon	Thaleichthys pacificus	NA[1]	V	Threatened
Pacific Hawaiian damselfly	Megalagrion pacificum	HI	I	Endangered
Pacific pocket mouse	Perognathus longimembris pacificus	CA	V	Endangered
Pagosa skyrocket	Ipomopsis polyantha	CO	P	Endangered
Pahranagat roundtail chub	Gila robusta jordani	NV	V	Endangered
Pahrump poolfish	Empetrichthys latos	NV	V	Endangered
Painted rocksnail	Leptoxis taeniata	AL	I	Threatened
Painted snake coiled forest snail	Anguispira picta	TN	I	Threatened
Paiute cutthroat trout	Oncorhynchus clarki seleniris	CA	V	Threatened
Palapalai aumakua	Dryopteris crinalis var. podosorus	HI	P	Endangered
Pale lilliput (pearlymussel)	Toxolasma cylindrellus	AL, TN	I	Endangered
Palezone shiner	Notropis albizonatus	AL, KY	V	Endangered
Palila (honeycreeper)	Loxioides bailleui	HI	V	Endangered
Pallid manzanita	Arctostaphylos pallida	CA	P	Threatened
Pallid sturgeon	Scaphirhynchus albus	AR, IA, IL, KS, KY, LA, MO, MS, MT, ND, NE, SD, TN	V	Endangered
Palma de manaca	Calyptronoma rivalis	PR	P	Threatened
Palmate-bracted bird's beak	Cordylanthus palmatus	CA	P	Endangered
Palo colorado	Ternstroemia luquillensis	PR	P	Endangered
Palo de jazmin	Styrax portoricensis	PR	P	Endangered
Palo de nigua	Cornutia obovata	PR	P	Endangered
Palo de ramon	Banara vanderbiltii	PR	P	Endangered
Palo de rosa	Ottoschulzia rhodoxylon	PR	P	Endangered

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Palos Verdes blue butterfly	*Glaucopsyche lygdamus palosverdesensis*	CA	I	Endangered
Pamakani	*Tetramolopium capillare*	HI	P	Endangered
Pamakani	*Viola chamissoniana ssp. chamissoniana*	HI	P	Endangered
Papala	*Charpentiera densiflora*	HI	P	Endangered
Papery whitlow-wort	*Paronychia chartacea*	FL	P	Threatened
Parachute beardtongue	*Penstemon debilis*	CO	P	Threatened
Pariette cactus	*Sclerocactus brevispinus*	UT	P	Threatened
Parish's daisy	*Erigeron parishii*	CA	P	Threatened
Pauoa	*Ctenitis squamigera*	HI	P	Endangered
Pawnee montane skipper	*Hesperia leonardus montana*	CO	I	Threatened
Pearlymussel, birdwing	*Lemiox rimosus*	TN, VA	I	EXPN
Pearlymussel, slabside	*Lexingtonia dolabelloides*	AL, KY, MS, TN, VA	I	PE
Peck's cave amphipod	*Stygobromus (=Stygonectes) pecki*	TX	I	Endangered
Pecos (=puzzle, =paradox) sunflower	*Helianthus paradoxus*	NM, TX	P	Threatened
Pecos assiminea snail	*Assiminea pecos*	NM, TX	I	Endangered
Pecos bluntnose shiner	*Notropis simus pecosensis*	NM	V	Threatened
Pecos gambusia	*Gambusia nobilis*	NM, TX	V	Endangered
Pedate checker-mallow	*Sidalcea pedata*	CA	P	Endangered
Peebles Navajo cactus	*Pediocactus peeblesianus var. peeblesianus*	AZ	P	Endangered
Peirson's milk-vetch	*Astragalus magdalenae var. peirsonii*	CA	P	Threatened
Pelos del diablo	*Aristida portoricensis*	PR	P	Endangered
Pendant kihi fern	*Adenophorus periens*	HI	P	Endangered
Peninsular bighorn sheep	*Ovis canadensis nelsoni*	CA	V	Endangered
Penland alpine fen mustard	*Eutrema penlandii*	CO	P	Threatened
Penland beardtongue	*Penstemon penlandii*	CO	P	Endangered
Pennell's bird's-beak	*Cordylanthus tenuis ssp. capillaris*	CA	P	Endangered

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Perdido Key beach mouse	*Peromyscus polionotus trissyllepsis*	AL, FL	V	Endangered
Persistent trillium	*Trillium persistens*	GA, SC	P	Endangered
Peter's Mountain mallow	*Iliamna corei*	VA	P	Endangered
Pigeon wings	*Clitoria fragrans*	FL	P	Threatened
Pilo	*Hedyotis mannii*	HI	P	Endangered
Pilo kea lau li`i	*Platydesma rostrata*	HI	P	Endangered
Pima pineapple cactus	*Coryphantha scheeri var. robustispina*	AZ	P	Endangered
Pine Hill ceanothus	*Ceanothus roderickii*	CA	P	Endangered
Pine Hill flannelbush	*Fremontodendron californicum ssp. decumbens*	CA	P	Endangered
Pink mucket (pearlymussel)	*Lampsilis abrupta*	AL, AR, IL, IN, KY, LA, MO, OH, PA, TN, VA, WV	I	Endangered
Piping plover	*Charadrius melodus*	AL, AR, CO, CT, DE, FL, IA, KS, LA, MA, MD, ME, MT, NC, ND, NE, NH, NJ, NM, NY, OK, RI, SC, SD, TX, VA	V	Threatened
Piping plover	*Charadrius melodus*	IL, IN, MI, MN, MS, NY, OH, PA, WI	V	Endangered
Pismo clarkia	*Clarkia speciosa ssp. immaculata*	CA	P	Endangered
Pitcher's thistle	*Cirsium pitcheri*	IL, IN, MI, WI	P	Threatened
Pitkin marsh lily	*Lilium pardalinum ssp. pitkinense*	CA	P	Endangered
Plicate rocksnail	*Leptoxis plicata*	AL	I	Endangered
Plymouth red-bellied turtle	*Pseudemys rubriventris bangsi*	MA	V	Endangered
Po`e	*Portulaca sclerocarpa*	HI	P	Endangered
Po`ouli (honeycreeper)	*Melamprosops phaeosoma*	HI	V	Endangered

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Pocket gopher, Olympia	*Thomomys mazama pugetensis*	WA	V	PT
Pocket gopher, Roy Prairie	*Thomomys mazama glacialis*	WA	V	PT
Pocket gopher, Tenino	*Thomomys mazama tumuli*	WA	V	PT
Pocket gopher, Yelm	*Thomomys mazama yelmensis*	WA	V	PT
Point Arena mountain beaver	*Aplodontia rufa nigra*	CA	V	Endangered
pomace fly [Unnamed]	*Drosophila aglaia*	HI	I	Endangered
pomace fly [Unnamed]	*Drosophila differens*	HI	I	Endangered
pomace fly [Unnamed]	*Drosophila hemipeza*	HI	I	Endangered
pomace fly [Unnamed]	*Drosophila heteroneura*	HI	I	Endangered
pomace fly [Unnamed]	*Drosophila montgomeryi*	HI	I	Endangered
pomace fly [Unnamed]	*Drosophila mulli*	HI	I	Threatened
pomace fly [Unnamed]	*Drosophila musaphila*	HI	I	Endangered
pomace fly [Unnamed]	*Drosophila neoclavisetae*	HI	I	Endangered
pomace fly [Unnamed]	*Drosophila obatai*	HI	I	Endangered
pomace fly [Unnamed]	*Drosophila ochrobasis*	HI	I	Endangered
pomace fly [Unnamed]	*Drosophila substenoptera*	HI	I	Endangered
pomace fly [Unnamed]	*Drosophila tarphytrichia*	HI	I	Endangered
Pondberry	*Lindera melissifolia*	AL, AR, GA, MO, MS, NC, SC	P	Endangered
Popolo	*Cyanea solanacea*	HI	P	PE
Popolo ku mai	*Solanum incompletum*	HI	P	Endangered
Prairie bush-clover	*Lespedeza leptostachya*	IA, IL, MN, WI	P	Threatened
Prairie-chicken, lesser	*Tympanuchus pallidicinctus*	CO, KS, NM, OK, TX	V	PT
Preble's meadow jumping mouse	*Zapus hudsonius preblei*	CO, WY	V	Threatened
Presidio clarkia	*Clarkia franciscana*	CA	P	Endangered
Presidio manzanita	*Arctostaphylos hookeri var. ravenii*	CA	P	Endangered
Price's potato-bean	*Apios priceana*	AL, IL, KY, MS, TN	P	Threatened
Prickly-apple, aboriginal	*Harrisia (=Cereus) aboriginum (=gracilis)*	FL	P	PE
Pu`uka`a	*Cyperus trachysanthos*	HI	P	Endangered

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Pua `ala	*Brighamia rockii*	HI	P	Endangered
Puerto Rican boa	*Epicrates inornatus*	PR	V	Endangered
Puerto Rican broad-winged hawk	*Buteo platypterus brunnescens*	PR	V	Endangered
Puerto Rican crested toad	*Peltophryne lemur*	PR	V	Threatened
Puerto Rican nightjar	*Caprimulgus noctitherus*	PR	V	Endangered
Puerto Rican parrot	*Amazona vittata*	PR	V	Endangered
Puerto Rican plain Pigeon	*Columba inornata wetmorei*	PR	V	Endangered
Puerto Rican sharp-shinned hawk	*Accipiter striatus venator*	PR	V	Endangered
Puritan tiger beetle	*Cicindela puritana*	CT, MA, MD	I	Threatened
Purple amole	*Chlorogalum purpureum*	CA	P	Threatened
Purple bankclimber (mussel)	*Elliptoideus sloatianus*	AL, FL, GA	I	Threatened
Purple bean	*Villosa perpurpurea*	TN, VA	I	Endangered
purple cat's paw (=purple cat's paw pearlymussel)	*Epioblasma obliquata obliquata*	AL, KY, OH, TN	I	Endangered
Pygmy fringe-tree	*Chionanthus pygmaeus*	FL	P	Endangered
Pygmy madtom	*Noturus stanauli*	TN	V	Endangered
Pygmy rabbit	*Brachylagus idahoensis*	WA	V	Endangered
Pygmy sculpin	*Cottus paulus (=pygmaeus)*	AL	V	Threatened
Quino checkerspot butterfly	*Euphydryas editha quino (=E. e. wrighti)*	CA	I	Endangered
Rabbitsfoot	*Quadrula cylindrica cylindrica*	AL, AR, IL, IN, KS, KY, LA, MS, MO, OH, OK, PA, TN	I	PT
Ragwort, San Francisco Peaks	*Packera franciscana*	AZ	P	T
Railroad Valley springfish	*Crenichthys nevadae*	NV	V	Threatened
Rayed bean	*Villosa fabalis*	IN, MI, NY, OH, PA, VA	I	Endangered

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Razorback sucker	*Xyrauchen texanus*	AZ, CA, CO, NM, NV, UT	V	Endangered
Red Hills salamander	*Phaeognathus hubrichti*	AL	V	Threatened
Red Hills vervain	*Verbena californica*	CA	P	Threatened
Red wolf	*Canis rufus*	FL, NC, SC	V	Endangered
Red-cockaded woodpecker	*Picoides borealis*	AL, AR, FL, GA, LA, MO, MS, NC, OK, SC, TX, VA	V	Endangered
Reedgrass, Hillegrand's	*Calamagrostis hillebrandii*	HI	P	PE
Relict darter	*Etheostoma chienense*	KY	V	Endangered
Relict trillium	*Trillium reliquum*	AL, GA, SC	P	Endangered
Reticulated flatwoods salamander	*Ambystoma bishopi*	FL, GA	V	Endangered
Rice rat	*Oryzomys palustris natator*	FL	V	Endangered
Ring pink (mussel)	*Obovaria retusa*	AL, KY, PA, TN	I	Endangered
Ringed map turtle	*Graptemys oculifera*	LA, MS	V	Threatened
Rio Grande silvery minnow	*Hybognathus amarus*	NM	V	Endangered
Riparian brush rabbit	*Sylvilagus bachmani riparius*	CA	V	Endangered
Riparian woodrat (=San Joaquin Valley)	*Neotoma fuscipes riparia*	CA	V	Endangered
Riverside fairy shrimp	*Streptocephalus woottoni*	CA	I	Endangered
Roan Mountain bluet	*Hedyotis purpurea var. montana*	NC, TN	P	Endangered
Roanoke logperch	*Percina rex*	VA	V	Endangered
Robber Baron cave meshweaver	*Cicurina baronia*	TX	I	Endangered
Robust (incl. Scotts Valley) spineflower	*Chorizanthe robusta (incl. vars. robusta and hartwegii)*	CA	P	Endangered
Rock gnome lichen	*Gymnoderma lineare*	NC, SC, TN, VA	P	Endangered
Roseate tern	*Sterna dougallii dougallii*	CT, MA, ME, NC, NH, NJ, NY, RI, VA	V	Endangered
Roseate tern	*Sterna dougallii dougallii*	FL, NC, PR, SC	V	Threatened

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Rose-mallow, Neches River	*Hibiscus dasycalyx*	TX	P	PT
Roswell springsnail	*Pyrgulopsis roswellensis*	NM	I	Endangered
Rough hornsnail	*Pleurocera foremani*	AL	I	Endangered
Rough pigtoe	*Pleurobema plenum*	AL, IN, KY, PA, TN, VA	I	Endangered
rough popcornflower	*Plagiobothrys hirtus*	OR	P	Endangered
Rough rabbitsfoot	*Quadrula cylindrica strigillata*	TN, VA	I	Endangered
Rough-leaved loosestrife	*Lysimachia asperulaefolia*	NC, SC	P	Endangered
Round Ebonyshell	*Fusconaia rotulata*	AL, FL	I	Proposed Endangered
Round rocksnail	*Leptoxis ampla*	AL	I	Threatened
Round-leaved chaff-flower	*Achyranthes splendens var. rotundata*	HI	P	Endangered
Royal marstonia (snail)	*Pyrgulopsis ogmorhaphe*	TN	I	Endangered
Rugel's pawpaw	*Deeringothamnus rugelii*	FL	P	Endangered
Running buffalo clover	*Trifolium stoloniferum*	AR, IN, KY, MO, OH, WV	P	Endangered
Rush darter	*Etheostoma phytophilum*	AL	V	Endangered
Ruth's golden aster	*Pityopsis ruthii*	TN	P	Endangered
Sacramento Mountains thistle	*Cirsium vinaceum*	NM	P	Threatened
Sacramento Orcutt grass	*Orcuttia viscida*	CA	P	Endangered
Sacramento prickly poppy	*Argemone pleiacantha ssp. pinnatisecta*	NM	P	Endangered
sage-grouse, Gunnison	*Centrocercus minimus*	CO, UT	V	PE
Saint Francis' satyr butterfly	*Neonympha mitchellii francisci*	NC	I	Endangered
Salamander, Austin blind	*Eurycea waterlooensis*	TX	V	PE
Salamander, Georgetown	*Eurycea naufragia*	TX	V	PE
Salamander, Jemez Mountains	*Plethodon neomexicanus*	NM	V	PE

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Salamander, Jollyville Plateau	*Eurycea tonkawae*	TX	V	PE
Salamander, Salado	*Eurycea chisholmensis*	TX	V	PE
Salt Creek tiger beetle	*Cicindela nevadica lincolniana*	NE	I	Endangered
Salt marsh bird's-beak	*Cordylanthus maritimus ssp. maritimus*	CA	P	Endangered
Salt marsh harvest mouse	*Reithrodontomys raviventris*	CA	V	Endangered
San Benito evening-primrose	*Camissonia benitensis*	CA	P	Threatened
San Bernardino bluegrass	*Poa atropurpurea*	CA	P	Endangered
San Bernardino Merriam's kangaroo rat	*Dipodomys merriami parvus*	CA	V	Endangered
San Bernardino Mountains bladderpod	*Lesquerella kingii ssp. bernardina*	CA	P	Endangered
San Bernardino springsnail	*Pyrgulopsis bernardina*	AZ	I	Proposed Endangered
San Bruno elfin butterfly	*Callophrys mossii bayensis*	CA	I	Endangered
San Clemente Island broom	*Lotus dendroideus ssp. traskiae*	CA	P	Endangered
San Clemente Island bush-mallow	*Malacothamnus clementinus*	CA	P	Endangered
San Clemente Island indian paintbrush	*Castilleja grisea*	CA	P	Endangered
San Clemente Island larkspur	*Delphinium variegatum ssp. kinkiense*	CA	P	Endangered
San Clemente Island woodland-star	*Lithophragma maximum*	CA	P	Endangered
San Clemente loggerhead shrike	*Lanius ludovicianus mearnsi*	CA	V	Endangered
San Clemente sage sparrow	*Amphispiza belli clementeae*	CA	V	Threatened
San Diego ambrosia	*Ambrosia pumila*	CA	P	Endangered
San Diego button-celery	*Eryngium aristulatum var. parishii*	CA	P	Endangered

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San Diego fairy shrimp	*Branchinecta sandiegonensis*	CA	I	Endangered
San Diego mesa-mint	*Pogogyne abramsii*	CA	P	Endangered
San Diego thornmint	*Acanthomintha ilicifolia*	CA	P	Threatened
San Francisco lessingia	*Lessingia germanorum (=L.g. var. germanorum)*	CA	P	Endangered
San Francisco garter snake	*Thamnophis sirtalis tetrataenia*	CA	V	Endangered
San Francisco manzanita	*Arctostaphylos franciscana*	CA	P	Proposed Endangered
San Francisco Peaks groundsel	*Senecio franciscanus*	AZ	P	Threatened
San Jacinto Valley crownscale	*Atriplex coronata var. notatior*	CA	P	Endangered
San Joaquin adobe sunburst	*Pseudobahia peirsonii*	CA	P	Threatened
San Joaquin kit fox	*Vulpes macrotis mutica*	CA	V	Endangered
San Joaquin Orcutt grass	*Orcuttia inaequalis*	CA	P	Threatened
San Joaquin wooly-threads	*Monolopia (=Lembertia) congdonii*	CA	P	Endangered
San Marcos salamander	*Eurycea nana*	TX	V	Threatened
San Marcos gambusia	*Gambusia georgei*	TX	V	Endangered
San Mateo thornmint	*Acanthomintha obovata ssp. duttonii*	CA	P	Endangered
San Mateo woolly sunflower	*Eriophyllum latilobum*	CA	P	Endangered
San Miguel Island fox	*Urocyon littoralis littoralis*	CA	V	Endangered
San Rafael cactus	*Pediocactus despainii*	UT	P	Endangered
Sand skink	*Neoseps reynoldsi*	FL	V	Threatened
Sandlace	*Polygonella myriophylla*	FL	P	Endangered
Sandplain gerardia	*Agalinis acuta*	CT, MA, MD, NY, RI	P	Endangered
Santa Ana River woolly-star	*Eriastrum densifolium ssp. sanctorum*	CA	P	Endangered
Santa Ana sucker	*Catostomus santaanae*	CA	V	Threatened

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Santa Barbara Island liveforever	*Dudleya traskiae*	CA	P	Endangered
Santa Catalina Island fox	*Urocyon littoralis catalinae*	CA	V	Endangered
Santa Clara Valley dudleya	*Dudleya setchellii*	CA	P	Endangered
Santa Cruz cypress	*Cupressus abramsiana*	CA	P	Endangered
Santa Cruz Island bush-mallow	*Malacothamnus fasciculatus var. nesioticus*	CA	P	Endangered
Santa Cruz Island dudleya	*Dudleya nesiotica*	CA	P	Threatened
Santa Cruz Island fox	*Urocyon littoralis santacruzae*	CA	V	Endangered
Santa Cruz Island fringepod	*Thysanocarpus conchuliferus*	CA	P	Endangered
Santa Cruz Island malacothrix	*Malacothrix indecora*	CA	P	Endangered
Santa Cruz Island rockcress	*Sibara filifolia*	CA	P	Endangered
Santa Cruz long-toed salamander	*Ambystoma macrodactylum croceum*	CA	V	Endangered
Santa Cruz tarplant	*Holocarpha macradenia*	CA	P	Threatened
Santa Monica Mountains dudleyea	*Dudleya cymosa ssp. ovatifolia*	CA	P	Threatened
Santa Rosa Island fox	*Urocyon littoralis santarosae*	CA	V	Endangered
Santa Rosa Island manzanita	*Arctostaphylos confertiflora*	CA	P	Endangered
Scaleshell mussel	*Leptodea leptodon*	AR, MO, NE, OK, SD	I	Endangered
Schaus swallowtail butterfly	*Heraclides aristodemus ponceanus*	FL	I	Endangered
Schweinitz's sunflower	*Helianthus schweinitzii*	NC, SC	P	Endangered
Scioto madtom	*Noturus trautmani*	OH	V	Endangered
Scotts Valley polygonum	*Polygonum hickmanii*	CA	P	Endangered
Scrub blazingstar	*Liatris ohlingerae*	FL	P	Endangered
Scrub buckwheat	*Eriogonum longifolium var. gnaphalifolium*	FL	P	Threatened

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Scrub lupine	Lupinus aridorum	FL	P	Endangered
Scrub mint	Dicerandra frutescens	FL	P	Endangered
Scrub plum	Prunus geniculata	FL	P	Endangered
Sculpin, grotto	Cottus sp.	MO	V	PE
Seabeach amaranth	Amaranthus pumilus	DE, NC, NJ, NY, SC, VA	P	Threatened
Sebastopol meadowfoam	Limnanthes vinculans	CA	P	Endangered
Sei whale	Balaenoptera borealis	CA, MA	V	Endangered
Sensitive joint-vetch	Aeschynomene virginica	MD, NC, NJ, VA	P	Threatened
Sentry milk-vetch	Astragalus cremnophylax var. cremnophylax	AZ	P	Endangered
Shale barren rockcress	Arabis serotina	VA, WV	P	Endangered
Shasta crayfish	Pacifastacus fortis	CA	I	Endangered
Sheepnose mussel	Plethobasus cyphyus	AL, IA, IL, IN, KY, MN, MO, MS, OH, PA, TN, VA, WI, WV	I	Endangered
Shenandoah salamander	Plethodon shenandoah	VA	V	Endangered
Shiny pigtoe	Fusconaia cor	AL, TN, VA	I	Endangered
Shinyrayed pocketbook	Lampsilis subangulata	AL, FL, GA	I	Endangered
Shivwits milk-vetch	Astragalus ampullarioides	UT	P	Endangered
Short-leaved rosemary	Conradina brevifolia	FL	P	Endangered
Shortnose sturgeon	Acipenser brevirostrum	CT, DE, FL, GA, MA, MD, ME, NC, NJ, NY, PA, RI, SC, VA	V	Endangered
Shortnose sucker	Chasmistes brevirostris	CA, OR	V	Endangered
Short's goldenrod	Solidago shortii	IN, KY	P	Endangered
Short-tailed albatross	Phoebastria (=Diomedea) albatrus	CA, HI, OR, WA	V	Endangered
Showy Indian clover	Trifolium amoenum	CA	P	Endangered
Showy stickseed	Hackelia venusta	WA	P	Endangered

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Shrimp, anchialine pool	*Vetericaris chaceorum*	HI	I	PE
Shrubby reed-mustard	*Schoenocrambe suffrutescens*	UT	P	Endangered
Sierra Nevada bighorn sheep	*Ovis canadensis sierrae*	CA	V	Endangered
Siler pincushion cactus	*Pediocactus (=Echinocactus,=Utahia) sileri*	AZ, UT	P	Threatened
Sinaloan jaguarundi	*Herpailurus (=Felis) yagouaroundi tolteca*	NA[1]	V	Endangered
Slackwater darter	*Etheostoma boschungi*	AL, TN	V	Threatened
Slender campeloma	*Campeloma decampi*	AL	I	Endangered
Slender chub	*Erimystax cahni*	TN, VA	V	Threatened
Slender Orcutt grass	*Orcuttia tenuis*	CA	P	Threatened
Slender rush-pea	*Hoffmannseggia tenella*	TX	P	Endangered
Slender-horned spineflower	*Dodecahema leptoceras*	CA	P	Endangered
Slender-petaled mustard	*Thelypodium stenopetalum*	CA	P	Endangered
Slickspot peppergrass	*Lepidium papilliferum*	ID	P	Threatened
Small Kauai (=puaiohi) thrush	*Myadestes palmeri*	HI	V	Endangered
Small whorled pogonia	*Isotria medeoloides*	CT, DE, GA, IL, MA, ME, MI, MO, NC, NH, NJ, NY, OH, PA, RI, SC, TN, VA, WV	P	Threatened
Small-anthered bittercress	*Cardamine micranthera*	NC, VA	P	Endangered
Small's milkpea	*Galactia smallii*	FL	P	Endangered
Smalltooth sawfish	*Pristis pectinata*	AL, FL, GA, LA, MS, NC, SC, TX	V	Endangered
Smith's blue butterfly	*Euphilotes enoptes smithi*	CA	I	Endangered
Smoky madtom	*Noturus baileyi*	TN	V	Endangered
Smooth coneflower	*Echinacea laevigata*	GA, NC, SC, VA	P	Endangered

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Snail darter	*Percina tanasi*	AL, GA, TN	V	Threatened
Snail, Diamond Y Spring	*Pseudotryonia (=Tryonia) adamantina*	TX	I	PE
Snail, Lanai tree	*Partulina semicarinata*	HI	I	PE
Snail, Lanai tree	*Partulina variabilis*	HI	I	PE
Snail, Phantom Cave	*Cochliopa texana*	TX	I	PE
Snake River physa snail	*Physa natricina*	ID	I	Endangered
Snakeroot	*Eryngium cuneifolium*	FL	P	Endangered
Sneed pincushion cactus	*Coryphantha sneedii var. sneedii*	NM, TX	P	Endangered
Snuffbox mussel	*Epioblasma triquetra*	AL, AR, IL, IN, KY, MI, MN, MO, MS, OH, PA, TN, VA, WI, WV	I	Endangered
Sockeye salmon	*Oncorhynchus (=Salmo) nerka*	OR, WA	V	Endangered
Sockeye salmon	*Oncorhynchus (=Salmo) nerka*	WA	V	Threatened
Socorro isopod	*Thermosphaeroma thermophilus*	NM	I	Endangered
Socorro springsnail	*Pyrgulopsis neomexicana*	NM	I	Endangered
Soft bird's-beak	*Cordylanthus mollis ssp. mollis*	CA	P	Endangered
Soft-leaved paintbrush	*Castilleja mollis*	CA	P	Endangered
Solano grass	*Tuctoria mucronata*	CA	P	Endangered
Sonoma alopecurus	*Alopecurus aequalis var. sonomensis*	CA	P	Endangered
Sonoma spineflower	*Chorizanthe valida*	CA	P	Endangered
Sonoma sunshine	*Blennosperma bakeri*	CA	P	Endangered
Sonora chub	*Gila ditaenia*	AZ	V	Threatened
Sonora tiger Salamander	*Ambystoma tigrinum stebbinsi*	AZ	V	Endangered
Sonoran pronghorn	*Antilocapra americana sonoriensis*	AZ	V	Endangered
South Texas ambrosia	*Ambrosia cheiranthifolia*	TX	P	Endangered

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Southeastern beach mouse	*Peromyscus polionotus niveiventris*	FL	V	Threatened
Southern acornshell	*Epioblasma othcaloogensis*	AL, TN	I	Endangered
Southern clubshell	*Pleurobema decisum*	AL, GA, MS	I	Endangered
Southern combshell	*Epioblasma penita*	AL, MS	I	Endangered
Southern kidneyshell	*Ptychobranchus jonesi*	AL, FL	I	Proposed Endangered
Southern mountain wild-buckwheat	*Eriogonum kennedyi var. austromontanum*	CA	P	Threatened
Southern pigtoe	*Pleurobema georgianum*	AL, GA, TN	I	Endangered
Southern sandshell	*Hamiota (=Lampsilis) australis*	AL, FL	I	Proposed Endangered
Southern sea otter	*Enhydra lutris nereis*	CA	V	Threatened
Southwestern willow flycatcher	*Empidonax traillii extimus*	AZ, CA, CO, NM, NV, TX, UT	V	Endangered
Spalding's catchfly	*Silene spaldingii*	ID, MT, OR, WA	P	Threatened
Speckled pocketbook	*Lampsilis streckeri*	AR	I	Endangered
Spectaclecase (mussel)	*Cumberlandia monodonta*	AL, AR, IA, IL, KS, KY, MN, MO, TN, VA, WI, WV	I	Endangered
Sperm whale	*Physeter catodon (=macrocephalus)*	CA, NC, PR	V	Endangered
Spikedace	*Meda fulgida*	AZ, NM	V	Threatened
Spotfin Chub	*Erimonax monachus*	AL, NC, TN, VA	V	Threatened
Spotted Seal	*Phoca largha*	NA[1]	V	Threatened
Spreading avens	*Geum radiatum*	NC, TN	P	Endangered
Spreading navarretia	*Navarretia fossalis*	CA	P	Threatened
Spring Creek bladderpod	*Lesquerella perforata*	TN	P	Endangered
Spring-loving centaury	*Centaurium namophilum*	CA, NV	P	Threatened
Springsnail (=Tryonia), Phantom	*Tryonia cheatumi*	TX	I	PE

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Springsnail, Gonzales	*Tryonia circumstriata(=stocktonensis)*	TX	I	PE
Springville clarkia	*Clarkia springvillensis*	CA	P	Threatened
Spruce-fir moss spider	*Microhexura montivaga*	NC, TN, VA	I	Endangered
Squirrel Chimney cave shrimp	*Palaemonetes cummingi*	FL	I	Threatened
St. Andrew beach mouse	*Peromyscus polionotus peninsularis*	FL	V	Endangered
St. Thomas prickly-ash	*Zanthoxylum thomasianum*	PR	P	Endangered
Staghorn coral	*Acropora cervicornis*	FL, PR	I	Threatened
Star cactus	*Astrophytum asterias*	TX	P	Endangered
Steamboat buckwheat	*Eriogonum ovalifolium var. williamsiae*	NV	P	Endangered
Stebbins' morning-glory	*Calystegia stebbinsii*	CA	P	Endangered
Steelhead	*Oncorhynchus (=Salmo) mykiss*	CA	V	Endangered
Steelhead	*Oncorhynchus (=Salmo) mykiss*	CA	V	Threatened
Steelhead	*Oncorhynchus (=Salmo) mykiss*	OR	V	Threatened
Steelhead	*Oncorhynchus (=Salmo) mykiss*	OR, WA	V	Threatened
Steelhead	*Oncorhynchus (=Salmo) mykiss*	WA	V	Threatened
Steller sea-lion	*Eumetopias jubatus*	CA, OR, WA	V	Threatened
Stephens' kangaroo rat	*Dipodomys stephensi (incl. D. cascus)*	CA	V	Endangered
Stirrupshell	*Quadrula stapes*	AL, MS	I	Endangered
Stock Island tree snail	*Orthalicus reses (not incl. nesodryas)*	FL	I	Threatened
Sucker, Zuni bluehead	*Catostomus discobolus yarrowi*	AZ, NM	V	PE
Suisun thistle	*Cirsium hydrophilum var. hydrophilum*	CA	P	Endangered
Sunfish, spring pygmy	*Elassoma alabamae*	AL	V	PT
Swamp pink	*Helonias bullata*	DE, GA, MD, NC, NJ, SC, VA	P	Threatened

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Tan riffleshell	*Epioblasma florentina walkeri (=E. walkeri)*	KY, TN, VA	I	Endangered
Tapered pigtoe	*Fusconaia burkei*	AL, FL	I	Proposed reatened
Tar River spinymussel	*Elliptio steinstansana*	NC	I	Endangered
Telephus spurge	*Euphorbia telephioides*	FL	P	Threatened
Tennessee yellow-eyed grass	*Xyris tennesseensis*	AL, GA, TN	P	Endangered
Terlingua Creek cat's-eye	*Cryptantha crassipes*	TX	P	Endangered
Texas ayenia	*Ayenia limitaris*	TX	P	Endangered
Texas blind salamander	*Typhlomolge rathbuni*	TX	V	Endangered
Texas poppy-mallow	*Callirhoe scabriuscula*	TX	P	Endangered
Texas prairie dawn-flower	*Hymenoxys texana*	TX	P	Endangered
Texas snowbells	*Styrax texanus*	TX	P	Endangered
Texas trailing phlox	*Phlox nivalis ssp. texensis*	TX	P	Endangered
Texas wild-rice	*Zizania texana*	TX	P	Endangered
Thoroughwort, Cape Sable	*Chromolaena frustrata*	FL	P	PE
Thread-leaved brodiaea	*Brodiaea filifolia*	CA	P	Threatened
Three Forks springsnail	*Pyrgulopsis trivialis*	AZ	I	Proposed Endangered
Tiburon jewelflower	*Streptanthus niger*	CA	P	Endangered
Tiburon mariposa lily	*Calochortus tiburonensis*	CA	P	Threatened
Tiburon paintbrush	*Castilleja affinis ssp. neglecta*	CA	P	Endangered
Tidewater goby	*Eucyclogobius newberryi*	CA	V	Endangered
Tiger beetle, Coral Pink Sand Dunes	*Cicindela albissima*	UT	I	PT
Tiny polygala	*Polygala smallii*	FL	P	Endangered
Tipton kangaroo rat	*Dipodomys nitratoides nitratoides*	CA	V	Endangered
Tobusch fishhook cactus	*Ancistrocactus tobuschii*	TX	P	Endangered
Todsen's pennyroyal	*Hedeoma todsenii*	NM	P	Endangered

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Tooth Cave ground beetle	*Rhadine persephone*	TX	I	Endangered
Tooth Cave pseudoscorpion	*Tartarocreagris texana*	TX	I	Endangered
Tooth Cave Spider	*Leptoneta myopica*	TX	I	Endangered
Topeka shiner	*Notropis topeka (=tristis)*	IA, KS, MN, MO, NE, SD	V	Endangered
Tree snail, Newcomb's	*Newcombia cumingi*	HI	I	PE
Triangular kidneyshell	*Ptychobranchus greenii*	AL, GA, TN	I	Endangered
Triple-ribbed milk-vetch	*Astragalus tricarinatus*	CA	P	Endangered
Tubercled blossom (pearlymussel)	*Epioblasma torulosa torulosa*	KY, TN, WV	I	Endangered
Tulotoma snail	*Tulotoma magnifica*	AL	I	Threatened
Tumbling Creek cavesnail	*Antrobia culveri*	MO	I	Endangered
Turgid blossom (pearlymussel)	*Epioblasma turgidula*	AL, AR, TN	I	Endangered
Uhiuhi	*Caesalpinia kavaiense*	HI	P	Endangered
Uinta Basin hookless cactus	*Sclerocactus wetlandicus*	UT	P	Threatened
Umtanum Desert buckwheat	*Eriogonum codium*	WA	P	Proposed Threatened
Unarmored threespine stickleback	*Gasterosteus aculeatus williamsoni*	CA	V	Endangered
Uncompahgre fritillary butterfly	*Boloria acrocnema*	CO	I	Endangered
Upland combshell	*Epioblasma metastriata*	AL, TN	I	Endangered
Utah prairie dog	*Cynomys parvidens*	UT	V	Threatened
Ute ladies'-tresses	*Spiranthes diluvialis*	CO, ID, MT, NE, NV, UT, WA, WY	P	Threatened
Uvillo	*Eugenia haematocarpa*	PR	P	Endangered
Vahl's boxwood	*Buxus vahlii*	PR	P	Endangered
Vail Lake ceanothus	*Ceanothus ophiochilus*	CA	P	Threatened
Valley elderberry longhorn beetle	*Desmocerus californicus dimorphus*	CA	I	Threatened

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Ventura marsh milk-vetch	*Astragalus pycnostachyus var. lanosissimus*	CA	P	Endangered
Verity's dudleya	*Dudleya verityi*	CA	P	Threatened
Vermilion darter	*Etheostoma chermocki*	AL	V	Endangered
Vernal pool fairy shrimp	*Branchinecta lynchi*	CA, OR	I	Threatened
Vernal pool tadpole shrimp	*Lepidurus packardi*	CA	I	Endangered
Vine Hill clarkia	*Clarkia imbricata*	CA	P	Endangered
Virgin Islands tree boa	*Epicrates monensis granti*	PR	V	Endangered
Virgin River Chub	*Gila seminuda (=robusta)*	AZ, NV, UT	V	Endangered
Virginia big-eared bat	*Corynorhinus (=Plecotus) townsendii virginianus*	KY, NC, VA, WV	V	Endangered
Virginia fringed mountain snail	*Polygyriscus virginianus*	VA	I	Endangered
Virginia northern flying squirrel	*Glaucomys sabrinus fuscus*	VA, WV	V	Endangered
Virginia round-leaf birch	*Betula uber*	VA	P	Threatened
Virginia sneezeweed	*Helenium virginicum*	MO, VA	P	Threatened
Virginia spiraea	*Spiraea virginiana*	GA, KY, NC, OH, PA, TN, VA, WV	P	Threatened
Waccamaw silverside	*Menidia extensa*	NC	V	Threatened
Wahane	*Pritchardia aylmer-robinsonii*	HI	P	Endangered
Walker's manioc	*Manihot walkerae*	TX	P	Endangered
Warm Springs pupfish	*Cyprinodon nevadensis pectoralis*	NV	V	Endangered
Warner sucker	*Catostomus warnerensis*	NV, OR	V	Threatened
Water howellia	*Howellia aquatilis*	CA, ID, MT, OR, WA	P	Threatened
Watercress darter	*Etheostoma nuchale*	AL	V	Endangered
Wawae`iole	*Huperzia mannii*	HI	P	Endangered
Wawae`iole	*Lycopodium (=Phlegmariurus) nutans*	HI	P	Endangered
Welsh's milkweed	*Asclepias welshii*	AZ, UT	P	Threatened

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Wenatchee Mountains checkermallow	Sidalcea oregana var. calva	WA	P	Endangered
West Indian manatee	Trichechus manatus	AL, FL, GA, LA, MS, NC, PR, SC, TX	V	Endangered
West Indian walnut (=Nogal)	Juglans jamaicensis	PR	P	Endangered
Western lily	Lilium occidentale	CA, OR	P	Endangered
Western prairie fringed orchid	Platanthera praeclara	IA, KS, MN, MO, ND, NE, OK, SD	P	Threatened
Western snowy plover	Charadrius alexandrinus nivosus	CA, OR, WA	V	Threatened
Wheeler's peperomia	Peperomia wheeleri	PR	P	Endangered
White Abalone	Haliotis sorenseni	CA	I	Endangered
White birds-in-a-nest	Macbridea alba	FL	P	Threatened
White bladderpod	Lesquerella pallida	TX	P	Endangered
White Bluffs bladderpod	Physaria douglasii tuplashensis	WA	P	Proposed Threatened
White catspaw (pearlymussel)	Epioblasma obliquata perobliqua	IN, OH	I	Endangered
White irisette	Sisyrinchium dichotomum	NC, SC	P	Endangered
White River spinedace	Lepidomeda albivallis	NV	V	Endangered
White River springfish	Crenichthys baileyi baileyi	NV	V	Endangered
White sedge	Carex albida	CA	P	Endangered
White sturgeon	Acipenser transmontanus	ID, MT	V	Endangered
White wartyback (pearlymussel)	Plethobasus cicatricosus	AL, IN, KY, TN	I	Endangered
White-haired goldenrod	Solidago albopilosa	KY	P	Threatened
White-necked crow	Corvus leucognaphalus	NA[1]	V	Endangered
White-rayed pentachaeta	Pentachaeta bellidiflora	CA	P	Endangered
Whooping crane	Grus americana	CO, KS, MT, ND, NE, OK, SD, TX	V	Endangered
Wide-leaf warea	Warea amplexifolia	FL	P	Endangered

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Willamette daisy	*Erigeron decumbens var. decumbens*	OR	P	Endangered
Willowy monardella	*Monardella viminea*	CA	P	Endangered
Winged mapleleaf	*Quadrula fragosa*	AR, MN, MO, OK, WI	I	Endangered
Winkler cactus	*Pediocactus winkleri*	UT	P	Threatened
Wireweed	*Polygonella basiramia*	FL	P	Endangered
Wolverine, North American	*Gulo gulo luscus*	CA, CO, ID, MN, NV, NM, OR, UT, WA, WY	V	PT
Wood stork	*Mycteria americana*	AL, FL, GA, MS, NC, SC	V	Endangered
Woodland caribou	*Rangifer tarandus caribou*	ID, WA	V	Endangered
Woundfin	*Plagopterus argentissimus*	AZ, NM, NV, UT	V	Endangered
Wright fishhook cactus	*Sclerocactus wrightiae*	UT	P	Endangered
Wyoming toad	*Bufo baxteri (=hemiophrys)*	WY	V	Endangered
Yadon's piperia	*Piperia yadonii*	CA	P	Endangered
Yaqui catfish	*Ictalurus pricei*	AZ	V	Threatened
Yaqui chub	*Gila purpurea*	AZ	V	Endangered
Yellow blossom (pearlymussel)	*Epioblasma florentina florentina*	AL, TN	I	Endangered
Yellow larkspur	*Delphinium luteum*	CA	P	Endangered
Yellow-blotched map turtle	*Graptemys flavimaculata*	MS	V	Threatened
Yellowcheek darter	*Etheostoma moorei*	AR	V	Endangered
Yelloweye rockfish	*Sebastes ruberrimus*	NA[1]	V	Threatened
Yellowfin madtom	*Noturus flavipinnis*	TN, VA	V	Threatened
Yellow-shouldered blackbird	*Agelaius xanthomus*	PR	V	Endangered
Yreka phlox	*Phlox hirsuta*	CA	P	Endangered
Yuma clapper rail	*Rallus longirostris yumanensis*	AZ, CA, NV	V	Endangered
Zapata bladderpod	*Lesquerella thamnophila*	TX	P	Endangered
Zayante band-winged grasshopper	*Trimerotropis infantilis*	CA	I	Endangered
Zuni fleabane	*Erigeron rhizomatus*	AZ, NM	P	Threatened

Note 1. Specific current distribution is not available, but these species are listed wherever found.

Reference:

USFWS. (2013). Species Reports, Environmental Conservation Online System. Retrieved April 03, 2013, from U.S. Fish and Wildlife Service, http://ecos.fws.gov/tess_public/.