Animal and Plant Health Inspection Service
U.S. DEPARTMENT OF AGRICULTURE

BASF Petition (19-317-01p) for Determination of Nonregulated Status of GMB151 Soybean Developed Using Genetic Engineering for Resistance to the Soybean Cyst Nematode and HPPD-inhibiting Herbicides

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ACRONYMS AND ABBREVIATIONS

AOSCA	Association of Official Seed Certifying Agencies
APHIS	Animal and Plant Health Inspection Service
C	carbon
CAA	Clean Air Act
CFR	Code of Federal Regulations
CH_4	methane
CO	carbon monoxide
CO_2	carbon dioxide
CWA	Clean Water Act
DNA	deoxyribonucleic acid
EA	environmental assessment
EO	Executive Order
EPA	Environmental Protection Agency
ESA	Endangered Species Act
FDA	Food and Drug Administration
FFDCA	Federal Food, Drug, and Cosmetic Act
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FQPA	Food Quality Protection Act
FR	Federal Register
GR	glyphosate-resistant
HPPD-4	4-hydroxyphenylpyruvate dioxygenase
HR	herbicide-resistant
HRAC	Herbicide Resistance Action Committee
IP	identity preservation
IPPC	International Plant Protection Convention
lb/A	pounds per acre
lbs	pounds
LMO	living modified organisms
MGs	maturity groups
MOA	mode of action

MT	metric tons
N_2O	nitrous oxide
NAAQS	National Ambient Air Quality Standards
NAPPO	North American Plant Protection Organization
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NO_2	nitrogen dioxide
NOP	National Organic Program
O_3	ozone
Pb	lead
PDP	Pesticide Data Program
PIPs	plant-incorporated protectants
PM	coarse particulate matter
$PM_{2.5}$	fine particles less than 2.5 micrometers in diameter
PM_{10}	particles greater than 2.5 micrometers and less than 10 micrometers in diameter
PPRA	Plant Pest Risk Analysis
SDWA	Safe Drinking Water Act of 1974
SO_2	sulfur dioxide
SOM	soil organic matter
SSA	sole source aquifer
T&E	threatened and endangered species
TMDL	total maximum daily loads
TSCA	Toxic Substances Control Act
U.S.	United States
U.S.C.	United States Code
USDA	United States Department of Agriculture
USFWS	United States Fish and Wildlife Service
WPS	Worker Protection Standard
WSSA	Weed Science Society of America

1 PURPOSE AND NEED

BASF Corporation, Research Triangle Park, North Carolina (referred to as BASF in this document) submitted a petition (19-317-01p) to the U.S. Department of Agriculture (USDA), Animal and Plant Health Inspection Service (APHIS) on January 28, 2020 (BASF 2020). The petitioner requested that APHIS make a regulatory determination for Soybean Event IND 00410-5 (referred to as GMB151 Soybean in this document), which was developed using genetic engineering. The petitioner asserted that GMB151 Soybean should no longer be regulated under Title 7 of the Code of Federal Regulations part 340 (7 CFR 340) because it does not pose a plant pest risk. As described in more detail elsewhere in this chapter, APHIS regulations provide that any person or entity with legal standing may submit a petition to the Agency with a request that an organism not be regulated because it is unlikely to pose a plant pest risk.

This Environmental Assessment (EA) was prepared by APHIS to evaluate the potential of effects from its regulatory decision for GMB151 Soybean to cause significant impacts on the human environment[1]. One purpose of a NEPA analysis is to ensure that agencies assess possible effects of their actions for significant impacts, and consider them in their decision-making process. This EA reports results of the Agency's thorough analysis of both a decision to continue regulating or to no longer regulate GMB151 Soybean as a plant pest. It includes a review of the Agency's findings about the potential for significant impacts from the effects, both beneficial and adverse, from either decision, and inform the public of these findings.

This EA has been prepared in compliance with the National Environmental Policy Act (NEPA, 42 U.S.C. § 4321 et seq.), the Council of Environmental Quality's (CEQ) NEPA-implementing regulations (40 CFR parts 1500-1508), and USDA and APHIS NEPA-implementing regulations (7 CFR part 1b, and 7 CFR part 372).

1.1 PURPOSE OF GMB151 SOYBEAN

GMB151 Soybean produces a modified 4-hydroxyphenylpyruvate dioxygenase (HPPD-4) enzyme, which is also produced naturally by the bacterium, *Pseudomonas fluorescens*. HPPD-4 confers resistance to herbicides that are HPPD inhibitors such as isoxaflutole. The source organism of the HPPD-4 protein, *P. fluorescens,* is a non-pathogenic bacterium that is ubiquitous in nature and has a history of safe use. HPPD proteins are also ubiquitous in nature in nearly all aerobic organisms, (e.g., bacteria, fungi, plants, and animals including mammals).

GMB151 Soybean also expresses a crystalline protein, Cry14Ab-1, that is an endotoxin naturally produced by a strain of the bacterium, *Bacillus thuringiensis*. Expression of Cry14Ab-1 in GMB151 Soybean confers resistance to the soybean cyst nematode (SCN), *Heterodera glycines* Ichinohehe.

BASF has indicated that the method of Hoekema et al. (1983), which involves the disarmed bacterium, *Agrobacterium tumefaciens* strain LBA4404, was used to mediate gene transfer. The

[1]Human environment includes the natural and physical environment and the relationship of people with that environment. When economic or social and natural or physical environmental effects are interrelated, the NEPA analysis may also address these potential impacts (40 CFR §1508.14).

Agrobacterium-mediated transformation vector, pSZ8832, containing the *cry14Ab-1.b* and *hppdPf-4Pa* gene cassettes, was used to insert the *cry14Ab-1.b* gene from *B. thuringiensis* and the *hppdPf-4Pa* gene from *P. fluorescens* into the GMB151 Soybean genome (BASF 2020).

SCN is a major pest of soybeans worldwide; it is an invasive pest occurring in most of the soybean growing regions of the United States (NCSRP No Date). Losses to soybean growers from SCN vary depending on location, genetic background of the variety, and the cropping system used. Susceptible varieties grown in the United States suffer yield reductions estimated at 15-30% or more (NCSRP No Date).

Planting soybean varieties resistant to SCN and rotating plantings with other crops that are not hosts of SCN are the most effective ways of managing SCN infestations. To date, more than one thousand SCN-resistant soybean varieties are available to farmers in the United States (Tylka and Mullaney 2018). If GMB151 Soybean is not regulated, it will likely be crossed with other commercially available SCN-resistant varieties, thereby creating lines with multiple resistance to extend the durability of both GMB151 Soybean and other SCN-resistant soybean varieties.

In addition to controlling invertebrate pests, effective weed management in soybean cropping systems is critical for maintaining high-yield production. Establishing good weed control is especially important during early vegetative growth, and also during the early reproductive growth stages (Van Acker and Swanton 1993). Herbicides are essential for weed management of many crops because they are a cost-effective method for weed control that helps make farming a profitable venture. Inclusion of resistance to HPPD-inhibiting herbicides in GMB151 Soybean will provide growers with an additional mode of action for the control of herbicide-resistant (HR) weeds, which provides more options to growers, when choosing weed control products.

1.2 COORDINATED FRAMEWORK FOR REGULATING BIOTECHNOLOGY

On June 26, 1986, the White House Office of Science and Technology Policy issued the "Coordinated Framework for the Regulation of Biotechnology" (referred to as the Coordinated Framework in this document), which outlined federal regulatory policy for ensuring the safety of biotechnology products (51 FR 23302 1986). The primary federal agencies responsible for oversight of biotechnology products are the U.S. Department of Agriculture (USDA), the U.S. Environmental Protection Agency (EPA), and the U.S. Food and Drug Administration (FDA).

In 2015, the Executive Office of the President (EOP) issued a memorandum directing the USDA, EPA, and FDA to clarify current roles and responsibilities in the regulation of biotechnology products; develop a long-term strategy to ensure that the federal biotechnology regulatory system is prepared for the future products of biotechnology; and commission an independent, expert analysis of the future landscape of biotechnology products. In 2016, the Emerging Technologies Interagency Policy Coordination Committee's Biotechnology Working Group (BTW) published the "National Strategy for Modernizing the Regulatory System for Biotechnology Products" (ETIPCC 2016). One recommendation was to modernize the Coordinated Framework to make the policy consistent with technological changes that occurred after its initial development in 1986. In response to the BTW recommendations, the policy was updated and published on January 4, 2017 (81 FR 65414 2017).

USDA-APHIS is responsible for protecting animal and plant health. USDA-APHIS regulates products of biotechnology that may pose a risk to agricultural plants and agriculturally important natural resources under the authorities provided by the plant pest provisions of the PPA, as amended (7 U.S. Code (U.S.C.) 7701–7772), and implementing regulations at 7 CFR 340.

The purpose of EPA oversight is to protect human and environmental health. EPA regulates pesticides under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) (7 U.S.C. 136 et seq.). EPA regulatory oversight of pesticides includes those expressed by organisms produced using genetic engineering, which are referred to as plant-incorporated protectants (PIPs). EPA has oversight authorized under the Federal Food, Drug, and Cosmetic Act (FFDCA; 21 U.S.C. 301 et seq.) to either set maximum residue limits, commonly referred to as tolerances, for pesticide residues that may remain on or in food and animal feed, or establish an exemption from the requirement for a tolerance.

Both FDA and USDA monitor food and animal feed for pesticide residues to enforce tolerances to ensure protection of human health. USDA collects data on pesticide residues as part of the Pesticide Data Program (PDP). PDP activities include sampling, testing, and reporting residues detected in meat and dairy products in the U.S. food supply. The program is implemented through cooperation with state agriculture departments and other federal agencies.

EPA uses PDP data to prepare pesticide dietary exposure assessments. EPA also regulates certain microorganisms that have been developed using genetic engineering (agricultural uses other than pesticides) under the Toxic Substances Control Act (15 U.S.C. 53 et seq.).

The purpose of FDA oversight is to ensure that human and animal foods and drugs are safe and sanitary. The FDA regulates a wide variety of products, including human and animal foods, cosmetics, human and veterinary drugs, and human biological products under the authority of the FFDCA and Food Safety Modernization Act.

1.3 PURPOSE AND NEED TO ISSUE A REGULATORY STATUS DETERMINATION

Under the authority of the plant pest provisions of the Plant Protection Act (7 U.S.C. 7701 *et seq*.), the regulations in 7 CFR 340 for movement of organisms modified or produced using genetic engineering regulate importation, interstate movement, or release into the environment of such organisms that are plant pests or pose a plausible plant pest risk.[2]

APHIS recently revised 7 CFR 340 and issued a final rule, published in the *Federal Register* on May 18, 2020 (85 FR 29790-29838, Docket No. APHIS-2018-0034).[3] APHIS' new Regulatory Status Review (RSR) process, which replaces the petition process for determination of

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[2]Genetic engineering in the context of 7 CFR 340 refers to biotechnology-based techniques that use recombinant, synthesized, or amplified nucleic acids to modify or create a genome. Various terms are used in the lay and scientific peer-reviewed literature in reference to new plant varieties that have been developed using modern molecular biology tools: "agricultural biotechnology," "genetically engineered," and "genetically modified." In this EA, the terms "genetic engineering" and "biotechnology" may be used interchangeably. The term "transgenic" may also be used when discussing or referring to a transgene introduced into the genome of a plant. Under the legacy regulations, USDA does not regulate plants developed by traditional breeding techniques, including, those using chemical- and radiation-based mutagenesis, if they are not plant pests.

[3]To view the final rule, go to www.regulations.gov and enter "APHIS-2018-0034" in the Search field.

nonregulated status process, became effective for all crops on October 1, 2021

The petition for a determination of nonregulated status that is the subject of this EA (BASF 2020) is being evaluated in accordance with the regulations at 7 CFR 340.6 (2020), as it was received by APHIS in January 2020 prior to the publication of the revised regulation. Pursuant to the terms set forth in the final rule, any person or entity can submit a petition to APHIS seeking a determination that an organism should not be regulated under 7 CFR 340. APHIS must respond to petitioners with a decision to approve or deny the regulatory action requested by a petitioner. An organism produced using genetic engineering is no longer subject to the requirements of 7 CFR 340 or the plant pest provisions of the PPA if APHIS determines, through the conduct of a Plant Pest Risk Assessment (PPRA), that it is unlikely to pose a plant pest risk.

Consistent with APHIS regulations (7 CFR 340), importation into, interstate movement within, and field trials of GMB151 Soybean in the United States require permits issued by APHIS or notifications acknowledged by the Agency. Since 2013, field trials of GMB151 Soybean have been conducted by BASF in diverse growing regions within the United States. Results from these field trials are reported in the GMB151 Soybean petition (BASF 2020), and analyzed for plant pest risk in an APHIS Plant Pest Risk Assessment (PPRA) (USDA-APHIS 2020).

In its petition, BASF provided evidence that GMB151 Soybean does not pose a plant pest risk or weediness potential, so it should not be regulated by APHIS (BASF 2020). If the Agency makes a determination of nonregulated status, it would pertain to GMB151 Soybean itself, and any progeny derived from crossing it with other soybean varieties that are not regulated under 7 CFR 340 (i.e., conventional soybean varieties, or other soybean varieties produced using genetic engineering that APHIS has determined are not regulated as plant pests). APHIS prepared this Environmental Assessment (EA), as required by the National Environmental Policy Act (NEPA), to determine if its regulatory decision (either to continue regulating or no longer regulate GMB151 Soybean) could have any significant impacts on the human environment. As part of the process required for NEPA compliance, this EA also informs the public about the environmental analysis the Agency made. It is intended to promote public participation and provide input to assist the APHIS decision maker in determining the regulatory status of GMB151 Soybean.

As required by 7 CFR 340.6, APHIS must respond to petitioners that request a determination of the regulated status of organisms produced using genetic engineering, including plants such as GMB151 Soybean. When a petition for nonregulated status is submitted, APHIS must determine if the organism is unlikely to pose a plant pest risk. The petitioner is required under 7 CFR 340 (§340.6(c)(4)) to provide information related to plant pest risk that the Agency may use to compare the plant pest risk of the regulated ~~article~~ organism to that of the corresponding (unmodified) organism. An organism produced using genetic engineering is no longer subject to the regulatory requirements of 7 CFR 340 or the plant pest provisions of the PPA, when APHIS determines that it is unlikely to pose a plant pest risk.

APHIS must respond to the January 2020 petition (19-317-01p) from BASF (BASF 2020) with a regulatory status decision for GMB151 Soybean consistent with 7 CFR 340. APHIS prepared this EA to document possible environmental effects of its decision, and evaluate their potential to cause significant impacts consistent with the Council of Environmental Quality’s (CEQ) NEPA regulations (40 CFR parts 1500-1508), and the USDA departmental and APHIS NEPA-implementing regulations and procedures (7 CFR part 1b, and 7 CFR part 372).

2 SCOPING AND PUBLIC INVOLVEMENT

APHIS seeks public comment on EAs through notices published in the Federal Register. On March 6, 2012, APHIS published in the *Federal Register* (77 FR 13258-13260, Docket No. APHIS-2011-0129) a notice describing its public review process for soliciting public comments and information when considering petitions for determinations of nonregulated status for organisms developed using genetic engineering.[4]

2.1 PUBLIC INVOLVEMENT FOR PETITION 19-317-01p

APHIS made the BASF petition requesting non-regulated status for GMB151 Soybean available for public review in a notification[5] in the *Federal Register* (85 FR 32004 2020) on May 28, 2020. The 60-day public comment period closed on July 27, 2020. APHIS received nine comments. The petition and comments are available[6] for public review on regulations.gov, the U.S. federal government web site that serves as an internet portal and document repository for U.S. government documents (Docket No. APHIS-2020-0023).

Two comments were supportive of removing regulatory constraints on the GMB151 Soybean variety. Another comment addressed the pesticide registration issue about the Cry14Ab-1 protein PIP, urging EPA to make it available as a new active ingredient. Two other comments, while generally supportive of the development of crops produced using genetic engineering, expressed concerns about the risks and liabilities from possible disruptive effects on U.S. exports if residues from a deregulated biotech soybean enter the supply chain in cases where the soybean has not been approved in export markets. They emphasized the need for careful vetting of biotech crops and the need for stewardship measures if commercialized. BASF emphasized in its petition, a commitment to stewardship to meet applicable regulatory requirements for GMB151 Soybean in the country of intended production and for key import countries to ensure compliance, maintain product integrity, and assist in minimizing the potential for trade disruptions (BASF 2020).

Four comments expressed opposition to a determination of nonregulated status for GMB151 Soybean based on general opposition to the use of organisms produced using genetic engineering, but did not cite or provide documentation specific to why the GMB151 Soybean variety should continue to be regulated under 7 CFR 340. All comments were considered, carefully analyzed for relevancy, and addressed in this EA according to NEPA regulatory requirements.

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[4]*Federal Register*, Vol. 77, No. 44, Tuesday, March 6, 2012, p.13258 – Biotechnology Regulatory Services; Changes Regarding the Solicitation of Public Comment for Petitions for Determinations of Nonregulated Status for Genetically Engineered Organisms. This noticed can be accessed at: http://www.gpo.gov/fdsys/pkg/FR-2012-03-06/pdf/2012-5364.pdf

[5]This notice can be accessed at: https://www.federalregister.gov/documents/2020/05/28/2020-11492/basf-corporation-petition-for-a-determination-of-nonregulated-status-for-plant-parasitic

[6]The docket can be accessed at: https://www.regulations.gov/docket/APHIS-2020-0023
The petition alone is also accessible on the APHIS web site: https://www.aphis.usda.gov/aphis/ourfocus/biotechnology/permits-notifications-petitions/petitions/petition-status

APHIS determined from its initial review of the petition for GMB151 Soybean that the review process for the PPRA and NEPA documents (EA and FONSI) should follow the second approach, as described in the Agency's 2012 revisions (77 FR 13258 2012) to the procedures it follows to promote public participation in its decision making relevant to the regulation of organisms produced using genetic engineering. This decision was made because APHIS has not previously analyzed plant pest risk for any soybean varieties that express the Cry14Ab-1 protein.

2.2 PUBLIC INVOLVEMENT FOR THE DRAFT EA FOR GMB151 SOYBEAN

As part of its NEPA compliance process, APHIS considered all comments submitted for the petition in a Draft EA prepared by the Agency. APHIS also prepared a Draft PPRA (USDA-APHIS 2020) to document the Agency's analysis of the possibility that GMB151 Soybean might pose unacceptable plant health or weediness risks. The public was informed about the availability of both documents for review in a *Federal Register* notice that announced a 30-day comment period that ended on September 16, 2021. APHIS received 2,743 comments. From its review of the comments, the Agency determined that the comments could be classified into five general categories: (1) support for non-regulation of GMB151 Soybean; (2) opposition because it was developed using genetic engineering; (3) opposition because it expresses a novel protein derived from *Bacillus thuringiensis*; (4) opposition because of concerns it will contribute to increased herbicide resistance in weeds; (5) opposition because of safety concerns that will result from increased use of isoxaflutole. The opposition topics are summarized in more detail below. The comments, as submitted, are available for review at: https://www.regulations.gov/document/APHIS-2020-0023-0012/comment

The majority of the comments were exactly the same or nearly identical. Many of these were contained in identical form letters submitted by different individuals who expressed their general opposition to the concept and use of genetic engineering for any purpose, or for the specific purpose of transferring genetic material from other biological sources to unrelated to crops. These were outside the scope of the PPRA, which was to analyze the potential for plant pest risk, and this EA which was to analyze the potential for significant environmental impacts. None of these comments provided any scientific documentation relevant to either of these analyses.

Some comments objected to an APHIS decision not to regulate GMB151 Soybean because it expresses a novel Cry protein from *Bacillus thuringiensis*, Cry14Ab-1, that has not been adequately evaluated for its pesticidal uses. However, APHIS emphasizes that this issue was considered by the petitioner (BASF 2020), which documented results of test studies for the non-target effects of the Cry14Ab-1 expressed in GMB151 Soybean. In addition, under the Coordinated Framework, EPA regulates pesticides, including PIPs, and it concluded on June 8, 2020 that available scientific data was sufficient to support a decision that the *B. thuringiensis* Cry14Ab-1 protein residue in or on soybean food and feed commodities are exempt from the requirement of a tolerance, when expressed as a PIP in soybean plants (85 FR 35008; 40 CFR 174.540).

Another group of comments focused on a concern that a new soybean crop variety expressing the trait for resistance to isoxaflutole specifically and HPPD-inhibiting herbicides in general would contribute to an increase in the development of weed resistance. This is primarily an issue that APHIS addressed in its PPRA (USDA-APHIS 2020) and concluded that any effects related to HPPD-herbicide resistance would not cause any plant pest risk. The analysis in this EA concluded that there would not be any significant impacts related to weed resistance from a determination of no regulatory authority for GMB151 Soybean. None of the comments received provided any scientific documentation to alter these conclusions.

Another class of comments objected to an APHIS decision not to regulate GMB151 Soybean because it would contribute to an increase in the use of isoxaflutole, which will increase human health and safety hazards and impacts on the environment. APHIS emphasizes that this issue was considered by the petitioner (BASF 2020), which submitted documentation of results of test studies related to human health and safety concerns and non-target effects of isoxaflutole. In addition, under the Coordinated Framework, EPA regulates pesticides, including chemical herbicides. EPA will continue to address human safety and health concerns, and potential environmental effects as part of its regulatory review process. BASF also showed that laboratory and field testing demonstrated that there are no biologically meaningful differences for compositional and nutritional characteristics between conventional and GMB151 Soybean.

In summary, none of the comments received documented evidence that the Agency had failed to consider and analyze in its Draft EA all possible environmental effects for significant impacts from a determination of the regulatory status for GMB151 Soybean. Also, none of the comments provided substantive documentation that the Agency's analysis in its Draft EA failed to consider that such a determination would result in significant impacts to the human environment, which would require that the Agency prepare an environmental impact statement.

2.3 SCOPE OF THE ANALYSIS

The issues addressed in this EA were developed by considering similar ones identified and addressed in prior NEPA documents, those identified in public comments for BASF's petition and other petitions for organisms produced using genetic engineering, information in the scientific literature on agricultural biotechnology, and issues identified by APHIS as specific to soybean crop production. These issues were addressed in this EA under the following subject categories:

Agricultural Production:

- Areas and Acreage of Soybean Production
- Agronomic Practices
- Soybean Seed Production
- Organic Soybean Production

Environmental Resources:

- Soil Quality
- Water Resources
- Air Quality
- Animal Communities
- Plant Communities
- Soil Microorganisms
- Biological Diversity
- Gene Movement

Animal Health:

- Animal Feed Quality
- Livestock Health

Human Health:

- Public Health
- Worker Health and Safety

Socioeconomics:

- Domestic Economic Environment
- Trade Economic Environment

Cumulative Impacts

Threatened and Endangered Species

Other U.S. Regulatory Approvals and Compliance with Other Laws

3 ALTERNATIVES

NEPA implementing regulations (40 C.F.R. § 1502.14) require the evaluation of all alternatives that appear reasonable and appropriate to the purpose and need of an agency's action. For this USDA APHIS action, a regulatory determination for BASF GMB151 Soybean, two alternatives were evaluated in this EA: (1) No Action Alternative, which would continue the current regulated status of GMB151 Soybean if selected; (2) Preferred Alternative, which would result in nonregulated status for GMB151 Soybean if selected.

3.1 NO ACTION ALTERNATIVE: CONTINUE REGULATING GMB151 SOYBEAN

Under the No Action Alternative, APHIS would deny the petition request by BASF (BASF 2020), so there would be no change in the regulatory status of GMB151 Soybean; it and any soybean varieties derived from it would continue to be regulated ~~articles~~ organisms under 7 CFR 340. APHIS would continue to require permits for introductions and movement of GMB151 Soybean grown in the United States. Because APHIS has concluded from its PPRA (USDA-APHIS 2020) that GMB151 Soybean is unlikely to pose a plant pest risk, choosing this alternative would not be an appropriate response to the petition for nonregulated status because it would not satisfactorily meet the purpose and need for making a science-based regulatory status decision pursuant to the requirements of 7 CFR 340.

2.2 PREFERRED ALTERNATIVE: NONREGULATED STATUS FOR GMB151 SOYBEAN

Under the Preferred Alternative, GMB151 Soybean and any varieties derived from crosses between it and other soybean varieties that are not regulated would no longer be regulated under 7 CFR 340. APHIS has determined that GMB151 Soybean is unlikely to pose a plant pest risk based on available scientific evidence (USDA-APHIS 2020), therefore, if this alternative is selected, permits or notifications acknowledged by APHIS would no longer be required to grow GMB151 Soybean or progeny derived from it in the United States. This alternative best meets the purpose and need to respond appropriately to the petition for nonregulated status of GMB151 Soybean based on the requirements in 7 CFR 340 and the Agency's authority under the plant pest provisions of the PPA.

3.3 ALTERNATIVES CONSIDERED BUT EXCLUDED FROM FURTHER DETAILED ANALYSIS IN THIS EA

APHIS considered several other alternatives for this EA. These included: approve the petition only in part as provided for in § 340.6(d)(3)(i) of the regulations (e.g., allow nonregulated status for GMB151 Soybean crops grown in limited regions of the United States); establish mandatory rules for isolation or geographic separation of biotech and non-biotech cropping systems; require testing for the presence of biotech crop plant material in non-biotech crops and commodities.

Based on the PPRA (USDA-APHIS 2020) for GMB151 Soybean and the Agency's past experience with regulating biotech soybean varieties under 7 CFR 340, APHIS concluded that it is unlikely to pose a plant pest risk. Therefore, the imposition of testing, release, and/or isolation requirements on GMB151 Soybean would be inconsistent with the Agency's statutory authority under the plant pest provisions of the PPA, implementing regulations at 7 CFR 340, and the federal regulatory policies of the Coordinated Framework. Because it would neither be reasonable nor appropriate for APHIS to evaluate alternatives for actions that exceed its statutory authority, the alternatives summarized above were excluded from further detailed analysis in this EA.

3.4 COMPARISON OF ALTERNATIVES

Table 1 includes a summary and comparison of possible impacts associated with selection of each of the alternatives evaluated in this EA. Details about the impact assessment for each are reported in Chapter 4 (Environmental Consequences).

Table 1. Summary of Potential Impacts and Consequences of Alternatives.

Attribute/Measure	Alternative A: No Action	Alternative B: Determination of Nonregulated Status
Agricultural Production		
Areas and Acreage of Soybean Production:	Current trends in acreage and areas of production are likely to continue to be driven by market conditions and federal policies that influence demand for U.S. soybeans (e.g., demand for animal feed, biodiesel and exports). U.S. 2020 soybean planted acreage (83.8 million) was up 10% from 2019 (USDA NASS 2020a), and is projected to remain level through 2028 (USDA-OCE 2018); selection of the No Action Alternative would not be expected to change this estimate, so would not increase or decrease soybean acreage.	If GMB151 Soybean were no longer regulated it would only be expected to be planted as an alternative to other varieties in the United States, so soybean acreage under the Preferred Alternative would be about the same as for the No Action Alternative.
Agronomic Practices:	Soybean management practices and methods that increase yield such as fertilization, crop rotation, irrigation, pest management, and plant residue management would be expected to continue as currently practiced. Some conservation tillage practices may be replaced by conventional tillage, where this is the only alternative to control increasing HR weed problems.	The agronomic characteristics and cultivation practices used for the production of GMB151 Soybean are the same as those used for the cultivation of other commercially available soybean varieties, so they would remain unchanged from the No Action Alternative.

Attribute/Measure	Alternative A: No Action	Alternative B: Determination of Nonregulated Status
Pesticide Use:	The EPA approves and labels uses of pesticides on soybeans. Commercial soybean growers would continue to use the same pesticides for soybean insect pests and weeds as are currently used.	The EPA regulatory oversight of pesticides would not change. Most nematicides for SCN are prescribed as seed treatments to be used in conjunction with resistant varieties. With the exception of SCN, GMB151 Soybean is susceptible to the same insect and other invertebrate pests and pathogens that affect most other commercially available conventional and biotech soybean varieties, so pest management practices would not change from the No Action Alternative. Growers with weeds resistant to herbicides with other modes of action may choose this HPPD-resistant variety for weed management.
Organic Soybean Production:	Methods currently used for certified seed production to maintain soybean seed identity and meet National Organic Standards would continue unchanged. The availability of biotech soybean is unrelated to the market share proportion of organic soybeans.	Measures used by organic soybean producers to manage, identify, and preserve organic production systems would not change. Similar to other commercially available biotech soybean varieties, GMB151 Soybean does not present any new or different issues or impacts for organic soybean producers or consumers. Other HR soybean varieties that are not regulated are currently planted by growers. GMB151 Soybean would only replace these as another HR alternative.

Attribute/Measure	Alternative A: No Action	Alternative B: Determination of Nonregulated Status
Soybean Seed Production:	Quality control methods, such as those of the Association of Official Seed Certifying Agencies (https://www.aosca.org/) for certifying seed to ensure varietal purity would continue to be available.	Practices to ensure varietal purity would remain the same as for the No Action Alternative. Tests would be available to determine the presence of genes that convey SCN and HPPD resistance traits in GMB151 Soybean.
Physical Environment		
Water Resources:	Agronomic practices that could impact water resources (e.g., irrigation, tillage practices, and the application of pesticides and fertilizers) would be expected to continue. The use of EPA-registered pesticides for soybean production in accordance with label directions would continue to prevent unacceptable risks to water quality. Historic trends of increased soybean yield on existing cropland would continue unchanged, so any current impacts on water resources from soybean production would not change significantly.	Except for replacing herbicides with other modes of action with HPPD-based herbicides, the production of GMB151 Soybean is not expected to change current agronomic practices, acreage, or the range of production areas, so current effects from runoff on water resources would not change. Use of HPPD-based herbicides likely offsets the need to change tillage practices to control HR weeds resistant to currently available herbicides, so soil erosion impacts on water quality from soybean production may be reduced or would not change. Other HPPD HR soybean varieties that APHIS assessed previously (USDA-APHIS 2014, 2013) are not regulated and are currently available to growers. If it is not regulated, GMB151 Soybean will only be another HPPD-resistant alternative to growers, so herbicide use will not change.

Attribute/Measure	Alternative A: No Action	Alternative B: Determination of Nonregulated Status
Air Quality:	Current soybean agronomic practices that impact air quality, such as tillage, application of farm chemicals, and use of exhaust-emitting mechanized equipment would not change, so current environmental impacts would not change significantly.	Except for replacing herbicides with other modes of action with HPPD-based herbicides, the production of GMB151 Soybean is not expected to differ significantly from the No Action Alternative. Use of HPPD herbicides would likely offset the need to change tillage practices to control HR weeds resistant to currently available herbicides, so soil erosion impacts on air quality from soybean production may be reduced or would not change significantly from that of the No Action alternative. HPPD use is not expected to increase relative to the no action alternative.
Soil Quality:	Most cropping practices that impact soil such as tillage, contouring, cover crops, agricultural chemical management, and crop rotation would continue unchanged, but some tillage practices (e.g., conservation), may change to conventional where this is the only alternative to control increasing HR weed problems.	Production of GMB151 Soybean would not be expected to change cropping practices. Use of HPPD herbicides would likely offset the need to change tillage practices to control HR weeds resistant to currently available herbicides, which would prevent or reduce soil quality losses from erosion. HPPD use is not expected to increase relative to the no action alternative.
Biological Resources		

Attribute/Measure	Alternative A: No Action	Alternative B: Determination of Nonregulated Status
Animal Communities:	Non-biotech and biotech soybeans that are not regulated have been shown to have no allergenic or toxic effects on animal communities. Soybean agronomic practices such as tillage, cultivation, farm chemical applications, and the use of mechanized agricultural equipment would continue to impact animal communities unchanged.	Field trials demonstrated that growth and disease characteristics of GMB151 Soybean are not significantly different from other soybean varieties that are not regulated, so no changes to soybean agronomic practices potentially impacting animal communities would occur other than the use of HPPD herbicide applications, where HR weeds resistant to other modes of action are a problem. HPPD use is not expected to increase relative to the no action alternative
Plant Communities:	Most commercial soybean acreage is planted with varieties developed using genetic engineering, and this would continue unchanged. Most agronomic practices would not change except where the continuing increasing problem of HR weeds forces growers to modify methods (e.g., tillage; alternative herbicide choices) to control weeds. Herbicide use in accordance with the EPA registration requirements would continue to ensure that no unacceptable risks to non-target plants and plant communities would occur.	Field trials and laboratory analyses show no differences between GMB151 Soybean and other soybean varieties (conventional and those developed using genetic engineering) in growth, reproduction, and susceptibility to pathogens and other pests except the target species (SCN). Except for the option to substitute HPPD herbicides with other herbicides currently used, agronomic practices to cultivate GMB151 Soybean would not differ from the No Action Alternative. HPPD use is not expected to increase relative to the no action alternative. .

Attribute/Measure	Alternative A: No Action	Alternative B: Determination of Nonregulated Status
Gene Movement:	GMB151 Soybean would continue to be cultivated only under regulated conditions. The availability of biotech, conventional, and organic soybeans would not change as a result of the continued regulation of GMB151 Soybean. Because there are no wild soybean relatives in the United States, and soybeans are mostly self-pollinated, gene flow and introgression from soybean to wild or weedy species are highly unlikely. Any risk is further limited because soybeans are not frost tolerant, do not reproduce vegetatively, exhibit poor seed dispersal, and any volunteers that persist in warmer U.S. climates can be easily controlled with common agronomic practices.	Field and laboratory test results show that there are no significant differences among the traits in GMB151 Soybean that influence gene flow or weediness, when compared to soybean varieties that are not regulated. Traits for SCN resistance and HPPD herbicide resistance would not change gene movement characteristics, so there would be no significant impacts compared to the No Action Alternative.

Attribute/Measure	Alternative A: No Action	Alternative B: Determination of Nonregulated Status
Soil Microorganisms:	Agronomic practices used for soybean production, such as soil inoculation, tillage and the application of agricultural chemicals (pesticides and fertilizers) that potentially impact microorganisms would continue unchanged.	Field and greenhouse tests show no significant differences from other nonregulated soybean varieties in the parameters measured to assess the symbiotic relationship of GMB151 Soybean with its *Rhizobium* spp. symbionts. GMB151 Soybean would not result in any significant changes to current soybean cropping practices that may impact microorganisms except that HPPD herbicides may be substituted for herbicides with other modes of action, where HR weeds are a problem. Other HPPD HR soybean varieties developed using genetic engineering that APHIS assessed previously (USDA-APHIS 2014, 2013) are not regulated and are currently available to growers. If it is not regulated, GMB151 Soybean will only be another HPPD-resistant alternative to growers, so herbicide use would not be expected to change.

Attribute/Measure	Alternative A: No Action	Alternative B: Determination of Nonregulated Status
Biological Diversity:	Agronomic practices used for soybean production and yield optimization, such as tillage, the application of agricultural chemicals (pesticides and fertilizers), timing of planting, and row spacing, would be expected to continue unchanged. Agronomic practices that benefit biodiversity both on cropland (e.g., intercropping, agroforestry, crop rotations, cover crops, and no-tillage) and on adjacent non-cropland (e.g., woodlots, fencerows, hedgerows, and wetlands) would remain the same.	GMB151 Soybean would not change current soybean cropping practices that may impact biodiversity because field and laboratory testing demonstrate its growth, reproduction, and interactions with pests and diseases are the same as or not significantly different from other nonregulated varieties other than its resistance to SCN. GMB151 Soybean poses no potential for naturally occurring, pollen-mediated gene flow and introgression of genes modified using genetic engineering, so is not expected to affect genetic diversity. Testing has confirmed that the Cry14Ab-1e protein expressed by GMB151 Soybean does not have unacceptable risks to or impacts on non-target organisms (BASF 2020).
Public Health		
Farm Worker Safety and Health:	Farm workers are exposed to potential allergens from soybean plants, hazards from farm equipment used to grow and harvest soybeans, and pesticides applied to soybeans. Hazards to farm workers would not change from selection of the No Action Alternative.	EPA Worker Protection Standards (WPS)implement protections for agricultural workers, handlers, and their families 40 CFR 170). If the Preferred Alternative were selected, GMB151 Soybean would not change current soybean cropping practices, so hazards would be the same as under the No Action Alternative.

Human Health:	Compositional and nutritional characteristics of nonregulated biotech soybean varieties have been determined to pose no risk to human health. EPA-approved pesticides would continue to be used for pest management in both biotech and conventional soybean cultivation. Use of registered pesticides in accordance with EPA-approved labels protect human health and worker safety. EPA also establishes tolerances for pesticide residue that give a reasonable certainty of no harm to the general population and any subgroup from the use of pesticides at the approved levels and methods of application.	Laboratory and field testing demonstrated that there are no biologically meaningful differences for compositional and nutritional characteristics between conventional and GMB151 Soybean. Safety testing of the GMB151 Soybean Cry14Ab-1 and HPPD proteins showed that they are degraded rapidly and completely in simulated gastric fluid. Testing also showed that the GMB151 Soybean Cry14Ab-1 and HPPD proteins have no similarities to known allergens, and are not toxic to mammals. On January 28, 2019, BASF initiated a consultation (BNF 172) with FDA that included molecular, compositional, nutritional data, and other food and feed safety assessment data related to GMB151 Soybean (BASF 2020). EPA has established a permanent exemption (82FR57137) from the requirement for a tolerance for the HPPD-4 protein expressed in all food commodities when used as an inert ingredient. In addition, EPA concluded on June 8, 2020 that *B. thuringiensis* Cry14Ab-1 protein residue in or on soybean food and feed commodities are exempt from the requirement of a tolerance when expressed

Attribute/Measure	Alternative A: No Action	Alternative B: Determination of Nonregulated Status
		as a PIP in soybean plants (85 FR 35008; 40 CFR 174.540).
Animal Feed:	GMB151 Soybean would remain regulated and not be allowed for distribution to the animal feed market. Soybean-based animal feed would still be available from currently cultivated soybean crops, including both biotech and conventional soybean varieties. Nonregulated biotech soybean varieties used as animal feed have been previously determined not to pose any risk to animal health.	Laboratory and field testing demonstrated that there are no biologically meaningful differences for compositional and nutritional characteristics between conventional and GMB151 Soybean. Safety testing of the GMB151 Soybean Cry14Ab-1 and HPPD proteins showed that they have no toxic potential to mammals, and are degraded rapidly and completely in simulated gastric fluid, when present in animal feed. On January 28, 2019, BASF initiated a consultation (BNF 172) with the FDA that included molecular, composition, and nutrition data, and other food and feed safety assessment data related to GMB151soybean (BASF 2020). In addition, EPA concluded on June 8, 2020 (40 CFR 174.540) that the Cry14Ab-1 protein is exempt from a food and feed tolerance, when it is expressed in soybean plants.
Socioeconomic Environment		

Attribute/Measure	Alternative A: No Action	Alternative B: Determination of Nonregulated Status
Domestic Economic Environment:	GMB151 Soybean would remain regulated by APHIS. Domestic growers would continue to utilize biotech and conventional soybean varieties based upon availability and market demand. U.S. soybeans would likely continue to be used domestically for animal feed with lesser amounts and byproducts used for oil or fresh consumption. Agronomic practices and conventional breeding techniques using herbicide- and pest-resistant varieties currently used to optimize yield and reduce production costs would be expected to continue unchanged. Average soybean yield is expected to continue to increase without expansion of soybean acreage while grower net returns are estimated to increase.	Field tests show the performance and composition of GMB151 Soybean is not substantially different from that of other conventional soybean reference varieties and although yield potential is increased, it would be similar to other commercially available conventional and biotech soybean varieties and subject to the same variables affecting agronomic practices and yields as other varieties. GMB151 Soybean would likely only replace other varieties of biotech soybean on existing cropland and not impact organic soybean production or markets. Since biotech soybeans represent over 90% of soybeans produced, the addition of GMB151 Soybean will have little incremental impact on the biotech sensitive market. Because losses from SCN would be reduced, soybean growers would likely experience improved profits under Alternative B.

Attribute/Measure	Alternative A: No Action	Alternative B: Determination of Nonregulated Status
Trade Economic Environment:	If GMB151 Soybean remains regulated by APHIS, U.S. soybean plantings will not be affected and are projected to rebound and remain relatively steady over the course of the next decade. U.S. soybeans will continue to be a major component of global production, and as a source of supply in the international market (USDA 2020). Although U.S. exports are expected to increase overall, increasing competition and tariffs on U.S. soybean exports are expected to reduce the U.S. export share (Hubbs 2018).	A determination of nonregulated status for GMB151 Soybean is not expected to have an effect on current trends affecting the trade economic environment. GMB151 Soybean is similar to other varieties developed using genetic engineering. If it becomes commercially available as a non-regulated variety, it would only be substituted to replace other varieties where SCN- and/or HPPD-resistant varieties are required for pest management. If the Preferred Alternative is selected, there would not be any difference from choosing the No Action Alternative. BASF emphasized in its petition a commitment to stewardship to meet applicable regulatory requirements for GMB151 Soybean in the country of intended production and for key import countries to ensure compliance, maintain product integrity, and assist in minimizing the potential for trade disruptions (BASF 2020).
Other Regulatory Approvals		
U.S. Agencies:	Existing approvals for other nonregulated soybeans developed using genetic engineering would not change.	EPA has concluded (40 CFR 174.540) that the Cry14Ab-1 protein is exempt from a food and feed tolerance, when it is expressed in soybean plants.

Attribute/Measure	Alternative A: No Action	Alternative B: Determination of Nonregulated Status
Other countries	The existing status of other soybeans developed using genetic engineering that are regulated in other countries would not change.	No Change from the No Action Alternative. BASF emphasized in its petition a commitment to stewardship to meet applicable regulatory requirements for GMB151 Soybean in the country of intended production and for key import countries to ensure compliance, maintain product integrity, and assist in minimizing the potential for trade disruptions (BASF 2020).
Compliance with Other Laws		
CAA, CWA, EOs:	Fully compliant	Fully compliant
	Fully compliant	Fully compliant

4 AFFECTED ENVIRONMENT

This chapter includes a review of the current status of the human environment as defined in the CEQ regulations for NEPA (40 CFR §1508.14). The components of the human environment that may be affected by a regulatory determination for GMB151 Soybean by APHIS under 7 CFR 340 were listed (see "Issues Considered") in Chapter 1. A detailed description for each component follows. This information was the basis for comparison to identify effects that may result from a regulatory determination for GMB151 Soybean, as the Agency performed its analysis to assess the potential for significant impacts from it decision.

4.1 AGRICULTURAL PRODUCTION OF SOYBEANS

Soybean (*Glycine max* (L.) Merr.) is an economically important leguminous crop that is a source of vegetable oil and protein. Soybeans are grown for their seed, which is processed to yield oil and meal. Among oil seed crops, soybeans are ranked first in the world as a source of oil production (Chung and Singh 2008). In the United States, soybeans are also a major source of livestock animal feed and biodiesel fuel (USB 2012).

The genus, *Glycine*, includes two subgenera and more than 25 species (Sherman-Broyles et al. 2014b). The subgenus *soja* consists of only two species, the cultivated *G. max* and its annual wild soybean progenitor, *G. soja* Sieb. & Zucc. The subgenus *glycine* includes at least 26 species. Most are perennials native to Australia and its surrounding islands. The domestication of *G. max* from its wild progenitor soybean (*G. soja* Sieb. & Zucc.) occurred in China or Southeast Asia between 3,000 and 9,000 years ago (Hymowitz 1970; Hymowitz and Newell 1981; Sedivy, Wu, and Hanzawa 2017).

Soybean is a self-pollinating species, propagated commercially by seed (OECD 2000). Soybean seeds contain about 18% oil and 38% protein (Hartman, West, and Herman 2011). Nearly all soybean meal (98%) is used for livestock or aquaculture feed (Hartman, West, and Herman 2011). Soybeans are grown worldwide. Leading soybean-producing countries include Argentina, Brazil, China, India and the United States (USDA-FAS 2019a, 2019b).

U.S. soybeans are grown mostly in the Midwest (Figure 1). Acreage increased rapidly after World War II until the late 1970s as a result of increased vegetable oil demand and higher meat consumption (USDA-ERS 2006). U.S. soybean acreage stabilized in the 1980s mostly because of farm programs that encouraged planting other crops.

In the 1990s, changes in farm programs, overseas demand, and lower production costs associated with herbicide-resistant (HR) crops, resulted in an increase in soybean acreage (USDA-ERS 2006). From 1992 to 2012, U.S. soybean acreage increased 31% from about 59.1 to 77.2 million acres (USDA-NASS 2012e, 2012d). About 90 million acres were planted in 2017 (Figure 2), followed by a decline in acreage that rebounded to about 83 million planted and harvested acres by 2020 (USDA-NASS 2020).

Soybean acreage in the major producing states (Figure 1) is commonly rotated with corn. Total soybean production in the United States (Figures 2 and 3) has increased in recent years because of an increase in both the area under cultivation and yield per unit area (USDA-NASS 2018b, 2017, 2017). A significant factor contributing to these increases in recent years is that soybean cultivation has expanded into the northern and western parts of the country because new improved short-season soybean varieties have been developed that are better adapted to the climate of that region, and provide better profits (USDA-ERS 2010b) than wheat or older soybean varieties.

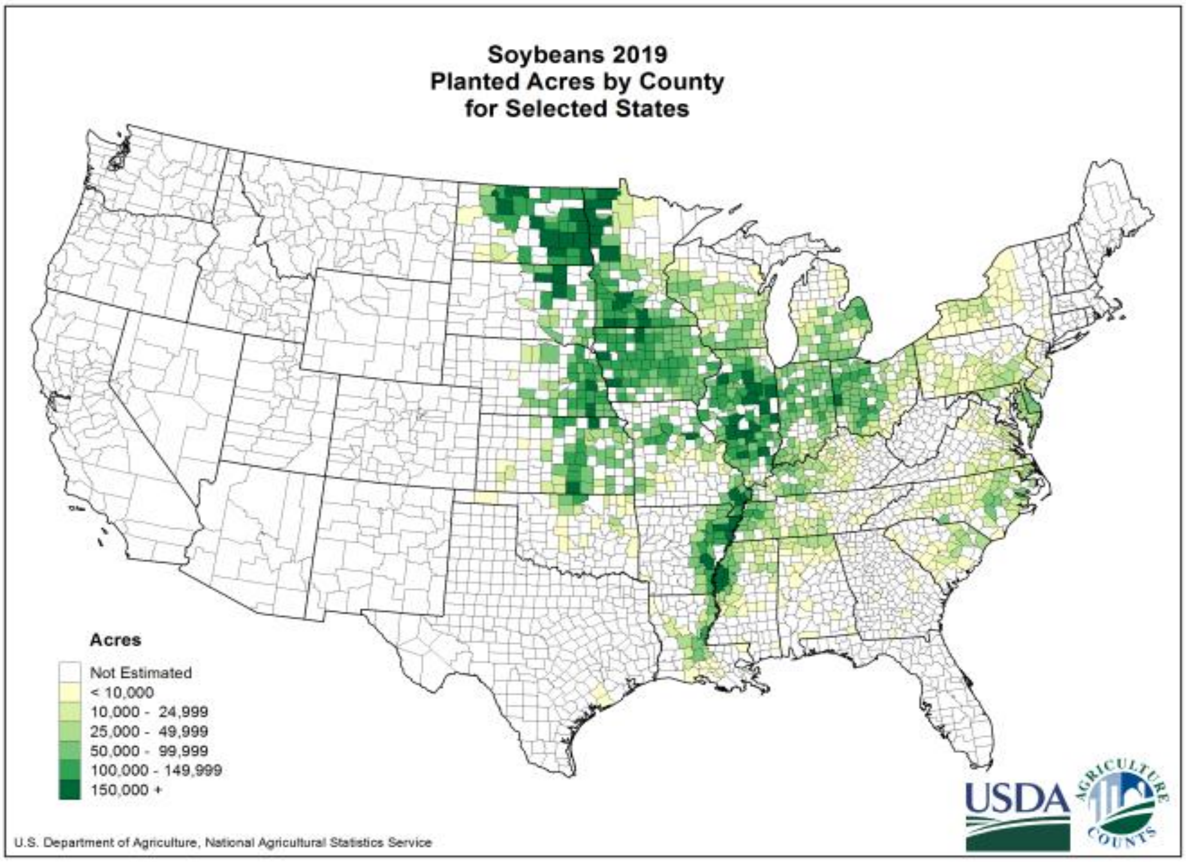

Figure 1. Soybean Planted Acres by County for Selected States.
Source: (USDA-NASS 2016b, 2020)

Soybean production has increased 35.6%, from nearly 2.2 billion bushels or 59.88 million metric tons (MT) in 1992 to approximately 3.0 billion bushels (81.7 million MT) in 2012. From 1991 to 2011, average yield increased approximately 17.6% from 34.2 bushels per acre to 41.5 bushels, but declined nationally in 2012 to 39.3 bushels per acre compared to 2011 average yields. By 2020, the harvest was 53.3 bushels per acre (USDA NASS 2020b).

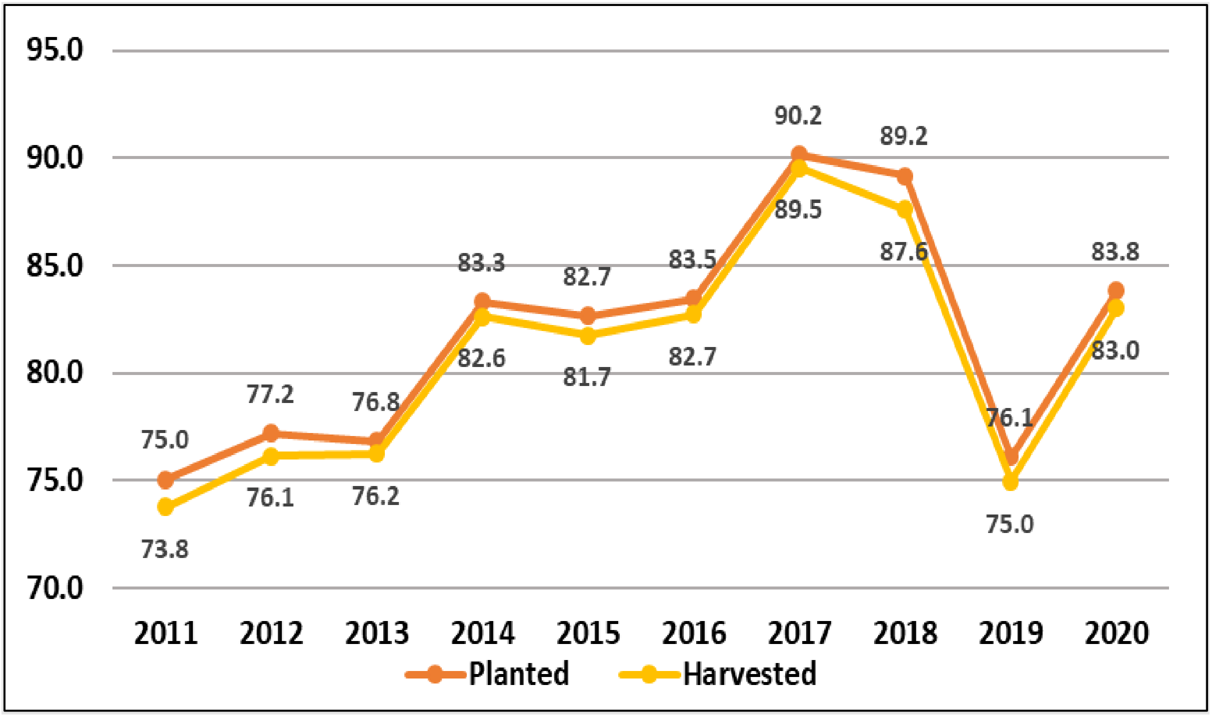

Figure 2. U.S. Soybean Acreage: 2011-2020
Source (USDA-NASS 2020)

USDA projects an estimated 3.6 billion bushels of soybeans (97.99 million MT) will be produced by the end of the 2021/2022 growing season. About 2.1 billion bushels (57.16 million MT) of this production will be used for domestic consumption and 1.6 billion bushels (43.55 million MT) will be exported (USDA-OCE 2012).

Improvements in soybean yield are challenged by both biotic and abiotic stress factors. Some typical abiotic stress factors include salinity, non-optimal temperatures, drought, flooding, and poor soil quality (Chung and Singh 2008). One objective of soybean breeding programs is to develop varieties that maintain yield under a broad array of environmental conditions.

Varieties have for many years been developed using conventional plant breeding methods. Combined with improved agronomic practices, these varieties have resulted in improved yields. The multigene components influencing soybean yield are complex. Genetic selection to develop soybean varieties adapted to lower yielding areas, and the need to develop regional soybean varieties for specific environments limits the availability and identification of those traits that can provide yield improvements across the entire spectrum of soybean production environments.

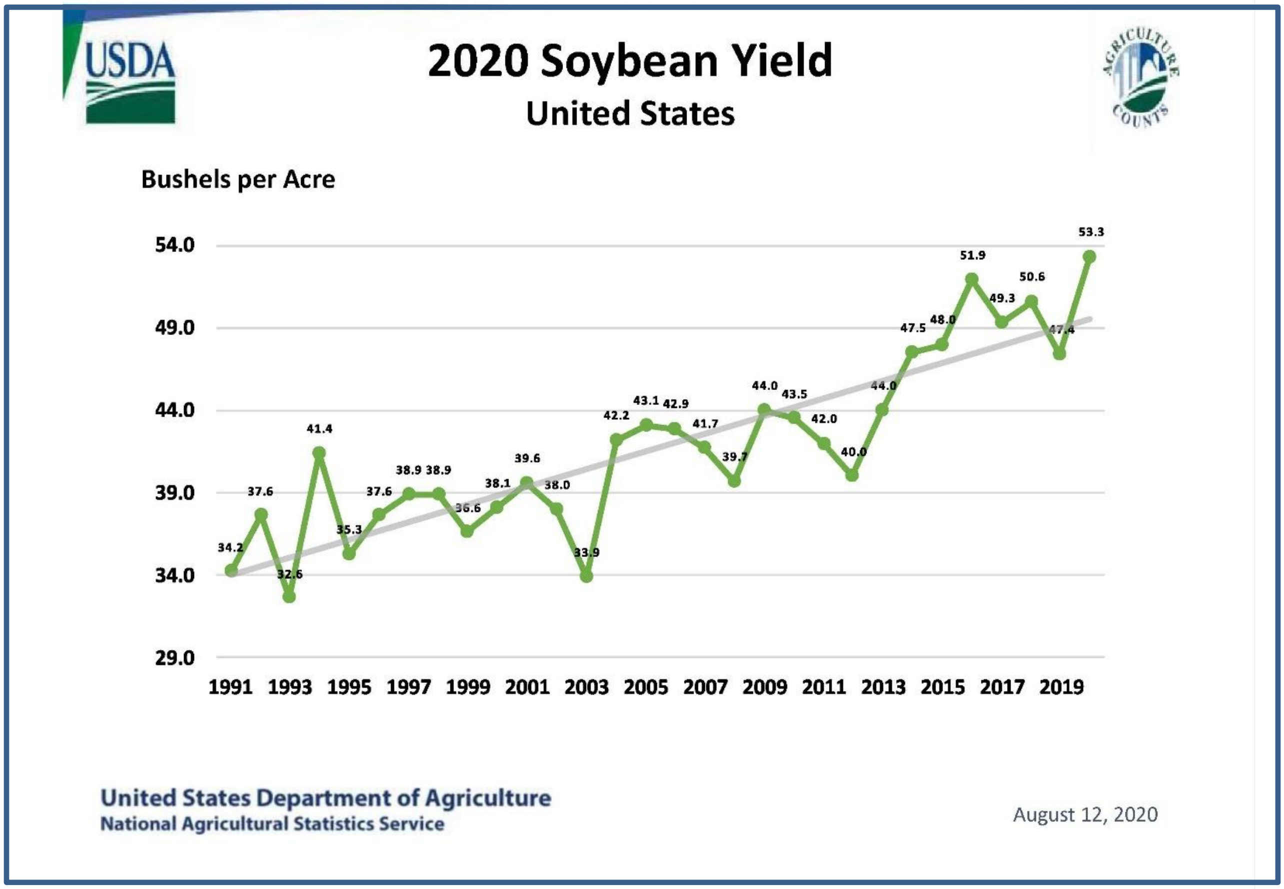

Figure 3. U.S. Soybean Yield: 1991-2019
Source: (USDA NASS 2020b)

4.1.1 Acreage and Regional Distribution of Soybean Production

Field testing of biotech crops began in the 1980s, (Fernandez-Cornejo and Caswell 2006), and biotech soybeans became commercially available in 1996 (USDA-ERS 2011a; Fernandez-Cornejo and Caswell 2006). By 2017, a biotech variety was gown on 94% of U.S. soybean acreage (Table 2) (USDA-ERS 2020a).

4.1.2 Agronomic Practices for Conventional Soybean Production

Soybeans are an herbaceous annual that grows as an erect bush (OECD 2000). It is a short-day plant, so flowers when days have fewer daylight hours (OECD 2000). As a result, photoperiod and temperature responses are important in determining areas of specific varietal adaptation. Soybean varieties are identified based on geographic bands of adaptation that run east-west, determined by latitude and day length. In North America, there are 13 described maturity groups (MGs), ranging from MG 000 in the north (45° latitude) to MG X near the equator. Within each maturity group, varieties are described as early, medium, or late maturing (OECD 2000).

Soybean seeds germinate at about 50°F (10°C). Under favorable conditions, seedlings emerge in 5-7 days. Inoculation of soybean fields, that were previously used to grow another crop, with

Bradyrhizobium japonicum, a nitrogen fixing bacterium that develops a symbiotic relationship with soybeans, dramatically increases plant production (OMAFRA 2011; Pedersen 2007; Missouri University of Science and Technology No Date). Inoculation is necessary for optimum efficiency of the nodules that form on soybean root systems (Pedersen 2007; Berglund and Helms 2003a). In the 1990s, the row spacing recommendation for soybeans was narrowed to seven inches to achieve greater yields. This was later changed to 15 inches to promote greater air circulation, which reduces diseases that impact yields (USDA-ERS 2010b).

Table 2. Biotech Soybeans as a Percentage of the Total U.S. Soybean Crop

STATE	Percentage of the U.S. Soybean Crops Planted in Varieties Developed Using Genetic Engineering Grown in:	
	2016	2017
Arkansas	96	97
Illinois	94	93
Indiana	92	92
Iowa	97	94
Kansas	95	94
Michigan	95	94
Minnesota	96	96
Mississippi	99	99
Missouri	89	87
Nebraska	96	94
North Dakota	95	95
Ohio	91	91
South Dakota	96	96
Wisconsin	94	92
Other States*	94	94
UNITED STATES	94	94
*All other states in the U.S. estimating program		

Source: (USDA-NASS 2018d)

Soybeans require more moisture to germinate than corn, and seed-to-soil contact is important for good early season soybean growth. An adequate water supply is especially important at planting, during pod-filling, and seed filling (Hoeft et al. 2000). Soybeans require approximately 20-25 inches of water during the growing season. In 2008, only 9% of harvested soybean acreage (about 12 million acres) was irrigated. States with the most irrigated soybean acreage are

Nebraska, Arkansas, Mississippi, Missouri, and Kansas (USDA-NASS 2010). There was no substantial change in irrigated U.S. soybean acreage between 2008 and 2015, Irwin, et al. 2017).

Soybeans tolerate a broad spectrum of growing environments, but maximum yields require optimum soil conditions that include a pH range of 6.0-7.0 (NSRL No Date), and adequate levels of phosphorus, potassium, calcium, and magnesium, plus other minor nutrients. Because soybeans develop a symbiotic relationship with *B. japonicum* that promotes nitrogen fixation from atmospheric nitrogen, fertilizer nitrogen is not always required for optimum soybean production. In areas with increased amounts of salt or carbonates, or those that have no past history of soybean production, nitrogen amendments prior to or at the time of planting have been shown to increase yield if soil tests reveal levels that are not adequate (Franzen 1999; Berglund and Helms 2003a).

When grown in rotation with corn, a common practice is to fertilize the preceding corn crop with enough phosphorus and potassium to provide sufficient carry over for the subsequent soybean crop, so no supplemental fertilizer is needed (Ebelhar et al. 2004b; Franzen 1999; Berglund and Helms 2003a; Franzen 2019). Adequate amounts of calcium and magnesium are normally present if soil pH is at or near the optimum pH or has been recently treated with dolomitic limestone to achieve an optimum pH (Frank 2000; Harris 2011).

Crop Rotation

Crop rotation is a sustainable agriculture practice of growing a series of different crops in the same field in succession, usually according to a planned cycle of plantings. The primary goal of crop rotation is to achieve maximum short term (annual or seasonal) crop yields in a system that sustains the long-term productivity of the fields. It is a strategy designed to prevent long-term profit loss from depletion of resources by maintaining them at a level that supports profitable crop productivity (Hoeft et al. 2000). When applied effectively, rotating crops can improve soil quality and fertility. Since the roots of soybean plants share a symbiotic relationship with *B. japonicum* that fixes atmospheric nitrogen, this may decrease the requirements for fertilizer inputs for following crops, such as corn or wheat. Crop rotation also tends to reduce the incidence of plant diseases, insect pests and weed competition (Berglund and Helms 2003a; USDA-ERS 1997). Crop rotation may also include fallow periods in which no crop is grown for a season, or seeding of fields with a cover crop that prevents soil erosion and can provide livestock forage (USDA-NRCS 2010a; Hoeft et al. 2000).

Maximizing economic returns results from rotating crops in a sequence that efficiently produces the most net profit. Many factors at the individual farm level influence crop rotation choices, including soil type, anticipated commodity prices, farm labor requirements, fuel, fertilizer and seed costs, and regional climatic conditions (Duffy 2011; Hoeft et al. 2000; Langemeier 1997).

Soybeans are commonly rotated with corn, winter wheat, spring cereals, and dry beans (OECD 2000). Cropland used for soybean and corn production is nearly identical in many areas, such as Illinois, where more than 90% of the cropland is planted in a two-year corn-soybean rotation (Hoeft et al. 2000). Approximately 95% of U.S. soybean acreage is in a rotation system.

Soybeans may also be a cover crop in short rotations for its fixed nitrogen contribution to soil (Hoorman, Islam, and Sundermeier 2009). Where continuous soybean production is undertaken, yields may be reduced in the second or later years because pest and disease incidence may increase (Monsanto 2010; Pedersen et al. 2001; Whitaker 2017). In the Midwest, the crops planted most often in rotation with soybean include corn and wheat. Those soybean plantings in the Southeast that are grown in a rotation are most frequently followed by corn and cotton. Corn is most often the crop of choice for rotation with soybeans grown in the coastal states of the eastern United States. Double-cropping soybeans is also an option to increase returns. Soybeans are frequently planted in winter wheat stubble to produce a second crop in the same growing season. Double-cropping maximizes profits if high commodity prices can support it, but careful management to achieve uniform stands to sustain high yields and profitability is needed. These requirements include selection of appropriate varieties, a higher seeding rate, closer row spacing, and adequate moisture for germination (McMahon 2011).

Tillage

Soybean growers till soil to prepare seedbeds, dislodge compaction, incorporate fertilizers and herbicides, manage drainage within and outside fields, and control weeds (Heatherly et al. 2009). Tillage systems include conventional, reduced, conservation (including mulch-till, strip-till, ridge-till, and no-till), and deep. The primary purpose of conservation tillage is to reduce soil erosion (Heatherly et al. 2009).

In conventional tillage, after harvest crop residue is plowed into the soil to prepare a clean seedbed for planting and to reduce the growth of weeds, leaving less than 15% of crop residue on the surface (Heatherly et al. 2009; Towery and Werblow 2010). Conservation tillage uses tools that disturb soil less and leave more crop residue on the surface (at least 30%). No-till farming only disturbs the soil for planting seed (Towery and Werblow 2010; USDA-NRCS 2005). Crop residue includes materials left in an agricultural field after the crop has been harvested, including stalks and stubble (stems), leaves and seed pods (USDA-NRCS 2005). Residue aids in conserving soil moisture and reducing wind and water-induced soil erosion (Heatherly et al. 2009; USDA-ERS 1997; USDA-NRCS 2005). No-till systems are not meant to control weeds or dislodge soil compaction, so other strategies such as herbicide applications and track management of heavy machinery must be used in no-till fields for these problems (Heatherly 2012).

Since 1996, the use of no-till has increased more than any other reduced tillage system. Nearly all of this shift is attributable to reliance on HR crop varieties (e.g., soybean, corn, cotton, canola) (Fawcett and Towery 2002). A 1997 survey revealed that farmers using no-till practices were more likely to adopt HR soybeans as an effective weed control practice, but the same study also found that the reliance on HR soybean varieties did not encourage adoption of no-till practices. However, later surveys revealed a corresponding increase in the use of no-till production practices (Sankula 2006; Carpenter et al. 2002) with the increase in availability of GR soybean varieties. From the introduction of GR soybeans in 1996 until 2004, no-till practices increased by 64% (Sankula 2006). Use of conservation tillage practices by U.S. soybean growers increased by 12 million acres (4.9 million hectares) from 51% in 1996 to 63% in 2008 (NRC 2010).

No-till soybean production is not suitable for all producers or areas. For example, no-till soybean production is less successful in heavier, cooler soils more typical of northern latitudes (NRC 2010; Kok, Fjell, and Kilgore 1997) where the potential for increased weed and insect pests and disease requires careful management (Pedersen et al. 2001; Peterson 1997; Shoup 2016; Peterson 2016).

Agronomic Inputs

Agronomic inputs, including water, soil and foliar nutrients, inoculants, fungicides, pesticides, and herbicides, are used in soybean production to maximize yields (Clevenger 2010; Hoeft et al. 2000; OECD 2000; OMAFRA 2011). Soil and foliar macronutrient applications to soybean primarily include nitrogen, phosphorous (phosphate), potassium (potash), calcium, and sulfur, with other micronutrient supplements such as zinc, iron, and magnesium applied as needed. Irrigation provides essential water for growth where rainfall is insufficient or erratic (see sections on Water Resources in this chapter, and Soil Quality in Chapter 4 for more details).

Nutrients. Fertilizers and other nutrients may be applied to the soil or sprayed on foliage in soybean production. Soil fertilizers have differential availability to plants based upon soil characteristics and moisture. For example, in a drought year, potassium may become fixed between clay layers until water moves through the soil again (Corn and Soybean Digest 2012). Fertilizers such as nitrogen, potassium and phosphorous may be incorporated into the soil at soybean planting by tillage or drilling. Fertilizer may be purposefully concentrated in bands at varying depths in the soil to enhance nutrient availability at different growth stages (Vitosh, Johnson, and Mengel 2007; Fernandez and White 2012). In conservation tillage, phosphorous and potassium may become vertically stratified from use of surface broadcast fertilizers that minimize soil disturbance. Therefore, there is a trend among farmers to enhance nutrient availability to sustain higher yields (Fernandez and White 2012).

On average, soybean removes 0.85 1bs of phosphate (phosphorous) and 1.2 lbs of potash (potassium) per bushel of seed produced (CAST 2009). Table 3 includes a summary of removal rates of nitrogen, phosphate and potassium for soybean, corn and wheat that are commonly rotated with soybean (Silva 2011). The data show that soybeans remove more nitrogen, potassium and phosphorous than either corn or wheat.

Table 3. Nutrient Removal Rates for Commonly Grown U.S. Grain Crops.

Crop	Pounds of Fertilizer Removed/Bushel Produced/Acre:		
	Nitrogen	Potash	Phosphate
Corn	0.9	0.37	0.27
Soybean	3.8	0.8	1.4
Wheat	1.2	0.63	0.37

Source: Silva (2011)

Research summarized by the Council for Agricultural and Science Technology indicates that adding nitrogen displaces rather than supplements natural cost-free nitrogen production in soybean cultivation, as the size, weight, and number of nitrogen-fixing nodules formed on soybean roots are actually reduced (CAST 2009). Application of nitrogen under drought conditions in acid subsoil conditions, in soils having low residual nitrogen, in a high-yield environment, or in late or double crop plantings has raised soybean yields, but not enough to offset the added cost. Potassium may change considerably from one testing time to the next, so it should also be regularly monitored to ensure optimum yields (CAST, 2009).

Phosphorous should be applied at least at the crop removal rate determined by regular soil testing. There is some concern that phosphorous for crop fertilizer is depleting phosphate rock deposits, which are a finite resource. However, finite does not necessarily mean that world reserves are being depleted. A recent analysis concluded that phosphate rock is not likely to become scarce within the next one hundred years (Heckenmueller, Narita, and Klepper 2014).

Soybeans are often grown in rotation with corn, and soil nutrient supplements applied to corn are often adequate to support soybean crops the following year without additional supplementation (Bender et al. 2013), making it more economical to apply nutrients such as nitrogen, potassium and phosphorous ahead of the corn crop in two-year corn-soybean rotations (CAST 2009). Other research has found that annual supplementation of potassium and phosphorous is most beneficial in the South where soybean to soybean rotation is more common (Heatherly 2012). Corn and soybean take up nutrients and both concentrate potassium and phosphorous in different compartments within the plant (Mallarino et al. 2011). Potassium is located mainly in the cytoplasm of cells and cell vacuoles, where it activates enzymes, regulates stomata functions, and assists in transfer of compounds across membranes. In contrast, most phosphorous is located in cell membranes and nucleic acids, which is incorporated into plant organic matter, and is a major component of the metabolic, energy-rich compounds that drive plant metabolism.

Compared to potassium, much more phosphorous is absorbed from the soil by soybeans. Some portion of these nutrients absorbed by the crop may be returned to the soil by leaving plant residue such as soybean foliage in the field (Mallarino et al. 2011).

Data for average chemical fertilizer application rates (USDA-NASS 2018e) for 2017 for USDA program states showed that nitrogen was applied at 18 lb/A, and phosphate and potash were applied at an average annual rate of 52 and 91 lb/A respectively. These supplements were applied on average only once per crop year. The relatively low rate of soybean nutrient supplementation likely results because most soybeans are rotated after corn crops that leave sufficient nutrients to sustain the subsequent soybean crop.

Inoculants. When added to soil as an inoculant, the bacterial symbiont, *B. japonicum* can increase soybean yields by about one bushel per acre (Conley and Christmas 2005). Historically, a nonsterile peat powder was applied to seed at planting as an inoculant carrier to the field. Improvements have since been made in inoculant manufacturing, such as using sterile carriers, adhesives to stick the inoculant to seeds, liquid carriers, concentrated frozen products, new organism strains, pre-inoculants, and inoculants containing extended biofertilizer and biopesticidal properties (Conley and Christmas 2005).

Pesticides. Feeding on soybean foliage, seed pods and roots by several different types of insects can reduce yield (Lorenz et al. 2006; Whitworth, Michaud, and Davis 2011). Nematodes are also serious pests, especially the soybean cyst nematode, because effective pesticides are not available (Nelson and Bradley 2003). A combination of crop rotation to a non-susceptible host and the use of resistant varieties are used to manage the problem (Nelson and Bradley 2003). However, these resistant soybean varieties often provide lower yields than other commercially available varieties.

***Insecticides and Nematicides*:** Economic thresholds for soybean insect infestations are used to decide if and when to apply integrated pest management (IPM) control measures (Higgins 1997; Whitworth 2016). Thresholds are typically based on field survey data for the number of pests present and/or extent of defoliation, such as those developed for management strategic plans of the National Information System of Regional IPM Centers (USDA 2011; IPM 2019). Data summarizing USDA NASS chemical insecticide a.i. (active ingredient) usage in 2017 for U.S. soybeans are included in Table 4. Based on total soybean acreage treated, the three most commonly applied insecticides were lambda-cyhalothrin, bifenthrin, and chlorpyrifos, which were applied to 8%, 5% and 3% of soybean acreage, respectively (USDA-NASS 2018a). Some growers may use other methods to control insect infestations including crop rotation, tillage, and biological control (i.e., beneficial organisms [predators and parasites of pest species]).

Table 4. Insecticides Most Commonly Applied to Soybean Acreage in 2017.

Insecticide (Active Ingredient: a.i.)	**Percent of Soybean Acreage Treated**	**Average Application Rate** (lbs a.i./acre)	**Total Applied** (lbs a.i.)
Lambda-cyhalothrin	8	0.03	215,000
Bifenthrin	5	0.06	247,000
Chlorpyrifos	3	0.34	876,000
Imidacloprid	2	0.08	109,000
Zeta-cypermethrin	2	0.02	25,000
Acephate	1	0.69	861,000
Chlorantraniliprole	1	0.06	55,000
Thiamethoxam	1	0.04	44,000
Beta-Cyfluthrin	1	0.04	41,000

Source: (USDA-NASS 2018a)

There are only a limited number of nematicides registered for use on soybeans to control SCN and other nematode pests because applying chemical methods for their control is not cost effective compared with other management alternatives. Most nematicides for SCN are prescribed as seed treatments to be used in conjunction with resistant varieties ((University of Arkansas Cooperative Extension Service 2021) (Tylka and Mullaney 2018; Program 2014; Nelson and Bradley 2003) (USDA-NASS 2018b; Shoup 2016).

Fungicides: Most plant diseases are caused by fungi, bacteria, or viruses. Planting resistant varieties is the most commonly used management method to control those plant pathogens that reduce soybean yields. In contrast, chemical pesticides are used less often, but among those used to treat soybean diseases, those used most frequently are fungicides.

Diseases that infect soybeans are caused by bacteria, fungi and viruses (Jardine 1997; Bradley 2018). The most serious soybean diseases include *Cercospora* foliar blight, purple seed stain, aerial blight, soybean rust, pod and stem blight, and anthracnose (Benedict 2011). Besides selecting varieties with resistance to the diseases prevalent in a growing region (Jardine 1997; Bradley 2018), growers plant sterilized disease-free seed (Jardine 1997), and use other best management practices (BMPs) such as rotating crops to prevent buildup of disease organisms in fields, and providing adequate nutrients and water for growth (Kandel 2019; Nelson 2011). Seed treatments with various chemicals such as fungicides, promote successful seed germination (Jardine 1997; Bradley 2018).

When other management measures fail to control diseases, soybean growers have chemical treatment options, but most are only effective on diseases caused by fungi (Benedict 2011). Fungicides most commonly applied to soybeans in 2017 were pyraclostrobin, fluxapyroxad, azoxystrobin, propiconazole, trifloxystrobin, and picoxystrobin (applied to 5%, 5%, 4%, 3%, 2%, and 1% of U.S. soybean acreage respectively (USDA-NASS 2018a).

Herbicides: Weed management for soybeans has been done primarily with herbicides since the mid-1960s, and will continue to be an important practice for the foreseeable future. One review of aggregate data for crop yield losses and herbicide use estimated a $16 billion (20%) U.S. crop production loss in value if herbicides were not used (Gianessi and Reigner 2007), even if additional tillage and hand weeding labor replaced herbicides.

The herbicides most commonly applied to soybeans in 2017 are listed in Table 5. Growers consider several factors when selecting a weed control program including cost, potential adverse effects on the crop, residual effects that limit following crop choices in a rotation cycle, and control efficacy. All herbicides and other pesticides can only be applied legally in strict accordance with their EPA registration labels. What is allowed by the label is a primary consideration for growers.

Management of Weed Herbicide Resistance

There are currently 262 species of weeds (152 dicots and 110 monocots) and 514 unique cases of HR weeds reported from throughout the world. Weeds have evolved resistance to 23 of the 26 known herbicide modes of action (MOAs) and to 167 different herbicides. HR weeds have been reported in 93 crops in 70 countries (Heap 2021).

For many years, growers were able to effectively control or suppress virtually all weeds in soybean with glyphosate. A number of weed species eventually developed resistance to glyphosate however, and the number of acres infested with resistant biotypes has been increasing. The Weed Science Society of America (WSSA) currently lists 50 weed species worldwide that are resistant to one or more herbicide MOAs and are associated with soybean cultivation. Seventeen are found in the United States (Heap 2021).

Herbicide usage trends since the adoption of biotech crops are the subject of much interest, research and debate. The initial assessments indicated a decline in herbicide use in the early years of HR crop production (Carpenter et al. 2002). Some argue that this was followed by an increase in the volume of herbicide usage as the HR varieties became increasingly popular (Benbrook 2009).

Table 5. Five Most Used Herbicides to Treat U.S. Soybean Acreage in 2017

Herbicide (Active Ingredient: a.i.)	**Percent of Acreage Treated**	**Average Application Rate** (lbs a.i./acre)	**Total Applied** (million lbs a.i.)
Glyphosate isopropylamine salt	46	1.145	44.2*
Glyphosate potassium salt	30	1.590	40.3*
Sulfentrazone	22	0.179	3.3
Fomesafen sodium	19	0.240	3.9*
Metribuzin	18	0.256	3.7
***Expressed as acid equivalent**			

Source: (USDA-NASS 2018a)

Others report a continuing decline in herbicide use with the adoption of biotech crops (Fernandez-Cornejo and Caswell 2006), or little or no change in the amount of herbicide active ingredients applied to soybeans (Brookes and Barfoot 2010). The contradictory findings have been attributed to the different measurement approaches used by researchers, the way data were adjusted for the effects of factors affecting pesticide use such as weather or cropping patterns, and the statistical procedures used to analyze the data (NRC 2010).

Herbicide applications and other weed control practices exert selection pressures on weed communities. This can change weed community structure (i.e., change the types of weeds present) that favors weeds that don't respond to the herbicide or other control methods being used (Owen 2008). Herbicide resistance is primarily caused by natural selection for individuals with HR traits within a population by repeated sub-lethal exposure to one or a limited number of herbicides (Duke 2005; Durgan and Gunsolus 2003). Dispersal of the HR weed seed and further selection by herbicide treatment contributes to the rapid spread of HR weeds to new locations.

Both the increased selection pressure resulting from the exclusive or extensive and widespread use of glyphosate herbicides on GR crops without other types of herbicides, and changes in weed management practices (i.e., conservation tillage or no-till) have resulted in weed population shifts and increased glyphosate resistance among some weed populations (Duke 2005; Owen 2008).

GR crops, themselves, do not influence weeds any more than non-GR crops. HR weed biotypes result from natural selection for those biotypes under the current weed control methods, rather than gene transfer from the crop to the weed. It is the prolonged use of the same weed control tactics by growers that causes long-term selection pressures that change weed communities and contribute to the induction of HR weeds (Owen 2008). More details about HR weeds are reviewed in the Plant Communities section of this chapter.

The management of GR weeds has become a substantial challenge for U.S. agriculture, especially soybean production, because good alternative options are limited (Owen 2011a; Powles 2008a; Powles 2008b). Some strategies proposed to manage GR weeds (Boerboom 1999; Beckie 2006; Sammons et al. 2007; Frisvold, Hurley, and Mitchell 2009), include:

- Rotating different herbicides that have different modes of action
- Site specific herbicide applications
- Use of highest labeled application rate allowed by the label (prevents sublethal dosing)
- Crop rotation
- Use of tillage for supplemental weed control
- Cleaning equipment between fields
- Controlling weed escapes
- Controlling weeds early
- Scouting for weeds before and after herbicide applications

Volunteer soybeans are not a widespread management problem, and occur most often in parts of the southern United States where winters are mild. In production systems where soybeans are rotated with other crops, soybeans can be a volunteer weed (Owen and Zelaya 2005a), but are not considered difficult to manage because soybean seeds rarely remain viable the following season and any interference they may pose to subsequent crops is minimal. Furthermore, herbicides, such as atrazine and metolachlor that are usually used for weed control in corn, the crop most often rotated with soybeans, are also effective at controlling volunteer soybean (Owen and Zelaya 2005a). Conversely, volunteer GR corn in soybean is a greater concern (Owen and Zelaya 2005a). With the widespread use of both GR corn and soybean, glyphosate is no longer effective to control corn volunteers. Growers must often include graminicides (herbicides that control weedy grasses) as part of their weed management strategy (Owen and Zelaya 2005a).

Soybean Yield Increases

Because of recent trends in farm production and land area, soybean growers will have the future challenge of expanding agricultural output by raising productivity on a stable or reduced land area (OECD-FAO 2020). This implies that most of the projected expansion in soybean production is expected to come from increasing yield, not increasing crop acreage (OECD-FAO 2020).

Egli (2008) reviewed historical trends in U.S. corn and soybean back to the first available data in 1924 to document soybean yield increases. Improved management practices such as mechanization, narrow-row planting, earlier planting, adoption of conservation tillage, increased weed control, and decreased harvest loss contributed to increased yields (Egli 2008). The breeding of disease resistant varieties has further enhanced crop yields. For example, De Bruin and Pedersen (2009) estimate SCN-resistant soybean varieties increased yields by 17--19% compared to non-resistant varieties.

USDA projections through 2021/2022 show an average annual rate of increased average yields of 0.45 bushels per acre for the period 2012/2013 to 2021/2022, which results in an average U.S. yield of 46.05 bushels per acre for the period (USDA-OCE 2018). While USDA projects increasing yields, the projected rate of increase is lower than the past rate. Current and future factors that negatively affect yield increases are the expansion of soybean production into northern and western parts of the country, where yields are typically lower than in the Midwest.

Soybean Seed Production

Growers may plant certified soybean seed, uncertified seed, and soybean seed grown and stored on individual farms (Oplinger and Amberson 1986). Seed production differs from grain production because of additional biological, technical, and quality control factors required to maintain varietal purity. Genetic purity in the production of commercial soybean seed is regulated through a system of seed certification which ensures the desired traits in that particular seed remain within purity standards (Bradford 2006).

The production and certification of foundation, registered, certified, or quality assurance seeds are administered by state and regional crop improvement associations, several of which are chartered under the laws of the state(s) they serve (e.g., see Virginia Crop Improvement Association No Date; SSCA No Date-a; Illinois Crop Improvement Association 2013; Mississippi Crop Improvement Association 2008, 2015; Illinois Crop Improvement Association 2019). These agencies certify varietal purity and identity, while issues concerning germination and mechanical purity are governed under state and federal seed laws.

Seed quality includes a variety of attributes, including genetic purity, vigor, weed seed content, seed borne diseases, and the presence of foreign material such as dirt or chaff (Bradford 2006). The genetic purity of the seed must be maintained to maximize the value of the new variety (Sundstrom et al. 2002). Some general examples of seed production practices include certification of origin and class, documentation of field cropping history, isolation from weeds and soybean grain crops, decontamination of cultivation, transportation, and storage equipment, and inspection and laboratory analysis of harvested seeds from approved fields (Virginia Crop Improvement Association No Date; South Dakota Crop Improvement Association 2011; SSCA No Date-a; Illinois Crop Improvement Association 2013; Mississippi Crop Improvement Association 2008). There are also crop specific field, inspection, isolation, and harvested seed purity standards (e.g., percentage of pure seed, inert matter, weed seeds, other crop seeds, other variety seeds, and germination) (South Dakota Crop Improvement Association 2011; Virginia Crop Improvement Association 2013; SSCA No Date-b).

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. States have developed laws to regulate the quality of seed available to farmers (Bradford 2006). Most of the laws are similar in nature and have general guidelines for providing information on the label for the following:

- Commonly accepted names of agricultural seeds
- Approximate total percentage by weight of purity
- Approximate total percentage of weight of weed seeds
- Name and approximate number per pound of each kind of noxious weed seeds
- Approximate percentage of germination of the seed
- Month and year the seed was tested

Various seed associations have standards to help maintain the quality of soybean seed. The AOSCA (AOSCA 2012c, 2013, 2019) defines the classes of seed as follows:

- *Breeder*: developed and used by plant breeders
- *Foundation*: progeny of Breeder or Foundation maintained to preserve specific genetic identity and purity

- *Registered*: progeny of Breeder or Foundation maintained for satisfactory genetic identity and purity
- *Certified*: progeny of Breeder, Foundation, or Registered handled to maintain satisfactory genetic identity and purity

Seed certification systems differ from Identity Preservation (IP) systems for certain agricultural commodities. IP refers to a system of production, handling, and marketing practices used to maintain the integrity and purity of crop products throughout the food supply chain (Sundstrom et al. 2002). IP systems are used to meet the demands for specialized grain products, including those from crops with output-specific traits (e.g., high oleic oil), without specific traits or attributes (e.g., conventional crops), grown under specific production methods (e.g., organic crops), and requiring rigorous safeguards and confinements practices (e.g., pharmaceutical and industrial crops) (Elbehri 2007).

Soybean is self-pollinated and propagated commercially from seed (OECD 2000; Hoeft et al. 2000). There are no *Glycine* spp. found outside of U.S. cultivation, so the potential for outcrossing is minimal (OECD 2000). Minimum Land, Isolation, Field, and Seed Standards (7 CFR part 201.76) specify isolation distances for the production of Foundation, Registered and Certified soybean seeds to prevent mechanical mixing from potential contaminating sources.

4.1.3 Agronomic Practices for Organic Soybean Production

In the United States, only products produced using specific methods and certified under the USDA’s Agricultural Marketing Service National Organic Program (NOP) can be labeled as “USDA Organic” (USDA-AMS 2008, 2020). Organic certification is a process for validation of production practices, not certification of the end product. USDA organic certification requires that specific production methods be documented by the producer and certified by an independent auditor.

An accredited organic certifying auditor conducts an annual review of a producer’s organic system plan and practices documented in records maintained on site. The auditor also makes on-site inspections to confirm accuracy of recordkeeping. Organic growers must maintain records to show that production and handling procedures comply with USDA organic standards. The NOP regulations (7 CFR § 205.2) specifically exclude certain methods, including those used in biotechnology, that cannot be used for the production of products labeled “USDA Organic.”

Common practices organic growers may use to exclude biotech products include planting only organic seed and staggering planting earlier or later than neighboring farmers who may be using biotech crops. Staggered plantings allow the crops to flower at different times establishing temporal isolation to minimize the possibility of cross-pollination (NCAT 2012).

Although the NOP 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 NOP standards (USDA-AMS 2008, 2020). The current NOP regulations do not specify an acceptable threshold level for the adventitious presence of biotech 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” (USDA-AMS 2008, 2020; Ronald and Fouche 2006).

4.2 PHYSICAL ENVIRONMENT

Components of the physical environment affected by soybean production in the United States are reviewed in this section. These include soil, water, and air quality.

4.2.1 Soil Quality

Soil consists of solids (minerals and organic matter), liquids, and gases. Inorganic and organic matter harbor 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 (USDA-NRCS 1999b), and is further distinguished by its ability to support rooted plants in a natural environment. Soil establishes the capacity of a site's biomass vigor and production in terms of air, water, temperature moderation, protection from toxins, and nutrient availability. Soils also determine a site's susceptibility to erosion by wind and water, and its flood attenuation capacity.

Important soil properties include temperature, pH, soluble salts, amount of organic matter, the carbon-nitrogen ratio, numbers of microorganisms and soil fauna, and all vary seasonally, and over extended periods of time (USDA-NRCS 1999b). Soil texture and organic matter levels directly influence its shear strength, nutrient holding capacity, and permeability. Soils are differentiated based on characteristics such as particle size, texture, and organic matter content (USDA-NRCS 2010b).

Soybeans are normally grown in agricultural fields managed for crop production and are best suited to fertile, well-drained medium-textured loam soils, but can be produced in a wide range of soil types (Berglund and Helms 2003a; NSRL No Date). Soybeans need a variety of macronutrients, such as nitrogen, phosphorus, potassium, calcium, magnesium, and sulfur, at various levels. They also require smaller amounts of micronutrients such as iron, zinc, copper, boron, manganese, molybdenum, cobalt, and chlorine. These micronutrients may be deficient in poor, weathered soils, sandy soils, alkaline soils, or soils excessively high in organic matter.

As with proper nutrient levels, soil pH is critical for soybean development. Soybeans grow best in soil that is slightly acidic (pH range: 6.0 - 7.0) (NSRL No Date). Soil with a pH that is too high (7.3 or greater) negatively affects yield (NSRL No Date; Cox et al. 2003). Similarly, soils that are high in clay and low in humus may impede plant emergence and development. Soils with some clay content may increase moisture availability during periods of low precipitation (Cox et al. 2003).

Soybean yield is highly dependent upon soil and climatic conditions. In the United States, the soil and climatic requirements for growing soybean are very similar to corn. The soils and climate in the Midwest, portions of the Great Plains and eastern regions of the United States provide sufficient water under normal climatic conditions to produce a soybean crop. Soil texture and structure are key components in determining water availability in soils. Medium-textured soils hold more water, allowing soybean roots to penetrate deeper in medium-textured soils than in clay soils (Berglund and Helms 2003a; Cox et al. 2003).

Land management practices for soybean cultivation can affect soil quality. While practices such as tillage, fertilization, the use of pesticides and other management tools can improve soil health, they can also cause substantial damage if not properly used. Several concerns relating to 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).

Conventional and conservation tillage may be used for the cultivation of soybean. 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 crop residue is one of the most effective conservation methods to reduce wind and water erosion. It 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 increase organic matter and improve 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 quality soil. It is instrumental in maintaining soil stability and structure, reduces the potential for erosion, provides energy for microorganisms, improves infiltration and water holding capacity, and is important in nutrient cycling, cation exchange[7] capacity, and the degradation of pesticides (USDA-NRCS 1996).

The residue left from conservation tillage practices 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 because the products of SOM decomposition, and the presence of fungal hyphae (filamentous structures that compose the main growth) and soil bacteria bind aggregates and soil particles together (USDA-NRCS 1996). Although soil erosion rates are dependent on numerous local conditions such as soil texture and crops grown, a comparison of 39 studies contrasting conventional and no-till practices showed that, on average, no-till practices reduce erosion by a factor of 488 times compared to conventional tillage (Montgomery 2007).

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 the corresponding reduction in the need for mechanical weed control (Carpenter et al. 2002). Conservation tillage also minimizes soil compaction because it reduces, but does not eliminate the number of times a field is tilled.

Other methods to improve soil quality include careful management of fertilizers and pesticides, the use of cover crops to increase plant diversity and limit the time soil is exposed to wind and rain, and the use of buffer strips, contour strips, wind breaks, crop rotations, and varying tillage practices (USDA-NRCS 2006b). Planting cover crops is another management practice that has become recognized as a way to increase plant diversity, reduce compaction, suppress disease,

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

control weeds, and enhance soil nutrients (NWF 2012; USDA-NASS 2012c; Lee et al. No Date; SARE 2012; Corn and Soybean Digest 2013; MDA 2012; USDA-NRCS 2011a; Hoorman et al. 2009; University of Georgia Soybean Team 2019) in addition to suppressing erosion by limiting the time soil is exposed to wind and rain effects.

Although conservation tillage benefits soil quality in several ways, it can also have negative effects. For example, under no-till practices, soil compaction may become a problem because tillage disrupts compacted areas (USDA-NRCS 1996). Another concern is that not all soils (such as wet and heavy clay soils) are suited for no-till. No-till practices may also increase pest abundance compared to conventional tillage (NRC 2010).

Numerous kinds of organisms that live in soils, ranging from microorganisms to larger macroinvertebrates, such as worms and insects, affect soil quality. The microorganisms that make up the soil community include bacteria, fungi, protozoa, and nematodes. Decomposers, such as bacteria, and saprophytic fungi, degrade plant and animal remains, organic materials, and some pesticides (USDA-NRCS 2004). Other organisms, such as protozoans, mites and nematodes, consume the decomposer microbes and release macro- and micronutrients, making them available for plant uptake.

Mutualists are another important group of soil microorganisms. These are the mycorrhizal fungi, nitrogen-fixing bacteria, and some free-living microbes that have coevolved with plants, and supply nutrients to and obtain food from their plant hosts (USDA-NRCS 2004). The bacterium, *B. japonicum*, associated with soybeans fixes nitrogen in root nodules on the plants (Franzen 1999). If a field has not been planted recently with soybeans (3-5 years), either the seed or seed zone must be inoculated with *B. japonicum* prior to soybean planting (Elmore 1984; Pedersen 2007).

Pesticide use has the potential to affect soil quality because it can impact the soil microbial community (see the section on Microorganisms in this chapter for more details). The length of persistence of herbicides in the environment is dependent on the concentration and rate of degradation by biotic and abiotic processes (Carpenter et al. 2002). Persistence is measured by the half-life, which equates to the length of time needed for the herbicide residue to degrade to half of its original concentration. The degradation of pesticides may be dependent on mineralization by microbes in soil, photodegradation in water, and leaching (US-EPA 2005). In soil, pesticide persistence may be strongly influenced by moisture, temperature, organic matter content and pH (FAO 1997; Senseman 2007).

4.2.2 Water Resources

Surface water quality is determined by the natural, physical, and chemical properties of the land that surrounds the water body. Topography, soil type, vegetative cover, minerals, and climate all influence water quality. Surface runoff is affected by meteorological factors such as rainfall intensity and duration, and physical factors such as vegetation, soil type, and topography. When land use affects one or more of these natural physical characteristics of the land, water quality is almost always impacted to some extent. These impacts may be positive or negative, depending on the type, duration and extent of land use.

Agricultural practices have the potential to substantively impact water quality because of the vast amount of acreage devoted to farming nationwide and the physical and chemical demands that agricultural use has on the land. The most common types of agricultural pollutants include excess sediment, fertilizers, animal manure, and pesticides. Agricultural non-point source pollution is the leading source of impacts on rivers and lakes, the third largest source of impairment to estuaries, and a major source of impairment to groundwater and wetlands (USDA-NRCS 2011b).

The principal law regulating pollution of the nation's water resources is the Federal Water Pollution Control Act of 1972, which is commonly referred to as the Clean Water Act (CWA). The EPA sets water quality standards, permitting requirements, and monitors water quality. The EPA sets the standards for water pollution abatement for all waters of the United States under CWA programs, but in most cases, gives qualified states the authority to issue and enforce permits. The CWA provides the authority to establish water quality standards, control discharges into surface and subsurface waters (including groundwater), develop waste treatment management plans and practices, and issue permits for discharges under the National Pollutant Discharge Elimination System. Section 303(d) of the CWA established a process for states to identify those waters within its boundaries that do not meet minimum water quality standards. Waters that do not meet clean water standards are classified under the CWA as "Impaired Waters." Impaired Waters cannot support one or more designated uses (e.g., swimming, propagation of aquatic life, drinking, and agricultural or industrial supply). Common pollutants evaluated include sediment, chemicals, fuels, biological contaminants and pathogens, and characteristics such as oxygen availability, water temperature, and water clarity.

Once a water body or stream segment is listed as impaired, the state must complete a plan to address the issue causing the impairment. States then develop total maximum daily loads (TMDLs) for priority waters that identify the amount of a specific pollutant from various sources that may be discharged to a water body, but still ensure that water quality standards are met for that body of water. Completion of the plan is generally all that is required to remove the stream segment from the 303(d) impaired water list and does not mean that water quality has changed. Once the TMDL is completed and approved by EPA (US-EPA 2012), the stream segment is placed on the 305(b) list of impaired streams with a completed TMDL.

Groundwater is water that flows underground and is stored in natural geologic formations called aquifers. It is ecologically important because it sustains ecosystems by releasing a constant supply of water into wetlands and contributes a sizeable amount of flow to permanent streams and rivers. Currently, the largest use of groundwater in the United States is irrigation, representing approximately 67.2% of all the groundwater pumped (NGWA 2017).

Approximately 9% of the planted acres of soybeans in the United States are irrigated (USDA-NASS 2010; USDA-ERS 2011b; USDA-NASS 2011). A majority (approximately 73%) of U.S. irrigated soybean farms occur in the Missouri and Lower Mississippi Water Resource Regions with soybean farms in the states of Nebraska, Arkansas, Mississippi, Missouri, and Kansas accounting for 85% of all irrigated soybean acres (USDA-NASS 2010).

In the United States, approximately 47% of the population depends on groundwater for its drinking water supply (NGWA 2017). Drinking water is protected under the Safe Drinking Water Act of 1974 (SDWA) (Public Law 93-523, 42 U.S.C. 300 *et seq*.). SDWA and subsequent amendments authorize the EPA to set national health-based standards for drinking water from source water to the tap to protect against both naturally-occurring and man-made contaminants that may be found. In an effort to protect source water, the Sole Source Aquifer (SSA) Program was developed to protect drinking water supplies in areas where there are few or no alternative sources to the groundwater resource for drinking water and other needs. EPA defines an 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 United States and its territories (US-EPA 2011c). The designation protects an area's groundwater resource by requiring EPA to review certain proposed projects receiving federal funds or approval within the designated area to ensure that they do not endanger the water source.

Use of pesticides can introduce chemicals to water through spray drift, cleaning of pesticide equipment, soil erosion, and filtration through soil to groundwater. Solubility (whether it readily dissolves in water), its adsorptive qualities (how tightly it binds to clay and humus particles in the soil), and its degradation (how fast it breaks down into harmless components) are some of the factors that influence the degree to which herbicide residue can infiltrate ground or surface water.

Planting HR soybean varieties enables growers to treat post-emergent soybeans for weed control, reducing or eliminating the need for cultivation. Approximately 94% of the soybean acreage in the United States is planted with HR soybean varieties (USDA-ERS 2017). Therefore growers who plant HR soybean varieties are more likely to use conservation tillage and no-till practices than growers of non-HR soybeans (Givens et al. 2009; Dill, CaJacob, and Padgette 2008). This trend has resulted in reduced surface water runoff and soil erosion (Locke, Zablotowicz, and Reddy 2008). Reduced tillage agricultural practices result in improved soil quality having high organic material that binds nutrients within the soil (see the section on Soil Quality in this chapter for more details). An increased amount of plant residue on the soil surface reduces the effects of pesticide usage on water resources by forming a physical barrier to erosion and runoff, allowing more time for absorption into the soil, and slowing soil moisture evaporation (Locke, Zablotowicz, and Reddy 2008). The use of HR soybean varieties has also promoted a shift to herbicides that have lower environmental impact, such as glyphosate (Fernandez-Cornejo and McBride 2002).

Nutrient applications to soybeans primarily include nitrogen, phosphorus (phosphate), potassium (potash), calcium, and sulfur, with other micronutrient supplements such as zinc, iron, and magnesium applied as needed. Runoff from cropland areas receiving manure or fertilizers contributes to increased phosphorous and nitrogen delivery to streams and lakes. This causes eutrophication[8] primarily from phosphorus, which is the limiting nutrient in freshwater ecosystems. Ammonium runoff into surface waters can result in the poisoning of aquatic organisms. Nitrate in runoff from fields is carried into rivers and lakes. Elevated nitrate levels in the Gulf of Mexico contribute to the hypoxia zone, an area depleted of oxygen and marine life.

Conservation tillage and other management practices are used to trap and control sediment and nutrient runoff. Water quality conservation practices benefit agricultural producers by lowering input costs and enhancing the productivity of working lands.

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[8]Eutrophication is the process by which a body of water becomes enriched in dissolved nutrients (such as phosphates) that stimulate the growth of aquatic plant life usually resulting in the depletion of dissolved oxygen.

4.2.3 Air Quality

The Clean Air Act (CAA) requires the EPA to set National Ambient Air Quality Standards (NAAQS) for certain common and widespread pollutants. The NAAQS, developed by the EPA to protect public health, sets limits for six criteria pollutants: ozone (O_3), nitrogen dioxide (NO_2), carbon monoxide (CO), sulfur dioxide (SO_2), lead (Pb), and inhalable particulates (particulates greater than 2.5 micrometers and less than 10 micrometers in diameter are defined as coarse particulate matter [PM_{10}], and those less than 2.5 micrometers in diameter are classified as fine particulate matter [$PM_{2.5}$]). The CAA requires states to achieve and maintain the NAAQS within their jurisdiction.

Each state may adopt requirements stricter than those of the national standard and each is also required by EPA to prepare an implementation plan with strategies to achieve and maintain the national standard for air quality within the state. Areas that violate air quality standards are designated as non-attainment areas for the criteria pollutant(s), 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 aerosols from herbicide and pesticide applications.

Because they reduce the need to till for weed control, HR soybeans have promoted the use of no-till or conservation tillage for soybean production. Decreased tillage reduces the use of emission-producing equipment (Table 6) and also causes less dust from particulates, potentially lowering rates of wind erosion, which benefits air quality (Towery and Werblow 2010).

Table 6. Examples of Estimated Annual Fuel Used for Different Tillage Methods

Estimated Use/1,000 Acres of Soybeans in Urbana, Illinois	Tillage Method			
	Conventional	Mulch-till	Ridge-till	No-till
Total fuel used*	5,239	4,369	3,460	2,330
Estimated fuel saved compared to that used for conventional tillage	--	870	1,779	2,909
Percent estimated savings	--	17%	34%	56%
*Diesel fuel in gallons				

Source: USDA-NRCS (2013a)

Volatilization of fertilizers, herbicides and pesticides from soil and plant surfaces introduces these chemicals into the air. One study in the Chesapeake Bay region (USDA-ARS, 2011) 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 study of volatilization of certain herbicides after application to fields found moisture in dew and soils in higher temperature regimes significantly increases volatilization rates (USDA-ARS, 2011).

Prescribed burning is a land treatment used under controlled conditions to accomplish resource management objectives. Open combustion produces particles of widely ranging size, depending to some extent on the rate of energy release of the fire (US-EPA 2011a). The extent to which agricultural and other prescribed burning may occur is regulated by individual state implementation plans to achieve compliance with the NAAQS. Prescribed burning of fields would likely occur only as a pre-planting option for soybean production based on individual farm characteristics.

Pesticide and herbicide spraying may impact air quality from drift and diffusion. Drift is defined by EPA as "the movement of pesticide through air at the time of application or soon thereafter, to any site other than that intended for application" (US-EPA 2000). Diffusion is gaseous transformation into 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).

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

4.3 BIOLOGICAL RESOURCES

Biological resources include animal, plant and microbiological organisms, and their assemblages that form living community structures in the environment.

4.3.1 Animal Communities

Agriculture dominates human uses of land (Robertson and Swinton 2005). In 2011, 917 million acres (approximately 47%) of the conterminous 48 states were dedicated to farming, including: crop production, pasture, rangeland, Conservation Reserve Program and Wetlands Reserve Program lands, or other government program uses. About 10% (88.8 million) of farmed acreage acres was for soybean production (Senseman 2007; USDA-NASS 2012b).

Intensely cultivated lands, such as those for commercial soybeans, provide less suitable habitat for wildlife than natural areas. A wide array of wildlife species occurs within the 31 major soybean-producing U.S. states. The types and numbers of animal species found in and near soybean fields is less diverse as compared to unmanaged natural habitats. How these lands are maintained influences the function and integrity of the wildlife populations they support and the ecosystem services they provide. Animal communities considered in this EA include wildlife species and their habitats. Wildlife refers to both native and introduced species of mammals, birds, amphibians, reptiles, invertebrates, and fin and shellfish.

Birds and Mammals

Soybean fields can provide both food and cover for a variety of birds, and small and large mammals. During the spring and summer months, soybean fields provide browse for rabbits, deer, rodents, other mammals, and birds such as upland gamebirds (Palmer, Bromley, and Anderson No Date). During the winter months, leftover and unharvested soybeans provide a food-source for wildlife; however, soybeans are poorly suited for meeting nutrient needs of wildlife, such as waterfowl, which require a high-energy diet (Krapu, Brandt, and Cox 2004).

A shift from conventional agricultural practices to conservation tillage and no-till practices has occurred on farms planting HR soybean varieties (Givens et al. 2009; Dill, CaJacob, and Padgette 2008). This increased use of conservation tillage practices has benefitted wildlife through improved water quality, availability of waste grain, retention of cover in fields, and increased populations of invertebrates (Sharpe 2010; Brady 2007). Conservation tillage practices that leave greater amounts of crop residue serve to increase the diversity and density of birds and mammals (USDA-NRCS 1999a).

Invertebrates

Increased residue from the shift to conservation tillage 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 source to fast growing young, and a nutrient-rich diet for migratory birds (USDA-NRCS 2016).

Insects, nematodes and other invertebrates can be beneficial to soybean production by cycling nutrients and preying on plant pests. Conversely, there are some invertebrates that are detrimental to soybean crops, including: soybean cyst nematode (*Heterodera glycines*); root knot nematodes (*Meloidogyne* spp.); bean leaf beetle (*Cerotoma trifurcata*); beet armyworm (*Spodoptera exigua*); blister beetle (*Epicauta* spp.); soybean podworm (*Helicoverpa zea*); shorthorned grasshoppers (*Acrididae* spp.); green cloverworm (*Hypena scabra*); seed corn beetle (*Stenolophus lecontei*); seed corn maggot (*Delia platura*); soybean aphid (*Aphis glycines*); soybean looper (*Pseudoplusia includens*); soybean stem borer (*Dectes texanus*); spider mites (*Tetranychus urticae*); stink bugs (green [*Acrosternum hiliare*] and brown [*Euschistus* spp.]); and velvetbean caterpillar (*Anticarsia gemmatalis*) (Palmer 2012; Whitworth 2016; Whitworth, Michaud, and Davis 2012).

While insects and nematodes are considered less problematic than weeds in U.S. soybean production, injury can impact yield, plant maturity, and seed quality. Consequently, these pests are managed during the growth and development of soybean to enhance soybean yield (Higley and Boethel 1994; Aref and Pike 1998).

Under FIFRA, all pesticides, including herbicides, insecticides and nematicides, that are sold or distributed in the United States must be registered by the EPA (US-EPA 2005). 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 the environment, including wildlife.

All pesticides registered prior to November 1, 1984 must also be reregistered to ensure that they meet the current, more stringent standards. EPA must find during its registration process (US-EPA, 2018) that a pesticide does not cause unreasonable adverse effects to the environment if used in accordance with the EPA-approved label instructions. Growers must adhere to EPA label use restrictions for herbicides and pesticides. These measures help to minimize potential impacts of their use on non-target wildlife species.

4.3.2 Plant Communities

Although U.S. soybeans are grown commercially in 31 states, most (95%) are produced in 18 states in the Midwest and Southeast (Figure 1), encompassing a wide range of physiographic regions, ecosystems, and climatic zones (USDA-NASS 2019). The types of vegetation, including the variety of weeds within and adjacent to soybean fields can vary greatly, depending on their geographic location.

In general, plant diversity surrounding crop fields is an important component of a sustainable agricultural system (Scherr and McNeely 2008; CBD 2020). Hedgerows, woodlands, fields, and other assemblages of plants in habitats surrounding crop fields serve as important reservoirs for a range of organisms—both beneficials and pests.

Soybean fields and surrounding edges for example, are habitats for weeds that adversely impact crop production directly through interference and resource competition. They serve as seed sources for weeds that invade soybean fields and also support insect pests and plant pathogens that impact soybeans. However, both the weedy and non-weedy plant species in habitats around fields provide valuable ecosystem services. Examples include habitat for pollen and nectar resources, and harborage for beneficial arthropods like biological control agents of soybean pests (e.g., lady beetles, spiders, and parasitic wasps) (Nichols and Altieri 2012; Scherr and McNeely 2008). Although soybeans are self-pollinated, pollen and nectar resources are indirectly important to soybeans by supporting some of the plant and animal species beneficial to soybean production. Surrounding plant communities for example can help regulate run-off, reduce soil erosion, and improve water quality, so when effectively managed, they provide benefits for crop production (Altieri and Letourneau 1982; Nichols and Altieri 2012).

Non-crop vegetation in soybean fields is limited by the extensive cultivation and weed control programs practiced by soybean producers. Plant communities bordering soybean fields can range from forests and woodlands to grasslands, aquatic habitats, and residential areas. Adjacent crops frequently include other soybean varieties, corn, cotton, or other field crops.

Weeds are classified as annuals, biennials, or perennials. Annuals and biennials are plants that complete their lifecycle within one year or two years respectively. Perennials are plants that live for more than two years. Weeds are also classified as broadleaf (dicots) or grass (monocots). Weeds can reproduce by seeds, rhizomes (underground creeping stems), or other underground parts. Annual grass and broadleaf weeds are considered the most common weed problems in soybeans (Krausz et al. 2001). However, with increased rates of conservation tillage, increases in perennial, biennial, and winter annual weed species are being observed (Durgan and Gunsolus 2003; Green and Martin 1996) Winter perennials are particularly competitive and difficult to control, as these weeds re-grow every year from rhizomes or root systems.

At least 55 weed species have been identified as commonly occurring in soybean production. Among the most common are: common lambsquarter (*Chenopodium album*), morning glory species (*Ipomoea* spp.), velvetleaf (*Abutilon theophrasti*), pigweed, (*Amaranthus* spp.), common cocklebur (*Xanthium strumarium*), foxtail (*Setaria* spp.), ragweed species (*Ambrosia* spp.), crabgrass (*Digitaria* spp.), barynyard grass (*Echinochloa crus-galli*), Johnsongrass (*Sorghum halepense*), and thistles (*Cirsium* spp.) (Heap 2021; Shoup 2016).

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

Herbicide resistance is described by the Weed Science Society of America as the “inherited ability of a plant to survive and reproduce following exposure to a dose of herbicide normally lethal to the wild type” (WSSA 2013). The first reports of weed resistance to herbicides were in the 1950s (WSSA 2011). Individual plants within a species can exhibit different responses to the same herbicide rate. Initially, herbicide rates are set to work effectively on the majority of the weed population under normal growing conditions.

Genetic variability, including herbicide resistance, is exhibited naturally in normal weed populations, although at very low frequencies. When only a single herbicide is continuously relied upon as the primary means of weed control, the number of weeds resistant to that herbicide compared to those susceptible to the herbicide may change as the surviving resistant weeds reproduce (Figure 4). With no change in weed control strategies, in time, the weed population may be composed of more and more resistant weeds (WSSA 2011).

The adoption of GR crops, including soybeans, resulted in growers changing historical weed management strategies and relying on a single herbicide, glyphosate, to control weeds in the field (Owen et al. 2011; Weirich et al. 2011). Reliance on a single management technique for weed control resulted in the selection for weeds resistant to that technique (Owen et al. 2011; Weirich et al. 2011). The development of GR weeds has necessitated a diversification of weed management strategies by growers. GR weeds have forced growers to respond to the problem by applying herbicides with different modes of action, using tank mixes, increasing the frequency of applications, and returning to tillage and other cultivation techniques to physically control HR species, when a specific herbicide proves to be ineffective (CAST 2012). Integrated weed management programs that use herbicides from different groups, vary cropping systems, rotate crops, and that use mechanical as well as chemical weed control methods, delay or prevent the selection of HR weed populations (Sellers, Ferrell, and MacDonald 2011; Gunsolus 2002).

There are 495 unique HR biotypes (Table 7) with herbicide resistance in 23 HRAC herbicide groups (Heap 2021). Strategies for managing and avoiding the development of HR weed populations are well developed. In most instances, crop producers are advised to and use IWM practices to address HR weed concerns (e.g., (Shaw et al. 2011; Vencill et al. 2012; Wilson et al. 2009). IWM consists of integrating multiple practices, including mechanical, cultural, chemical, and biological weed control tactics, into a weed management program to optimize control of a particular weed problem. IWM can include specifically timed applications of herbicides, the use of herbicides with multiple modes of action, crop rotation, cover crops, various tillage practices, weed surveillance, and hand-pulling or hoeing (CLI 2015; Garrison et al. 2014; Owen 2011b).

Developers of HR varieties provide stewardship and IWM guidance to crop producers in accordance with and responsive to EPA requirements and WSSA recommendations. In 2017, EPA issued PR Notice 2017-2, *Guidance for Herbicide-Resistance Management, Labeling, Education, Training and Stewardship* (US-EPA 2017b). Through PRN 2017-2, EPA provides HR weed management guidance for herbicides undergoing registration review and for label registration (i.e., new herbicide active ingredients, and new uses proposed for HR crops and other case-specific registration actions). To assist growers in managing weeds, individual states track the prevalent weeds in crops in their area and provide the most effective means for their management, typically through state agricultural extension services and regional IPM Centers (e.g., see (IPM 2015) that work with USDA to develop crop profiles and timelines.

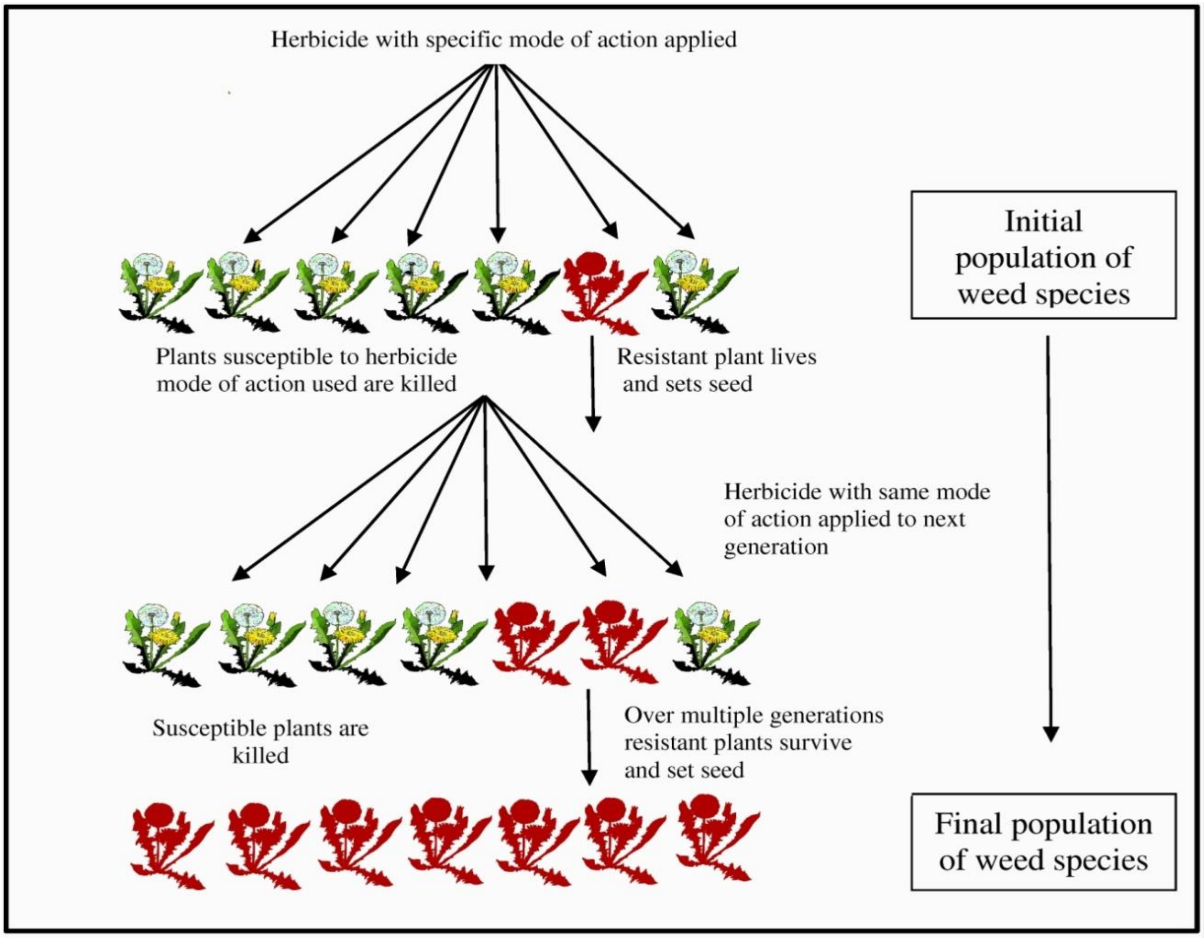

Figure 4. Schematic Diagram of the Development of Herbicide Resistance.
Source: Adapted from (Tharayil-Santhakumar 2003)

Runoff, spray drift, and volatilization of herbicides have the potential to impact non-target plant communities in proximity to fields where herbicides are used. The extent of damage to non-target plants exposed to herbicides is determined by their overall vigor, the amount and type of herbicide to which the plant is exposed, and the growing conditions after contact.

The total rainfall the first few days after herbicide applications can influence the amounts of leaching and runoff. However, it has been estimated that even after heavy rains, herbicide losses to runoff generally do not exceed 5-10% of the total applied. Planted vegetation, such as grass buffer strips, or crop residues can effectively reduce runoff. Volatilization typically occurs during application, but herbicide deposits on plants or soil can also volatilize (Tu, Hurd, and Randall 2001; USDA-FS 2009).

Table 7. Summary of World-wide HR Weeds by Herbicide Group

Herbicide Group	HRAC Group	Herbicide Example	Dicots	Monocots	Total
ALS inhibitors	B	Chlorsulfuron	98	62	160
Photosystem II inhibitors	C1	Atrazine	51	23	74
ACCase inhibitors	A	Sethoxydim	0	48	48
EPSP synthase inhibitors	G	Glyphosate	22	20	42
Synthetic Auxins	O	2,4-D	30	8	38
PSI Electron Diverter	D	Paraquat	22	10	32
PSII inhibitors	C2	Chlorotoluron	11	18	29
PPO inhibitors	E	Oxyfluorfen	10	3	13
Microtubule inhibitors	K1	Trifluralin	2	10	12
Lipid Inhibitors	N	Triallate	0	10	10
Carotenoid biosynthesis (unknown target)	F3	Amitrole	1	5	6
Long chain fatty acid inhibitors	K3	Butachlor	0	5	5
PSII inhibitors (Nitriles)	C3	Bromoxynil	3	1	4
Carotenoid biosynthesis inhibitors	F1	Diflufenican	3	1	4
Glutamine synthase inhibitors	H	Glufosinate-ammonium	0	4	4
Cellulose inhibitors	L	Dichlobenil	0	3	3
Antimicrotubule mitotic disrupter	Z	Flamprop-methyl	0	3	3
HPPD inhibitors	F2	Isoxaflutole	2	0	2
DOXP inhibitors	F4	Clomazone	0	2	2
Mitosis inhibitors	K2	Propham	0	1	1
Unknown	Z	Endothall	0	1	1
Cell elongation inhibitors	Z	Difenzoquat	0	1	1
Total Number of Unique HR Biotypes:			**256**	**239**	**495**

*HRAC: Herbicide Resistance Action Committee

Source: (Heap 2021)

Spray drift is a concern for non-target effects on susceptible plants growing adjacent to fields when herbicides are used in the production of soybeans. This potential impact results from off-target herbicide drift (US-EPA 2010b). Damage from spray drift typically occurs at field edges or at shelterbelts (i.e., windbreaks), but highly volatile herbicides may drift farther into a field. The risk of off-target herbicide drift is recognized by the EPA, which has incorporated both equipment and management restrictions to address drift on the EPA-approved herbicide labels. These EPA label restrictions include requirements that the grower manage droplet size, spray boom height above the crop canopy, restrict applications to specified wind speeds and environmental conditions, and use drift control agents (US-EPA 2010b).

4.3.3 Gene Flow and Weediness

Gene flow to and from agroecosystems can occur on both spatial and temporal scales. In general, plant pollen is an important way that genes are transmitted. The rate and success of pollen-mediated gene flow is dependent on numerous external factors in addition to the donor and recipient plant. General external factors related to pollen-mediated gene flow include the presence, abundance, and distance of sexually-compatible plant species; overlap of flowering phenology between populations; the mechanism of pollination; the biology and amount of pollen produced; and weather conditions, including temperature, wind, and humidity (Zapiola et al. 2008). Seed-mediated gene flow also depends on many factors, including the presence, and magnitude of seed dormancy, contribution and participation in various dispersal pathways, and environmental conditions and events.

Soybean (*G. max*) is native to Asia. It does not have any feral or weedy relatives in the United States. Soybean is considered a highly self-pollinated species, propagated by seed (OECD 2000). Pollination typically takes place on the day the flower opens. The soybean flower stigma is receptive to pollen approximately 24 hours before anthesis (i.e., the period in which a flower is fully open and functional) and remains receptive for 48 hours after anthesis. Anthesis normally occurs in late morning, depending on the environmental conditions. The pollen usually remains viable for two to four hours, and no viable pollen can be detected by late afternoon. Natural or artificial cross-pollination can only take place during the short time when the pollen is viable, and soybean's reproductive characteristics (e.g., flower orientation that reduces its exposure to wind, internal anthers, and clumping and stickiness of the pollen) decrease the dispersion ability of pollen (Yoshimura 2011).

As a highly self-pollinated species, cross-pollination of soybean plants to adjacent plants of other soybean varieties occurs at a very low (0-6.3%) frequency (Ray et al. 2003; USDA-APHIS 2011; Caviness 1966; Yoshimura, Matsuo, and Yasuda 2006). A study of soybeans grown in Arkansas found that cross-pollination of soybeans in adjacent rows averaged between 0.1% and 1.6%, but may be as high as 2.5% (Ahrent and Caviness 1994). Abud et al. (2007) illustrated that as distance is increased from the soybean pollination source, the chance of cross-pollination is decreased. This study found that at a distance of 1 meter, outcrossing averaged about 0.5%, at 2 meters about 0.1%, at 4 meters about 0.05%, and at 10 meters less than 0.01%.

Gene flow by seed is usually dependent on natural dispersal mechanisms, such as water, wind, or 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). Soybean seeds do not possess the characteristics for efficient seed-mediated gene flow. Soybean seeds are heavy and, therefore, are not readily or naturally dispersed by wind or water (Mallory-Smith and Zapiola 2008). Similarly, soybean seeds and seedpods do not have physical characteristics that encourage animal transport (OECD 2000). Soybeans also lack dormancy, a characteristic that allows dispersal in time by maintaining seeds and their genes within the soil for several years (OECD 2000; Mallory-Smith and Zapiola 2008).

Horizontal gene transfer and expression of DNA from a plant species to bacteria is unlikely to occur (Keese 2008). Many bacteria that are closely associated with plants have been described by sequencing them genetically, including *Agrobacterium* and *Rhizobium* (Kaneko et al. 2000; Kaneko et al. 2002; Wood et al. 2001). In cases where a review of sequence data implied that horizontal gene transfer occurred, evidence indicated that these events occurred over an evolutionary time scale (i.e., over millions of years) (Brown 2003; Koonin, Makarova, and Aravind 2001). 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 1998).

4.3.4 Microorganisms

Soil microorganisms significantly influence soil structure formation, decomposition of organic matter, toxin removal, nutrient cycling, and most biochemical soil processes (Garbeva, van Veen, and van Elsas 2004). They also suppress soil-borne plant diseases and promote plant growth (Doran, Sarrantonio, and Liebig 1996). One estimated range of the number of bacterial species in a gram of soil is between 6,400 and 3838 thousand (Curtis, Sloan, and Scannell 2002). The soil microbial community includes nitrogen-fixing microbes such as the soybean mutualist *B. japonicum*, mycorrhizal fungi, and free-living bacteria[9]; saprophytic fungi responsible for decomposition, denitrifying bacteria and fungi, phosphorus-solubilizing bacteria and fungi, and pathogenic microbes (USDA-NRCS 2004).

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), agricultural management practices (crop rotation, tillage, herbicide and fertilizer application, and irrigation) and cropping history (Garbeva, van Veen, and van Elsas 2004; Garbeva, van Elsas, and van Veen 2008).

Some types of soil microorganisms share metabolic pathways with plants that may be affected by herbicides. Tillage disrupts multicellular relationships among microorganisms, and crop rotation changes soil conditions in ways that favor different microbial communities. Plant roots, including those of soybean, release a variety of compounds into the soil creating a unique environment for microorganisms in the rhizosphere (root zone). Microbial diversity in the rhizosphere may be extensive and differs from the microbial community in the bulk soil (Garbeva, van Veen, and van Elsas 2004). More information about how soybean microbes, biotech crops, and herbicide use may affect soil microbial communities follows.

[9]Organisms that are able to obtain food without the need for a host organism.

Soybean Microbes

An important group of soil microorganisms associated with legumes, including soybean, are the mutualists. These include mycorrhizal fungi, nitrogen-fixing bacteria, and some free-living microbes that have co-evolved with plants that supply nutrients to and obtain food from their plant hosts (USDA-NRCS 2004). Legumes have developed symbiotic relationships with specific nitrogen-fixing bacteria in the family *Rhizobiaceae* that induce the formation of root nodules where bacteria reduce atmospheric nitrogen to ammonia that is usable by plants (Gage 2004). *B. japonicum* is the bacterium specifically associated with soybeans (Franzen 2019). If a field has not been planted with soybean within 3-5 years, either the seed or seed zone must be inoculated with *B. japonicum* prior to soybean planting to increase productivity (Berglund and Helms 2003a; Pedersen 2007).

In addition to beneficial microorganisms, there are also several microbial pathogens that cause disease in soybean and vary somewhat depending on the region. These include fungal pathogens such as rhizoctonia stem rot (*Rhizoctonia solani*), brown stem rot (*Phialophora gregata*), sudden death syndrome (*Fusarium solani* race A), charcoal root rot (*Macrophomina phaseolina*); bacterial pathogens such as bacterial blight (*Pseudomonas syringae*) and bacterial pustule (*Xanthomonas campestri*), and viral pathogens such as soybean mosaic virus and tobacco ringspot virus (Ruhl 2007; SSDW No Date). The soybean cyst nematode (*Heterodera glycines*) is a microscopic parasite that infects the roots of soybeans. Management to control disease outbreaks varies by region, and pathogen/parasite, but include common practices such as crop rotation, weed control, planting resistant varieties, and proper planting and tillage practices.

Biotech Crop Impacts on Microbes

All soils, including agricultural soils are complex, dynamic ecosystems. Changes in agricultural practices and natural variations in season, weather, plant development stages, geographic location, soil type, and plant species or varieties can impact the microbial community (Kowalchuk, Bruinsma, and van Veen 2003; US-EPA 2009). Direct impacts may include changes to the structure (species richness and diversity) and function of the microbial community in the rhizosphere caused by the biological activity of the inserted gene(s). Indirect impacts may result from changes in the composition of root exudates, plant litter, or agricultural practices (Kowalchuk, Bruinsma, and van Veen 2003; US-EPA 2009). Several reviews of the investigations into the impact of plants developed using genetic engineering on microbial soil communities found that most of them concluded there was either minor or no detectable non-target effects (Kowalchuk, Bruinsma, and van Veen 2003; US-EPA 2009; Hart 2006).

4.3.5 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). Loss of biodiversity can result in more costly management practices 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 (Altieri 1999). 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 harvesting limit the diversity of plants and animals (Lovett, Price, and Lovett 2003).

Biodiversity can be maintained or reintroduced into agroecosystems through the use of woodlots, fencerows, hedgerows, and wetlands. Agronomic practices that may be used to support biodiversity include intercropping (the planting of two or more crops simultaneously to 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 (compost, green manure, animal manure, etc.), and hedgerows and windbreaks (Altieri 1999). Integrated pest management strategies include several practices that increase biodiversity such as retaining small, diverse natural plant refuges and minimal management of field borders.

A variety of federally supported programs, such as the USDA funded Sustainable Agriculture Research and Education Program, and partnership programs between EPA and the agricultural community, support sustainable agricultural practices that are intended to protect the environment, conserve natural resources, and promote cropland biodiversity (i.e.,(USDA-NIFA 2017; US-EPA 2017a).

4.4 ANIMAL FEED

Animal agriculture consumes 98% of the U.S. soybean meal produced and 70% of soybeans produced worldwide (USB 2011d). Poultry consume more than 48% of domestic soybean meal or 11.92 million MT of the U.S. soybean crop with soy oil increasingly replacing animal fats and oils in broiler diets (ASA 2012b; USB 2011c). Soybean can be the dominant component of livestock diets, such as in poultry, where upwards of 66% of their protein intake is derived from soy. Other animals fed domestic soybean include swine (26%), beef cattle (12%), dairy cattle (9%), other (e.g., farm-raised fish 3%), and household pets (3%) (USB 2011a; ASA 2010a; USB 2011b).

Although the soybean market is dominated by seed production, soybeans have a long history in the United States as a nutritious grazing forage, hay, and silage crop for livestock (Blount et al. 2009). Soybean may be harvested for hay or grazed from the flowering stage to near maturity. The best soybean for forage is in the beginning pod stage (Johnson, Dunphy, and Poore 2007; Gonzalez and Burch 2019). For silage, it should be harvested at maturity before leaf loss, and mixed with a carbohydrate source, such as corn, for optimal fermentation characteristics (Blount et al. 2009). Varieties of soybean have been developed specifically for grazing and hay, but use of the standard varieties are recommended by some because of the whole plant feeding value.

Similar to the regulatory oversight for direct human consumption of soybean 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 soybean developed using genetic engineering must comply with all applicable legal and regulatory requirements, which in turn protects human health. To help ensure compliance, biotech 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. A developer who intends to commercialize a food derived from a biotech source consults with FDA to identify and discuss relevant safety, nutritional, or other regulatory issues regarding food derived from such crops, and then submits a summary of its scientific and regulatory assessment of the food to FDA. FDA evaluates the submission and responds to the developer by letter.

Growers must adhere to EPA label use restrictions for pesticides used to produce a soybean crop before using it as forage, hay, or silage. Under Section 408 of FFDCA, EPA regulates the levels of pesticide residues that can remain on feed from pesticide applications (US-EPA 2010a). These tolerances are the maximum amount of pesticide residue that can legally be present in food or feed, and if pesticide residues in food or feed are found to exceed the tolerance value, it is considered adulterated and subject to seizure.

4.5 HUMAN HEALTH

This section provides a summary of the human health concerns for public health related to the human consumption of products derived from soybeans developed using genetic engineering, and those related to occupational health and health and safety from potential exposure to agricultural hazards.

4.5.1 Public Health

Human health concerns surrounding biotech soybeans focus primarily on human and animal consumption. Soybeans yield both solid (meal) and liquid (oil) products. Soybean meal is high in protein and is used for products such as tofu, soymilk, meat replacements, and protein powder. It also provides a natural source of dietary fiber (USB 2018). Nearly 98% of soybean meal produced in the United States is used as animal feed, while less than 2% is used to produce soy flour and proteins for food use. Soybean liquids are used to produce salad and cooking oils, baking and frying fat, and margarine. Soybean oil is low in saturated fats, high in polyunsaturated and monounsaturated fats, and contains essential omega-3 fatty acids. Soybean oil comprises nearly 70% of the oils consumed in U.S. households (ASA 2010b).

Soybean varieties developed for conventional use or for use in organic production systems, are not routinely required to be evaluated by any regulatory agency in the United States for human food or animal feed safety prior to market release. Food and feed manufacturers are responsible under FFDCA rules for ensuring that the products they market are safe and properly labeled.

Biotech organisms for food and feed may undergo a voluntary consultation process with the FDA prior to release onto the market. In a consultation, a developer who intends to commercialize a food derived from a biotech source meets with the FDA representatives to identify and discuss relevant safety, nutritional, or other regulatory issues. It then submits to the FDA a summary of its scientific and regulatory assessment of the food. This process includes: (1) an evaluation of the amino acid sequence introduced into the food crop to confirm whether the protein is related to known toxins and allergens; (2) an assessment of the protein's potential for digestion; and (3) an evaluation of the history of safe use in food (Hammond and Jez 2011). The FDA evaluates the submission and responds to the developer by letter with any concerns it may have or additional information it may require. Several international agencies also review food safety associated with food derived from biotech sources including the European Food Safety Agency and the Australia and New Zealand Food Standards Agency.

Foods derived from biotech sources undergo a comprehensive safety evaluation before entering the market, including reviews under the Codex Alimentarius, the European Food Safety Agency, and the World Health Organization (FAO 2009; Hammond and Jez 2011). Food safety reviews frequently will compare the compositional characteristics of crop varieties developed using genetic engineering with conventional varieties. This comparison also evaluates the composition of the modified crop under actual agronomic conditions, including various agronomic inputs (FAO 2009; Aumaitre et al. 2002). Composition characteristics evaluated in these comparative tests include moisture, protein, fat, carbohydrates, ash, minerals, dietary fiber, essential and non-essential amino acids, fatty acids, vitamins, and antinutrients.

There are multiple ways in which organisms can be genetically modified through human intervention (e.g., traditional cross breeding, chemical or radiation-mediated mutagenesis, and genetic engineering using the methods of biotechnology). Unexpected and unintended compositional changes can arise with all forms of genetic modification, including both conventional hybridizing and genetic engineering (NRC 2004), however, no adverse health effects from genetic engineering have been documented in the human population. Reviews on the nutritional quality of foods have generally concluded that there are no significant nutritional differences in food and animal feeds derived from conventional versus biotech plants(Faust 2002; Flachowsky, Chesson, and Aulrich 2005).

Before a pesticide can be used on a food crop, the EPA must establish a tolerance, the maximum residue level of a pesticide that can remain on a crop or in foods processed from a crop, or establish an exemption for a tolerance (US-EPA 2010a). Both the FDA and USDA monitor foods for pesticide residues and enforce tolerances (USDA-AMS 2011). If pesticide residues in excess of a tolerance are detected on food, the food is considered adulterated and is subject to seizure. The USDA has implemented the Pesticide Data Program (PDP) to collect data on pesticides residues on food (USDA-AMS 2016). The EPA uses PDP data to prepare pesticide dietary exposure assessments pursuant to the FQPA. Pesticide tolerances have been established for most commodities, including soybeans, and have been published in the *Federal Register*, 40 CFR part 180, and the *Indexes to Part 180 Tolerance Information for Pesticide Chemicals in Food and Feed Commodities* (US-EPA 2011b).

4.5.2 Occupational Health and Worker Safety

Agriculture is one of the most hazardous U.S. work environments. Pesticides, particularly herbicides, are used on most soybean acreage in the United States. To protect all workers, the National Institute of Occupational Safety and Health has been authorized by Congress to establish and enforce safety standards as part of a program to address high-risk issues in the work place. In response to the specific risks of poisoning and injuries among agricultural workers from pesticide exposure, the EPA has also established safeguards under its Worker Protection Standard (WPS) (40 CFR part 170) (US-EPA 2017c). The WPS establishes protections for more than 2.5 million agricultural workers in the United States who handle pesticides at more than 560,000 workplace sites on farms, forests, nurseries, and greenhouses.

The Occupational Safety and Health Administration requires all employers to protect their employees from hazards associated with pesticides and herbicides. The EPA WPS, updated in

2015 (US-EPA, 2017d), establishes specific safety procedures that that must be followed by employers who hire workers who handle pesticides. The WPS requires pesticide safety training, notification of pesticide applications, use of personal protective equipment, restricted entry intervals (reentry times) following pesticide application, decontamination supplies and practices, and access to emergency medical assistance. The EPA pesticide registration process also includes protections for worker health. Under FIFRA, all pesticides sold or distributed in the United States must be registered by the EPA (US-EPA 2018). Registration decisions are based on scientific studies that assess the chemical's potential toxicity and environmental impact. All pesticides registered prior to November 1, 1984 must also be reregistered to ensure that they meet the current, more stringent standards. During the registration decision, the EPA must find that a pesticide does not cause unreasonable adverse effects to human health or the environment if used in accordance with its approved label instructions (OSTP 2001).

EPA labels for pesticides include use restrictions and safety measures to mitigate exposure risks. Pesticide applicators are required to use registered pesticides consistent with the instructions issued by the EPA that are listed on the label for each registered pesticide product. Worker safety precautions and use restrictions are included on pesticide registration labels. These include instructions for the levels of personal protection required for agricultural workers to safely handle and apply pesticides. Further details to achieve compliance are provided in the EPA WPS (US-EPA 2017c). When used in accordance with the EPA registration label, pesticides do not cause any unacceptable health risk to workers.

4.6 SOCIOECONOMIC ISSUES

Socioeconomic issues that are affected by soybean production in the United States are reviewed in this section. These issues are separated into two categories here, domestic economic environment and international trade environment.

4.6.1 Domestic Economic Environment

In 2020, soybean accounted for 26.5% of U.S. principal crop acreage. The 2020 crop represented a 10% increase in total acreage from 2019 with 88.8 million acres planted in the United States. HR varieties produced using genetic engineering were planted on 94% of this acreage (USDA-NASS 2020). Fourteen states (Arkansas, Illinois, Indiana, Iowa Kansas, Michigan, Minnesota, Mississippi, Missouri, Nebraska, North Dakota, Ohio, and South Dakota and Wisconsin) accounted for most of the U.S. soybean production.

Soybean production cost data are compiled every 4-8 years by USDA-ERS as part of its Agricultural Resource Management Survey. For soybeans in 2019, typical operating costs per planted acre included purchased seed ($56.10), fertilizer and soil amendments ($24.48), other chemicals ($26.05), and irrigation water ($0.07). Total operating costs were $159.27 per planted soybean acre (USDA-ERS 2020b).

There is consistent evidence that farmers obtain substantial financial and non-financial benefits as a result of adoption of biotech crops. These benefits include increased income from off-farm labor, increased flexibility and simplicity in the application of pesticides, an ability to adopt more farming practices that have less environmental impact; increased consistency of weed control; increased human safety; equipment savings; and labor savings (Fernandez-Cornejo and McBride 2000; Duke and Powles 2009; Fernandez-Cornejo, C. Hendricks, and Mishra 2005; Fernandez-

Cornejo and McBride 2002; Hurley, Mitchell, and Frisvold 2009; Marra, Piggott, and Carlson 2004; USDA-ERS 2020a).

Most of the soybean crop is crushed to produce oil and meal. In the United States, almost all (98%) of the soybean meal is used for animal feed. Most of the oil produced is used for human consumption; the balance is used for industrial products. Soybean oil represents almost 70% of the oils consumed by U.S. households. A noteworthy ongoing shift affecting soybean demand is an increased interest in using soybeans for biofuel production. From 1999 to 2009, the consumption of soybean biodiesel has increased from 0.5 to 1,070 million gallons (ASA 2012a).

Organic production methods account for only about 0.14% of the total U.S. soybean crop value. Although only a small proportion (about 0.09%) of the U.S. soybean crop is grown organically (USDA-ERS 2020b), it is more profitable per unit (bushel) of production than conventional systems that use non-biotech or biotech soybean varieties because the premium prices paid for soybeans certified as organically grown more than offset higher production costs (McBride and Greene 2009). Another factor contributing to enhanced profitability of organic soybeans is consumer demand for organically certified food in general, which has been experiencing a double-digit growth rate for more than a decade (USDA-ERS 2020b). The incentive for growers to choose conventional production systems is that organic methods are much more labor intensive, so organic farms tend to be much smaller than those that use conventional, highly mechanized systems. As a result, the latter yield higher overall profits per grower because the volume of production more than offsets premium prices paid for organically certified soybeans (McBride and Greene 2009).

4.6.2 International Trade Environment

Processed soybeans are the world's largest source of animal protein feed and the second largest source of vegetable oil. The United States is one of the world's leading soybean producers and the second-leading exporter. Soybeans comprise about 90% of U.S. oilseed production, while other oilseeds, including peanuts, sunflower seed, canola, and flax, make up the remainder (USDA-ERS 2017).

The total value of U.S. agricultural exports was $135 billion in 2016 (USDA-ERS 2017). Of this total, $23 billion was from soybean exports, ranking them first among all U.S. agricultural commodity exports. Since 2005, the percentage of U.S. soybean production that has been exported has increased from about 30% to nearly 50% (Figure 5). Despite the long-term trend in increasing export volume of U.S. soybean production, the U.S. share of the global export market has been declining (Figure 6) since 1980.

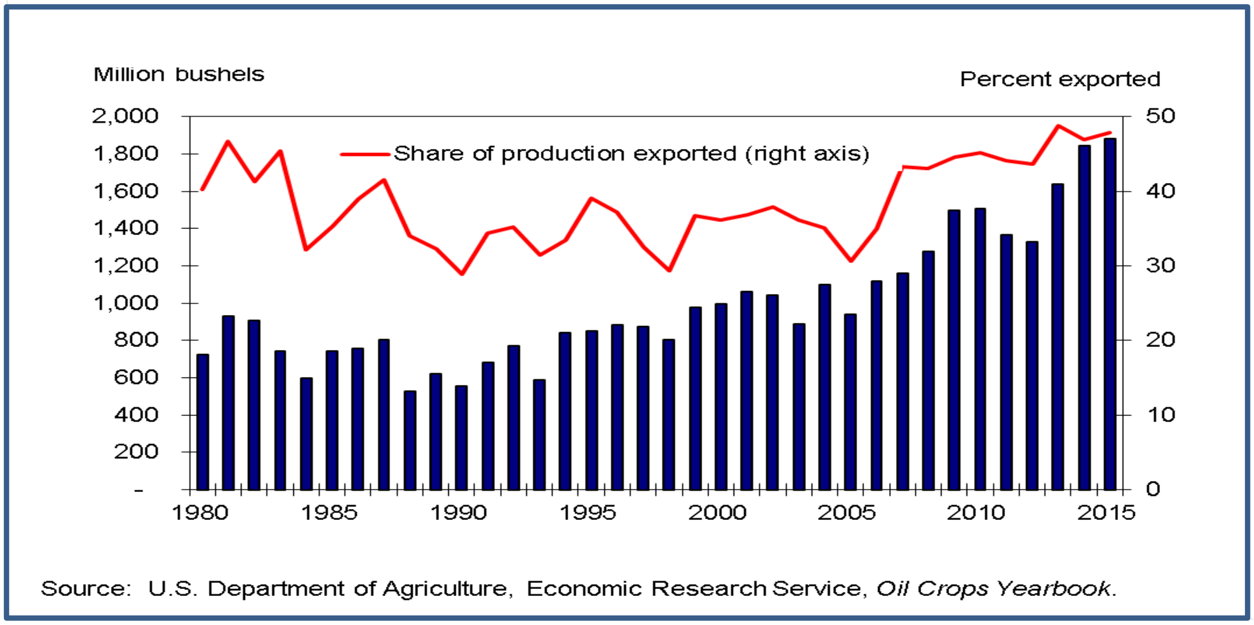

Figure 5. U.S. Soybean Export Volume and Percent Exported.
Source: (USDA-NASS 2018f)

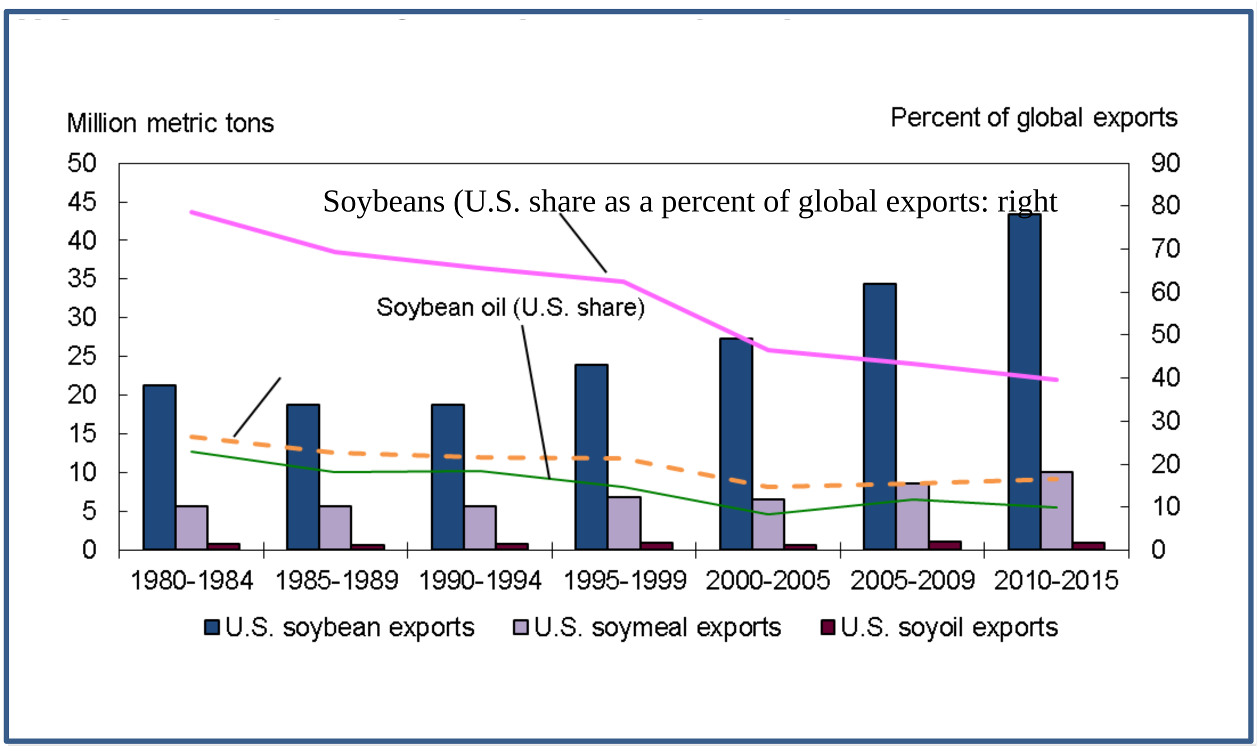

Figure 6. U.S. Soybean Export Volume and Percent of Global Market.
Source: (USDA-NASS 2018f)

The United States, Brazil, Argentina, Paraguay, and Canada, account for 96.1% of the bulk soybean exported, while Argentina, Brazil, the United States, India, and Paraguay account for 90.4% of the soybean meal exported (Table 8). Argentina, the European Union (EU), and Brazil are the dominant countries in terms of soybean oil exports accounting for 75.4%. China, the EU, Mexico, and Japan are the major importers of world bulk soybean, accounting for 82.9% of total imports, whereas the EU, Indonesia, Thailand, Japan and Vietnam are the largest importers of soybean meal with a world share of 55.0% (USDA-FAS 2013). China and India are the major importers of soybean oil with a world share of 35.8% (USDA-FAS 2013). Between 1996 and 2011, 28 countries, including the United States, adopted the use of biotech crops, the largest being U.S., Brazil, Argentina, India, and Canada (Clive 2011). Prior to exporting GMB151 Soybean, BASF is expected to seek biotechnology regulatory approvals in all major import countries that have a functioning regulatory system to assure global compliance and support of international trade.

Table 8. World Soybean Production* (metric tons) in 2018

Location	Soybean
Argentina	37.80
Brazil	122.00
Canada	7.72
China	15.20
European Union	2.54
India	8.35
Mexico	0.43
Paraguay	10.3
United States	341.54
Total Foreign	221.48
*Major Producers	

Source: (USDA-NASS 2018f)

5 ENVIRONMENTAL CONSEQUENCES

Possible environmental impacts from selecting either the No Action Alternative or the Preferred Alternative as part of regulatory decision making by APHIS for GMB151 Soybean were considered in this chapter. Details about how APHIS evaluated environmental impacts, results of the analyses it performed to assess whether or not they caused impacts, and the Agency's conclusions about the significance of impacts it identified are presented in this chapter. Pursuant to CEQ regulations APHIS considers the direct impacts of both alternatives.

5.1 ENVIRONMENTAL ANALYSIS

For this chapter, those impacts that were categorized as direct were evaluated. A direct impact was considered to be one solely caused by an Agency action without any intervening intermediate steps. An example is conversion of land use from non-agricultural to agricultural in response to an action that increases demand for a crop.

5.2 SCOPE OF THE ENVIRONMENTAL ANALYSIS

Those resource areas listed in Chapter 1 (see Issues Considered) that may be affected by selecting either the No Action Alternative or the Preferred Alternative were considered for this EA. Impacts were defined as those effects likely to result in permanent changes to the environment. Impacts were evaluated for significance by analyzing the positive or negative changes from the existing (baseline) conditions described in Chapter 3 (Affected Environment). Wherever possible, APHIS used data that supported a quantitative analysis of the impacts of selecting either the No Action Alternative or the Preferred Alternative. When data were not available or were insufficient to support a quantitative assessment, APHIS made qualitative assessments of the impacts of an Agency regulatory decision for GMB151 Soybean.

APHIS limited its environmental analyses to the geographic areas that currently support U.S. soybean production. These analyses were also made under the assumption that most U.S. farmers who produce soybeans rely on widely accepted best management practices (BMPs). It was also assumed that if GMB151 Soybean was no longer regulated by APHIS and became widely planted, farmers would use the same BMPs that are currently used for soybean production in the United States.

The Cry14Ab-1 protein expressed by GMB151 Soybean confers resistance to the soybean cyst nematode (SCN),) *Heterodera glycines*, the. GMB151 also produces a modified 4-hydroxyphenylpyruvate dioxygenase (HPPD-4) enzyme that confers resistance to HPPD-inhibitor herbicides such as isoxaflutole (BASF 2020). Production of the HPPD-4 enzyme in crops developed using genetic engineering has been evaluated previously in EAs by APHIS (USDA-APHIS 2018, 2013, 2014) and those assessments are incorporated into this EA by reference. In one of these evaluations (USDA-APHIS 2013), the organism (*Pseudomonas fluorescens* strain 32) that was the source of the gene that produces the HPPD-4 protein is the same one used to develop GMB151 Soybean (BASF 2020). Since the previous APHIS assessments did not identify any significant impacts associated with the HPPD-4 enzyme or the gene that produces it, no further analysis of the HPPD-4 enzyme was performed for this EA.

APHIS emphasizes that it has regulatory authority over GMB151 Soybean plants, but EPA has regulatory authority over herbicides that are applied to the crop. The scope of this EA covers the possible direct impacts that would result primarily from the cultivation and use of the plant. EPA is considering impacts from the use of HPPD-inhibitor herbicides on GMB151 plants as part of its registration process. USDA is relying on EPA's authoritative assessments and will not duplicate the assessment prepared by EPA. This EA will provide informative assessments, but not the determinative document for any impacts of herbicide usage, since that analysis will be completed by EPA under its regulatory authority.

5.3 AGRICULTURAL PRODUCTION OF SOYBEAN

U.S. soybean acreage is concentrated primarily in the Midwest (Figure 1), where yields are highest (USDA-NASS 2016a). Soybean acreage has expanded recently to the northern and western parts of the country. This has resulted because of the availability of newer improved soybean varieties better adapted to provide higher yields under the short-season climatic conditions of those areas (USDA-ERS 2010b). This has been a major factor contributing to a 31% increase in recent years to a total U.S. soybean acreage of about 83 million acres (USDA-NASS 2019). Current trends in U.S. biotech soybean production are expected to continue unchanged in the major soybean producing states listed previously in Chapter 3 (Table 2).

5.3.1 Locations and Acreage of Soybean Production: No Action Alternative

Under the No Action Alternative, GMB151 Soybean would remain regulated and would not be commercially available for production. Soybean varieties developed using genetic engineering were introduced in the United States in 1996 (USDA-ERS 2011a; Fernandez-Cornejo and Caswell 2006). By 2017, 94% of U.S. soybean acreage was planted in a variety produced using genetic engineering (USDA-NASS 2018c). Most of this shift by growers to biotech soybeans resulted because of the cost-effective benefits gained from improved weed control with HR varieties.

The trend of planting primarily biotech soybeans in the United States will likely continue under the No Action Alternative as new varieties are developed with new traits or that combine different traits desired by growers and consumers. For example, during the past decade, APHIS has considered petitions for nonregulated status for biotech soybean varieties that combine resistance to multiple herbicides, provide insect resistance, or modify nutritional properties of the oil derived from soybeans. Although these current trends for development of new biotech soybean varieties are expected to continue, U.S. soybean acreage and production is not expected to change in the foreseeable future, and selection of the No Action Alternative is unlikely to alter this projection.

5.3.2 Locations and Acreage of Soybean Production: Preferred Alternative

BASF conducted phenotypic, agronomic, and environmental interaction trials with GMB151 Soybean and a soybean control parental line that had not been modified using genetic engineering that had a genetic background similar to GMB151 Soybean. The results of the combined trials demonstrated that there were no substantial agronomic or phenotypic differences between GMB151 Soybean and its comparator control or other commercial soybean varieties. Other than resistance to SCN, GMB151 Soybean confers no novel agronomic benefit compared to other soybean varieties. It would only be expected to replace currently planted soybean varieties, where SCN has been a pest problem, so soybean production trends and U.S. soybean acreage are unlikely to change.

Because GMB151 Soybean is anticipated to increase yields, it might be expected to replace other varieties of soybean currently grown. Since the middle of the last century, changes in soybean varieties have contributed to increased yields, as have improved management practices. From 1991 to 2011, average soybean yield increased approximately 17.6% from 34.2 bushels per acre in 1991 to 41.5 bushels per acre in 2011, then declined slightly in 2012 to 39.3. Since 1991, U.S. soybean production acreage has increased 31% (USDA-NASS 2018c).

As described for the No Action Alternative, the USDA has projected that soybean acreage will remain relatively steady during the next decade (USDA-OCE, 2018). Based upon its phenotypic and agronomic similarity to other soybean varieties, GMB151 Soybean is also subject to the same variables affecting yield in other soybean varieties, such as management practices and weather (see "Agronomic Inputs" in Chapter 3 for more details). It is unlikely that a significant change in U.S. soybean production acreage would result from a determination of nonregulated status of GMB151 Soybean. Therefore, effects on soybean production acreage under the Preferred Alternative would be the same as for the No Action Alternative and would not differ from current baseline conditions reviewed in Chapter 3, so no significant impacts are anticipated.

5.3.3 Agronomic Practices: No Action Alternative

Under the No Action Alternative, GMB151 Soybean would continue to be subject to the regulatory requirements of 7 CFR 340 and plant pest provisions of the PPA. However, growers would still have access to conventional and nonregulated biotech soybean varieties currently available. The potential environmental impacts associated with the agronomic practices and inputs used for the production of biotech and conventional soybean varieties such as conventional and conservation tillage, soil and foliar fertilization, crop rotation, irrigation, pest (insects and weeds) and disease management with herbicides, pesticides, and fungicides, and crop residue management would be unaffected by continued regulation of GMB151 Soybean.

A variety of herbicide choices are available to growers, including those used for preplant only, pre-emergent herbicides often with residual activity, those used as post-emergent herbicides, and combinations of both. EPA approves and labels uses of pesticides on soybeans. Under the No-Action Alternative, commercial soybean growers would continue to use the same pesticides for soybean insect pests and weeds as are currently used.

5.3.4 Agronomic Practices: Preferred Alternative

A determination of nonregulated status of GMB151 Soybean is not expected to result in changes to current soybean cropping practices. BASF's studies (BASF 2020) demonstrated that except for its capacity to control SCN, GMB151 Soybean is essentially the same as other commercial soybean varieties in terms of agronomic characteristics and cultivation practices.

Soybeans are grown mostly in rotation with corn. In two-year rotations, a common practice is to fertilize the previous year's corn crop with enough phosphorus and potassium to allow for the subsequent soybean crop to be grown with no supplemental fertilizer as it is more economical than two separate applications (Franzen 2019; Berglund and Helms 2003b; Ebelhar et al. 2004a). About two-thirds of U.S. soybean is grown in rotation with corn. However, annual supplementation of nutrients is common in soybeans that are not grown in rotation with another crop. Regular testing of soil fertility levels and supplementation if needed is already widely recommended in soybean production for achieving optimal yields. Current practices in soybean include 41% of soybean acreage annually supplemented with phosphate (phosphorous) and 42% annually supplemented with potash (potassium) (USDA-NASS 2018b). These and other agronomic baseline conditions as reviewed in Chapter 3 would be the same as for the No-Action Alternative, so no significant impacts on agronomic practices are anticipated if the Preferred Alternative is selected.

5.3.5 Soybean Seed Production: No Action Alternative

Under the No Action Alternative, current soybean seed production practices are not expected to change. Several factors influence optimal planting rate for soybean such as row spacing, seed germination rate, soil conditions, climate, disease and pest pressure, past tillage practices and crop rotation (Robinson and Conley 2007). Seeding rate is also determined by the plant population desired by the grower. Growers may plant certified soybean seed, uncertified seed, and seed that is grown and stored on individual farms (Oplinger and Amberson 1986).

The production of the soybean seed crop for foundation, registered, certified, or quality control seed requires biological, technical, and quality control practices to maintain varietal purity greater than that for soybean grain production. The production and certification of soybean seed is regulated by state or regional crop improvement agencies that are chartered under the laws of the state(s) they serve (e.g., see Virginia Crop Improvement Association No Date; SSCA No Date-a; Illinois Crop Improvement Association 2013; Mississippi Crop Improvement Association 2008, 2015; Illinois Crop Improvement Association 2019). The procedures followed by certified seed producers to ensure varietal purity and identity during the cultivation, harvest, storage, and transportation of soybean seed are not expected to change under the No Action Alternative.

Seed genetic purity is maintained to maximize the value of a new variety (Sundstrom et al. 2002), of which a seed certification process ensures that the desired traits remain within purity standards (Bradford 2006) (for more details see Chapter 3: Soybean Seed Production). Seed producers routinely submit applications to the AOSCA National Variety Review Boards for review and recommendation for inclusion into seed certification programs. For example, in September 2012, AOSCA recommended the inclusion of 60 varieties of soybean expressing high yield traits by three seed producing companies for certification (AOSCA 2012b, 2012a). It is expected that soybean seed producers would continue to implement measures to preserve the identity of their seed varieties if the No Action Alternative is selected.

5.3.6 Soybean Seed Production: Preferred Alternative

Field trials conducted by BASF have not demonstrated any agronomic or phenotypic differences between GMB151 Soybean and conventional soybean varieties that would require changes to soybean seed production practices (BASF 2020). Based on the data provided by BASF, APHIS has concluded that the availability of GMB151 Soybean under the Preferred Alternative would not alter the agronomic practices, cultivation locations, seed production practices or quality characteristics of conventional and biotech soybean seed production. BASF has also indicated GMB151 Soybean will be adopted into existing maturation groups to match the area in which it would be cultivated. Therefore, its adoption would not alter planting practices of soybean grown for seed: soybean seed production associated with the Preferred Alternative would not be any different than practices under the No Action Alternative, so no significant impacts on soybean seed production are anticipated if the Preferred Alternative is selected.

5.3.7 Organic and Conventional Soybean Production: No Action Alternative

Under the No Action Alternative, GMB151 Soybean would remain subject to the regulatory requirements of 7 CFR 340 and the plant pest provisions of the PPA. Biotech, conventional and organic soybean production would not change as a result of the continued regulation of GMB151 Soybean. Organic and conventional soybean growers would continue to use the same methods they currently use to manage crop identity, preserve the integrity of their production systems, and maintain organic certification. As described in Chapter 3 (Affected Environment: Organic Soybean Production), organic and conventional soybean production is a small portion of the soybean market (USDA NASS 2017).

5.3.8 Organic and Conventional Soybean Production: Preferred Alternative

Biotech soybeans are already extensively used by farmers, while organic (less than 1.0%) and conventional (less than 10.0%) soybean production represents a small percentage of the total U.S. soybean acreage. Organic and -conventional soybean acreage is unlikely to change significantly, regardless of whether new conventional or biotech soybean varieties, such as GMB151 Soybean, become available for commercial production.

When compared to other biotech varieties of soybean, GMB151 Soybean does not present any new or different issues or potential impacts for organic and other specialty soybean producers and consumers. Organic producers employ a variety of measures to manage, identify and preserve the integrity of organic production systems. Agronomic tests conducted by BASF found that GMB151 Soybean is substantially equivalent to conventional soybeans (BASF 2020). Pollination characteristics are similar to other soybean varieties currently available to growers. Since soybeans exhibit limited pollen movement and are mostly self-pollinating (Abud et al. 2007; Caviness 1966; OECD 2000; Ray et al. 2003; Yoshimura 2011), there is no indication that organic and conventional soybean crops will be affected by a determination of nonregulated status for GMB151 Soybean if they continue to be produced in accordance with current agronomic practices to meet organic standards such as those of the NOP.

The trend in the cultivation of biotech, conventional, and organic soybean varieties, and the corresponding production systems to maintain varietal integrity are likely to remain the same as those for the No Action Alternative. Therefore, impacts on organic and conventional soybean growers if a determination of nonregulated status for GMB151 Soybean is made (i.e., selection of the Preferred Alternative) would be the same as or similar to the No Action Alternative, so no significant impacts on organic and conventional soybean production are anticipated if the Preferred Alternative is selected.

5.4 PHYSICAL ENVIRONMENT

5.4.1 Soil Quality: No Action Alternative

Under the No Action Alternative, current soybean soil management practices that affect soil quality, including the use of cover crops to limit the time soil is exposed to wind and rain, tillage methods to reduce erosion and compaction, control weeds, and enhance nutrients, careful management of fertilizers and pesticides, crop rotation, establishing windbreaks and contour plowing (for more details see Chapter 3: Agronomic Practices) would be expected to continue unchanged. Growers would continue to choose methods based on weed, insect, and disease pressure, as well as the costs of seed and other inputs consistent with BMPs they currently use.

5.4.2 Soil Quality: Preferred Alternative

A determination of nonregulated status for GMB151 Soybean is not expected to change current soybean cropping practices that may impact soil quality. BASF studies demonstrated that GMB151 Soybean is essentially indistinguishable from conventional and other biotech soybean varieties in terms of agronomic characteristics and cultivation practices (BASF 2020).

The Cry14Ab-1 protein expressed by GMB151 Soybean is not expected to have any effects on the physicochemical characteristics of soil (BASF 2020). In particular, mutual symbiotic relationships between soybean and the Rhizobiaceae and Bradyrhizobiaceae are unlikely to be negatively affected. Many Cry proteins derived from *B. thuringiensis* are rapidly degraded in a variety of soil types and these proteins do not accumulate (Head et al. 2002; Mendelsohn et al. 2003; Dubelman et al. 2005). For a few Cry proteins, residual amounts of Bt proteins may persist for extended periods, but the levels detected are not biologically significant (Feng et al. 2011). However, EPA has concluded in a risk assessment that available data indicates that there is short term accumulation of Cry1F and Cry1Ac proteins in agricultural soil. It concluded that Cry proteins have a short half-life, and are unlikely to affect soil invertebrates or significantly impact soil microbiota (US-EPA 2014).

Soil quality may be impacted by a soybean crop through direct interaction with soil fauna at the root system and by the degradation of remaining plant tissue after harvest. However, compositional analysis of GMB151 Soybean forage tissue (i.e., stems and leaves) revealed no significant or consistent differences between it and the conventional control variety (BASF 2020). There also were no differences between GMB151 Soybean and the conventional control variety with respect to plant-environment interactions or plant-symbiont interactions. Because of the compositional similarities between GMB151 Soybean and conventional soybeans, and the examined safety of the GMB151 Soybean gene products, it is not anticipated that GMB151 Soybean interactions with soil fauna or the impact of degradation of its stubble remaining in fields following harvest would be significantly different from that of conventional soybean. Based on the Agency’s analyses of this information, overall impacts to soil under the Preferred Alternative are not expected to differ from those of the No Action Alternative, so no significant impacts on soil are anticipated if the Preferred Alternative is selected.

5.4.3 Water Resources: No Action Alternative

Current soybean management practices, including irrigation, and pesticide and fertilizer applications, would be expected to continue unchanged under the No Action Alternative. Under the authority of FIFRA, environmental risks of pesticide use are assessed during the registration processes of the EPA, and are regularly reevaluated to ensure that registered uses continue to pose no unreasonable risks to humans or the environment, including risks to water resources.

The trend towards conservation tillage or no-tillage practices since the adoption of HR soybean varieties is expected to continue, resulting in reduced surface water run-off and soil erosion (Dill, CaJacob, and Padgette 2008; Givens et al. 2009). Conservation tillage and other management practices are used to trap and control sediment and nutrient runoff. Water quality conservation practices benefit agricultural producers by lowering input costs and enhancing the productivity of working lands.

As of 2018, nitrogen, potassium, and phosphorous were applied to 18%, 25%, and 23% respectively of soybean acreage in 19 states surveyed (USDA-NASS 2018e). Production practices for any soybean variety remove more nutrients from soils (Pedersen 2008) than less intensive methods. Regular testing of soil fertility is required and applications of nutrients are not uncommon in soybean production (USDA-NASS 2018a). Less nitrogen is typically used for soybeans than for other crops because like other legumes, soybeans fix nitrogen in the soil through their symbiotic relationship with rhizomatous bacteria (CAST 2009).

5.4.4 Water Resources: Preferred Alternative

No differences in morphological characteristics and agronomic requirements were found between GMB151 Soybean and a conventional comparator (BASF 2020). Therefore, cultivation of GMB151 Soybean would not necessitate changes in current agronomic practices for soybean production, so current impacts of soybean cultivation on water quality would not change if GMB151 Soybean were no longer regulated under 7 CFR 340. BASF evaluated on a site-specific basis abiotic stressors such as drought and flood, and found no difference between GMB151 Soybean and its comparator. As described previously, if GMB151 Soybean is no longer regulated under 7 CFR 340, neither total U.S. soybean acreage nor its locations would change, so there would be no shifts in how or where water quality impacts related to soybean cultivation would occur in the United States. For these reasons, a determination of nonregulated status of GMB151 Soybean is unlikely to change the current irrigation practices in commercial soybean production.

Adoption of HR crops is associated with increased use of no-till and reduced till practices that benefit water quality by reducing runoff loads from soil erosion (Givens et al. 2009; Dill, CaJacob, and Padgette 2008). The adoption rate of HR soybeans has steadily increased since their introduction in 1996. Today, more than 94% of U.S. commercially grown soybeans are herbicide resistant (USDA-NASS 2018c). This trend is unlikely to change if GMB151 Soybean were to become commercially available.

Runoff from cropland areas receiving manure or fertilizer contributes to increased phosphorous and nitrogen in streams and lakes. In fresh water systems, phosphorus is the limiting factor causing eutrophication (see Chapter 3, Water Resources, for more details). Up to 41% of soybean acreage has been annually supplemented with phosphorous (USDA-NASS 2018a). Since GMB151 Soybean is unlikely to change total U.S. soybean acreage or where soybeans are grown in the United States, impacts to water resources from fertilization are not expected to differ from those of the No Action Alternative, so no significant impacts on water resources are anticipated if the Preferred Alternative is selected.

5.4.5 Air Quality: No Action Alternative

Under the No Action Alternative, current air quality impacts from the soybean agronomic practices described in Chapter 3 such as tillage, cultivation, and agrochemical applications would continue unchanged. Applications of EPA-registered pesticides would continue unchanged, as would any associated environmental impacts because as part of its reregistration process, the EPA regularly reevaluates registered pesticides to ensure that they continue to pose no unacceptable risks. Of particular relevance to air quality, this process includes identifying methods to reduce pesticide drift, which are included on pesticide labels and approved by the EPA. Under the No Action Alternative use of pesticides according to EPA-approved labels would not pose unreasonable risk to air quality. The trend towards conservation tillage and no-till practices associated with cultivating HR soybean varieties, which reduces exhaust emissions from agricultural equipment and airborne dust from soil disturbance is also likely to continue

(Dill, CaJacob, and Padgette 2008; Givens et al. 2009).

5.4.6 Air Quality: Preferred Alternative

No differences in morphological characteristics and agronomic requirements were found between GMB151 Soybean and a conventional comparator (BASF 2020). Therefore, if the Preferred Alternative is selected, cultivation of GMB151 Soybean would not result in changes to most current soybean agronomic practices (e.g., fertilizer and pesticide applications). The addition of HPPD-herbicide resistance provides another option (e.g., isoxaflutole) for resistant weed control, which when combined with SCN resistance should contribute to maintaining the current level of usage of no-till practices. Therefore, no changes to emission sources (i.e., tillage and fossil-fuel-burning equipment would be expected. As described previously commercial use of GMB151 Soybean would neither increase the total U.S. soybean acreage nor modify the existing U.S. soybean production range. Since no changes to agronomic practices for the cultivation of GMB151 Soybean, and no increase in area or acreage are expected if the Preferred Alternative is selected, impacts to air quality are expected to be the same as the No Action Alternative, so no significant impacts on air quality are anticipated if the Preferred Alternative is selected.

5.5 BIOLOGICAL RESOURCES

5.5.1 Animal Communities: No Action Alternative

Under the No Action Alternative, animal species would continue to be affected by agronomic practices associated with soybean production, such as tillage, cultivation, pesticide and fertilizer applications, and the use of agricultural equipment (Sharpe 2010; Brady 2007; Palmer, Bromley, and Anderson No Date; USDA-NRCS 1999a) no differently than they are currently. Some of these current practices have potential to impact animal communities. For example, if tillage rates were to increase as a means of weed suppression, it could possibly diminish benefits to wildlife from conservation tillage practices. Some pesticides for weed, insect, and disease control may also impact animal communities. However, environmental risks of pesticides to wildlife and their habitats are assessed by the EPA in its registration process and are regularly reevaluated to establish uses that have a reasonable certainty of not causing harm to non-target animals and their habitats.

5.5.2 Animal Communities: Preferred Alternative

A determination of nonregulated status of GMB151 Soybean is not expected to result in changes to current soybean cropping practices. BASF's studies demonstrated GMB151 Soybean is the same as other soybean varieties in terms of agronomic characteristics and cultivation practices (BASF 2020). Therefore, replacement of other biotech and conventional soybean varieties with GMB151 Soybean will not alter agronomic practices currently used (e.g., crop rotation; weed management; cultivation), so no changes in effects from those of current soybean cultivation practices on wildlife that use soybean fields for cover and forage (as described in Chapter 3 in "Animal Communities") are likely.

Field trials showed that GMB151 Soybean does not confer any biologically significant differences to susceptibility or tolerance to invertebrate pests other than SCN. This indicates that there would be no changes to agronomic practices, such as increased use of pesticides, that could impact wildlife.

Results of testing of non-target organisms presented by BASF indicated that the Cry14Ab-1 protein expressed by GMB151 Soybean is unlikely to be toxic when consumed by animals other than the target species (SCN). On January 28, 2019, BASF initiated a consultation (BNF 172) with the FDA that included molecular, composition, and nutrition data, and other food and feed safety assessment data related to GMB151 Soybean (BASF 2020). In addition, EPA concluded on June 8, 2020 (40 CFR 174.540) that the Cry14Ab-1 protein is exempt from a food and feed tolerance, when it is expressed in soybean plants. Based on the above information, there are no expected hazards associated with the Cry14Ab-1 protein expressed by GMB151 Soybean from exposure to or consumption by animals that reside in or near soybean fields.

The source organism of the HPPD-4 protein, *P. fluorescens* strain A32, is a non-pathogenic bacterium that is ubiquitous in nature and has a history of safe use. HPPD proteins are also ubiquitous in nature in nearly all aerobic organisms, (e.g., bacteria, fungi, plants, and animals including mammals). The HPPD-4 protein has no significant amino acid sequence similarity to known allergens or toxins, is rapidly degraded in simulated gastric fluid, and exhibited no effects in an acute oral mouse toxicity test. Also, EPA has established a permanent exemption (82FR57137) from the requirement for a tolerance for the HPPD-4 protein expressed in all food commodities when used as an inert ingredient.

Based on available evidence, GMB151 Soybean is unlikely to pose a hazard to wildlife species. As a result, APHIS concluded, effects, if any on wildlife species, would be the same as those for the No Action Alternative, so no significant impacts on animal communities are anticipated if the Preferred Alternative is selected.

5.5.3 Plant Communities: No Action Alternative

Under the No Action Alternative, GMB151 Soybean would remain under APHIS regulation. Current soybean production would likely continue unchanged. Growers would continue to select the agronomic practices such as tillage, irrigation, row spacing, timing of planting, and weed management that optimize soybean yield and efficiency that they currently use.

Plant species that typically compete with soybean production would be managed through the use of mechanical, cultural, and chemical control methods. Multiple herbicides would continue to be used for weed control in soybean fields. Runoff, spray drift, and volatilization of herbicides have the potential to impact non-target plant communities growing in proximity to fields in which herbicides are used. The environmental effects of pesticide use are assessed by the EPA in the pesticide registration process and are regularly reevaluated by the EPA in its reregistration process under FIFRA. In this process, where appropriate, steps to reduce pesticide drift and volatilization are included on a pesticide’s label approved by the EPA to minimize off-target effects.

5.5.4 Plant Communities: Preferred Action Alternative

A determination of nonregulated status of GMB151 Soybean is not expected to result in changes to current soybean cropping practices. Field trials and laboratory analyses conducted by BASF showed no evidence of differences between GMB151 Soybean and other biotech and conventional soybean in growth, reproduction, or interactions with pests and diseases except for resistance to SCN (BASF 2020). The expression of the Cry14Ab-1 protein by GMB151 Soybean will provide a PIP that will reduce or eliminate SCN soybean crop damage. The PIP is not expected to cause plant disease or increase susceptibility of GMB151 Soybean, or other soybean varieties derived from it, to diseases or other pests (USDA-APHIS 2020).

Similar to the No Action Alternative, weeds within fields of GMB151 Soybean could be managed using mechanical, cultural, and chemical control. There are no differences expected in the use of herbicides or other pesticides in the production of GMB151 Soybean, when compared to other biotech and conventional soybean varieties (USDA-APHIS 2020). Except for the option to substitute isoxaflutole for other herbicides used, agronomic practices to cultivate GMB151 Soybean would not differ from the No Action Alternative. Other isoxaflutole-resistant soybean varieties that are not regulated are currently available to growers. GMB151 Soybean would only replace these as another alternative to growers, so isoxaflutole use is not expected to change. If a determination of nonregulated status is made for GMB151 Soybean, the risks to wild plants and agricultural productivity from weedy GMB151 Soybean populations are negligible because volunteer soybean populations can be easily managed and there are no feral or weedy relatives in the United States (Carpenter et al. 2002).

Based on the information reviewed, APHIS has determined that the effects on other vegetation in and around soybean fields from a determination of nonregulated status for GMB151 Soybean are identical to those under the No Action Alternative so no significant impacts on plant communities are anticipated if the Preferred Alternative is selected.

5.5.5 Gene Flow and Weediness: No Action Alternative

Under the No Action Alternative, GMB151 Soybean would remain under APHIS regulation. The availability of biotech, conventional and organic soybeans would not change as a result of the continued regulation of GMB151 Soybean. Because soybean is mostly self-pollinated, its cross-pollination rate significantly decreases with distance, and there are no wild and weedy relatives in the US, introgression of soybean pollen to wild or weedy species is virtually impossible. In addition, volunteer soybeans are typically not a major problem in agroecosystems, and regionally where volunteer soybean populations can develop, the volunteer plants are manageable and do not represent a serious weed threat (York, Beam, and Culpepper 2005).

5.5.6 Gene Flow and Weediness: Preferred Alternative

A determination of nonregulated status of GMB151 Soybean is not expected to pose greater pollen- or seed-mediated gene flow, or increased potential for weediness than that of currently cultivated soybean varieties. There were no differences between GMB151 Soybean and conventional soybean varieties tested that would increase the potential for gene flow from GMB151 Soybean or otherwise increase its weediness (BASF 2020).

APHIS evaluated information in its PPRA (USDA-APHIS 2020) on the inserted genetic material, the potential for vertical and horizontal gene transfer, and weedy characteristics of GMB151 Soybean and concluded it would not represent any plant pest risk. Field trials and laboratory data for GMB151 Soybean indicate no plant pathogenic properties or weediness characteristics (BASF 2020). Based on agronomic data and compositional analyses, GMB151 Soybean was found to be substantially equivalent to conventional soybeans and would no more likely become a plant pest than conventional soybeans. The reproductive characteristics of GMB151 Soybean are essentially equivalent to other biotech and conventional soybean varieties (BASF 2020). GMB151 Soybean would not persist in unmanaged environments and does not demonstrate a competitive advantage compared to conventional soybeans. Neither of the traits in GMB151 Soybean (SCN and resistance to HPPD-inhibiting herbicides such as isoxaflutole) present a risk of increased weediness. The reproductive mechanism in soybeans also makes the potential for cross-pollination of GMB151 Soybean with other soybean varieties highly unlikely (BASF 2020).

In reference to interspecific gene transmission, studies have indicated that horizontal gene transfer and expression of DNA from a plant species to bacteria is unlikely to occur (Keese 2008). Furthermore, there is no evidence that bacteria closely associated with plants and/or their constituent parts contain genes derived from plants (Kaneko et al. 2000; Kaneko et al. 2002; Wood et al. 2001). When horizontal gene transfer has been observed, it has been on an evolutionary time scale of millions of years (Brown 2003; Koonin, Makarova, and Aravind 2001). Based on this information, APHIS has concluded that horizontal gene flow from GMB151 Soybean to other unrelated organisms would be highly unlikely.

If a determination of nonregulated status is made for GMB151 Soybean, the risks to wild plants and agricultural productivity from weedy GMB151 Soybean populations are negligible, as volunteer soybean populations can be easily managed and there are no feral or weedy relatives in the United States (Carpenter et al. 2002). If present as volunteer soybean, GMB151 Soybean would not be considered difficult to control, as soybean seeds rarely remain viable the following season and are easily managed with cultivation, hand weeding, or the application of herbicides. In addition, since no feral or weedy species of soybean exist in the United States (Ellstrand, Prentice, and Hancock 1999; OECD 2000), GMB151 Soybean poses no potential for either naturally occurring, pollen-mediated gene flow or introgression of genes modified using genetic engineering. Based on the information reviewed, APHIS has determined that the effects on other vegetation in and around soybean fields from a determination of nonregulated status for GMB151 Soybean are indistinguishable from those under the No Action Alternative. Therefore, no significant impacts associated with gene flow or weediness are anticipated if the Preferred Alternative is selected.

5.5.7 Microorganisms: No Action Alternative

Under the No Action Alternative, GMB151 Soybean would remain under APHIS regulation. The availability of biotech, conventional, and organic soybeans would not change as a result of the continued regulation of GMB151 Soybean. Agronomic practices used for soybean production, such as soil inoculation, tillage, and the application of agricultural chemicals (pesticides and fertilizers) that potentially impact microorganisms, would continue unchanged.

5.5.8 Microorganisms: Preferred Alternative

A determination of nonregulated status of GMB151 Soybean is not expected to change current soybean cropping practices that may affect microorganisms. Possible impacts of GMB151 Soybean on microbial communities would be identical or similar to those for conventional soybeans and other biotech varieties. GMB151 Soybean could have some effect on the structure of the soil microbial community in which it is planted, which could include nitrogen-fixing bacteria and mycorrhizal fungi; bacteria, actinomycetes (filamentous bacteria), and saprophytic fungi responsible for decomposition; denitrifying bacteria and fungi; phosphorus-solubilizing bacteria and fungi; as well as pathogenic and parasitic microbes (USDA-NRCS 2004). Testing by BASF revealed no significant differences found in the parameters measured to assess the relationship of the legume and its associated symbiont between GMB151 Soybean and the conventional comparators (BASF 2020).

As with other biotech soybean varieties in high yield production systems, the cultivation of GMB151 Soybean may remove more nutrients, particularly phosphorus and potassium, than lower yielding conventional varieties, necessitating testing and possibly increased soil nutrient amendments. Soil organisms require varying amounts of both macronutrients, including phosphorus, and micronutrients (USDA-NRCS 2004). Several studies have demonstrated *B. japonicum* activity, root nodulation, and nitrogen fixation are positively correlated with phosphorus levels (Beck and Munns 1984; Cassman, Whitney, and Stockinger 1980; Israel 1987; Mullen, Israel, and Wollum 1988; Sa and Israel 1991; Tsvetkova and Georgiev 2003). Likewise, potassium is necessary for nodule formation and bacteria-mediated nitrogen fixation in soybean and other nitrogen-fixing legumes (IPNI 1998; Mengel, Haghparast, and Kock 1974). Applications of these nutrients to soybean is not an uncommon practice and is widely recommended to sustain the yields of all soybean varieties.

Field and greenhouse tests show no significant differences from other nonregulated conventional and biotech soybean varieties in the parameters measured to assess the relationship of GMB151 Soybean with its symbionts. GMB151 Soybean would not result in any significant changes to current soybean cropping practices except that it may be grown where SCN is a problem and/or where isoxaflutole may be substituted for herbicides with other modes of action that are ineffective against HR weeds. Other isoxaflutole-resistant biotech soybean varieties that are not regulated are currently available to growers. GMB151 Soybean would only replace these as another alternative to growers, so isoxaflutole usage would not be expected to change.

Based on the above information, overall impacts to microorganisms under the Preferred Alternative would be indistinguishable from those under the No Action Alternative. Therefore, there are no indications that the effects of commercially growing GMB151 Soybean would cause significant impacts to microorganisms if the Preferred Alternative were selected.

5.5.9 Biodiversity: No Action Alternative

Under the No Action Alternative, GMB151 Soybean would remain under APHIS regulation. The availability of biotech, conventional and organic soybeans would not change. Agronomic practices used for soybean production and yield optimization, such as tillage, the application of agricultural chemicals (pesticides and fertilizers), timing of planting, row spacing, and scouting for pest infestations would be expected to continue unchanged. Agronomic practices that benefit biodiversity both on cropland (e.g., intercropping, agroforestry, crop rotations, cover crops, and no-tillage) and on adjacent non-cropland (e.g., woodlots, fencerows, hedgerows, and wetlands) would also remain the same.

5.5.10 Biodiversity: Preferred Alternative

A determination of nonregulated status of GMB151 Soybean is not expected to result in changes in current soybean cropping practices that may impact biodiversity. Trials conducted by BASF showed no differences between GMB151 Soybean and other biotech and conventional soybean in growth, reproduction, or interactions with pests and diseases that might impact biodiversity. Similar to the No Action Alternative, weeds within fields of GMB151 Soybean could be managed using mechanical, cultural, and chemical control. Growers would determine the best method necessary to manage pests based on individual needs. The environmental risks of pesticide use are assessed by the EPA in the pesticide registration process and are regularly reevaluated by the EPA as part of its reregistration process under FIFRA. Pesticide use in accordance with label instructions established by the EPA would not result in unreasonable risks to the environment. Under the Preferred Alternative, potential impacts to biodiversity from runoff, spray drift, and volatilization of agricultural chemicals such as pesticides, herbicides, and fungicides are not expected to be substantially different from those associated with the No Action Alternative.

Possible risks to biodiversity from the production of biotech crops include the disturbance of biosystems, including the agroecosystem, and permanent loss or changes in species diversity or the genetic diversity within a species (Snow et al. 2005). The intensive farming practices associated with agricultural lands limit the diversity of plants and animals (Lovett, Price, and Lovett 2003).

Diversity in adjacent natural areas, and those areas established to promote biodiversity (e.g., woodlots, fencerows, hedgerows, and wetlands) tend to have greater biodiversity than does cropland. Agronomic practices for the production of GMB151 Soybean are not expected to change from those currently used for other commercially available biotech and conventional soybean varieties. Because of cost effectiveness, control measures for SCN rely mostly on planting resistant varieties rather than making nematicide applications to soybeans. Most nematicides are used for soybean seed treatments, which would not change if the Preferred Alternative is selected. Therefore, impacts on species diversity would be the same as or similar to those of the No Action Alternative. Agronomic practices commonly used to increase farm-scale biodiversity are also unlikely to change. As described previously for gene flow and weediness, GMB151 Soybean has no potential to produce naturally occurring, pollen-mediated gene flow and introgression of genes modified using genetic engineering, so is not expected to affect genetic diversity, which could have an impact on biodiversity.

For GMB151 Soybean, the most important concern related to biodiversity is the possibility that expression of the Cry14Ab-1 protein might adversely impact non-target organisms. Residues of certain Cry proteins are known to persist in soil (Feng et al. 2011), but at levels so low as to be negligible in terms of their capacity to impact non-target organisms. EPA assesses risks of biopesticides, which include possible impacts of Cry proteins that are PIPs (US-EPA 2014), and has concluded that risks associated with the GMB151 Soybean Cry14Ab-1 protein are negligible, so does not require a food or feed tolerance (40 CFR 174.540) for it. Test results reported by BASF for off-target effect of the Cry14Ab-1 protein expressed by GMB151 Soybean indicate that there are no unacceptable risks to or impacts on non-target organisms (BASF 2020).

Based on the information summarized above, overall effects on biodiversity under the Preferred Alternative are expected to be the same as or so similar to the No Action Alternative, that they would be indistinguishable. Therefore, there are no indications that the effects of commercially growing GMB151 Soybean would cause significant impacts to biodiversity if the Preferred Alternative were selected.

5.6 ANIMAL HEALTH

5.6.1 Animal Feed—No Action Alternative

Under the No Action Alternative, GMB151 Soybean would continue to be regulated. Soybean-based animal feed derived from both conventional and those biotech varieties that are not regulated under 7 CFR 340 would continue to be available. Nonregulated biotech soybeans used as animal feed have previously been determined to not pose any risk to animal health.

5.6.2 Animal Feed—Preferred Alternative

Results of studies conducted by BASF confirmed that there are no differences in the quality of animal feed produced from GMB151 Soybean compared to feed derived from both conventional and those biotech varieties that are not regulated under 7 CFR 340 (BASF 2020). APHIS critically reviewed data provided by and information in the scientific literature cited by (BASF 2020), and concluded that a determination of nonregulated status of GMB151 Soybean would not alter the nutritional quality of animal feed derived from it.

Possible effects to livestock from a determination of nonregulated status for GMB151 Soybean are related to concerns about the potential health impacts on animals from consuming soybean products containing residues of the Cry14Ab-1 protein. Safety evaluations conducted by BASF followed Codex Alimentarius Commission procedures recommended to assess potential adverse impacts to animals and humans.

Safety studies included: (1) characterization of the physicochemical and functional properties of the Cry14Ab-1 protein; (2) quantification of the Cry14Ab-1 protein levels in plant tissues; (3) comparison of the amino acid sequence of the Cry14Ab-1 protein in GMB151 Soybean to known allergens, gliadins, glutenins, toxins, and other biologically-active proteins known to have adverse effects on mammals; (4) evaluation of the digestibility of the Cry14Ab-1 protein in simulated gastric and intestinal fluids; (5) documentation of the presence of related proteins in several plant species currently consumed; and (6) investigation of the potential mammalian toxicity through an oral gavage assay. The Cry14Ab-1 protein was determined to have no amino acid sequence similar to known allergens, lacked toxic potential to mammals, and was degraded rapidly and completely in gastric fluid (85 FR 35008).

As part of its regulatory compliance process, BASF submitted supporting data and EPA concluded that the Cry14Ab-1 is not toxic or allergenic to mammals, so it does not require a food or feed tolerance (40 CFR 174.540) for Cry14Ab-1 protein when it is a plant-incorporated protectant (US-EPA 2020). Pesticide residue tolerances for pesticides listed in 40 CFR § 180 establish residue limits for soybean forage, hay, hulls, and seed (US-EPA, 2010a) that are protective of livestock and human health.

Based on the above information, there are no expected hazards associated with the consumption of GMB151 Soybean by animals, so it is unlikely to pose a hazard to any livestock species. The results of studies conducted by BASF confirmed that the crops containing these proteins can be safely used as animal feed (BASF 2020). There are no differences in feed safety between the GMB151 Soybean and other varieties currently available under the No Action Alternative. Therefore, APHIS has concluded that a determination of nonregulated status of GMB151 Soybean would not have significant impacts on animal feed or the health of livestock that consume it. Overall impacts of selecting the Preferred alternative would be the same as or similar to those of the No Action Alternative.

5.7 HUMAN HEALTH

5.7.1 Public Health: No Action Alternative

Under the No Action Alternative, GMB151 Soybean would remain under APHIS regulation. Human exposure to existing biotech and conventional soybean varieties would not change under this alternative. The same EPA-registered pesticides would continue to be used for pest management in conjunction with both biotech and conventional soybean cultivation. The environmental risks of pesticide use are assessed by the EPA in its pesticide registration process and are regularly reevaluated under its reregistration process to ensure that pesticides do not cause unreasonable adverse effects on human health or the environment.

The EPA also establishes maximum residue limits for pesticides that are referred to as tolerances (US-EPA 2010a). Tolerances represent the maximum amount of pesticide residues that can remain on or in food or feed. These levels have been carefully determined using scientific data to establish exposure levels that will not cause adverse health effects. The EPA sets tolerances for pesticides to meet FQPA safety standards for the U.S. population and designated sensitive populations (i.e., infants and children) to ensure that there is a reasonable certainty of no harm to the general population and any subgroup. Food or feed may not be distributed for consumption if it contains residues of one or more pesticides that exceed a tolerance. Food and feed with pesticide residues that exceed a tolerance are considered adulterated and may be seized. The FDA and USDA monitor foods for pesticide residues and enforce tolerances (USDA-AMS, 2018). For more details about tolerances, go to the EPA web site at: http://www.epa.gov/pesticides/bluebook/chapter11.html

5.7.2 Public Health: Preferred Alternative

BASF conducted safety evaluations using Codex Alimentarius Commission procedures to assess any potential adverse impacts to humans or animals resulting from environmental releases and consumption of GMB151 Soybean (BASF 2020). The gene regulating the expression of the Cry14Ab-1 protein, and the Cry14Ab-1 protein itself were determined to have no amino acid sequences similar to known allergens and lacked toxic potential to mammals. As part of its regulatory compliance process, BASF submitted supporting data, and EPA concluded that risks associated with the GMB151 Soybean are negligible, so it does not require a food or feed tolerance (40 CFR 174.540) for Cry14Ab-1 protein when it is a plant-incorporated protectant. Pesticide residue tolerances for pesticides listed in 40 CFR § 180 establish residue limits for soybean forage, hay, hulls, and seed (US-EPA, 2010a) that are protective of livestock and human health.

Based on this information, including field and laboratory data and scientific literature provided by BASF and safety data for other biotech soybeans, APHIS concluded that there would not be any adverse human health effects from a determination of nonregulated status of GMB151 Soybean. Human consumption of food products derived from GMB151 Soybean would not be different from those derived from conventional or biotech soybean varieties that are not regulated under 7 CFR 340. Likewise, human consumption of food products derived from livestock fed feed derived from GMB151 Soybean would not be different from products from livestock fed feed from conventional or biotech soybean varieties that are not regulated under 7 CFR 340 because no significant impacts on animal health were identified for GMB151 Soybean (see the preceding section for details). Impacts from choosing the Preferred Alternative would be the same as those for the No Action Alternative, so would not have significant impacts on human health.

5.7.3 Worker Safety: No Action Alternative

The availability of biotech, conventional, and organic soybeans would not change as a result of the continued regulation of GMB151 Soybean. Because of cost effectiveness, control measures for SCN rely mostly on planting resistant varieties rather than making nematicide applications to soybeans. Most nematicides are used for soybean seed treatments, which would not change if the Preferred Alternative is selected. Therefore, agronomic practices used for soybean production, such as the application of agricultural chemicals (pesticides and fertilizers), would be expected to continue unchanged. Growers will continue to choose agronomic practices based on weed, insect and disease pressures, cost of seed and other inputs, technology fees, human safety, potential for crop injury, and ease and flexibility of the production system (Farnham 2001; Heiniger 2000; University of Arkansas 2006). Worker safety is taken into consideration by the EPA in the pesticide registration and reregistration processes. Pesticides are regularly reevaluated by the EPA for each pesticide to maintain its registered status under FIFRA. Occupational Safety and Health Administration requires all employers to protect their employees from hazards associated with pesticides and herbicides. When used according to label directions, pesticides can be used with a reasonable certainty of no harm to human health and no unreasonable environmental risks.

The EPA Worker Protection Standards (WPS) (40 CFR Part 170) implement protections for agricultural workers, handlers, and their families. These WPS requirements were revised in 2015 to implement even stronger standards that became effective on January 2, 2017, with further revisions implemented on January 2, 2018. The EPA has also issued guidance for farm managers about how to implement the new standards (US-EPA 2017c).

5.7.4 Worker Safety: Preferred Alternative

A determination of nonregulated status of GMB151 Soybean is not expected to result in changes in current soybean cropping practices. Similar to the No Action Alternative, it is expected that EPA-registered pesticides, fertilizers, and other chemicals that are currently used for soybean production would continue to be used by growers. The EPA's core pesticide risk assessment and regulatory processes ensure that each registered pesticide continues to meet the highest standards of safety including all populations of non-target species and humans, and if used in accordance with the label, can be demonstrated to pose a reasonable certainty of no harm to humans, including those employed in agricultural and farm-related occupations, and no unreasonable adverse effects to the environment. The EPA WPS (40 CFR Part 170) would be the same as that described for the No Action Alternative. Growers are required to use pesticides in accordance with the application instructions provided on the EPA registration label for each pesticide product label, and follow the additional guidance (US-EPA 2017c) issued by the EPA to ensure farm worker safety. These label restrictions are legally enforceable and are enforced by EPA and the states (Federal Insecticide, Fungicide, and Rodenticide Act 7 USC 136j (a)(2)(G) Unlawful Acts).

Exposure to GMB151 Soybean under the Preferred Alternative is not expected to pose any changes to existing human health risks. Based on the above information, occupational health and safety risks under the Preferred Alternative are expected to be the same as or similar to those associated with the No Action Alternative.

5.8 SOCIOECONOMIC IMPACTS

5.8.1 Domestic Economic Environment: No Action Alternative

Under the No Action Alternative, GMB151 Soybean would remain under APHIS regulation. Growers and other parties who are involved in production, handling, processing, or consumption of soybeans would continue to have access to other nonregulated biotech and conventional soybean varieties. Domestic growers would continue to utilize biotech and conventional soybean varieties based upon availability and market demand. Current production practices, using biotech varieties to optimize yield and reduce production costs would not change if the No Action Alternative is selected. Grower net returns are estimated to increase approximately 24% from $303 to $375 per acre by the end of the period, 2013/2014 to 2021/2022, despite an estimated 3% rise in seed and residual costs, and 10.3% rise in overall per acre cost of production.

5.8.2 Domestic Economic Environment: Preferred Alternative

In field tests conducted by BASF, the performance and composition of GMB151 Soybean was determined not to be substantially different from that of other soybean varieties. If no longer regulated, GMB151 Soybean would be subject to the same variables that affect yield of other biotech and conventional soybean varieties such as weather, timing and density of planting, and soil nutrients Growers are familiar with yield improvements using increased yield varieties obtained through traditional breeding techniques, and more recently, increased yields from better weed control and disease resistance in biotech soybean varieties. As noted previously, soybean yields have increased steadily since 1924 (USDA-NASS 2012d).

GMB151 Soybean would be expected to be adopted by growers who are already growing biotech soybeans. The rate of adoption would depend on SCN distribution and this equates to increased yield and ultimately profitability after production costs. It is unlikely the availability of GMB151 Soybean would significantly impact the domestic economic environment. Past and recent increases in U.S. soybean acreage have occurred as growers replaced other crops with soybeans; not by bringing new lands into production. U.S. total cropland has remained relatively stable since the mid-20th century. Since 94% of U.S. soybean acreage is planted with biotech soybean varieties (USDA-NASS 2018c), it is likely that GMB151 Soybean would only replace other varieties of biotech soybean grown on existing cropland. Historically, soybean yields have been increasing for decades. In more recent times, this has resulted from conventional cross-breeding of high yielding varieties with biotech varieties, and applying improved management practices. Growers would have to make an independent assessment as to whether the benefits of GMB151 Soybean would offset higher seed cost.

Based upon the preceding information, the potential domestic economic impacts from a determination of nonregulated status for GMB151 Soybean would be similar to or no different than those under the No Action Alternative, so there would not be any significant impacts from selecting the Preferred Alternative.

5.8.3 International Trade Economic Environment: No Action Alternative

If the No Action Alternative is selected, GMB151 Soybean would continue to be regulated by APHIS. It is unlikely the current soybean market trade trends would change if GMB151 Soybean remained a regulated article. U.S. soybeans will continue to be a major contributor to global soybean production, and the United States will continue to be major exporter and supplier in the international market.

5.8.4 International Trade Economic Environment: Preferred Alternative

There are several factors that influence worldwide prices for oilseed, including soybean and its products. These include energy costs, fluctuations in currency exchange rates, government policies, national population size, per capita income, global market conditions, and trends and practices in market trading and speculation (Trostle 2008b; Trostle 2008a; Irwin and Good 2009). These factors influence the value derived from soybeans. If this value increases, it gets distributed between consumers in the form of lower product prices and growers and distributors as increased profits.

Projections from current trends in U.S. production indicate that it is unlikely that U.S. soybean acreage will increase significantly, so if it became commercially available, GMB151 Soybean, would likely only replace other biotech soybean varieties, where SCN is a pest problem. Any impact on soybean market prices from the potential increased yield from GMB151 Soybean production would likely be negligible because GMB151 would be used primarily to prevent potential losses and maintain current yield levels. Therefore, it would not alter the value currently derived from U.S. soybean production, so would not have any significant impact on the international trade environment for U.S. exports of soybean products.

USDA projects that from 2013/2014 to 2021/2022, the national annual average of U.S. soybean yield is expected to increase approximately 8% without expanding acreage, but the U.S. average farm price per bushel of soybean is predicted to vary only between $10.30 and $11.35. Grower annual net returns per acre are estimated to increase on average approximately 24% over the same period, despite an estimated approximately 3% rise in seed and residual costs, and 10.3% rise in overall per acre cost of production (USDA-OCE 2012). Adoption of GMB151 Soybean would likely be gradual at a pace equal to the extent growers find value in another higher than average yielding soybean variety.

It is not expected that if available, GMB151 Soybean would affect world attitudes towards biotech crops. The adventitious presence of biotech products in other food or feed continues to be a concern of some international trade partners, but if available, GMB 151 Soybean would not be expected to change the acceptability of U.S. soybean exports because most U.S. soybeans are already produced from biotech varieties. In its petition, BASF has asserted its commitment to stewardship to meet applicable regulatory requirements for GMB151 Soybean in the country of intended production and for key import countries to ensure compliance, maintain product integrity, and assist in minimizing the potential for trade disruptions (BASF 2020).

Based on these considerations, the potential impacts to the trade economic environment from a determination of nonregulated status of GMB151 Soybean would be similar to or no different than those currently observed for the No Action Alternative. Therefore, a determination of nonregulated status of GMB151 Soybean is not expected to have any significant impact on total annual U.S. soybean production, and no significant impacts on the international trade economic environment affecting U.S. soybean exports.

6 CUMULATIVE IMPACTS

The CEQ regulations define a cumulative impact (40 CFR part 1508, Section 1508.7 as follows: *Cumulative impact* is the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.

In Chapter 4, APHIS analyzed individually the environmental consequences that may result from choosing either the No Action or Preferred Alternative. As part of that analysis, APHIS considered the potential direct impacts on those aspects of the human environment related to the petition, and any subsequent commercial production of GMB151 Soybean. In this chapter, potential cumulative impacts of a decision about the regulatory status of GMB151 Soybean are reviewed.

6.1 METHODOLOGY AND ASSUMPTIONS

For its analysis, APHIS assumed that if no direct impacts on a resource area were identified as part of its analyses of impacts from a regulatory decision for GMB151 Soybean under Environmental Consequences (Chapter 4), then there cannot be any cumulative impacts on that resource area. When possible, effects were quantified for the analysis to measure the potential to cause significant impacts, otherwise, qualitative assessments were made.

APHIS limited its cumulative impacts analysis to the areas in the United States where soybeans are commercially grown. The potential for significant impacts from effects identified by the Agency as being reasonably foreseeable cumulative impacts were analyzed under the assumption that farmers, who grow soybean varieties developed using genetic engineering, conventional or organic soybeans would continue to use the same BMPs they currently use if GMB151 Soybean were no longer regulated.

Biotech soybeans grown in the United States are frequently produced from varieties that have multiple biotech traits. Such varieties are referred to as “stacked” hybrids, and some have been developed using the same recombinant DNA techniques used to produce single-trait biotech varieties. These are subject to APHIS regulation under 7 CFR 340 until a determination of nonregulated status is made. However, stacked hybrids can also be developed using traditional cross breeding to combine biotech traits from different biotech varieties, including those that have previously been evaluated individually by APHIS and have been determined to have nonregulated status. Therefore, if APHIS makes a determination of nonregulated status for GMB151 Soybean, it is likely that the traits from GMB151 will be bred into other soybean varieties that are not regulated by the Agency.

If it is no longer regulated, traditional plant breeding methods could be used to develop stacked trait hybrids between GMB151 Soybean and other biotech soybean varieties that have previously been determined to have nonregulated status. These include, for example, varieties that are resistant to herbicides and certain insect pests, and those expressing modified nutritional profiles. If GMB151 Soybean were no longer regulated, cross breeding it with other biotech soybean varieties to produce stacked trait varieties is a reasonably foreseeable action.

6.2 CUMULATIVE IMPACTS: SOYBEAN AGRICULTURAL PRODUCTION

Except for its resistance to SCN and isoxaflutole, GMB151 Soybean is agronomically and compositionally similar to conventional and biotech soybean varieties that are not regulated by APHIS (BASF 2020).

Neither the No Action Alternative nor the Preferred Alternative are expected to change total U.S. soybean acreage or cause any shift in the regions where soybean crops are currently grown for grain or seed. Total U.S. cropland has remained relatively steady since the middle of the last century. Increases in soybean acreage have occurred during this period, but this is the result of replacing other crops on existing cropland (USDA-ERS 2011c). Future increases in soybean production will likely be from improved soybean varieties and production methods that increase yield rather than expand production area (OECD-FAO 2008). Most soybeans currently grown in the United States are biotech varieties (USDA-ERS 2012a). Long-term projections indicate that soybean acreage will remain level until 2028 (USDA-OCE 2018). If it were no longer regulated, it is expected that GMB151 Soybean would replace other similar biotech soybean varieties and would not increase current total U.S. acreage or change the areas where soybeans are grown. Therefore, there would be no difference in the environmental impacts of selecting either the Preferred Alternative or the No Action Alternative on total U.S. soybean acreage or the locations where soybeans are grown for seed or grain, so there would not be any associated cumulative impacts.

Based upon past and current trends, the addition of another biotech soybean variety would not have any impacts on the ability of organic soybean producers to maintain their current market share. U.S. organic soybean production acreage has fluctuated somewhat from year to year between 82,143 and 126,000 acres during the period, 1997-2011 (USDA-ERS 2010a; USDA-NASS 2012a). This represented about 0.09% of total U.S. soybean acreage in 2011 (USDA-NASS 2012a). The most recent data puts U.S. organic soybean acreage at 124,591 in 2016, compared to 94,841 in 2015 (USDA-AMS 2017), which indicates little fluctuation from the previously reported trends. Availability of another biotech soybean variety, such as GMB151 Soybean would not be expected to alter any impacts that biotech soybeans currently have on organic soybean production, so no cumulative impacts will be associated with selecting either the No Action Alternative or the Preferred Alternative.

Studies by BASF demonstrated that, in terms of agronomic characteristics and cultivation practices such as tillage, fertilization, irrigation, pest and disease control measures, crop rotation, and irrigation, GMB151 Soybean is similar to other biotech currently grown. Therefore, GMB151 Soybean production is likely to require the same fertilizer inputs as other high yield soybean systems utilizing conventional or biotech soybean varieties. Supplementing soybean crops with nutrients is not uncommon (USDA-NASS 2018e), and BMPs that include soil fertility testing and supplementation recommendations to optimize nutrient replacement and maximize yield potential are widely used (Pedersen 2008; CAST 2009; Mallarino et al. 2011; Silva 2011; Snyder 2000; Specht et al. 2006).

If GMB151 Soybean were no longer regulated, it would be grown in rotation with other crops such as corn or wheat, no differently than any other high yield soybean varieties. In two-year corn-soybean rotations, enough potassium and phosphorus amendments are commonly applied to the corn crop to sustain the soybean crop the following year without additional supplementation

(Bender et al. 2013). However, recent research has shown higher yielding corn varieties may remove more phosphorous than is applied on average, and soil fertility testing prior to soybean planting is recommended (Bender et al. 2013). Potassium and phosphorus are commonly applied annually where soybeans are not rotated, which is the predominant practice in the South (Heatherly 2012). Testing soil fertility and supplementing nutrients is widely recommended and used in soybean production to achieve optimal yield potential (Pedersen 2008; CAST 2009; Mallarino et al. 2011; Silva 2011; Snyder 2000; Specht et al. 2006). There is no evidence that cultivation of GMB151 Soybean would require changes to any of these fertilization practices in soybean production.

Since the agronomic requirements and cultivation practices for GMB151 Soybean are the same as those for other high yield conventional and biotech soybean varieties currently grown in the United States, any environmental impacts from current soybean production in the United States would not be altered if GMB151 Soybean were no longer regulated by APHIS. Because there would be no changes in impacts, APHIS concluded that there would not be any cumulative impacts associated with selecting either the No Action Alternative or the Preferred Alternative.

6.3 CUMULATIVE IMPACTS: PHYSICAL ENVIRONMENT

Current agronomic practices for soybeans are important sources of impacts on the physical environment. Agronomic practices that have the potential to impact soil, water, and air quality, such as tillage, agricultural inputs (fertilizers and pesticides), and irrigation would not change following a determination of nonregulated status of GMB151 Soybean because GMB151 Soybean is agronomically and morphologically similar to other biotech and conventional soybeans. 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 remain the same under both Alternatives.

Because of its similarity to other commercially available biotech soybean varieties, and the likelihood that GMB151 Soybean would only replace other similar varieties, it would not change the acreage or locations of current U.S. soybean production. Therefore, any existing impacts on water, soil, and air quality from current U.S. soybean production practices would not change if GMB151 Soybean were no longer regulated by APHIS. As a result, there would be no difference in impacts from choosing either the Preferred Alternative or the No Action Alternative, and APHIS concluded that selection of either the No Action Alternative or the Preferred Alternative would not result in any cumulative impacts on the physical environment.

6.4 CUMULATIVE IMPACTS: BIOLOGICAL RESOURCES

Commercial cultivation of GMB151 Soybean, or progeny derived from it would not be expected to contribute in a cumulative manner to impacts on biological resources any differently than that of cultivation of current soybean varieties. GMB151 Soybean is both agronomically and compositionally similar to other conventional and biotech soybean varieties that are not regulated (BASF 2020). Therefore, if it were no longer regulated, GMB151 Soybean would not alter current U.S. soybean agronomic practices, so the impacts of those practices on animal and plant communities, microorganisms, and biodiversity would not change.

The traits for protection from SCN and resistance to isoxaflutole in GMB151 Soybean do not exert any influence on its weediness, so they do not represent any weediness risks that differ from other currently available soybean varieties. If present as a volunteer in crops rotated with soybeans, GMB151 Soybean would not be difficult to control because soybean seeds rarely remain viable the following season and are easily managed by hand weeding, cultivation, or herbicide applications.

The reproductive characteristics of GMB151 Soybean are also equivalent to other biotech and conventional soybean varieties (BASF 2020). Since soybean plants are mostly self-pollinating and have limited ability to disperse pollen, there is little or no potential for cross pollination of GMB151 Soybean with other soybean varieties. Since no feral or weedy species of soybean exist in the United States (Ellstrand, Prentice, and Hancock 1999; OECD 2000), GMB151 Soybean poses no potential for either naturally occurring, pollen-mediated gene flow or introgression of genes modified using genetic engineering. The risk of gene flow and weediness of GMB151 Soybean is no greater than that of other conventional and nonregulated biotech soybean varieties.

The maximum amount of herbicide active ingredient applied to varieties of GMB151 Soybean stacked with additional HR traits would be limited by the EPA registration for the product used. Other isoxaflutole-resistant biotech soybean varieties that are not regulated are currently available to growers. GMB151 Soybean would only replace these as another alternative to growers, so isoxaflutole usage would not change. As with other herbicides used for soybean cultivation, isoxaflutole used in accordance with EPA registration requirements would continue to ensure that there are no unacceptable risks to non-target organisms or the environment. Since there is no anticipated increase in U.S. soybean acreage in the foreseeable future, and no anticipated change in the acreage of isoxaflutole-resistant soybeans if GMB151 Soybean were no longer regulated, total isoxaflutole usage is unlikely to change because current EPA-labeled uses of isoxaflutole are expected to remain the same. Possible impacts on biological resources from the application of pesticides to stacked GMB151 Soybean varieties would not be any different from those resulting from biotech soybeans, when used in accordance with label instructions.

Results of the Agency’s analysis, which is summarized above, support the conclusion that there would be no impacts on biological resources if GMB151 Soybean were no longer regulated. In addition, existing impacts on biological resources associated with current soybean cultivation in the United States would not be altered. Because potential direct impacts on biological resources do not significantly differ between the No Action and Preferred Alternatives, there are no reasonably foreseeable cumulative impacts that would derive from the commercial cultivation of GMB151 Soybean or its progeny.

6.5 CUMULATIVE IMPACTS: ANIMAL FEED AND HUMAN HEALTH

Food and feed derived from biotech soybeans must be in compliance with all applicable legal and regulatory requirements. Results of previous analyses presented in Chapter 4 in the Human Health and Animal Feed sections described how the Agency considers the EPA pesticide registration process in APHIS EAs for biotech organisms that affect how pesticides are used. Under the authorizations of FIFRA, the EPA assesses environmental risks of pesticides, and once they are registered for use, regularly reevaluates them. As part of the registration process, the

EPA considers human health impacts from the use of pesticides and must determine that the pesticide will not cause unreasonable adverse effects on human health.

Worker safety is considered by the EPA in the pesticide registration and reregistration processes. If GMB151 Soybean is determined to have nonregulated status and is subsequently stacked in biotech soybean varieties with other HR traits, the total amount of herbicides that may be applied would be limited to the per application and per year rates established by the EPA. When used in compliance with EPA registration label specifications, pesticides present minimal risk to human health and worker safety. Pesticide residue tolerances for pesticides listed in 40 CFR § 180 establish residue limits for soybean forage, hay, hulls, and seed (US-EPA 2010a) that are protective of livestock and human health. EPA has also concluded that risks associated with the GMB151 Soybean are negligible, so it does not require a food or feed tolerance (40 CFR 174.540) for the Cry14Ab-1 protein when it is a plant-incorporated protectant (CFR 174.522).

APHIS has determined that there are no past, present, or reasonably foreseeable actions that would aggregate with the effects of a determination of nonregulated status for GMB151 Soybean that would adversely impact human health or animal feed. Based on its review of available information, APHIS has concluded that there is no evidence that any impacts that may result from a determination of nonregulated status for GMB151 Soybean would compound to cause significant cumulative impacts to human health or animal feed. Therefore, selection of either the No Action Alternative or the Preferred Alternative would not result in any cumulative impacts on human health and animal feed.

6.6 CUMULATIVE IMPACTS: SOCIOECONOMICS

The increase in U.S. soybean acreage during the past few decades has been associated with an increase in double cropping and the replacement of other crops with soybeans, not by bringing new lands into production (USDA-ERS 2011d). If it were no longer regulated, GMB151 Soybean would likely replace conventional or other biotech soybean varieties on existing cropland. Most (94%) U.S. soybean acreage is currently planted with biotech soybean varieties (USDA-NASS 2018c), and combined trials have confirmed that GMB151 Soybean is phenotypically and agronomically similar to other soybean conventional and biotech varieties that are not regulated by APHIS (BASF 2020), so adding a new soybean variety would not impact the domestic economic environment. Since impacts to the domestic economic environment would not change, there would not be any cumulative impacts on the domestic economic environment associated with selecting either the No Action Alternative or the Preferred Alternative.

Soybean yields have been increasing for decades. During the past few decades this has resulted from the development of conventionally bred and biotech varieties with high yielding traits, and improved management practices (Pedersen 2008; Specht et al. 2006). U.S. soybean acreage is projected to remain level at least until 2028, but with an anticipated 8% per acre yield gain. Despite potential increased production, prices for soybeans per bushel are not expected to change appreciably (remaining between $10.30 and $11.35 per bushel), but annual production net value is expected to increase (USDA-OCE 2012). Soybean supply is a function of the amount of acreage planted and crop yield. While domestic soybean yield has recently increased, primarily without increasing production acreage, demand for soybean products also increased, offsetting any downward pressure on farm soybean prices from any potential over supply (NRC 2010).

Nonregulated GMB151 Soybean is not expected to adversely impact the current trends affecting the seed, feed, or food trade and may have a negligible impact from increased yields. Apart from SCN and isoxaflutole resistance, GMB151 Soybean is essentially indistinguishable from other soybean varieties in terms of agronomic, morphologic, and compositional characteristics (BASF 2020). Increased farm productivity if GMB151 Soybean were no longer regulated may increase U.S competitiveness in the global economy, although many other factors affect worldwide prices for soybean, including energy costs, monetary exchange rates, government policies, population size and growth rate, per capita income, global market conditions, and trends and practices in market trading and speculation (Trostle 2008b; Trostle 2008a; Irwin and Good 2009). How any value derived from GMB151 Soybean is distributed between consumers in the form of reduced prices and growers as increased profits would be subject to these factors. Based upon the above information, any impact to soybean market prices from production of GMB151 Soybean would be negligible.

Another consideration is that since GMB151 Soybean is agronomically and compositionally similar to other commercially available soybean varieties, there would be no major changes to agronomic inputs or practices if it were determined to have nonregulated status. Like any other high-yield soybean variety, GMB151 Soybean has been shown to deplete potassium and phosphorous in soil more than other varieties. But as described above, supplementation of these nutrients in soybean production is not uncommon, and soil fertility testing and supplementation as indicated by tests and known crop soil nutrient removal rates is widely recommended in soybean production to achieve yield potential (Pedersen 2008; CAST 2009; Mallarino et al. 2011; Silva 2011; Snyder 2000; Specht et al. 2006). Advances in soybean yield have been attributed to development of conventionally bred higher yield varieties that also have herbicide and or other resistance traits developed using genetic engineering.

Another possible way that the soybean socioeconomic environment might be impacted by GMB151 Soybean would be if it were stacked with other biotech soybean traits that altered production costs of the agronomic practices used to produce soybeans. Although conservation tillage is used in conjunction with soybean production, there is an increasing trend to use strip tillage to support adequate soil fertility (Fernandez and White 2012).

More than half of the U.S. soybean crop acreage is in a two-year rotation with corn or wheat. Fertilization of a preceding corn crop is usually made at a level that supports the following soybean crop. However, recent research has shown that high yielding HR and IR corn varieties developed using genetic engineering may remove more phosphorous than is applied, so soil testing prior to planting of any soybean variety is recommended (Bender et al. 2013). In the South, where soybean crops are not rotated, fertilizer is applied annually (Heatherly 2012). Where crop rotation is practiced (e.g., corn-soybean-wheat rotation) phosphorous applications to replace nutrients removed and balance nutrient inputs are recommended (PPI 2003).

If GMB151 Soybean were no longer regulated, it would not be expected to change the choices of production systems soybean growers currently use (i.e., biotech, conventional, or organic). Organic soybean growers in particular supply a niche market that is a small portion of the U.S. market. As mentioned above regarding cumulative impacts on organic soybean production, adding biotech varieties to the domestic market is not related to the ability of organic production systems to maintain their market share.

It is possible that GMB151 Soybean would not be approved for import into other countries. Because the United States and other countries already have access to other soybean varieties, and GMB151 Soybean would only replace other biotech varieties already in the marketplace, its availability only to U.S. producers would not likely impact the economic trade environment. In 2011/2012, 42% of domestically produced U.S. soybean was dedicated to the export market (USDA-ERS 2012b, 2016). If GMB151 Soybean were not approved for import by other countries, but were not regulated in the United States, it would not likely affect the supply of U.S. soybean eligible for export to other countries. In contrast, if it were approved in the United States and for import by other countries, because of its similarity to other soybean varieties, the likelihood is that it would replace other such varieties, so would not increase the acreage or locations of soybean production in the United States. In its petition, BASF has also asserted its commitment to stewardship to meet applicable regulatory requirements for GMB151 Soybean in the country of intended production and for key import countries to ensure compliance, maintain product integrity, and assist in minimizing the potential for trade disruptions (BASF 2020). Therefore, it’s unlikely GMB151 Soybean would impact the supply of U.S. soybean available for export, there would be no potential cumulative impacts related to past and present actions if either the Preferred Alternative or the No Action Alternative is selected.

7 THREATENED AND ENDANGERED SPECIES

The Endangered Species Act (ESA) of 1973, as amended, is a far-reaching wildlife conservation law. Congress passed the ESA to prevent extinctions facing many species of fish, wildlife and plants. The purpose of the ESA is to conserve threatened and endangered species (T&E) and the habitats on which they depend as key components of America's natural heritage. The U.S. Fish & Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS) together comprise "the Services" and implement the ESA by working in coordination with other federal, state, and local agencies, Tribes, non-governmental organizations, and private citizens.

Before a plant or animal species can receive protection under the ESA, it must be added to the federal list of T&E animal and plant species. T&E species are those plants and animals at risk of becoming extinct throughout all or part of their geographic range (endangered species) or those at risk of becoming endangered in the foreseeable future throughout all or a significant portion of their range (threatened species).

The Services add a species to the list when they determine the species to be endangered or threatened by 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;
- Inadequacy of existing regulatory mechanisms; and
- Natural or manmade factors affecting its survival.

Once a species is added to the list, in accordance with the ESA, protective measures apply to the species and its habitat. These measures include protection from adverse effects of federal activities.

7.1 ESA REQUIREMENTS FOR FEDERAL AGENCIES

Section 7(a)(2) of the ESA requires consultation with USFWS and/or the NMFS. Federal agencies must consult to ensure that any action they authorize, fund, or carry out ". . . is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of habitat of such species . . .". It is the responsibility of the federal agency taking the action to assess the effects of the action and consult with the USFWS and NMFS if it is determined that the action "may affect" listed species or designated critical habitat (a process known as a Section 7 Consultation).

To facilitate the development of its ESA consultation requirements, APHIS met with the USFWS from 1999 to 2003 to discuss factors relevant to APHIS' regulatory authority and effects analysis practices for petitions for nonregulated status of biotech crop lines. By working with USFWS, APHIS developed a process for conducting an effects determination consistent with the Plant Protection Act (PPA) of 2000 (Title IV of Public Law 106-224). APHIS uses this process to fulfill its obligations and responsibilities under Section 7 of the ESA for biotechnology regulatory actions.

As described in Chapters 1 and 2, the APHIS regulatory authority over biotech organisms under the PPA is limited to those instances when there are reasons to believe a biotech organism could pose a plant pest risk, or when the Agency does not have sufficient information to determine that a biotech organism is unlikely to pose a plant pest risk. BASF has requested that APHIS determine that GMB151 Soybean is not a plant pest as defined by the PPA (BASF 2020; USDA-APHIS 2018). If APHIS concludes from its PPRA that GMB151 Soybean does not pose a plant pest risk, then it is not subject to the plant pest provisions of the PPA or the regulations of 7 CFR part 340, and the Agency has no authority to regulate it. For this EA, APHIS analyzed the potential effects of GMB151 Soybean on listed T&E species, their critical habitats, and proposed T&E species and their proposed critical habitats. For the analysis as part of this EA, APHIS thoroughly reviewed data related to GMB151 Soybean, and supporting data to determine possible effects on listed and proposed T&E species and critical habitat.

For each petition for a crop variety developed using genetic engineering, APHIS considers the following:

- A review of the biology, taxonomy, and weediness potential of the crop plant and its sexually compatible relatives
- Characterization of each modified using genetic engineering with respect to its structure and function and the nature of the organism from which it was obtained
- A determination of where the new gene 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)
- Analysis to determine if a plant variety developed using genetic engineering sexually compatible with any T&E species or a host of any T&E species
- Any other information about the potential for an organism to pose a plant pest risk

APHIS met with USFWS officials on June 15, 2011, to discuss and clarify whether APHIS has any obligations under the ESA regarding analyzing the effects on T&E species that may occur from the use of pesticides associated with biotech crops. As a result of these joint discussions, USFWS and APHIS have agreed that it is not necessary for APHIS to perform an ESA effects analysis on pesticide use associated with biotech crops because EPA has both regulatory authority over the labeling of pesticides under FIFRA, and the necessary technical expertise to assess pesticide effects on the environment. APHIS has no statutory authority to authorize or regulate the use of pesticides by soybean growers. Those plant varieties developed using genetic engineering that elicit plant-incorporated protectants (PIPs) are regulated by EPA under FIFRA. Under APHIS regulations (7 CFR 340), the Agency only has authority to regulate GMB151 Soybean and other biotech organisms if they pose a plant pest risk (7 CFR § 340.1). APHIS does not have jurisdiction to regulate other risks from biotech organisms like those from pesticides used on biotech organisms.

7.2 POTENTIAL EFFECTS OF GMB151 SOYBEAN ON T&E SPECIES AND CRITICAL HABITAT

APHIS evaluated the potential effects that a determination of nonregulated status of GMB151 Soybean may have, if any, on federally listed T&E species and species proposed for listing, as well as designated critical habitat, and habitat proposed for designation. As described in detail in this EA and in the petition (BASF 2020), BASF used recombinant DNA techniques to insert genes into soybean in its development of GMB151 Soybean. The genes inserted confer specific resistance to the nematode pest, *Heterodera glycines*, commonly referred to as the soybean cyst nematode (SCN), as well as resistance to HPPD herbicides, such as isoxaflutole. More details about the development of GMB151 Soybean are available for review in the BASF petition and the PPRA (BASF 2020; USDA-APHIS 2020).

Based on the information submitted by the applicant and reviewed by APHIS, GMB151 Soybean, with the exceptions of the nematode resistance and HPPD resistance, is agronomically and compositionally comparable to other biotech soybean with the same or similar traits and with conventional soybeans (BASF 2020).

APHIS has determined that the characteristics and cultivation practices required for GMB151 Soybean are indistinguishable from agronomic practices used to grow other soybean varieties. No changes in practices are expected if the Agency determines that it should no longer regulate the ~~article~~GMB151 soybean. APHIS considered the potential for GMB151 Soybean to extend the range of soybean production and also the potential to extend agricultural production into new natural areas. Although GMB151 Soybean may replace certain other varieties of soybean that are cultivated currently, APHIS does not expect the introduction of GMB151 Soybean to result in new soybean acreage to be planted in areas of the United States that are not currently used. Therefore, the issues considered in this review focus on the potential of a determination of nonregulated status for GMB151 Soybean for effects on T&E species in the areas where soybeans are currently grown. APHIS obtained and reviewed the USFWS list (Appendix A) of T&E species (listed and proposed) from the USFWS Environmental Conservation Online System for all states and U.S. territories where soybeans are produced (USFWS 2021).

For its analysis on T&E plants and critical habitat, APHIS focused on: the agronomic differences between the regulated ~~article~~ organism and soybean varieties currently grown; the potential for increased weediness; and the potential for gene movement to native plants, listed species, and species proposed for listing.

For its analysis of potential effects on T&E animals, APHIS focused on the implications of exposure to the Bt derived Cry protein expressed in GMB151 Soybean, and the ability of the plants to serve as a host for a T&E species. The novel genes and traits associated with GMB151 Soybean are summarized in Table 9.

Table 9. Proteins Produced by GMB151 Soybean that are Novel in Soybean

Regulated Article	Protein	Desired Phenotypic Effects
BASF GMB151 Soybean	Cry14Ab-1 protein encoded by *cry14Ab-1.b* gene from *Bacillus thuringiensis*	Toxicity to nematodes, including the soybean pest, soybean cyst nematode (SCN) (*Heterodera glycines*)
	HPPD-4 protein encoded by *hppdPf-4Pa gene* from *Pseudomonas fluorescens*	Resistance to herbicides with HPPD-inhibitor active ingredients such as isoxaflutole

Source: (BASF 2020)

7.2.1 Threatened and Endangered Plant Species and Critical Habitat

The agronomic and morphologic characteristics data provided by BASF (BASF 2020) were used in the APHIS analysis of the weediness potential for GMB151 Soybean and evaluated for the potential to impact T&E species and critical habitat. Agronomic studies conducted by BASF evaluated the performance of GMB151 Soybean in 11 field sites in different soybean growing regions of the United States.

Based on comparative assessments, agronomic performance of GMB151 Soybean was the same as or similar to conventional comparators and reference varieties. No substantive differences were detected between GMB151 Soybean and conventional soybeans varieties when comparing hardiness, persistence, seed dormancy, germination, or susceptibility to pests and diseases. These data supported the conclusion that the weediness potential of GMB151 Soybean is unchanged with respect to conventional soybean varieties and that GMB151 Soybean lacks weediness potential and plant pest risk (BASF 2020). These results and a subsequent analysis of the findings as reported in the PPRA indicated that, other than the intended effect of nematode resistance to SCN and resistance to HPPD-inhibiting herbicides, there were no differences detected between GMB151 Soybean, and conventional soybean varieties (BASF 2020; USDA-APHIS 2020). The analysis also found that there were no differences between GMB151 Soybean and other biotech crop varieties including soybean varieties developed using genetic engineering that express the same enzyme for HPPD-inhibitor herbicide resistance that were previously evaluated by APHIS and determined to have no effect on T&E species (USDA-APHIS 2018, 2013, 2014).

Cultivated soybeans and its wild progenitor, *Glycine soja*, are native to Asia. Wild species in the subgenus *Glycine* are also found in Australia, including perennial species, but wild relatives of soybeans do not grow in the United States (Sherman-Broyles et al. 2014a). Soybeans do not have any of the attributes of successful weeds, and have been cultivated (USDA-APHIS 2014) worldwide without any reports of becoming weedy, or forming non-weedy persistent feral populations (see "Weediness" Section, Chapter 3 for more details). The Global Invasive Species Database confirms that there are no *Glycine* species or closely related taxa that are listed as invasive weeds (ISSG 2019). Any risk is further limited because soybeans seeds are not frost tolerant, so they do not overwinter well (Meyer and Badaruddin 2001). The seeds are heavy so exhibit poor seed dispersal characteristics, and plants do not reproduce vegetatively. Despite these limitations, soybeans sometimes produce volunteers that interfere with corn or other rotational crops, but are not considered to be difficult to manage (Owen and Zelaya 2005b). Because soybeans are essentially autogamous, movement of genes introduced using genetic engineering from outcrossing attributable to pollen dispersal is negligible (Owen and Zelaya 2005b).

APHIS evaluated the potential of GMB151 Soybean to cross with listed T&E species. From a review of the list of T&E plant species (Appendix A) in the states where soybeans are grown, APHIS determined that GMB151 Soybean is not sexually compatible with any listed T&E plant species or plants proposed for listing. None of the listed plants are in the same genus as soybeans, nor are any known to cross pollinate with any species in the genus, *Glycine*.

Based on available information, APHIS concluded that if GMB151 Soybean will have no effect on T&E plant species or on critical habitats in the United States.

7.2.2 Threatened and Endangered Animal Species and Critical Habitat

Threatened and endangered animal species that may be exposed to the components of GMB151 Soybean would include those T&E species that inhabit soybean fields and potentially feed on GMB151 Soybean. To identify potential effects on T&E animal species, APHIS analyzed the risks to them from consuming GMB151 Soybean.

Exposure of T&E species is only likely if they occur in the areas where soybeans are grown because soybean plant parts (seeds, pollen, crop debris) are not transported long distances without human intervention. Therefore, the effects analysis evaluated those animal species that frequent soybean fields, or may be present in their immediate vicinity.

Nutrition, Composition, Agronomics, and Food Safety of GMB151 Soybean

BASF performed compositional analyses on GMB151 Soybean. BASF analyzed tissues of GMB151 Soybean and compared the compositional data to those of the conventional counterpart and reference varieties. The agronomic performance of GMB151 Soybean was evaluated at 11 field sites in different soybean growing regions of United States. The results of the compositional analysis and the comparative assessment demonstrated that GMB151 Soybean grain and forage are comparable to that derived from conventional soybean reference varieties (BASF 2020).

BASF evaluated the potential toxicity and allergenicity of the HPPD and Cry14Ab-1 proteins expressed in GMB151 Soybean in particular and showed that they have no significant homology to known protein toxins and allergens. They are the same as or similar to proteins present in many plant species including edible plants, indicating a history of prior exposure and a history of safe use. Also, levels of HPPD and Cry14Ab-1 proteins in seed and forage tissues of GMB151 Soybean grown under field trial conditions were extremely low—low enough to be regarded as negligible (BASF 2020). BASF presented data for this conclusion in its consultation with the FDA for its molecular, compositional, nutritional , and food and feed safety assessment for GMB151soybean (BASF 2020). In addition, on December 4, 2017, EPA published is final rule that exempts the HPPD-4 protein from the requirement of a food and feed tolerance, based on its analyses and determinations of absence of risk (82FR57137): https://www.govinfo.gov/content/pkg/FR-2017-12-04/pdf/FR-2017-12-04.pdf

On June 8, 2020, EPA concluded that Cry14Ab-1 residue in or on soybean food and feed commodities is exempt from a tolerance if it results from a PIP in soybean plants (85 FR 35008; 40 CFR 174.540). These rules are based on extensive analysis of toxicity and exposure.

APHIS reviewed all available evidence (referenced above) and concluded that except for the *cry14Ab-1.b* and *hppdPf-4Pa* gene inserts and the proteins they express, GMB151 soybean is compositionally, agronomically, and nutritionally equivalent to conventional soybean varieties (BASF 2020; USDA-APHIS 2020). Therefore, except for the possible effects of its transformed genetic components, GMB151 Soybean would not have any impacts on any animal species including T&E animal species. APHIS also concluded from the available toxicity data that the components of GMB151 Soybean would be unlikely to have impacts on any animal species other than the intended target species (i.e., SCN). To eliminate any possibility of impacts on T&E animal species, APHIS considered in its effects analysis, possible risks from toxic effects on specific taxa of T&E species and the likelihood of their exposure.

Exposure to GMB151 Soybean Genes and Proteins It Expresses

APHIS considered potential exposure to the *cry14Ab-1.b* and the *hppdPf-4Pa* gene inserts in the GMB151 Soybean genome, and to the Cry14Ab-1 and HPPD proteins expressed in the plant tissues of GMB151 Soybeans by those genes.

The *hppdPf-4Pa* gene was isolated from the bacterium, *Pseudomonas fluorescens* strainA32. *P. fluorescens* is a Gram-negative, rod-shaped, motile, asporogenous, aerobic bacterium. It is ubiquitous in the environment, including soil, water, and food (OECD 1997). Therefore, natural exposure of it and its gene products to a wide variety of animals including T&E species can be assumed. *P. fluorescens* has many beneficial uses in agriculture, human health, and bioremediation. It is not described as allergenic, toxic, or pathogenic to healthy humans and animals and has an overall history of safe use (BASF 2020). APHIS previously evaluated a soybean cultivar engineered to incorporate the same gene from *P. fluorescens* strainA32 to express the same HPPD protein and determined that it had no effects on T&E species (USDA-APHIS 2013).

All Cry proteins and *cry* genes have been isolated from *Bacillus thuringiensis*, a bacterium that is ubiquitous in the environment (OECD 1997). Therefore, natural exposure to *B. thuringiensis*, its genes and gene products to a wide variety of animals including T&E species can be assumed. None have been described as allergenic, toxic, or pathogenic to healthy humans and animals, having an overall history of safe use (Mendelsohn et al. 2003; Siegel 2001; Betz, Hammond, and Fuchs 2000; Farmer et al. 2017; Farias et al. 2014).

BASF results showed that the *cry14Ab-1.b* and *hppdPf-4Pa* genes in GMB151 Soybean do not result in any biologically meaningful differences between it and conventional soybean varieties (BASF 2020), and show no evidence of health risks to humans and animals. Safety testing of the GMB151 Soybean Cry14Ab-1 and HPPD proteins showed that they are degraded rapidly and completely in simulated gastric fluid. Testing also showed that the GMB151 Soybean Cry14Ab-1 and HPPD proteins have no similarities to known allergens, and are not toxic to mammals. EPA has established a permanent exemption (82FR57137) from the requirement for a tolerance for the HPPD-4 protein expressed in all food commodities when used as an inert ingredient. In addition, EPA concluded on June 8, 2020 that *B. thuringiensis* Cry14Ab-1 protein residue in or on soybean food and feed commodities are exempt from a tolerance, when used as a plant-incorporated protectant (PIP) in soybean (85 FR 35008; 40 CFR 174.540).

The use of biotech crops expressing Cry proteins has been shown to reduce the use of broad spectrum insecticides without significant impacts on diversity of non-target insects (Romeis, Meissle, and Bigler 2006; Romeis et al. 2008; Marvier et al. 2007; Wolfenbarger et al. 2008; Naranjo 2009). Bt toxins expressed in plants developed using genetic engineering for pest management are generally regarded as safe because of their rapid degradation in the environment, and their selective mode of action that makes them highly specific for a narrow spectrum of pests (Glare and O'Callaghan 2000; Sanvido, Romeis, and Bigler 2007; Romeis, Meissle, and Bigler 2006; Romeis et al. 2008). The specificity of Cry proteins for certain invertebrates and absence of toxicity for birds and mammals results from the highly specific receptors for these proteins in the gut of target species (Arora et al. 2007).

HPPD proteins are ubiquitous in nature in nearly all aerobic organisms, including the kingdoms of bacteria, fungi, plants, and animals including mammals. HPPD amino acid sequences have been determined in bacteria such as *Streptomyces avermitilis*, in fungi such as *Aspergillus fumigatus,* in plants such as *A. thaliana*, and in animals such as the free-living nematode, *Caenorhabditis elegans*; the mouse, *Mus musculus*, and humans. In particular, HPPD proteins have been characterized in organisms present in human food, such as carrots, barley, swine, and bovines (BASF 2020).

Potential Toxicity and Exposure of Vertebrate T&E Species to GMB151 Soybean

Because soybean plant parts (stems, leave, roots, seeds, pollen, and crop residues) are not transported long distances without human intervention, vertebrate animal exposure to components of GMB151 Soybean would be limited to those that occur in and around soybean fields. The review in the Affected Environment (Chapter 3 of this EA) documents evidence that demonstrates that soybean fields are poor habitats for birds and mammals in comparison to uncultivated lands. However, a few birds and mammals visit or inhabit soybean fields at various times throughout the soybean production cycle, so could be exposed to GMB 151 Soybean if it were no longer regulated.

APHIS has concluded previously that the same *hppdPf-4Pa* gene and the HPPD protein expressed by it in soybeans has no effects on T&E species (USDA-APHIS 2013). In addition, numerous studies (e.g., (Mendelsohn et al. 2003; Siegel 2001; Betz, Hammond, and Fuchs 2000; Farmer et al. 2017; Farias et al. 2014) have demonstrated that Cry proteins in general do not have toxic effects on vertebrate animals including T&E vertebrate species. Based on the absence of any known risks from toxicity to the components of GMB151 Soybean and the absence of or limited likelihood of exposure if it were not regulated, APHIS concluded that there would be no effects to T&E vertebrate species.

Potential Toxicity and Exposure of Invertebrate T&E Species to GMB151 Soybean

Because soybean plant parts (stems, leave, roots, seeds, pollen, and crop residues) are not transported long distances without human intervention, invertebrate animal exposure to components of GMB151 Soybean would be limited to those that occur in and around soybean fields.

The environmental safety assessment reported in the petition (see Appendices 3, 7, and 8) for GMB151 Soybean (BASF 2020) included an in vitro feeding assay of potential impacts to non-target organisms (NTOs). No adverse effects were observed from NTO species tested with Cry14Ab-1 protein including adult and larval honeybees, two soil-dwelling organisms (Collembola and earthworms), three predator organisms (two species of ladybird beetle and one green lacewing species), one aquatic organism (water flea), one mammal (mouse), and one avian species (bobwhite quail). The bioassay did detect activity of the Cry14Ab-1 on the roundworm, *Caenorhabditis elegans*. However, a two-year field assessment indicated that cultivation of GMB151 Soybean was unlikely to have negative effects on non-target free-living nematodes (BASF 2020). Based on the environmental safety assessment, the cultivation of GMB151 Soybean is unlikely to pose any risk to NTOs at expected field exposure levels. According to the USFWS list of T&E species (Appendix A), no nematodes or roundworms are threatened or endangered, nor are any currently proposed for listing.

APHIS also considered the risks to non-target organisms in its PPRA (pp. 15-17) from consuming GMB151 Soybean with specific reference to agriculture. Based on its review and analysis of the data collected from assays to evaluate the activity spectrum of Cry 14Ab-1, effects on free living nematodes, and effects on other non-target organisms, the Agency concluded that exposure to and/or consumption of GMB Soybean and the PIP it expresses are unlikely to have any adverse impacts to nontarget organisms beneficial to agriculture (USDA-APHIS 2020).

Because the evaluation of NTOs did not detect any adverse effects other than in vitro activity on the roundworm, *C. elegans* (BASF 2020), and the spectrum of activity observed for Cry proteins is narrow (Pigott and Ellar 2007; Wolfenbarger et al. 2008), the remainder of the APHIS T&E animal species analysis focused on taxa within the Class, Insecta. The cross-activity of Cry proteins has been reviewed by van Frankenhuyzen (2013). Cry14 proteins tend to be mostly active on nematodes, but show some activity against coleopteran species. Based on this evidence, APHIS concluded that T&E species in other insect orders (e.g., Lepidoptera, Hymenoptera, and Diptera) would not be affected by the Cry 14Ab-1 expressed by GMB151 Soybean. Therefore, the remainder of the effects analysis focused on coleopterans.

According to the USFWS list of T&E species (Appendix A), all of the listed T&E coleopterans are aquatic or predatory species in both the larval and adult stage. Based on this information, APHIS concluded that these species either could not or would not be exposed to the Cry14Ab-1 protein expressed by GMB151 Soybean, because they don’t live in the same habitat or will not feed on soybeans. Therefore, they will not be affected by it. In addition, APHIS noted that BASF conducted non-target studies on two coleopteran species (ladybird beetles) and reported results that showed no effects.

Potential to Serve as a Host Plant for T&E Species

APHIS also considered the possibility that GMB151 Soybean could serve as a host plant for T&E animal species (i.e., a listed insect or other organisms that may use the soybean plant to complete its lifecycle). A review of the T&E species list did not reveal any species that would be likely to use any members of the genus *Glycine* as a host plant (USFWS 2020). Combined, the above information indicates that GMB151 Soybean and its progeny are not expected to have any effects on T&E animal species. There is no increased risk of toxicity or allergenicity impacts directly to animal species from contact with or feeding on GMB151 Soybean. Based on this analysis, APHIS concluded that contact with GMB151 Soybean plants or plant parts by T&E species is unlikely, and if it occurred, consumption would not affect any listed T&E animal species or animal species proposed for listing.

Based on the above analysis, previous analyses of similar soybean varieties by APHIS that have received a determination of non-regulated status by the Agency, information in the peer-reviewed literature and the petition, APHIS concluded that exposure to and/or consumption of GMB151 Soybean and the HPPD and Cry proteins it expresses, there will be no effects on any threatened or endangered animal species or species proposed for listing.

7.3 SUMMARY

After reviewing the possible effects of a determination of nonregulated status of GMB151 Soybean, APHIS has not identified any stressor that would or could affect the reproduction, numbers, or distribution of a listed T&E species or those proposed for listing. As a result, a detailed exposure analysis for individual species is not necessary. APHIS also considered the potential effect of a determination of nonregulated status of GMB151 Soybean on designated critical habitat or habitat proposed for designation. Compared to other soybean varieties that are currently in use, APHIS determined that GMB151 Soybean production would not differentially affect critical habitat. Like many crops, soybean has been selected for yield rather than its ability to compete and persist in the environment. GMB151 Soybean is not expected to outcompete other plants and persist outside of direct cultivation. Soybean is not sexually compatible with, and does not serve as a host species for, any T&E species or species proposed for listing. There is no evidence that any T&E species or species proposed for listing will consume GMB151 Soybean, therefore APHIS concluded that they will not be subject to any allergic or toxic reactions.

Based on this evidence, APHIS has concluded that a determination of nonregulated status of GMB151 Soybean, and the corresponding environmental release of this soybean variety will have no effect on T&E 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 ESA, or the concurrence of the USFWS or NMFS is not required.

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

8.1 FEDERAL LAWS AND REGULATIONS

The statutes most relevant to APHIS determinations of regulatory status are the National Environmental Policy Act of 1969 (NEPA), the Clean Water Act of 1972 (CWA), the Safe Drinking Water Act of 1974 (SDWA), the Clean Air Act of 1970 (CAA), the Endangered Species Act of 1973 (ESA), and the National Historic Preservation Act of 1966 (NHPA). Compliance with the requirements of the ESA has been addressed in Chapter 6. Compliance with the requirements of the other relevant laws, NEPA, CWA, SDWA, CAA, and NHPA, is specifically addressed in the following subsections.

8.1.1 National Environmental Policy Act (NEPA)

NEPA is designed to ensure transparency and communication on the possible environmental effects of federal actions prior to implementation of a proposed federal action. The Act and implementing regulations require federal agencies to document, in advance and in detail, the potential effects of their actions on the human environment, so as to ensure that both decision makers and the public fully understanding the possible environmental outcomes of federal actions. APHIS has prepared this EA to document the potential environmental outcomes of the alternatives considered, consistent with the requirements of NEPA (42 United States Code (U.S.C) 4321, *et seq*.) and Council on Environmental Quality implementing regulations at 40 CFR parts 1500-1508.

8.1.2 Clean Water Act, Safe Drinking Water Act, and Clean Air Act

The CWA, SDWA, and CAA authorize EPA to regulate air and water quality in the United States. This EA evaluates the potential changes in soybean crop production and byproducts associated with approving the petition for a determination of nonregulated status to GMB151 Soybean. APHIS determined that the cultivation of GMB151 Soybean would not lead to the increase in or expansion of the area in soybean production. Because GMB151 Soybean is compositionally, agronomically, and phenotypically equivalent to other conventional varieties and those developed using genetic engineering (BASF 2020), the potential impacts to water and air quality from the commercial cultivation of GMB151 Soybean would be no different than that of currently cultivated soybean varieties. The herbicide resistance conferred by the genetic modification of GMB151 Soybean is not expected to result in any changes in water usage for cultivation or post-harvest processing of soybean. APHIS assumes any use of isoxaflutole will be compliant with the EPA registration and label requirements. Based on these analyses, APHIS concludes that a determination of nonregulated status for GMB151 Soybean would not lead to circumstances that resulted in non-compliance with the requirements of the CWA, CAA, and SDWA.

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

The National Historic Preservation Act of 1966 (NHPA; Public Law 89-665; 16 U.S.C. 470 et seq.) designates federal agencies that are proposing federally funded or permitted projects on historic properties (buildings, archaeological sites, etc.) to consider the impacts using the required Section 106 Review process.

The NHPA 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 impacts on historic properties; and 2) if so, to evaluate the impacts of such undertakings on historic resources and consult with the Advisory Council on Historic Preservation (i.e., State Historic Preservation Office, Tribal Historic Preservation Officers), as appropriate.

A determination of nonregulated status of GMB151 Soybean would not directly or indirectly cause alteration in the character or use of historic properties protected under the NHPA. It 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 important scientific, cultural, or historical resources.

Standard agricultural practices for land preparation, planting, irrigation, and harvesting of plants would be used on these agricultural lands, including the use of EPA-registered pesticides. Adherence to the EPA label use restrictions for pesticides will mitigate impacts to the human environment, including historic and cultural resources.

In general, common agricultural activities that would be used in cultivation of GMB151 Soybean do not have the potential to introduce visual, atmospheric, or noise elements to areas in which they are used that could result in impacts on the character or use of historic properties. These cultivation practices are already being conducted throughout the soybean production regions. If GMB151 Soybean were available for cultivation, it would not change any of these agronomic practices that would result in an adverse impact under the NHPA.

8.2 EXECUTIVE ORDERS WITH DOMESTIC IMPLICATIONS

The following executive orders (EOs) require consideration of the potential impacts of the federal action to various segments of the population.

> EO 12898 (US-Archives 1994): “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, low-income communities, and Indian Tribes from being subjected to disproportionately high and adverse human health or environmental effects.
>
> EO 13045 (US-Archives 1997): “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. This 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.

EO 13175: "Consultation and Coordination with Indian Tribal Governments" charges Executive departments and agencies with a responsibility of engaging in consultation and collaboration with tribal governments; strengthening the government-to-government relationship between the United States and Indian Tribes; and reducing the imposition of unfunded mandates upon Indian Tribes. This EO emphasizes and pledges that federal agencies will communicate and collaborate with tribal officials when proposed federal actions have potential tribal implications.

The No Action and Preferred Alternatives were analyzed with respect to EO 12898, EO 13045 and EO 13175. Neither alternative is expected to have a disproportionate adverse impact on minorities, low-income populations, children, or tribal entities. APHIS determined that the cultivation of GMB151 Soybean would not lead to the increase in or expansion of the area in soybean production. A determination of nonregulated status of GMB151 Soybean is not likely to impact cultural resources on tribal properties. Any farming activities by farmers on tribal lands are only conducted at a Tribe's request. Thus, the Tribes would have control over any potential conflict with cultural resources on tribal properties. The Proposed action, a determination of nonregulated status of GMB151 Soybean is not expected to impact cultural resources on tribal properties.

Available mammalian toxicity data associated with the HAHB4 protein confirmed the safety of GMB151 Soybean 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 GMB151 Soybean.

APHIS assumes that growers will adhere to herbicide use precautions and restrictions. Pesticide labels include use precautions and restrictions intended to protect workers and their families from exposures. As discussed in Chapter 4 (under Human Health), it is expected that EPA-registered pesticides, fertilizers, and other chemicals that are currently used for soybean production, determined by the EPA not to have adverse impacts to human health when used in accordance with label instructions, would continue to be used by growers on GMB151 Soybean using application rates currently approved for conventional soybean varieties and those developed using genetic engineering. Based on these factors, a determination of nonregulated status for GMB151 Soybean is not expected to have disproportionate adverse impacts on minorities, low-income populations, or children.

EO 13751: "Safeguarding the Nation from the Impacts of Invasive Species"

Invasive species are defined as those species that are both not native to the ecosystem under consideration and that also harm the environment, economy or human health. Collectively, they constitute a major concern in the United States and elsewhere. This second EO regarding invasive species directs actions to continue coordinated federal prevention and control efforts related to invasive species. This order maintains the National Invasive Species Council (Council) and the Invasive Species Advisory Committee; adds additional members to the Council; clarifies the operations of the Council; incorporates increased considerations of human and environmental health, climate change, technological innovation, and other emerging priorities into federal efforts to address invasive species; and strengthens coordinated, cost-efficient federal action.

Soybean is not listed in the United States as a noxious weed species by the U.S. government (USDA-NRCS 2013b), nor is it listed as an invasive species by major invasive plant data bases. Cultivated soybean seed does not usually exhibit dormancy and requires specific environmental conditions to grow as a volunteer the following year (OECD 2000). Any volunteers that may become established do not compete well with the succeeding planted crop and are easily managed using standard weed control practices. Field trials and laboratory tests indicate GMB151 Soybean has no plant pathogenic properties or weediness characteristics. The agronomic, compositional, and reproductive characteristics of GMB151 Soybean are substantially equivalent to both other soybean varieties developed using genetic engineering and conventional varieties. The trait for increased yield is not expected to contribute to increased weediness without changes in a combination of other characteristics associated with weediness, such as hard seed and increased lodging, among other characteristics. Non-engineered soybean, as well as other HR soybean varieties, are widely grown in the United States. Based on historical experience with these varieties and the data submitted by the applicant and reviewed by APHIS, GMB151 Soybean plants are sufficiently similar in fitness characteristics to other soybean varieties currently grown and are not expected to become weedy or invasive.

> **EO 13186 (US-Archives 2001): "Responsibilities of Federal Agencies to Protect Migratory Birds,"** states that federal agencies taking actions that have, or are likely to have a measurable negative impact on migratory bird populations are directed to develop and implement, within two years, a Memorandum of Understanding (MOU) with the Fish and Wildlife Service that shall promote the conservation of migratory bird populations.

Migratory birds may be found in soybean fields. While soybean does not meet the nutritional requirements for many migratory birds (Krapu, Brandt, and Cox 2004), they may forage for insects and weed seeds found in and adjacent to soybean fields. As described in Chapter 4 (under Animal Communities), data submitted by the applicant has shown no difference in compositional and nutritional quality of GMB151 Soybean compared with other varieties developed using genetic engineering and conventional varieties, apart from the presence of the SCN and isoxaflutole resistance traits. GMB151 Soybean is not expected to be allergenic, toxic, or pathogenic to wildlife. The results provided by BASF indicate that the expression of the Cry14Ab-1 protein is unlikely to be a toxin in animal diets.

Based on the Agency's assessment of GMB151 Soybean, APHIS concluded it is unlikely that a determination of nonregulated status of GMB151 Soybean would have any negative effects on migratory bird populations.

8.3 INTERNATIONAL IMPLICATIONS

> EO 12114 (US-Archives 2010), "Environmental Effects Abroad of Major Federal Actions" requires federal officials to take into consideration any potential environmental impacts outside the United States, 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 United States if it makes a determination of nonregulated status for GMB151 Soybean. All existing national and international regulatory authorities and phytosanitary regimes that currently apply to introductions of new soybean varieties internationally apply equally to those covered by an APHIS determination of nonregulated status under 7 CFR part 340.

Any international trade of GMB151 Soybean subsequent to a determination of nonregulated status would be fully subject to national phytosanitary requirements and be in accordance with phytosanitary standards developed under the International Plant Protection Convention (IPPC) (IPPC 2013). 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 2013). 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. There are currently 183 IPPC[10] countries. In April 2004, a standard for Plant Risk Analysis of living modified organisms (LMOs) was adopted at a meeting of the governing body of the IPPC as a supplement to an existing standard: International Standard for Phytosanitary 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 Plant Risk Analysis for importation as to whether the LMO poses a potential pest risk resulting from the genetic modification. APHIS pest risk assessment procedures for organisms developed using genetic engineering are consistent with the guidance developed under the IPPC. In addition, issues that may relate to commercialization and transboundary movement of particular agricultural commodities produced through biotechnology are being addressed in other international forums and through national regulations.

The *Cartagena Protocol on Biosafety* is a treaty under the United Nations Convention on Biodiversity 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 became effective on September 11, 2003, and currently, there are 198 parties [11] that have signed the Protocol. Although the United States is not a party to the Convention on Biodiversity, and thus not a party to the Cartagena Protocol on Biosafety, U.S. exporters will still need to comply with those regulations that importing countries which are Parties to the Protocol have promulgated to comply with their obligations. The first intentional transboundary movement of LMOs intended for environmental release (field trials or commercial planting) will require consent from the importing country under an advanced informed agreement provision, which includes a requirement for a risk assessment consistent with Annex III of the Protocol and the required documentation.

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 United States, and within the OECD. NAPPO has completed four modules for releasing plant varieties developed using genetic engineering 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 United States, Mexico, and Canada. In addition, bilateral discussions on biotechnology regulatory issues are held regularly with other countries including Argentina, Brazil, Japan, China, and Korea.

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[10]For a list of countries, go to: https://www.ippc.int/en/countries/all/list-countries/

[11]For a list of signers, go to: http://bch.cbd.int/protocol/parties/

8.4 IMPACTS ON UNIQUE CHARACTERISTICS OF GEOGRAPHIC AREAS

A determination of nonregulated status of GMB151 Soybean is not expected to impact unique characteristics of geographic areas such as park lands, prime farmlands, wetlands, wild and scenic areas, or ecologically critical areas.

BASF has presented results of agronomic field trials for GMB151 Soybean. The results of these field trials demonstrate there are no differences in agronomic practices between GMB151 Soybean and conventional hybrids that are needed for their cultivation. The common agricultural practices that would be carried out in the cultivation of GMB151 Soybean are not expected to deviate from current practices, including the use of EPA-registered pesticides. The product is expected to be grown on agricultural land currently suitable for production of soybean and would only replace existing varieties; it is not expected to increase the acreage of soybean production.

There are no proposed major ground disturbances; no new physical destruction or damage to property; no alterations of property, wildlife habitat, or landscapes; and no prescribed sale, lease, or transfer of ownership of any property. This action is limited to a determination of nonregulated status of GMB151 Soybean. This action would not convert land use to nonagricultural use and, therefore, would have no adverse impact on prime farmland. Standard agricultural practices for land preparation, planting, irrigation, and harvesting of plants would be used on agricultural lands planted to GMB151 Soybean, including the use of EPA-registered pesticides. Adherence by growers to EPA label requirements for all pesticides will prevent adverse effects on the human environment.

Based on these findings, including the assumption that pesticide label requirements are in place to protect unique geographic areas and that those requirements will be adhered to, a determination of nonregulated status for GMB151 Soybean will not impact unique characteristics of geographic areas such as park lands, prime farm lands, wetlands, wild and scenic areas, or ecologically critical areas.

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APPENDIX A. THREATENED OR ENDANGERED SPECIES

U.S. Fish & Wildlife Service

ECOS

ECOS / Species Reports / Species Search

U.S. Listed Threatened, Endangered, and Proposed Species as of 11/15/20

U.S. Listed Threatened, Endangered, and Proposed Species as of 11/15/20

1653 Records

Parameters:

Listing Statuses: Endangered, Threatened, Not Listed in the US

Scientific Name	Common Name	Family	Federal Listing Status
Abronia macrocarpa	Large-fruited sand-verbena	Nyctaginaceae	Endangered
Abutilon eremitopetalum	No common name	Malvaceae	Endangered
Abutilon menziesii	Ko`oloa`ula	Malvaceae	Endangered
Abutilon sandwicense	No common name	Malvaceae	Endangered
Acaena exigua	Liliwai	Rosaceae	Endangered
Acanthomintha ilicifolia	San Diego thornmint	Lamiaceae	Threatened
Acanthomintha obovata ssp. duttonii	San Mateo thornmint	Lamiaceae	Endangered
Accipiter striatus venator	Puerto Rican sharp-shinned hawk	Accipitridae	Endangered
Achatinella spp.	Oahu tree snails	Achatinellidae	Endangered
Achyranthes mutica	No common name	Amaranthaceae	Endangered
Achyranthes splendens var. rotundata	Round-leaved chaff-flower	Amaranthaceae	Endangered
Acipenser brevirostrum	Shortnose sturgeon	Acipenseridae	Endangered
Acipenser medirostris	green sturgeon	Acipenseridae	Threatened
Acipenser oxyrinchus (=oxyrhynchus) desotoi	Atlantic sturgeon (Gulf subspecies)	Acipenseridae	Threatened
Acipenser oxyrinchus oxyrinchus	Atlantic sturgeon	Acipenseridae	Endangered
Acipenser oxyrinchus oxyrinchus	Atlantic sturgeon	Acipenseridae	Threatened

Scientific Name	Common Name	Family	Federal Listing Status
Acipenser transmontanus	White sturgeon	Acipenseridae	Endangered
Acmispon dendroideus var. traskiae (=Lotus d. ssp. traskiae)	San Clemente Island lotus (=broom)	Fabaceae	Threatened
Aconitum noveboracense	Northern wild monkshood	Ranunculaceae	Threatened
Acrocephalus familiaris kingi	Nihoa millerbird (old world warbler)	Muscicapidae	Endangered
Acrocephalus luscinia	Nightingale reed warbler (old world warbler)	Sylviidae	Endangered
Acropora cervicornis	Staghorn coral	Acroporidae	Threatened
Acropora palmata	Elkhorn coral	Acroporidae	Threatened
Adelocosa anops	Kauai cave wolf or pe'e pe'e maka 'ole spider	Lycosidae	Endangered
Adenophorus periens	Pendant kihi fern	Polypodiaceae	Endangered
Adiantum vivesii	No common name	Adiantaceae	Endangered
Aerodramus vanikorensis bartschi	Mariana gray swiftlet	Apodidae	Endangered
Aeschynomene virginica	Sensitive joint-vetch	Fabaceae	Threatened
Agalinis acuta	Sandplain gerardia	Scrophulariaceae	Endangered
Agave eggersiana	No common name	Agavaceae	Endangered
Agelaius xanthomus	Yellow-shouldered blackbird	Icteridae	Endangered
Akialoa stejnegeri	Kauai akialoa (honeycreeper)	Drepanidinae	Endangered
Alasmidonta atropurpurea	Cumberland elktoe	Unionidae	Endangered
Alasmidonta heterodon	Dwarf wedgemussel	Unionidae	Endangered
Alasmidonta raveneliana	Appalachian elktoe	Unionidae	Endangered
Alectryon macrococcus	Mahoe	Sapindaceae	Endangered
Allium munzii	Munz's onion	Liliaceae	Endangered
Alopecurus aequalis var. sonomensis	Sonoma alopecurus	Poaceae	Endangered
Amaranthus brownii	No common name	Amaranthaceae	Endangered
Amaranthus pumilus	Seabeach amaranth	Amaranthaceae	Threatened

Scientific Name	Common Name	Family	Federal Listing Status
Amazona vittata	Puerto Rican parrot	Psittacidae	Endangered
Amblema neislerii	Fat threeridge (mussel)	Unionidae	Endangered
Amblyopsis rosae	Ozark cavefish	Amblyopsidae	Threatened
Ambrosia cheiranthifolia	South Texas ambrosia	Asteraceae	Endangered
Ambrosia pumila	San Diego ambrosia	Asteraceae	Endangered
Ambrysus amargosus	Ash Meadows naucorid	Naucoridae	Threatened
Ambystoma bishopi	Reticulated flatwoods salamander	Ambystomatidae	Endangered
Ambystoma californiense	California tiger Salamander	Ambystomatidae	Endangered
Ambystoma californiense	California tiger Salamander	Ambystomatidae	Threatened
Ambystoma cingulatum	Frosted Flatwoods salamander	Ambystomatidae	Threatened
Ambystoma macrodactylum croceum	Santa Cruz long-toed salamander	Ambystomatidae	Endangered
Ambystoma tigrinum stebbinsi	Sonora tiger Salamander	Ambystomatidae	Endangered
Ameiva polops	St. Croix ground lizard	Teiidae	Endangered
Ammodramus maritimus mirabilis	Cape Sable seaside sparrow	Emberizidae	Endangered
Ammodramus savannarum floridanus	Florida grasshopper sparrow	Emberizidae	Endangered
Amorpha crenulata	Crenulate lead-plant	Fabaceae	Endangered
Amphianthus pusillus	Little amphianthus	Scrophulariaceae	Threatened
Amphispiza belli clementeae	San Clemente sage sparrow	Emberizidae	Threatened
Amsinckia grandiflora	Large-flowered fiddleneck	Boraginaceae	Endangered
Amsonia kearneyana	Kearney's blue-star	Apocynaceae	Endangered
Anaea troglodyta floridalis	Florida leafwing Butterfly	Nymphalidae	Endangered
Anas laysanensis	Laysan duck	Anatidae	Endangered
Anas wyvilliana	Hawaiian (=koloa) Duck	Anatidae	Endangered
Anaxyrus californicus	Arroyo (=arroyo southwestern) toad	Bufonidae	Endangered
Anaxyrus canorus	Yosemite toad	Bufonidae	Threatened

Scientific Name	Common Name	Family	Federal Listing Status
Anguispira picta	Painted snake coiled forest snail	Stylommataphora	Threatened
Anolis roosevelti	Culebra Island giant anole	Iguanidae	Endangered
Anoxypristis cuspidata	Narrow sawfish	Pristidae	Endangered
Antilocapra americana sonoriensis	Sonoran pronghorn	Antilocapridae	Endangered
Antrobia culveri	Tumbling Creek cavesnail	Hydrobiidae	Endangered
Antrolana lira	Madison Cave isopod	Cirolanidae	Threatened
Aphelocoma coerulescens	Florida scrub-jay	Corvidae	Threatened
Apios priceana	Prices potato-bean	Fabaceae	Threatened
Aplodontia rufa nigra	Point Arena mountain beaver	Aplodontidae	Endangered
Apodemia mormo langei	Lange's metalmark butterfly	Lycaenidae	Endangered
Arabis georgiana	Georgia rockcress	Brassicaceae	Threatened
Arabis hoffmannii	Hoffmann's rock-cress	Brassicaceae	Endangered
Arabis macdonaldiana	McDonald's rock-cress	Brassicaceae	Endangered
Arabis perstellata	Braun's rock-cress	Brassicaceae	Endangered
Arabis serotina	Shale barren rock cress	Brassicaceae	Endangered
Arctocephalus townsendi	Guadalupe fur seal	Phocidae	Threatened
Arctomecon humilis	Dwarf Bear-poppy	Papaveraceae	Endangered
Arctostaphylos confertiflora	Santa Rosa Island manzanita	Ericaceae	Endangered
Arctostaphylos franciscana	Franciscan manzanita	Ericaceae	Endangered
Arctostaphylos glandulosa ssp. crassifolia	Del Mar manzanita	Ericaceae	Endangered
Arctostaphylos hookeri var. ravenii	Presidio Manzanita	Ericaceae	Endangered
Arctostaphylos morroensis	Morro manzanita	Ericaceae	Threatened
Arctostaphylos myrtifolia	Ione manzanita	Ericaceae	Threatened
Arctostaphylos pallida	Pallid manzanita	Ericaceae	Threatened
Arenaria cumberlandensis	Cumberland sandwort	Caryophyllaceae	Endangered
Arenaria paludicola	Marsh Sandwort	Caryophyllaceae	Endangered

Scientific Name	Common Name	Family	Federal Listing Status
Arenaria ursina	Bear Valley sandwort	Caryophyllaceae	Threatened
Argemone pleiacantha ssp. pinnatisecta	Sacramento prickly poppy	Papaveraceae	Endangered
Argyroxiphium kauense	Mauna Loa (=Ka'u) silversword	Asteraceae	Endangered
Argyroxiphium sandwicense ssp. macrocephalum	`Ahinahina	Asteraceae	Threatened
Argyroxiphium sandwicense ssp. sandwicense	`Ahinahina	Asteraceae	Endangered
Argythamnia blodgettii	Blodgett's silverbush	Euphorbiaceae	Threatened
Aristida chaseae	No common name	Poaceae	Endangered
Aristida portoricensis	Pelos del diablo	Poaceae	Endangered
Arkansia wheeleri	Ouachita rock pocketbook	Unionidae	Endangered
Asclepias meadii	Mead's milkweed	Asclepiadaceae	Threatened
Asclepias welshii	Welsh's milkweed	Asclepiadaceae	Threatened
Asimina tetramera	Four-petal pawpaw	Annonaceae	Endangered
Asplenium dielerectum	Asplenium-leaved diellia	Aspleniaceae	Endangered
Asplenium dielfalcatum	No common name	Aspleniaceae	Endangered
Asplenium diellaciniatum	No common name	Aspleniaceae	Endangered
Asplenium dielmannii	No common name	Aspleniaceae	Endangered
Asplenium dielpallidum	No common name	Aspleniaceae	Endangered
Asplenium peruvianum var. insulare	No common name	Aspleniaceae	Endangered
Asplenium scolopendrium var. americanum	American hart's-tongue fern	Aspleniaceae	Threatened
Asplenium unisorum	No common name	Aspleniaceae	Endangered
Assiminea pecos	Pecos assiminea snail	Assimineidae	Endangered
Astelia waialealae	Pa`iniu	Liliaceae	Endangered
Astragalus albens	Cushenbury milk-vetch	Fabaceae	Endangered
Astragalus ampullarioides	Shivwits milk-vetch	Fabaceae	Endangered
Astragalus applegatei	Applegate's milk-vetch	Fabaceae	Endangered

Scientific Name	Common Name	Family	Federal Listing Status
Astragalus bibullatus	Guthrie's (=Pyne's) ground-plum	Fabaceae	Endangered
Astragalus brauntonii	Braunton's milk-vetch	Fabaceae	Endangered
Astragalus clarianus	Clara Hunt's milk-vetch	Fabaceae	Endangered
Astragalus cremnophylax var. cremnophylax	Sentry milk-vetch	Fabaceae	Endangered
Astragalus holmgreniorum	Holmgren milk-vetch	Fabaceae	Endangered
Astragalus humillimus	Mancos milk-vetch	Fabaceae	Endangered
Astragalus jaegerianus	Lane Mountain milk-vetch	Fabaceae	Endangered
Astragalus lentiginosus var. coachellae	Coachella Valley milk-vetch	Fabaceae	Endangered
Astragalus lentiginosus var. piscinensis	Fish Slough milk-vetch	Fabaceae	Threatened
Astragalus magdalenae var. peirsonii	Peirson's milk-vetch	Fabaceae	Threatened
Astragalus montii	Heliotrope milk-vetch	Fabaceae	Threatened
Astragalus osterhoutii	Osterhout milkvetch	Fabaceae	Endangered
Astragalus phoenix	Ash meadows milk-vetch	Fabaceae	Threatened
Astragalus pycnostachyus var. lanosissimus	Ventura Marsh Milk-vetch	Fabaceae	Endangered
Astragalus robbinsii var. jesupi	Jesup's milk-vetch	Fabaceae	Endangered
Astragalus schmolliae	Chapin Mesa milkvetch	Fabaceae	Proposed Threatened
Astragalus tener var. titi	Coastal dunes milk-vetch	Fabaceae	Endangered
Astragalus tricarinatus	Triple-ribbed milk-vetch	Fabaceae	Endangered
Astrophytum asterias	Star cactus	Cactaceae	Endangered
Athearnia anthonyi	Anthony's riversnail	Pleuroceridae	Endangered
Atlantea tulita	Puerto Rico harlequin butterfly	Nymphalidae	Proposed Threatened
Atriplex coronata var. notatior	San Jacinto Valley crownscale	Chenopodiaceae	Endangered
Auerodendron pauciflorum	No common name	Rhamnaceae	Endangered

Scientific Name	Common Name	Family	Federal Listing Status
Ayenia limitaris	Texas ayenia	Sterculiaceae	Endangered
Baccharis vanessae	Encinitas baccharis	Asteraceae	Threatened
Balaena mysticetus	Bowhead whale	Balaenidae	Endangered
Balaenoptera borealis	Sei whale	Balaenopteridae	Endangered
Balaenoptera musculus	Blue whale	Balaenopteridae	Endangered
Balaenoptera physalus	Finback whale	Balaenopteridae	Endangered
Banara vanderbiltii	Palo de ramon	Flacourtiaceae	Endangered
Baptisia arachnifera	Hairy rattleweed	Fabaceae	Endangered
Batrachoseps aridus	Desert slender salamander	Plethodontidae	Endangered
Batrisodes texanus	Coffin Cave mold beetle	Pselaphidaeae	Endangered
Batrisodes venyivi	Helotes mold beetle	Pselaphidae	Endangered
Berberis nevinii	Nevin's barberry	Berberidaceae	Endangered
Berberis pinnata ssp. insularis	Island Barberry	Berberidaceae	Endangered
Betula uber	Virginia round-leaf birch	Betulaceae	Threatened
Bidens amplectens	Ko`oko`olau	Asteraceae	Endangered
Bidens campylotheca ssp. pentamera	Ko`oko`olau	Asteraceae	Endangered
Bidens campylotheca ssp. waihoiensis	Ko`oko`olau	Asteraceae	Endangered
Bidens conjuncta	Ko`oko`olau	Asteraceae	Endangered
Bidens hillebrandiana ssp. hillebrandiana	kookoolau	Asteraceae	Endangered
Bidens micrantha ssp. ctenophylla	Ko`oko`olau	Asteraceae	Endangered
Bidens micrantha ssp. kalealaha	Ko`oko`olau	Asteraceae	Endangered
Bidens wiebkei	Ko`oko`olau	Asteraceae	Endangered
Bison bison athabascae	Wood Bison	Bovidae	Threatened
Blennosperma bakeri	Sonoma sunshine	Asteraceae	Endangered
Boloria acrocnema	Uncompahgre fritillary butterfly	Nymphalidae	Endangered

Scientific Name	Common Name	Family	Federal Listing Status
Boltonia decurrens	Decurrent false aster	Asteraceae	Threatened
Bombus affinis	Rusty patched bumble bee	Apidae	Endangered
Bombus franklini	Franklin's bumblebee	Apidae	Proposed Endangered
Bonamia grandiflora	Florida bonamia	Convolvulaceae	Threatened
Bonamia menziesii	No common name	Convolvulaceae	Endangered
Brachylagus idahoensis	Columbia Basin Pygmy Rabbit	Leporidae	Endangered
Brachyramphus marmoratus	Marbled murrelet	Alcidae	Threatened
Branchinecta conservatio	Conservancy fairy shrimp	Branchinectidae	Endangered
Branchinecta longiantenna	Longhorn fairy shrimp	Branchinectidae	Endangered
Branchinecta lynchi	Vernal pool fairy shrimp	Branchinectidae	Threatened
Branchinecta sandiegonensis	San Diego fairy shrimp	Branchinectidae	Endangered
Branta (=Nesochen) sandvicensis	Hawaiian goose	Anatidae	Threatened
Brickellia mosieri	Florida brickell-bush	Asteraceae	Endangered
Brighamia insignis	Olulu	Campanulaceae	Endangered
Brighamia rockii	Pua `ala	Campanulaceae	Endangered
Brodiaea filifolia	Thread-leaved brodiaea	Liliaceae	Threatened
Brodiaea pallida	Chinese Camp brodiaea	Liliaceae	Threatened
Brychius hungerfordi	Hungerford's crawling water Beetle	Halipilidae	Endangered
Bufo hemiophrys baxteri	Wyoming Toad	Bufonidae	Endangered
Bufo houstonensis	Houston toad	Bufonidae	Endangered
Bulbophyllum guamense	Cebello halumtano	Orchidaceae	Threatened
Buteo platypterus brunnescens	Puerto Rican broad-winged hawk	Accipitridae	Endangered
Buxus vahlii	Vahl's boxwood	Buxaceae	Endangered
Calamagrostis expansa	Maui reedgrass	Poaceae	Endangered
Calamagrostis hillebrandii	Hillebrand's reedgrass	Poaceae	Endangered
Calidris canutus rufa	Red knot	Scolopacidae	Threatened

Scientific Name	Common Name	Family	Federal Listing Status
Callicarpa ampla	Capa rosa	Verbenaceae	Endangered
Callirhoe scabriuscula	Texas poppy-mallow	Malvaceae	Endangered
Callophrys mossii bayensis	San Bruno elfin butterfly	Lycaenidae	Endangered
Calochortus tiburonensis	Tiburon mariposa lily	Liliaceae	Threatened
Calyptranthes thomasiana	No common name	Myrtaceae	Endangered
Calyptridium pulchellum	Mariposa pussypaws	Portulacaceae	Threatened
Calyptronoma rivalis	Palma de manaca	Arecaceae	Threatened
Calystegia stebbinsii	Stebbins' morning-glory	Convolvulaceae	Endangered
Cambarus aculabrum	Benton County cave crayfish	Cambaridae	Endangered
Cambarus callainus	Big Sandy crayfish	Cambaridae	Threatened
Cambarus cracens	Slenderclaw crayfish	Cambaridae	Proposed Threatened
Cambarus veteranus	Guyandotte River crayfish	Cambaridae	Endangered
Cambarus zophonastes	Hell Creek Cave crayfish	Cambaridae	Endangered
Camissonia benitensis	San Benito evening-primrose	Onagraceae	Threatened
Campanula robinsiae	Brooksville bellflower	Campanulaceae	Endangered
Campeloma decampi	Slender campeloma	Viviparidae	Endangered
Campephilus principalis	Ivory-billed woodpecker	Picidae	Endangered
Canavalia molokaiensis	`Awikiwiki	Fabaceae	Endangered
Canavalia napaliensis	`Awikiwiki	Fabaceae	Endangered
Canavalia pubescens	`Awikiwiki	Fabaceae	Endangered
Canis lupus baileyi	Mexican wolf	Canidae	Endangered
Canis rufus	Red wolf	Canidae	Endangered
Caprimulgus noctitherus	Puerto Rican nightjar	Caprimulgidae	Endangered
Cardamine micranthera	Small-anthered bittercress	Brassicaceae	Endangered
Caretta caretta	Loggerhead sea turtle	Cheloniidae	Endangered
Caretta caretta	Loggerhead sea turtle	Cheloniidae	Threatened
Carex albida	White sedge	Cyperaceae	Endangered
Carex lutea	Golden sedge	Cyperaceae	Endangered
Carex specuicola	Navajo sedge	Cyperaceae	Threatened

Scientific Name	Common Name	Family	Federal Listing Status
Castilleja affinis ssp. neglecta	Tiburon paintbrush	Scrophulariaceae	Endangered
Castilleja campestris ssp. succulenta	Fleshy owl's-clover	Scrophulariaceae	Threatened
Castilleja cinerea	Ash-grey paintbrush	Scrophulariaceae	Threatened
Castilleja grisea	San Clemente Island Paintbrush	Scrophulariaceae	Threatened
Castilleja levisecta	golden paintbrush	Orobanchaceae	Threatened
Castilleja mollis	Soft-leaved paintbrush	Scrophulariaceae	Endangered
Catesbaea melanocarpa	No common name	Rubiaceae	Endangered
Catostomus discobolus yarrowi	Zuni bluehead Sucker	Catostomidae	Endangered
Catostomus santaanae	Santa Ana sucker	Catostomidae	Threatened
Catostomus warnerensis	Warner sucker	Catostomidae	Threatened
Caulanthus californicus	California jewelflower	Brassicaceae	Endangered
Ceanothus ferrisae	Coyote ceanothus	Rhamnaceae	Endangered
Ceanothus ophiochilus	Vail Lake ceanothus	Rhamnaceae	Threatened
Ceanothus roderickii	Pine Hill ceanothus	Rhamnaceae	Endangered
Cenchrus agrimonioides	Kamanomano	Poaceae	Endangered
Centaurium namophilum	Spring-loving centaury	Gentianaceae	Threatened
Centrocercus minimus	Gunnison sage-grouse	Phasianidae	Threatened
Cercocarpus traskiae	Catalina Island mountain-mahogany	Rosaceae	Endangered
Cereus eriophorus var. fragrans	Fragrant prickly-apple	Cactaceae	Endangered
Chamaecrista glandulosa var. mirabilis	No common name	Fabaceae	Endangered
Chamaecrista lineata keyensis	Big Pine partridge pea	Fabaceae	Endangered
Chamaesyce deltoidea pinetorum	Pineland sandmat	Euphorbiaceae	Threatened
Chamaesyce deltoidea serpyllum	Wedge spurge	Euphorbiaceae	Endangered

Scientific Name	Common Name	Family	Federal Listing Status
Chamaesyce deltoidea ssp. deltoidea	Deltoid spurge	Euphorbiaceae	Endangered
Chamaesyce garberi	Garber's spurge	Euphorbiaceae	Threatened
Chamaesyce hooveri	Hoover's spurge	Euphorbiaceae	Threatened
Charadrius melodus	Piping Plover	Charadriidae	Endangered
Charadrius melodus	Piping Plover	Charadriidae	Threatened
Charadrius nivosus nivosus	Western snowy plover	Charadriidae	Threatened
Charpentiera densiflora	Papala	Amaranthaceae	Endangered
Chasiempis ibidis	Oahu elepaio	Monarchidae	Endangered
Chasmistes brevirostris	Shortnose Sucker	Catostomidae	Endangered
Chasmistes cujus	Cui-ui	Catostomidae	Endangered
Chasmistes liorus	June sucker	Catostomidae	Endangered
Chelonia mydas	Green sea turtle	Cheloniidae	Endangered
Chelonia mydas	Green sea turtle	Cheloniidae	Threatened
Chilabothrus granti	Virgin Islands tree boa	Boidae	Endangered
Chionanthus pygmaeus	Pygmy fringe-tree	Oleaceae	Endangered
Chlorogalum purpureum	Purple amole	Agavaceae	Threatened
Chorizanthe howellii	Howell's spineflower	Polygonaceae	Endangered
Chorizanthe orcuttiana	Orcutt's spineflower	Polygonaceae	Endangered
Chorizanthe pungens var. hartwegiana	Ben Lomond spineflower	Polygonaceae	Endangered
Chorizanthe pungens var. pungens	Monterey spineflower	Polygonaceae	Threatened
Chorizanthe robusta var. hartwegii	Scotts Valley spineflower	Polygonaceae	Endangered
Chorizanthe robusta var. robusta	Robust spineflower	Polygonaceae	Endangered
Chorizanthe valida	Sonoma spineflower	Polygonaceae	Endangered
Chromolaena frustrata	Cape Sable Thoroughwort	Asteraceae	Endangered
Chrosomus saylori	Laurel dace	Cyprinidae	Endangered
Chrysopsis floridana	Florida golden aster	Asteraceae	Endangered

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Cicindela dorsalis dorsalis	Northeastern beach tiger beetle	Cicindelidae	Threatened
Cicindela nevadica lincolniana	Salt Creek Tiger beetle	Cicindelidae	Endangered
Cicindela ohlone	Ohlone tiger beetle	Cicindelidae	Endangered
Cicindela puritana	Puritan tiger beetle	Cicindelidae	Threatened
Cicindelidia floridana	Miami tiger beetle	Carabidae	Endangered
Cicurina baronia	Robber Baron Cave Meshweaver	Dictynidae	Endangered
Cicurina madla	Madla Cave Meshweaver	Dictynidae	Endangered
Cicurina venii	Braken Bat Cave Meshweaver	Dictynidae	Endangered
Cicurina vespera	Government Canyon Bat Cave Meshweaver	Dictynidae	Endangered
Cirsium fontinale var. fontinale	Fountain thistle	Asteraceae	Endangered
Cirsium fontinale var. obispoense	Chorro Creek bog thistle	Asteraceae	Endangered
Cirsium hydrophilum var. hydrophilum	Suisun thistle	Asteraceae	Endangered
Cirsium loncholepis	La Graciosa thistle	Asteraceae	Endangered
Cirsium pitcheri	Pitcher's thistle	Asteraceae	Threatened
Cirsium vinaceum	Sacramento Mountains thistle	Asteraceae	Threatened
Cladonia perforata	Florida perforate cladonia	Cladoniaceae	Endangered
Clarkia franciscana	Presidio clarkia	Onagraceae	Endangered
Clarkia imbricata	Vine Hill clarkia	Onagraceae	Endangered
Clarkia speciosa ssp. immaculata	Pismo clarkia	Onagraceae	Endangered
Clarkia springvillensis	Springville clarkia	Onagraceae	Threatened
Clematis morefieldii	Morefields leather flower	Ranunculaceae	Endangered
Clematis socialis	Alabama leather flower	Ranunculaceae	Endangered
Clemmys muhlenbergii	bog turtle	Emydidae	Threatened

Scientific Name	Common Name	Family	Federal Listing Status
Clermontia drepanomorpha	`Oha wai	Campanulaceae	Endangered
Clermontia lindseyana	`Oha wai	Campanulaceae	Endangered
Clermontia oblongifolia ssp. brevipes	`Oha wai	Campanulaceae	Endangered
Clermontia oblongifolia ssp. mauiensis	`Oha wai	Campanulaceae	Endangered
Clermontia peleana	`Oha wai	Campanulaceae	Endangered
Clermontia pyrularia	`Oha wai	Campanulaceae	Endangered
Clermontia samuelii	`Oha wai	Campanulaceae	Endangered
Clitoria fragrans	Pigeon wings	Fabaceae	Threatened
Coccyzus americanus	Yellow-billed Cuckoo	Cuculidae	Threatened
Colinus virginianus ridgwayi	Masked bobwhite (quail)	Phasianidae	Endangered
Colubrina oppositifolia	Kauila	Rhamnaceae	Endangered
Columba inornata wetmorei	Puerto Rican plain Pigeon	Columbidae	Endangered
Conradina brevifolia	Short-leaved rosemary	Lamiaceae	Endangered
Conradina etonia	Etonia rosemary	Lamiaceae	Endangered
Conradina glabra	Apalachicola rosemary	Lamiaceae	Endangered
Conradina verticillata	Cumberland rosemary	Lamiaceae	Threatened
Consolea corallicola	Florida semaphore Cactus	Cactaceae	Endangered
Cordia bellonis	No common name	Boraginaceae	Endangered
Cordylanthus maritimus ssp. maritimus	Salt marsh bird's-beak	Scrophulariaceae	Endangered
Cordylanthus mollis ssp. mollis	Soft bird's-beak	Scrophulariaceae	Endangered
Cordylanthus palmatus	Palmate-bracted bird's beak	Scrophulariaceae	Endangered
Cordylanthus tenuis ssp. capillaris	Pennell's bird's-beak	Scrophulariaceae	Endangered
Cornutia obovata	Palo de nigua	Verbenaceae	Endangered
Corvus hawaiiensis	Hawaiian (='alala) Crow	Corvidae	Endangered
Corvus kubaryi	Mariana (=aga) Crow	Corvidae	Endangered
Corvus leucognaphalus	White-necked crow	Corvidae	Endangered

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Corynorhinus (=Plecotus) townsendii ingens	Ozark big-eared bat	Vespertilionidae	Endangered
Corynorhinus (=Plecotus) townsendii virginianus	Virginia big-eared bat	Vespertilionidae	Endangered
Coryphantha minima	Nellie cory cactus	Cactaceae	Endangered
Coryphantha ramillosa	Bunched cory cactus	Cactaceae	Threatened
Coryphantha robbinsorum	Cochise pincushion cactus	Cactaceae	Threatened
Coryphantha scheeri var. robustispina	Pima pineapple cactus	Cactaceae	Endangered
Coryphantha sneedii var. leei	Lee pincushion cactus	Cactaceae	Threatened
Coryphantha sneedii var. sneedii	Sneed pincushion cactus	Cactaceae	Endangered
Cottus paulus (=pygmaeus)	Pygmy Sculpin	Cottidae	Threatened
Cottus specus	Grotto Sculpin	Cottidae	Endangered
Cranichis ricartii	No common name	Orchidaceae	Endangered
Crenichthys baileyi baileyi	White River springfish	Cyprinodontidae	Endangered
Crenichthys baileyi grandis	Hiko White River springfish	Cyprinodontidae	Endangered
Crenichthys nevadae	Railroad Valley springfish	Cyprinodontidae	Threatened
Crescentia portoricensis	Higuero de sierra	Bignoniaceae	Endangered
Crocodylus acutus	American crocodile	Crocodylidae	Threatened
Crotalaria avonensis	Avon Park harebells	Fabaceae	Endangered
Crotalus willardi obscurus	New Mexican ridge-nosed rattlesnake	Crotalidae	Threatened
Cryptantha crassipes	Terlingua Creek cat's-eye	Boraginaceae	Endangered
Cryptobranchus alleganiensis alleganiensis	Eastern Hellbender Missouri DPS	Cryptobranchidae	Proposed Endangered
Cryptobranchus alleganiensis bishopi	Ozark Hellbender	Cryptobranchidae	Endangered
Crystallaria cincotta	diamond Darter	Percidae	Endangered
Ctenitis squamigera	Pauoa	Aspleniaceae	Endangered
Cucurbita okeechobeensis ssp. okeechobeensis	Okeechobee gourd	Cucurbitaceae	Endangered

Scientific Name	Common Name	Family	Federal Listing Status
Cumberlandia monodonta	Spectaclecase (mussel)	Margaritiferidae	Endangered
Cupressus abramsiana	Santa Cruz cypress	Cupressaceae	Threatened
Cupressus goveniana ssp. goveniana	Gowen cypress	Cupressaceae	Threatened
Cyanea acuminata	Haha	Campanulaceae	Endangered
Cyanea asarifolia	Haha	Campanulaceae	Endangered
Cyanea asplenifolia	Haha	Campanulaceae	Endangered
Cyanea calycina	Haha	Campanulaceae	Endangered
Cyanea copelandii ssp. copelandii	Haha	Campanulaceae	Endangered
Cyanea copelandii ssp. haleakalaensis	Haha	Campanulaceae	Endangered
Cyanea crispa	haha	Campanulaceae	Endangered
Cyanea dolichopoda	Haha	Campanulaceae	Endangered
Cyanea dunbariae	haha	Campanulaceae	Endangered
Cyanea duvalliorum	haha	Campanulaceae	Endangered
Cyanea eleeleensis	Haha	Campanulaceae	Endangered
Cyanea gibsonii	haha	Campanulaceae	Endangered
Cyanea glabra	Haha	Campanulaceae	Endangered
Cyanea grimesiana ssp. grimesiana	Haha	Campanulaceae	Endangered
Cyanea grimesiana ssp. obatae	Haha	Campanulaceae	Endangered
Cyanea hamatiflora ssp. carlsonii	Haha	Campanulaceae	Endangered
Cyanea hamatiflora ssp. hamatiflora	Haha	Campanulaceae	Endangered
Cyanea horrida	haha nui	Campanulaceae	Endangered
Cyanea humboldtiana	Haha	Campanulaceae	Endangered
Cyanea kauaulaensis	No common name	Campanulaceae	Endangered
Cyanea kolekoleensis	Haha	Campanulaceae	Endangered

Scientific Name	Common Name	Family	Federal Listing Status
Cyanea koolauensis	Haha	Campanulaceae	Endangered
Cyanea kuhihewa	Haha	Campanulaceae	Endangered
Cyanea kunthiana	Haha	Campanulaceae	Endangered
Cyanea lanceolata	Haha	Campanulaceae	Endangered
Cyanea lobata	Haha	Campanulaceae	Endangered
Cyanea longiflora	Haha	Campanulaceae	Endangered
Cyanea magnicalyx	haha	Campanulaceae	Endangered
Cyanea mannii	Haha	Campanulaceae	Endangered
Cyanea maritae	haha	Campanulaceae	Endangered
Cyanea marksii	Haha	Campanulaceae	Endangered
Cyanea mauiensis	haha	Campanulaceae	Endangered
Cyanea mceldowneyi	Haha	Campanulaceae	Endangered
Cyanea munroi	haha	Campanulaceae	Endangered
Cyanea obtusa	Haha	Campanulaceae	Endangered
Cyanea pinnatifida	Haha	Campanulaceae	Endangered
Cyanea platyphylla	\`aku\`aku	Campanulaceae	Endangered
Cyanea procera	Haha	Campanulaceae	Endangered
Cyanea profuga	Haha	Campanlaceae	Endangered
Cyanea purpurellifolia	Haha	Campanulaceae	Endangered
Cyanea recta	Haha	Campanulaceae	Threatened
Cyanea remyi	Haha	Campanulaceae	Endangered
Cyanea rivularis	Haha	Campanulaceae	Endangered
Cyanea shipmanii	Haha	Campanulaceae	Endangered
Cyanea solanacea	Popolo	Campanulaceae	Endangered
Cyanea st.-johnii	Haha	Campanulaceae	Endangered
Cyanea stictophylla	Haha	Campanulaceae	Endangered
Cyanea superba	Haha	Campanulaceae	Endangered
Cyanea tritomantha	\`aku	Campanulaceae	Endangered
Cyanea truncata	Haha	Campanulaceae	Endangered

Scientific Name	Common Name	Family	Federal Listing Status
Cyanea undulata	Haha	Campanulaceae	Endangered
Cyathea dryopteroides	Elfin tree fern	Cyatheaceae	Endangered
Cycas micronesica	Fadang	Cycadaceae	Threatened
Cycladenia humilis var. jonesii	Jones Cycladenia	Apocynaceae	Threatened
Cyclargus (=Hemiargus) thomasi bethunebakeri	Miami Blue Butterfly	Lycaenidae	Endangered
Cyclosorus boydiae	Kupukupu makalii	Thelypteridaceae	Endangered
Cyclura stejnegeri	Mona ground Iguana	Iguanidae	Threatened
Cynomys parvidens	Utah prairie dog	Sciuridae	Threatened
Cyperus fauriei	No common name	Cyperaceae	Endangered
Cyperus neokunthianus	No common name	Cyperaceae	Endangered
Cyperus pennatiformis	No common name	Cyperaceae	Endangered
Cyperus trachysanthos	Pu`uka`a	Cyperaceae	Endangered
Cyprinella caerulea	Blue shiner	Cyprinidae	Threatened
Cyprinella formosa	Beautiful shiner	Cyprinidae	Threatened
Cyprinodon bovinus	Leon Springs pupfish	Cyprinodontidae	Endangered
Cyprinodon diabolis	Devils Hole pupfish	Cyprinodontidae	Endangered
Cyprinodon elegans	Comanche Springs pupfish	Cyprinodontidae	Endangered
Cyprinodon macularius	Desert pupfish	Cyprinodontidae	Endangered
Cyprinodon nevadensis mionectes	Ash Meadows Amargosa pupfish	Cyprinodontidae	Endangered
Cyprinodon nevadensis pectoralis	Warm Springs pupfish	Cyprinodontidae	Endangered
Cyprinodon radiosus	Owens pupfish	Cyprinodontidae	Endangered
Cyprogenia stegaria	Fanshell	Unionidae	Endangered
Cyrtandra crenata	Ha`iwale	Gesneriaceae	Endangered
Cyrtandra cyaneoides	Mapele	Gesneriaceae	Endangered
Cyrtandra dentata	Ha`iwale	Gesneriaceae	Endangered
Cyrtandra ferripilosa	haiwale	Gesneriaceae	Endangered
Cyrtandra filipes	Ha`iwale	Gesneriaceae	Endangered

Scientific Name	Common Name	Family	Federal Listing Status
Cyrtandra giffardii	Ha`iwale	Gesneriaceae	Endangered
Cyrtandra gracilis	Haiwale	Gesneriaceae	Endangered
Cyrtandra hematos	Ha`iwale	Gesneriaceae	Endangered
Cyrtandra kaulantha	Ha`iwale	Gesneriaceae	Endangered
Cyrtandra limahuliensis	Ha`iwale	Gesneriaceae	Threatened
Cyrtandra munroi	Ha`iwale	Gesneriaceae	Endangered
Cyrtandra nanawaleensis	haiwale	Gesneriaceae	Endangered
Cyrtandra oenobarba	Ha`iwale	Gesneriaceae	Endangered
Cyrtandra oxybapha	Ha`iwale	Gesneriaceae	Endangered
Cyrtandra paliku	Haiwale	Gesneriaceae	Endangered
Cyrtandra polyantha	Ha`iwale	Gesneriaceae	Endangered
Cyrtandra sessilis	Ha`iwale	Gesneriaceae	Endangered
Cyrtandra subumbellata	Ha`iwale	Gesneriaceae	Endangered
Cyrtandra tintinnabula	Ha`iwale	Gesneriaceae	Endangered
Cyrtandra viridiflora	Ha`iwale	Gesneriaceae	Endangered
Cyrtandra wagneri	haiwale	Gesneriaceae	Endangered
Cyrtandra waiolani	Haiwale	Gesneriaceae	Endangered
Dalea carthagenensis floridana	Florida prairie-clover	Fabaceae	Endangered
Dalea foliosa	Leafy prairie-clover	Fabaceae	Endangered
Daphnopsis helleriana	No common name	Thymelaeaceae	Endangered
Deeringothamnus pulchellus	Beautiful pawpaw	Annonaceae	Endangered
Deeringothamnus rugelii	Rugel's pawpaw	Annonaceae	Endangered
Deinandra (=Hemizonia) conjugens	Otay tarplant	Asteraceae	Threatened
Deinandra increscens ssp. villosa	Gaviota Tarplant	Asteraceae	Endangered
Delissea rhytidosperma	No common name	Campanulaceae	Endangered
Delissea subcordata	Oha	Campanulaceae	Endangered
Delissea undulata	No common name	Campanulaceae	Endangered

Scientific Name	Common Name	Family	Federal Listing Status
Delphinapterus leucas	beluga whale	Monodontidae	Endangered
Delphinium bakeri	Baker's larkspur	Ranunculaceae	Endangered
Delphinium luteum	Yellow larkspur	Ranunculaceae	Endangered
Delphinium variegatum ssp. kinkiense	San Clemente Island larkspur	Ranunculaceae	Endangered
Deltistes luxatus	Lost River sucker	Catostomidae	Endangered
Dendrobium guamense	No common name	Orchidaceae	Threatened
Dendrogyra cylindrus	Pillar Coral	Meandrinidae	Threatened
Dendroica chrysoparia	Golden-cheeked warbler (=wood)	Parulidae	Endangered
Deparia kaalaana	No common name	Woodsiaceae	Endangered
Dermochelys coriacea	Leatherback sea turtle	Dermochelyidae	Endangered
Desmocerus californicus dimorphus	Valley elderberry longhorn beetle	Cesambycidae	Threatened
Dicerandra christmanii	Garrett's mint	Lamiaceae	Endangered
Dicerandra cornutissima	Longspurred mint	Lamiaceae	Endangered
Dicerandra frutescens	Scrub mint	Lamiaceae	Endangered
Dicerandra immaculata	Lakela's mint	Lamiaceae	Endangered
Digitaria pauciflora	Florida pineland crabgrass	Poaceae	Threatened
Dinacoma caseyi	Casey's June Beetle	Scarabaeidae	Endangered
Dionda diaboli	Devils River minnow	Cyprinidae	Threatened
Diplacus vandenbergensis	Vandenberg monkeyflower	Phrymaceae	Endangered
Diplazium molokaiense	No common name	Woosiaceae	Endangered
Dipodomys heermanni morroensis	Morro Bay kangaroo rat	Heteromyidae	Endangered
Dipodomys ingens	Giant kangaroo rat	Heteromyidae	Endangered
Dipodomys merriami parvus	San Bernardino Merriam's kangaroo rat	Heteromyidae	Endangered
Dipodomys nitratoides exilis	Fresno kangaroo rat	Heteromyidae	Endangered
Dipodomys nitratoides nitratoides	Tipton kangaroo rat	Heteromyidae	Endangered

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Dipodomys stephensi (incl. D. cascus)	Stephens' kangaroo rat	Heteromyidae	Endangered
Discus macclintocki	Iowa Pleistocene snail	Discidae	Endangered
Dodecahema leptoceras	Slender-horned spineflower	Polygonaceae	Endangered
Doryopteris angelica	No common name	Pteridaceae	Endangered
Doryopteris takeuchii	No common name	Pteridaceae	Endangered
Drepanis coccinea	\`I\`iwi	Fringillidae	Threatened
Dromus dromas	Dromedary pearlymussel	Unionidae	Endangered
Drosophila aglaia	Hawaiian picture-wing fly	Drosophilidae	Endangered
Drosophila differens	Hawaiian picture-wing fly	Drosophilidae	Endangered
Drosophila digressa	Hawaiian picture-wing fly	Drosophilidae	Endangered
Drosophila hemipeza	Hawaiian picture-wing fly	Drosophilidae	Endangered
Drosophila heteroneura	Hawaiian picture-wing fly	Drosophilidae	Endangered
Drosophila montgomeryi	Hawaiian picture-wing fly	Drosophilidae	Endangered
Drosophila mulli	Hawaiian picture-wing fly	Drosophilidae	Threatened
Drosophila musaphilia	Hawaiian picture-wing fly	Drosophilidae	Endangered
Drosophila neoclavisetae	Hawaiian picture-wing fly	Drosophilidae	Endangered
Drosophila obatai	Hawaiian picture-wing fly	Drosophilidae	Endangered
Drosophila ochrobasis	Hawaiian picture-wing fly	Drosophilidae	Endangered
Drosophila sharpi	Hawaiian picture-wing fly	Drosophilidae	Endangered
Drosophila substenoptera	Hawaiian picture-wing fly	Drosophilidae	Endangered
Drosophila tarphytrichia	Hawaiian picture-wing fly	Drosophilidae	Endangered
Drymarchon corais couperi	Eastern indigo snake	Colubridae	Threatened
Dryopteris crinalis var. podosorus	Palapalai aumakua	Dryopteridaceae	Endangered
Dryopteris glabra var. pusilla	Hohiu	Dryopteridaceae	Endangered
Dubautia herbstobatae	Na\`ena\`e	Asteraceae	Endangered
Dubautia imbricata ssp. imbricata	Na\`ena\`e	Asteraceae	Endangered
Dubautia kalalauensis	Naenae	Asteraceae	Endangered

Scientific Name	Common Name	Family	Federal Listing Status
Dubautia kenwoodii	Naenae	Asteraceae	Endangered
Dubautia latifolia	Koholapehu	Asteraceae	Endangered
Dubautia pauciflorula	Na`ena`e	Asteraceae	Endangered
Dubautia plantaginea ssp. humilis	Na`ena`e	Asteraceae	Endangered
Dubautia plantaginea ssp. magnifolia	Na`ena`e	Asteraceae	Endangered
Dubautia waialealae	Na`ena`e	Asteraceae	Endangered
Dudleya abramsii ssp. parva	Conejo dudleya	Crassulaceae	Threatened
Dudleya cymosa ssp. marcescens	Marcescent dudleya	Crassulaceae	Threatened
Dudleya cymosa ssp. ovatifolia	Santa Monica Mountains dudleyea	Crassulaceae	Threatened
Dudleya nesiotica	Santa Cruz Island dudleya	Crassulaceae	Threatened
Dudleya setchellii	Santa Clara Valley dudleya	Crassulaceae	Endangered
Dudleya stolonifera	Laguna Beach liveforever	Crassulaceae	Threatened
Dudleya traskiae	Santa Barbara Island liveforever	Crassulaceae	Endangered
Dudleya verityi	Verity's dudleya	Crassulaceae	Threatened
Echinacea laevigata	Smooth coneflower	Asteraceae	Endangered
Echinocactus horizonthalonius var. nicholii	Nichol's Turk's head cactus	Cactaceae	Endangered
Echinocereus chisoensis var. chisoensis	Chisos Mountain hedgehog Cactus	Cactaceae	Threatened
Echinocereus fendleri var. kuenzleri	Kuenzler hedgehog cactus	Cactaceae	Threatened
Echinocereus reichenbachii var. albertii	Black lace cactus	Cactaceae	Endangered
Echinocereus triglochidiatus var. arizonicus	Arizona hedgehog cactus	Cactaceae	Endangered
Echinocereus viridiflorus var. davisii	Davis' green pitaya	Cactaceae	Endangered
Echinomastus erectocentrus var. acunensis	Acuna Cactus	Cactaceae	Endangered

Scientific Name	Common Name	Family	Federal Listing Status
Echinomastus mariposensis	Lloyd's Mariposa cactus	Cactaceae	Threatened
Elaphoglossum serpens	No common name	Lomariopsidaceae	Endangered
Elaphrus viridis	Delta green ground beetle	Carabidae	Threatened
Elassoma alabamae	Spring pygmy sunfish	Elassomatidae	Threatened
Eleutherodactylus cooki	Guajon	Leptodactylidae	Threatened
Eleutherodactylus jasperi	Golden coqui	Leptodactylidae	Threatened
Eleutherodactylus juanariveroi	Llanero Coqui	Leptodactylidae	Endangered
Elimia crenatella	Lacy elimia (snail)	Pleuroceridae	Threatened
Elliptio chipolaensis	Chipola slabshell	Unionidae	Threatened
Elliptio lanceolata	Yellow lance	Unionidae	Threatened
Elliptio spinosa	Altamaha Spinymussel	Unionidae	Endangered
Elliptio steinstansana	Tar River spinymussel	Unionidae	Endangered
Elliptoideus sloatianus	Purple bankclimber (mussel)	Unionidae	Threatened
Emballonura semicaudata rotensis	Pacific sheath-tailed Bat	Emballonuridae	Endangered
Emballonura semicaudata semicaudata	Pacific sheath-tailed Bat	Emballonuridae	Endangered
Emoia slevini	Slevin's skink	Scincidae	Endangered
Empetrichthys latos	Pahrump poolfish	Cyprinodontidae	Endangered
Empidonax traillii extimus	Southwestern willow flycatcher	Tyrannidae	Endangered
Enceliopsis nudicaulis var. corrugata	Ash Meadows sunray	Asteraceae	Threatened
Enhydra lutris kenyoni	Northern Sea Otter	Mustelidae	Threatened
Enhydra lutris nereis	Southern sea otter	Mustelidae	Threatened
Epicrates inornatus	Puerto Rican boa	Boidae	Endangered
Epicrates monensis monensis	Mona boa	Boidae	Threatened
Epinephelus striatus	Nassau grouper	Serranidae	Threatened
Epioblasma brevidens	Cumberlandian combshell	Unionidae	Endangered
Epioblasma capsaeformis	Oyster mussel	Unionidae	Endangered

Scientific Name	Common Name	Family	Federal Listing Status
Epioblasma florentina curtisii	Curtis pearlymussel	Unionidae	Endangered
Epioblasma florentina florentina	Yellow blossom (pearlymussel)	Unionidae	Endangered
Epioblasma florentina walkeri (=E. walkeri)	Tan riffleshell	Unionidae	Endangered
Epioblasma metastriata	Upland combshell	Unionidae	Endangered
Epioblasma obliquata obliquata	Purple Cat's paw (=Purple Cat's paw pearlymussel)	Unionidae	Endangered
Epioblasma obliquata perobliqua	White catspaw (pearlymussel)	Unionidae	Endangered
Epioblasma othcaloogensis	Southern acornshell	Unionidae	Endangered
Epioblasma penita	Southern combshell	Unionidae	Endangered
Epioblasma torulosa gubernaculum	Green blossom (pearlymussel)	Unionidae	Endangered
Epioblasma torulosa rangiana	Northern riffleshell	Unionidae	Endangered
Epioblasma torulosa torulosa	Tubercled blossom (pearlymussel)	Unionidae	Endangered
Epioblasma triquetra	Snuffbox mussel	Unionidae	Endangered
Epioblasma turgidula	Turgid blossom (pearlymussel)	Unionidae	Endangered
Eragrostis fosbergii	Fosberg's love grass	Poaceae	Endangered
Eremalche kernensis	Kern mallow	Malvaceae	Endangered
Eremichthys acros	Desert dace	Cyprinidae	Threatened
Eremophila alpestris strigata	Streaked Horned lark	Alaudidae	Threatened
Eretmochelys imbricata	Hawksbill sea turtle	Cheloniidae	Endangered
Eriastrum densifolium ssp. sanctorum	Santa Ana River woolly-star	Polemoniaceae	Endangered
Erigeron decumbens	Willamette daisy	Asteraceae	Endangered
Erigeron parishii	Parish's daisy	Asteraceae	Threatened
Erigeron rhizomatus	Zuni fleabane	Asteraceae	Threatened
Erignathus barbatus nauticus	bearded Seal	Phocidae	Threatened
Erimonax monachus	Spotfin Chub	Cyprinidae	Threatened

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Erimystax cahni	Slender chub	Cyprinidae	Threatened
Erinna newcombi	Newcomb's snail	Lymnaeidae	Threatened
Eriodictyon altissimum	Indian Knob mountainbalm	Namaceae	Endangered
Eriodictyon capitatum	Lompoc yerba santa	Hydrophyllaceae	Endangered
Eriogonum apricum (incl. var. prostratum)	Ione (incl. Irish Hill) buckwheat	Polygonaceae	Endangered
Eriogonum codium	Umtanum Desert buckwheat	Polygonaceae	Threatened
Eriogonum gypsophilum	Gypsum wild-buckwheat	Polygonaceae	Threatened
Eriogonum kennedyi var. austromontanum	Southern mountain wild-buckwheat	Polygonaceae	Threatened
Eriogonum longifolium var. gnaphalifolium	Scrub buckwheat	Polygonaceae	Threatened
Eriogonum ovalifolium var. vineum	Cushenbury buckwheat	Polygonaceae	Endangered
Eriogonum ovalifolium var. williamsiae	Steamboat buckwheat	Polygonaceae	Endangered
Eriogonum pelinophilum	Clay-Loving wild buckwheat	Polygonaceae	Endangered
Eriophyllum latilobum	San Mateo woolly sunflower	Asteraceae	Endangered
Eryngium aristulatum var. parishii	San Diego button-celery	Apiaceae	Endangered
Eryngium constancei	Loch Lomond coyote thistle	Apiaceae	Endangered
Eryngium cuneifolium	Snakeroot	Apiaceae	Endangered
Erysimum capitatum var. angustatum	Contra Costa wallflower	Brassicaceae	Endangered
Erysimum menziesii	Menzies' wallflower	Brassicaceae	Endangered
Erysimum teretifolium	Ben Lomond wallflower	Brassicaceae	Endangered
Erythronium propullans	Minnesota dwarf trout lily	Liliaceae	Endangered
Etheostoma akatulo	bluemask darter	Percidae	Endangered
Etheostoma boschungi	Slackwater darter	Percidae	Threatened
Etheostoma chermocki	Vermilion darter	Percidae	Endangered
Etheostoma chienense	Relict darter	Percidae	Endangered

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Etheostoma etowahae	Etowah darter	Percidae	Endangered
Etheostoma fonticola	Fountain darter	Percidae	Endangered
Etheostoma moorei	Yellowcheek Darter	Percidae	Endangered
Etheostoma nianguae	Niangua darter	Percidae	Threatened
Etheostoma nuchale	Watercress darter	Percidae	Endangered
Etheostoma okaloosae	Okaloosa darter	Percidae	Threatened
Etheostoma osburni	Candy darter	Percidae	Endangered
Etheostoma percnurum	Duskytail darter	Percidae	Endangered
Etheostoma phytophilum	Rush Darter	Percidae	Endangered
Etheostoma rubrum	Bayou darter	Percidae	Threatened
Etheostoma scotti	Cherokee darter	Percidae	Threatened
Etheostoma sellare	Maryland darter	Percidae	Endangered
Etheostoma spilotum	Kentucky arrow darter	Percidae	Threatened
Etheostoma susanae	Cumberland darter	Percidae	Endangered
Etheostoma trisella	Trispot darter	Percidae	Threatened
Etheostoma wapiti	Boulder darter	Percidae	Endangered
Eua zebrina	Snail [no common name]	Partulidae	Endangered
Eubalaena glacialis	North Atlantic Right Whale	Balaenidae	Endangered
Eubalaena japonica	North Pacific Right Whale	Balaenidae	Endangered
Euchloe ausonides insulanus	Island marble Butterfly	Pieridae	Endangered
Eucyclogobius newberryi	Tidewater goby	Gobiidae	Endangered
Eugenia bryanii	No common name	Myrtaceae	Endangered
Eugenia haematocarpa	Uvillo	Myrtaceae	Endangered
Eugenia koolauensis	Nioi	Myrtaceae	Endangered
Eugenia woodburyana	No common name	Myrtaceae	Endangered
Eumeces egregius lividus	Bluetail mole skink	Scincidae	Threatened
Eumetopias jubatus	Steller sea lion	Otariidae	Endangered
Eumops floridanus	Florida bonneted bat	Molossidae	Endangered
Euphilotes battoides allyni	El Segundo blue butterfly	Lycaenidae	Endangered

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Euphilotes enoptes smithi	Smith's blue butterfly	Lycaenidae	Endangered
Euphorbia celastroides var. kaenana	`Akoko	Euphorbiaceae	Endangered
Euphorbia deppeana	`Akoko	Euphorbiaceae	Endangered
Euphorbia eleanoriae	`Akoko	Euphorbiaceae	Endangered
Euphorbia haeleeleana	`Akoko	Euphorbiaceae	Endangered
Euphorbia halemanui	"Akoko	Euphorbiaceae	Endangered
Euphorbia herbstii	`Akoko	Euphorbiaceae	Endangered
Euphorbia kuwaleana	`Akoko	Euphorbiaceae	Endangered
Euphorbia remyi var. kauaiensis	`Akoko	Euphorbiaceae	Endangered
Euphorbia remyi var. remyi	`Akoko	Euphorbiaceae	Endangered
Euphorbia rockii	`Akoko	Euphorbiaceae	Endangered
Euphorbia skottsbergii var. skottsbergii	Ewa Plains `akoko	Euphorbiaceae	Endangered
Euphorbia telephioides	Telephus spurge	Euphorbiaceae	Threatened
Euphydryas editha bayensis	Bay checkerspot butterfly	Nymphalidae	Threatened
Euphydryas editha quino (=E. e. wrighti)	Quino checkerspot butterfly	Nymphalidae	Endangered
Euphydryas editha taylori	Taylor's (=whulge) Checkerspot	Nymphalidae	Endangered
Euproserpinus euterpe	Kern primrose sphinx moth	Sphingidae	Threatened
Eurycea chisholmensis	Salado Salamander	Plethodontidae	Threatened
Eurycea nana	San Marcos salamander	Plethodontidae	Threatened
Eurycea naufragia	Georgetown Salamander	Plethodontidae	Threatened
Eurycea sosorum	Barton Springs salamander	Plethodontidae	Endangered
Eurycea tonkawae	Jollyville Plateau Salamander	Plethodontidae	Threatened
Eurycea waterlooensis	Austin blind Salamander	Plethodontidae	Endangered
Eutrema penlandii	Penland alpine fen mustard	Brassicaceae	Threatened
Exocarpos luteolus	Heau	Santalaceae	Endangered
Exocarpos menziesii	Heau	Santalaceae	Endangered

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Falco femoralis septentrionalis	Northern Aplomado Falcon	Falconidae	Endangered
Faxonius peruncus	Big Creek Crayfish	Cambaridae	Proposed Threatened
Faxonius quadruncus	St. Francis River Crayfish	Cambaridae	Proposed Threatened
Festuca hawaiiensis	No common name	Poaceae	Endangered
Festuca ligulata	Guadalupe fescue	Poaceae	Endangered
Festuca molokaiensis	No common name	Poaceae	Endangered
Flueggea neowawraea	Mehamehame	Phyllanthaceae	Endangered
Fremontodendron californicum ssp. decumbens	Pine Hill flannelbush	Sterculiaceae	Endangered
Fremontodendron mexicanum	Mexican flannelbush	Sterculiaceae	Endangered
Fritillaria gentneri	Gentner's Fritillary	Liliaceae	Endangered
Fulica americana alai	Hawaiian coot	Rallidae	Endangered
Fundulus julisia	Barrens topminnow	Cyprinodontidae	Endangered
Fusconaia burkei	Tapered pigtoe	Unionidae	Threatened
Fusconaia cor	Shiny pigtoe	Unionidae	Endangered
Fusconaia cuneolus	Finerayed pigtoe	Unionidae	Endangered
Fusconaia escambia	Narrow pigtoe	Unionidae	Threatened
Fusconaia masoni	Atlantic pigtoe	Unionidae	Proposed Threatened
Fusconaia rotulata	Round Ebonyshell	Unionidae	Endangered
Fusconaia subrotunda	Longsolid	Unionidae	Proposed Threatened
Galactia smallii	Small's milkpea	Fabaceae	Endangered
Galium buxifolium	Island bedstraw	Rubiaceae	Endangered
Galium californicum ssp. sierrae	El Dorado bedstraw	Rubiaceae	Endangered
Gallicolumba stairi	Friendly Ground-Dove	Columbidae	Endangered
Gallinula chloropus guami	Mariana common moorhen	Rallidae	Endangered
Gallinula galeata sandvicensis	Hawaiian common gallinule	Rallidae	Endangered
Gambelia silus	Blunt-nosed leopard lizard	Crotaphytidae	Endangered
Gambusia gaigei	Big Bend gambusia	Poeciliidae	Endangered

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Gambusia georgei	San Marcos gambusia	Poeciliidae	Endangered
Gambusia heterochir	Clear Creek gambusia	Poeciliidae	Endangered
Gambusia nobilis	Pecos gambusia	Poeciliidae	Endangered
Gammarus acherondytes	Illinois cave amphipod	Gammaridae	Endangered
Gammarus desperatus	Noel's Amphipod	Gammaridae	Endangered
Gammarus hyalleloides	Diminutive Amphipod	Gammaridae	Endangered
Gammarus pecos	Pecos amphipod	Gammaridae	Endangered
Gardenia brighamii	Hawaiian gardenia (=Na`u)	Rubiaceae	Endangered
Gardenia mannii	Nanu	Rubiaceae	Endangered
Gardenia remyi	Nanu	Rubiaceae	Endangered
Gasterosteus aculeatus williamsoni	Unarmored threespine stickleback	Gasterosteidae	Endangered
Geocarpon minimum	No common name	Caryophyllaceae	Threatened
Geranium arboreum	Nohoanu	Geraniaceae	Endangered
Geranium hanaense	Nohoanu	Geraniaceae	Endangered
Geranium hillebrandii	Nohoanu	Geraniaceae	Endangered
Geranium kauaiense	Nohoanu	Geraniaceae	Endangered
Geranium multiflorum	Nohoanu	Geraniaceae	Endangered
Gesneria pauciflora	No common name	Gesneriaceae	Threatened
Geum radiatum	Spreading avens	Rosaceae	Endangered
Gila bicolor ssp.	Hutton tui chub	Cyprinidae	Threatened
Gila bicolor ssp. mohavensis	Mohave tui chub	Cyprinidae	Endangered
Gila bicolor ssp. snyderi	Owens Tui Chub	Cyprinidae	Endangered
Gila cypha	Humpback chub	Cyprinidae	Endangered
Gila ditaenia	Sonora chub	Cyprinidae	Threatened
Gila elegans	Bonytail	Cyprinidae	Endangered
Gila intermedia	Gila chub	Cyprinidae	Endangered
Gila nigrescens	Chihuahua chub	Cyprinidae	Threatened
Gila purpurea	Yaqui chub	Cyprinidae	Endangered

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Gila robusta jordani	Pahranagat roundtail chub	Cyprinidae	Endangered
Gila seminuda (=robusta)	Virgin River Chub	Cyprinidae	Endangered
Gilia tenuiflora ssp. arenaria	Monterey gilia	Polemoniaceae	Endangered
Gilia tenuiflora ssp. hoffmannii	Hoffmann's slender- flowered gilia	Polemoniaceae	Endangered
Glaucomys sabrinus coloratus	Carolina northern flying squirrel	Sciuridae	Endangered
Glaucopsyche lygdamus palosverdesensis	Palos Verdes blue butterfly	Lycaenidae	Endangered
Goetzea elegans	Beautiful goetzea	Solanaceae	Endangered
Gonocalyx concolor	No common name	Ericaceae	Endangered
Gopherus agassizii	Desert tortoise	Testudinidae	Threatened
Gopherus polyphemus	Gopher tortoise	Testudinidae	Threatened
Gouania hillebrandii	No common name	Rhamnaceae	Endangered
Gouania meyenii	No common name	Rhamnaceae	Endangered
Gouania vitifolia	No common name	Rhamnaceae	Endangered
Graptemys flavimaculata	Yellow-blotched map turtle	Emydidae	Threatened
Graptemys oculifera	Ringed map turtle	Emydidae	Threatened
Graptopetalum bartramii	Bartram stonecrop	Crassulaceae	Proposed Threatened
Grindelia fraxinipratensis	Ash Meadows gumplant	Asteraceae	Threatened
Grus americana	Whooping crane	Gruidae	Endangered
Grus canadensis pulla	Mississippi sandhill crane	Gruidae	Endangered
Gymnoderma lineare	Rock gnome lichen	Cladoniaceae	Endangered
Gymnogyps californianus	California condor	Cathartidae	Endangered
Gymnomyza samoensis	Mao (= maomao) (honeyeater)	Meliphagidae	Endangered
Hackelia venusta	Showy stickseed	Boraginaceae	Endangered
Halcyon cinnamomina cinnamomina	Guam Micronesian kingfisher	Alcedinidae	Endangered
Haliotis cracherodii	Black Abalone	Haliotidae	Endangered
Haliotis sorenseni	White Abalone	Haliotidae	Endangered

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Halophila johnsonii	Johnson's seagrass	Hydrocharitaceae	Threatened
Hamiota australis	Southern sandshell	Unionidae	Threatened
Haplostachys haplostachya	Honohono	Lamiaceae	Endangered
Harperocallis flava	Harper's beauty	Liliaceae	Endangered
Harrisia (=Cereus) aboriginum (=gracilis)	Aboriginal Prickly-apple	Cactaceae	Endangered
Harrisia portoricensis	Higo Chumbo	Cactaceae	Threatened
Hedeoma todsenii	Todsen's pennyroyal	Lamiaceae	Endangered
Hedyotis megalantha	Paudedo	Rubiaceae	Endangered
Hedyotis purpurea var. montana	Roan Mountain bluet	Rubiaceae	Endangered
Helenium virginicum	Virginia sneezeweed	Asteraceae	Threatened
Helianthemum greenei	Island rush-rose	Cistaceae	Threatened
Helianthus paradoxus	Pecos (=puzzle, =paradox) sunflower	Asteraceae	Threatened
Helianthus schweinitzii	Schweinitz's sunflower	Asteraceae	Endangered
Helianthus verticillatus	Whorled Sunflower	Asteraceae	Endangered
Helminthoglypta walkeriana	Morro shoulderband (=Banded dune) snail	Helminthoglyptida	Endangered
Helonias bullata	Swamp pink	Liliaceae	Threatened
Hemignathus affinis	Maui nukupuu	Fringillidae	Endangered
Hemignathus hanapepe	Kauai nukupuu	Fringillidae	Endangered
Hemignathus wilsoni	akiapolaau	Drepanidinae	Endangered
Hemistena lata	Cracking pearlymussel	Unionidae	Endangered
Heraclides aristodemus ponceanus	Schaus swallowtail butterfly	Papilionidae	Endangered
Heritiera longipetiolata	Ufa-halomtano	Sterculiaceae	Endangered
Herpailurus (=Felis) yagouaroundi cacomitli	Gulf Coast jaguarundi	Felidae	Endangered
Herpailurus (=Felis) yagouaroundi tolteca	Sinaloan Jaguarundi	Felidae	Endangered

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Hesperia dacotae	Dakota Skipper	Hesperiidae	Threatened
Hesperia leonardus montana	Pawnee montane skipper	Hesperiidae	Threatened
Hesperolinon congestum	Marin dwarf-flax	Linaceae	Threatened
Hesperomannia arborescens	No common name	Asteraceae	Endangered
Hesperomannia arbuscula	No common name	Asteraceae	Endangered
Hesperomannia lydgatei	No common name	Asteraceae	Endangered
Heterelmis comalensis	Comal Springs riffle beetle	Elmidae	Endangered
Hexastylis naniflora	Dwarf-flowered heartleaf	Aristolochiaceae	Threatened
Hibiscadelphus distans	Kauai hau kuahiwi	Malvaceae	Endangered
Hibiscadelphus giffardianus	Hau kuahiwi	Malvaceae	Endangered
Hibiscadelphus hualalaiensis	Hau kuahiwi	Malvaceae	Endangered
Hibiscadelphus woodii	Hau kuahiwi	Malvaceae	Endangered
Hibiscus arnottianus ssp. immaculatus	Koki`o ke`oke`o	Malvaceae	Endangered
Hibiscus brackenridgei	(=Native yellow hibiscus) ma`o hau hele	Malvaceae	Endangered
Hibiscus clayi	Clay's hibiscus	Malvaceae	Endangered
Hibiscus dasycalyx	Neches River rose-mallow	Malvaceae	Threatened
Hibiscus waimeae ssp. hannerae	Koki`o ke`oke`o	Malvaceae	Endangered
Himantopus mexicanus knudseni	Hawaiian stilt	Recurvirostridae	Endangered
Hoffmannseggia tenella	Slender rush-pea	Fabaceae	Endangered
Holocarpha macradenia	Santa Cruz tarplant	Asteraceae	Threatened
Howellia aquatilis	Water howellia	Campanulaceae	Threatened
Hudsonia montana	Mountain golden heather	Cistaceae	Threatened
Huperzia mannii	Wawae`iole	Lycopodiaceae	Endangered
Huperzia nutans	Wawae`iole	Lycopodiaceae	Endangered
Huperzia stemmermanniae	No common name	Lycopodiaceae	Endangered
Hybognathus amarus	Rio Grande Silvery Minnow	Cyprinidae	Endangered

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Hylaeus anthracinus	Anthricinan yellow-faced bee	Hylaeidae	Endangered
Hylaeus assimulans	Assimulans yellow-faced bee	Hylaeidae	Endangered
Hylaeus facilis	Easy yellow-faced bee	Hylaeidae	Endangered
Hylaeus hilaris	Hilaris yellow-faced bee	Hylaeidae	Endangered
Hylaeus kuakea	Hawaiian yellow-faced bee	Colletidae	Endangered
Hylaeus longiceps	Hawaiian yellow-faced bee	Hylaeidae	Endangered
Hylaeus mana	Hawaiian yellow-faced bee	Colletidae	Endangered
Hymenoxys herbacea	Lakeside daisy	Asteraceae	Threatened
Hymenoxys texana	Texas prairie dawn-flower	Asteraceae	Endangered
Hypericum cumulicola	Highlands scrub hypericum	Hypericaceae	Endangered
Hypolepis hawaiiensis var. mauiensis	olua	Dennstaedtiaceae	Endangered
Hypolimnas octocula marianensis	Mariana eight-spot butterfly	Nymphalidae	Endangered
Hypomesus transpacificus	Delta smelt	Osmeridae	Threatened
Icaricia (Plebejus) shasta charlestonensis	Mount Charleston blue butterfly	Lycaenidae	Endangered
Icaricia icarioides fenderi	Fender's blue butterfly	Lycaenidae	Endangered
Icaricia icarioides missionensis	Mission blue butterfly	Lycaenidae	Endangered
Ictalurus pricei	Yaqui catfish	Ictaluridae	Threatened
Ilex cookii	Cook's holly	Aquifoliaceae	Endangered
Ilex sintenisii	No common name	Aquifoliaceae	Endangered
Iliamna corei	Peter's Mountain mallow	Malvaceae	Endangered
Ipomopsis polyantha	Pagosa skyrocket	Polemoniaceae	Endangered
Ipomopsis sancti-spiritus	Holy Ghost ipomopsis	Polemoniaceae	Endangered
Iris lacustris	Dwarf lake iris	Iridaceae	Threatened
Ischaemum byrone	Hilo ischaemum	Poaceae	Endangered
Ischnura luta	Rota blue damselfly	coenagrionidae	Endangered
Isodendrion hosakae	Aupaka	Violaceae	Endangered

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Isodendrion laurifolium	Aupaka	Violaceae	Endangered
Isodendrion longifolium	Aupaka	Violaceae	Threatened
Isodendrion pyrifolium	Kula wahine noho	Violaceae	Endangered
Isoetes louisianensis	Louisiana quillwort	Isoetaceae	Endangered
Isoetes melanospora	Black spored quillwort	Isoetaceae	Endangered
Isoetes tegetiformans	Mat-forming quillwort	Isoetaceae	Endangered
Isotria medeoloides	Small whorled pogonia	Orchidaceae	Threatened
Ivesia kingii var. eremica	Ash Meadows ivesia	Rosaceae	Threatened
Ivesia webberi	Webber's ivesia	Rosaceae	Threatened
Jacquemontia reclinata	Beach jacquemontia	Convolvulaceae	Endangered
Joinvillea ascendens ascendens	`Ohe	Joinvilleaceae	Endangered
Juglans jamaicensis	West Indian Walnut (=Nogal)	Juglandaceae	Endangered
Justicia cooleyi	Cooley's water-willow	Acanthaceae	Endangered
Juturnia kosteri	Koster's springsnail	Hydrobiidae	Endangered
Kadua cookiana	'Awiwi	Rubiaceae	Endangered
Kadua cordata remyi	kopa	Rubiaceae	Endangered
Kadua coriacea	Kio`ele	Rubiaceae	Endangered
Kadua degeneri	No common name	Rubiaceae	Endangered
Kadua fluviatilis	Kamapua`a	Rubiaceae	Endangered
Kadua haupuensis	No common name	Rubiaceae	Endangered
Kadua laxiflora	pilo	Rubiaceae	Endangered
Kadua parvula	No common name	Rubiaceae	Endangered
Kadua st.-johnii	No common name	Rubiaceae	Endangered
Kanaloa kahoolawensis	Kohe malama malama o kanaloa	Fabaceae	Endangered
Keysseria (=Lagenifera) erici	No common name	Asteraceae	Endangered
Keysseria (=Lagenifera) helenae	No common name	Asteraceae	Endangered

Scientific Name	Common Name	Family	Federal Listing Status
Kinosternon sonoriense longifemorale	Sonoyta mud turtle	Kinosternidae	Endangered
Kokia cookei	Cooke's koki`o	Malvaceae	Endangered
Kokia drynarioides	Koki`o	Malvaceae	Endangered
Kokia kauaiensis	Koki`o	Malvaceae	Endangered
Korthalsella degeneri	Hulumoa	Santalaceae	Endangered
Labordia cyrtandrae	Kamakahala	Loganiaceae	Endangered
Labordia helleri	Kamakahala	Loganiaceae	Endangered
Labordia lorenciana	No common name	Loganiaceae	Endangered
Labordia lydgatei	Kamakahala	Loganiaceae	Endangered
Labordia pumila	Kamakahala	Loganiaceae	Endangered
Labordia tinifolia var. lanaiensis	Kamakahala	Loganiaceae	Endangered
Labordia tinifolia var. wahiawaensis	Kamakahala	Loganiaceae	Endangered
Labordia triflora	Kamakahala	Loganiaceae	Endangered
Lampsilis abrupta	Pink mucket (pearlymussel)	Unionidae	Endangered
Lampsilis altilis	Finelined pocketbook	Unionidae	Threatened
Lampsilis higginsii	Higgins eye (pearlymussel)	Unionidae	Endangered
Lampsilis perovalis	Orangenacre mucket	Unionidae	Threatened
Lampsilis powellii	Arkansas fatmucket	Unionidae	Threatened
Lampsilis rafinesqueana	Neosho Mucket	Unionidae	Endangered
Lampsilis streckeri	Speckled pocketbook	Unionidae	Endangered
Lampsilis subangulata	Shinyrayed pocketbook	Unionidae	Endangered
Lampsilis virescens	Alabama lampmussel	Unionidae	Endangered
Lanius ludovicianus mearnsi	San Clemente loggerhead shrike	Laniidae	Endangered
Lanx sp.	Banbury Springs limpet	Lymnaeidae	Endangered
Lasiurus cinereus semotus	Hawaiian hoary bat	Vespertilionidae	Endangered
Lasmigona decorata	Carolina heelsplitter	Unionidae	Endangered

Scientific Name	Common Name	Family	Federal Listing Status
Lasthenia burkei	Burke's goldfields	Asteraceae	Endangered
Lasthenia conjugens	Contra Costa goldfields	Asteraceae	Endangered
Laterallus jamaicensis ssp. jamaicensis	Eastern Black rail	Rallidae	Threatened
Layia carnosa	Beach layia	Asteraceae	Endangered
Leavenworthia crassa	Fleshy-fruit gladecress	Brassicaceae	Endangered
Leavenworthia exigua laciniata	Kentucky glade cress	Brassicaceae	Threatened
Leavenworthia texana	Texas golden Gladecress	Brassicaceae	Endangered
Lednia tumana	Meltwater lednian stonefly	Nemouridae	Threatened
Lemiox rimosus	Birdwing pearlymussel	Unionidae	Endangered
Leopardus (=Felis) pardalis	Ocelot	Felidae	Endangered
Leopardus (=Felis) wiedii	Margay	Felidae	Endangered
Lepanthes eltoroensis	No common name	Orchidaceae	Endangered
Lepidium arbuscula	`Anaunau	Brassicaceae	Endangered
Lepidium barnebyanum	Barneby ridge-cress	Brassicaceae	Endangered
Lepidium orbiculare	No common name	Brassicaceae	Endangered
Lepidium papilliferum	Slickspot peppergrass	Brassicaceae	Threatened
Lepidochelys kempii	Kemp's ridley sea turtle	Cheloniidae	Endangered
Lepidochelys olivacea	Olive ridley sea turtle	Cheloniidae	Threatened
Lepidomeda albivallis	White River spinedace	Cyprinidae	Endangered
Lepidomeda mollispinis pratensis	Big Spring spinedace	Cyprinidae	Threatened
Lepidomeda vittata	Little Colorado spinedace	Cyprinidae	Threatened
Lepidurus packardi	Vernal pool tadpole shrimp	Caenestheriidae	Endangered
Leptocereus grantianus	No common name	Cactaceae	Endangered
Leptodea leptodon	Scaleshell mussel	Unionidae	Endangered
Leptonycteris nivalis	Mexican long-nosed bat	Phyllostomidae	Endangered
Leptoxis ampla	Round rocksnail	Pleuroceridae	Threatened

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Leptoxis foremani	Interrupted (=Georgia) Rocksnail	Pleuroceridae	Endangered
Leptoxis plicata	Plicate rocksnail	Pleuroceridae	Endangered
Leptoxis taeniata	Painted rocksnail	Pleuroceridae	Threatened
Lepyrium showalteri	Flat pebblesnail	Hydrobiidae	Endangered
Lespedeza leptostachya	Prairie bush-clover	Fabaceae	Threatened
Lesquerella congesta	Dudley Bluffs bladderpod	Brassicaceae	Threatened
Lesquerella kingii ssp. bernardina	San Bernardino Mountains bladderpod	Brassicaceae	Endangered
Lesquerella lyrata	Lyrate bladderpod	Brassicaceae	Threatened
Lesquerella pallida	White bladderpod	Brassicaceae	Endangered
Lesquerella perforata	Spring Creek bladderpod	Brassicaceae	Endangered
Lesquerella thamnophila	Zapata bladderpod	Brassicaceae	Endangered
Lesquerella tumulosa	Kodachrome bladderpod	Brassicaceae	Endangered
Lessingia germanorum (=L.g. var. germanorum)	San Francisco lessingia	Asteraceae	Endangered
Liatris helleri	Heller's blazingstar	Asteraceae	Threatened
Liatris ohlingerae	Scrub blazingstar	Asteraceae	Endangered
Lilaeopsis schaffneriana var. recurva	Huachuca water-umbel	Apiaceae	Endangered
Lilium occidentale	Western lily	Liliaceae	Endangered
Lilium pardalinum ssp. pitkinense	Pitkin Marsh lily	Liliaceae	Endangered
Limnanthes floccosa ssp. californica	Butte County meadowfoam	Limnanthaceae	Endangered
Limnanthes pumila ssp. grandiflora	Large-flowered woolly meadowfoam	Limnanthaceae	Endangered
Limnanthes vinculans	Sebastopol meadowfoam	Limnanthaceae	Endangered
Lindera melissifolia	Pondberry	Lauraceae	Endangered
Linum arenicola	Sand flax	Linaceae	Endangered
Linum carteri carteri	Carter's small-flowered flax	Linaceae	Endangered

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Lioplax cyclostomaformis	Cylindrical lioplax (snail)	Viviparidae	Endangered
Lipochaeta fauriei	Nehe	Asteraceae	Endangered
Lipochaeta lobata var. leptophylla	Nehe	Asteraceae	Endangered
Lipochaeta micrantha	Nehe	Asteraceae	Endangered
Lipochaeta venosa	No common name	Asteraceae	Endangered
Lipochaeta waimeaensis	Nehe	Asteraceae	Endangered
Lirceus usdagalun	Lee County cave isopod	Asellidae	Endangered
Lithophragma maximum	San Clemente Island woodland-star	Saxifragaceae	Endangered
Lobelia koolauensis	No common name	Campanulaceae	Endangered
Lobelia monostachya	No common name	Campanulaceae	Endangered
Lobelia niihauensis	No common name	Campanulaceae	Endangered
Lobelia oahuensis	No common name	Campanulaceae	Endangered
Lomatium bradshawii	Bradshaw's desert-parsley	Apiaceae	Endangered
Lomatium cookii	Cook's lomatium	Apiaceae	Endangered
Loxioides bailleui	Palila (honeycreeper)	Drepanidinae	Endangered
Loxops caeruleirostris	Akekee	Fringillidae	Endangered
Loxops coccineus	Hawaii akepa	Drepanidinae	Endangered
Loxops ochraceus	Maui akepa	Drepanidinae	Endangered
Lupinus aridorum	Scrub lupine	Fabaceae	Endangered
Lupinus nipomensis	Nipomo Mesa lupine	Fabaceae	Endangered
Lupinus sulphureus ssp. kincaidii	Kincaid's Lupine	Fabaceae	Threatened
Lupinus tidestromii	Clover lupine	Fabaceae	Endangered
Lycaeides argyrognomon lotis	Lotis blue butterfly	Lycaenidae	Endangered
Lycaeides melissa samuelis	Karner blue butterfly	Lycaenidae	Endangered
Lycaena hermes	Hermes copper butterfly	Lycaenidae	Proposed Threatened
Lynx canadensis	Canada Lynx	Felidae	Threatened
Lyonia truncata var. proctorii	No common name	Ericaceae	Endangered

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Lysimachia asperulaefolia	Rough-leaved loosestrife	Primulaceae	Endangered
Lysimachia daphnoides	lehua makanoe	Primulaceae	Endangered
Lysimachia filifolia	No common name	Primulaceae	Endangered
Lysimachia iniki	No common name	Primulaceae	Endangered
Lysimachia lydgatei	No common name	Primulaceae	Endangered
Lysimachia maxima	No common name	Primulaceae	Endangered
Lysimachia pendens	No common name	Primulaceae	Endangered
Lysimachia scopulensis	No common name	Primulaceae	Endangered
Lysimachia venosa	No common name	Primulaceae	Endangered
Macbridea alba	White birds-in-a-nest	Lamiaceae	Threatened
Maesa walkeri	No common name	Myrsinaceae	Threatened
Malacothamnus clementinus	San Clemente Island bush-mallow	Malvaceae	Endangered
Malacothamnus fasciculatus var. nesioticus	Santa Cruz Island bush-mallow	Malvaceae	Endangered
Malacothrix indecora	Santa Cruz Island malacothrix	Asteraceae	Endangered
Malacothrix squalida	Island malacothrix	Asteraceae	Endangered
Manduca blackburni	Blackburn's sphinx moth	Sphingidae	Endangered
Manihot walkerae	Walker's manioc	Euphorbiaceae	Endangered
Margaritifera hembeli	Louisiana pearlshell	Unionidae	Threatened
Margaritifera marrianae	Alabama pearlshell	Margaritiferidae	Endangered
Marshallia mohrii	Mohr's Barbara's buttons	Asteraceae	Threatened
Marsilea villosa	Ihi`ihi	Marsileaceae	Endangered
Martes caurina	Pacific Marten, Coastal Distinct Population Segment	Mustelidae	Threatened
Masticophis lateralis euryxanthus	Alameda whipsnake (=striped racer)	Colubridae	Threatened
Meda fulgida	Spikedace	Cyprinidae	Endangered
Medionidus acutissimus	Alabama moccasinshell	Unionidae	Threatened
Medionidus parvulus	Coosa moccasinshell	Unionidae	Endangered

Scientific Name	Common Name	Family	Federal Listing Status
Medionidus penicillatus	Gulf moccasinshell	Unionidae	Endangered
Medionidus simpsonianus	Ochlockonee moccasinshell	Unionidae	Endangered
Medionidus walkeri	Suwannee moccasinshell	Unionidae	Threatened
Megalagrion leptodemas	Crimson Hawaiian damselfly	Coenagrionidae	Endangered
Megalagrion nesiotes	Flying earwig Hawaiian damselfly	Coenagrionidae	Endangered
Megalagrion nigrohamatum nigrolineatum	Blackline Hawaiian damselfly	Coenagrionidae	Endangered
Megalagrion oceanicum	Oceanic Hawaiian damselfly	Coenagrionidae	Endangered
Megalagrion pacificum	Pacific Hawaiian damselfly	Coenagrionidae	Endangered
Megalagrion xanthomelas	Orangeblack Hawaiian damselfly	Coenagrionidae	Endangered
Megapodius laperouse	Micronesian megapode	Megapodiidae	Endangered
Megaptera novaeangliae	Humpback whale	Balaenopteridae	Threatened
Melamprosops phaeosoma	Po`ouli (honeycreeper)	Drepanidinae	Endangered
Melanthera kamolensis	nehe	Asteraceae	Endangered
Melanthera tenuifolia	Nehe	Asteraceae	Endangered
Melicope adscendens	Alani	Rutaceae	Endangered
Melicope balloui	Alani	Rutaceae	Endangered
Melicope christophersenii	Alani	Rutaceae	Endangered
Melicope degeneri	Alani	Rutaceae	Endangered
Melicope haupuensis	Alani	Rutaceae	Endangered
Melicope hiiakae	Alani	Rutaceae	Endangered
Melicope knudsenii	Alani	Rutaceae	Endangered
Melicope lydgatei	Alani	Rutaceae	Endangered
Melicope makahae	Alani	Rutaceae	Endangered
Melicope mucronulata	Alani	Rutaceae	Endangered
Melicope munroi	Alani	Rutaceae	Endangered
Melicope ovalis	Alani	Rutaceae	Endangered
Melicope pallida	Alani	Rutaceae	Endangered

Scientific Name	Common Name	Family	Federal Listing Status
Melicope paniculata	Alani	Rutaceae	Endangered
Melicope puberula	Alani	Rutaceae	Endangered
Melicope quadrangularis	Alani	Rutaceae	Endangered
Melicope reflexa	Alani	Rutaceae	Endangered
Melicope saint-johnii	Alani	Rutaceae	Endangered
Melicope zahlbruckneri	Alani	Rutaceae	Endangered
Menidia extensa	Waccamaw silverside	Atherinidae	Threatened
Mentzelia leucophylla	Ash Meadows blazingstar	Loasaceae	Threatened
Mesodon clarki nantahala	noonday snail	Polygyridae	Threatened
Mezoneuron kavaiense	Uhi uhi	Fabaceae	Endangered
Microhexura montivaga	Spruce-fir moss spider	Dipluridae	Endangered
Microlepia strigosa var. mauiensis	No common name	Dennstaedtiaceae	Endangered
Microtus californicus scirpensis	Amargosa vole	Cricetidae	Endangered
Microtus pennsylvanicus dukecampbelli	Florida salt marsh vole	Cricetidae	Endangered
Mimulus michiganensis	Michigan monkey-flower	Scrophulariaceae	Endangered
Mirabilis macfarlanei	MacFarlane's four-o'clock	Nyctaginaceae	Threatened
Mitracarpus maxwelliae	No common name	Rubiaceae	Endangered
Mitracarpus polycladus	No common name	Rubiaceae	Endangered
Moapa coriacea	Moapa dace	Cyprinidae	Endangered
Moho braccatus	Kauai `o`o (honeyeater)	Meliphagidae	Endangered
Monachus schauinslandi	Hawaiian monk seal	Phocidae	Endangered
Monardella viminea	Willowy monardella	Lamiaceae	Endangered
Monolopia (=Lembertia) congdonii	San Joaquin wooly-threads	Asteraceae	Endangered
Mucuna sloanei var. persericea	sea bean	Fabaceae	Endangered
Mustela nigripes	Black-footed ferret	Mustelidae	Endangered
Myadestes lanaiensis rutha	Molokai thrush	Muscicapidae	Endangered

Scientific Name	Common Name	Family	Federal Listing Status
Myadestes myadestinus	Large Kauai (=kamao) Thrush	Muscicapidae	Endangered
Myadestes palmeri	Small Kauai (=puaiohi) Thrush	Muscicapidae	Endangered
Mycetophyllia ferox	Rough Cactus Coral	Mussidae	Threatened
Mycteria americana	Wood stork	Ciconiidae	Threatened
Myotis grisescens	Gray bat	Vespertilionidae	Endangered
Myotis septentrionalis	Northern Long-Eared Bat	Vespertilionidae	Threatened
Myotis sodalis	Indiana bat	Vespertilionidae	Endangered
Myrcia paganii	No common name	Myrtaceae	Endangered
Myrsine fosbergii	Kolea	Myrsinaceae	Endangered
Myrsine juddii	Kolea	Primulaceae	Endangered
Myrsine knudsenii	Kolea	Primulaceae	Endangered
Myrsine linearifolia	Kolea	Primulaceae	Threatened
Myrsine mezii	Kolea	Primulaceae	Endangered
Myrsine vaccinioides	Kolea	Primulaceae	Endangered
Navarretia fossalis	Spreading navarretia	Polemoniaceae	Threatened
Navarretia leucocephala ssp. pauciflora (=N. pauciflora)	Few-flowered navarretia	Polemoniaceae	Endangered
Navarretia leucocephala ssp. plieantha	Many-flowered navarretia	Polemoniaceae	Endangered
Necturus alabamensis	Black warrior (=Sipsey Fork) Waterdog	Proteidae	Endangered
Necturus lewisi	Neuse River waterdog	Proteidae	Proposed Threatened
Neoleptoneta microps	Government Canyon Bat Cave Spider	Leptonetidae	Endangered
Neoleptoneta myopica	Tooth Cave Spider	Leptonetidae	Endangered
Neonympha mitchellii francisci	Saint Francis' satyr butterfly	Nymphalidae	Endangered
Neonympha mitchellii mitchellii	Mitchell's satyr Butterfly	Nymphalidae	Endangered
Neoseps reynoldsi	Sand skink	Scincidae	Threatened

Scientific Name	Common Name	Family	Federal Listing Status
Neostapfia colusana	Colusa grass	Poaceae	Threatened
Neotoma floridana smalli	Key Largo woodrat	Cricetidae	Endangered
Neotoma fuscipes riparia	Riparian woodrat (=San Joaquin Valley)	Muridae	Endangered
Neraudia angulata	No common name	Urticaceae	Endangered
Neraudia ovata	No common name	Urticaceae	Endangered
Neraudia sericea	No common name	Urticaceae	Endangered
Nerodia clarkii taeniata	Atlantic salt marsh snake	Colubridae	Threatened
Nerodia erythrogaster neglecta	Copperbelly water snake	Colubridae	Threatened
Nervilia jacksoniae	No common name	Orchidaceae	Threatened
Nesogenes rotensis	No common name	Verbenaceae	Endangered
Newcombia cumingi	Newcomb's Tree snail	Achatinellidae	Endangered
Nicrophorus americanus	American burying beetle	Silphidae	Threatened
Nitrophila mohavensis	Amargosa niterwort	Chenopodiaceae	Endangered
Nolina brittoniana	Britton's beargrass	Agavaceae	Endangered
Nothocestrum breviflorum	`Aiea	Solanaceae	Endangered
Nothocestrum latifolium	`Aiea	Solanaceae	Endangered
Nothocestrum peltatum	`Aiea	Solanaceae	Endangered
Nototrichium humile	Kulu`i	Amaranthaceae	Endangered
Notropis albizonatus	Palezone shiner	Cyprinidae	Endangered
Notropis buccula	Smalleye Shiner	Cyprinidae	Endangered
Notropis cahabae	Cahaba shiner	Cyprinidae	Endangered
Notropis girardi	Arkansas River shiner	Cyprinidae	Threatened
Notropis mekistocholas	Cape Fear shiner	Cyprinidae	Endangered
Notropis oxyrhynchus	Sharpnose Shiner	Cyprinidae	Endangered
Notropis simus pecosensis	Pecos bluntnose shiner	Cyprinidae	Threatened
Notropis topeka (=tristis)	Topeka shiner	Cyprinidae	Endangered
Noturus baileyi	Smoky madtom	Ictaluridae	Endangered

Scientific Name	Common Name	Family	Federal Listing Status
Noturus crypticus	Chucky Madtom	Ictaluridae	Endangered
Noturus flavipinnis	Yellowfin madtom	Ictaluridae	Threatened
Noturus furiosus	Carolina madtom	Ictaluridae	Proposed Endangered
Noturus placidus	Neosho madtom	Ictaluridae	Threatened
Noturus stanauli	Pygmy madtom	Ictaluridae	Endangered
Noturus trautmani	Scioto madtom	Ictaluridae	Endangered
Numenius borealis	Eskimo curlew	Scolopacidae	Endangered
Oarisma poweshiek	Poweshiek skipperling	Hesperiidae	Endangered
Obovaria retusa	Ring pink (mussel)	Unionidae	Endangered
Obovaria subrotunda	Round hickorynut	Unionidae	Proposed Threatened
Oceanodroma castro	Band-rumped storm-petrel	Hydrobatidae	Endangered
Ochrosia haleakalae	Holei	Apocynaceae	Endangered
Ochrosia kilaueaensis	Holei	Apocynaceae	Endangered
Odocoileus virginianus clavium	Key deer	Cervidae	Endangered
Odocoileus virginianus leucurus	Columbian white-tailed deer	Cervidae	Threatened
Oenothera deltoides ssp. howellii	Antioch Dunes evening-primrose	Onagraceae	Endangered
Oncorhynchus (=Salmo) kisutch	Coho salmon	Salmonidae	Endangered
Oncorhynchus (=Salmo) kisutch	Coho salmon	Salmonidae	Threatened
Oncorhynchus (=Salmo) mykiss	Steelhead	Salmonidae	Endangered
Oncorhynchus (=Salmo) mykiss	Steelhead	Salmonidae	Threatened
Oncorhynchus (=Salmo) nerka	Sockeye salmon	Salmonidae	Endangered
Oncorhynchus (=Salmo) nerka	Sockeye salmon	Salmonidae	Threatened
Oncorhynchus (=Salmo) tshawytscha	Chinook salmon	Salmonidae	Endangered

Scientific Name	Common Name	Family	Federal Listing Status
Oncorhynchus (=Salmo) tshawytscha	Chinook salmon	Salmonidae	Threatened
Oncorhynchus aguabonita whitei	Little Kern golden trout	Salmonidae	Threatened
Oncorhynchus apache	Apache trout	Salmonidae	Threatened
Oncorhynchus clarkii henshawi	Lahontan cutthroat trout	Salmonidae	Threatened
Oncorhynchus clarkii seleniris	Paiute cutthroat trout	Salmonidae	Threatened
Oncorhynchus clarkii stomias	Greenback Cutthroat trout	Salmonidae	Threatened
Oncorhynchus gilae	Gila trout	Salmonidae	Threatened
Oncorhynchus keta	Chum salmon	Salmonidae	Threatened
Opuntia treleasei	Bakersfield cactus	Cactaceae	Endangered
Orbicella annularis	Lobed Star Coral	Faviidae	Threatened
Orbicella faveolata	Mountainous Star Coral	Faviidae	Threatened
Orbicella franksi	Boulder star coral	Merulinidae	Threatened
Orcinus orca	Killer whale	Delphinidae	Endangered
Orconectes shoupi	Nashville crayfish	Cambaridae	Endangered
Orcuttia californica	California Orcutt grass	Poaceae	Endangered
Orcuttia inaequalis	San Joaquin Orcutt grass	Poaceae	Threatened
Orcuttia pilosa	Hairy Orcutt grass	Poaceae	Endangered
Orcuttia tenuis	Slender Orcutt grass	Poaceae	Threatened
Orcuttia viscida	Sacramento Orcutt grass	Poaceae	Endangered
Oreomystis bairdi	Akikiki	Fringillidae	Endangered
Oreomystis mana	Hawaii creeper	Drepanidinae	Endangered
Orthalicus reses (not incl. nesodryas)	Stock Island tree snail	Bulimulidae	Threatened
Oryzomys palustris natator	Silver rice rat	Muridae	Endangered
Osmoxylon mariannense	No common name	Araliaceae	Endangered
Ostodes strigatus	Snail [no common name]	Potaridae	Endangered
Ottoschulzia rhodoxylon	Palo de rosa	Icacinaceae	Endangered

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Ovis canadensis nelsoni	Peninsular bighorn sheep	Bovidae	Endangered
Ovis canadensis sierrae	Sierra Nevada bighorn sheep	Bovidae	Endangered
Oxyloma haydeni kanabensis	Kanab ambersnail	Succineidae	Endangered
Oxypolis canbyi	Canby's dropwort	Apiaceae	Endangered
Oxytheca parishii var. goodmaniana	Cushenbury oxytheca	Polygonaceae	Endangered
Oxytropis campestris var. chartacea	Fassett's locoweed	Fabaceae	Threatened
Pacifastacus fortis	Shasta crayfish	Cambaridae	Endangered
Packera franciscana	San Francisco Peaks ragwort	Asteraceae	Threatened
Palaemonetes cummingi	Squirrel Chimney Cave shrimp	Palaemonidae	Threatened
Palaemonias alabamae	Alabama cave shrimp	Atyidae	Endangered
Palaemonias ganteri	Kentucky cave shrimp	Atyidae	Endangered
Palmeria dolei	crested honeycreeper (Akohekohe)	Drepanidinae	Endangered
Panicum fauriei var. carteri	Carter's panicgrass	Poaceae	Endangered
Panicum niihauense	Lau `ehu	Poaceae	Endangered
Panthera onca	Jaguar	Felidae	Endangered
Paronychia chartacea	Papery whitlow-wort	Caryophyllaceae	Threatened
Paroreomyza flammea	Molokai creeper	Drepanidinae	Endangered
Paroreomyza maculata	Oahu creeper	Drepanidinae	Endangered
Partula gibba	Humped tree snail	Partulidae	Endangered
Partula langfordi	Langford's tree snail	Partulidae	Endangered
Partula radiolata	Guam tree snail	Partulidae	Endangered
Partulina semicarinata	Lanai tree snail	Achatinellidae	Endangered
Partulina variabilis	Lanai tree snail	Achatinellidae	Endangered
Parvisedum leiocarpum	Lake County stonecrop	Crassulaceae	Endangered
Pectis imberbis	Beardless chinch weed	Asteraceae	Proposed Endangered
Pedicularis furbishiae	Furbish lousewort	Scrophulariaceae	Endangered

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Pediocactus (=Echinocactus,=Utahia) sileri	Siler pincushion cactus	Cactaceae	Threatened
Pediocactus bradyi	Brady pincushion cactus	Cactaceae	Endangered
Pediocactus despainii	San Rafael cactus	Cactaceae	Endangered
Pediocactus knowltonii	Knowlton's cactus	Cactaceae	Endangered
Pediocactus peeblesianus fickeiseniae	Fickeisen plains cactus	Cactaceae	Endangered
Pediocactus peeblesianus var. peeblesianus	Peebles Navajo cactus	Cactaceae	Endangered
Pediocactus winkleri	Winkler cactus	Cactaceae	Threatened
Pegias fabula	Littlewing pearlymussel	Unionidae	Endangered
Pekania pennanti	Fisher	Mustelidae	Endangered
Peltophryne lemur	Puerto Rican crested toad	Bufonidae	Threatened
Penstemon debilis	Parachute beardtongue	Plantaginaceae	Threatened
Penstemon haydenii	Blowout penstemon	Scrophulariaceae	Endangered
Penstemon penlandii	Penland beardtongue	Scrophulariaceae	Endangered
Pentachaeta bellidiflora	White-rayed pentachaeta	Asteraceae	Endangered
Pentachaeta lyonii	Lyon's pentachaeta	Asteraceae	Endangered
Peperomia subpetiolata	`Ala `ala wai nui	Piperaceae	Endangered
Peperomia wheeleri	Wheeler's peperomia	Piperaceae	Endangered
Percina antesella	Amber darter	Percidae	Endangered
Percina aurolineata	Goldline darter	Percidae	Threatened
Percina aurora	Pearl darter	Percidae	Threatened
Percina jenkinsi	Conasauga logperch	Percidae	Endangered
Percina pantherina	Leopard darter	Percidae	Threatened
Percina rex	Roanoke logperch	Percidae	Endangered
Percina tanasi	Snail darter	Percidae	Threatened
Perognathus longimembris pacificus	Pacific pocket mouse	Heteromyidae	Endangered
Peromyscus gossypinus allapaticola	Key Largo cotton mouse	Muridae	Endangered

Scientific Name	**Common Name**	**Family**	**Federal Listing Status**
Peromyscus polionotus allophrys	Choctawhatchee beach mouse	Muridae	Endangered
Peromyscus polionotus ammobates	Alabama beach mouse	Muridae	Endangered
Peromyscus polionotus niveiventris	Southeastern beach mouse	Muridae	Threatened
Peromyscus polionotus peninsularis	St. Andrew beach mouse	Muridae	Endangered
Peromyscus polionotus phasma	Anastasia Island beach mouse	Muridae	Endangered
Peromyscus polionotus trissyllepsis	Perdido Key beach mouse	Muridae	Endangered
Peucedanum sandwicense	Makou	Apiaceae	Threatened
Phacelia argillacea	Clay phacelia	Hydrophyllaceae	Endangered
Phacelia formosula	North Park phacelia	Hydrophyllaceae	Endangered
Phacelia insularis ssp. insularis	Island phacelia	Hydrophyllaceae	Endangered
Phacelia submutica	DeBeque phacelia	Hydrophyllaceae	Threatened
Phaeognathus hubrichti	Red Hills salamander	Plethodontidae	Threatened
Phlox hirsuta	Yreka phlox	Polemoniaceae	Endangered
Phlox nivalis ssp. texensis	Texas trailing phlox	Polemoniaceae	Endangered
Phoca (=Pusa) hispida botnica	Ringed Seal	Phocidae	Threatened
Phoca (=Pusa) hispida hispida	Ringed Seal	Phocidae	Threatened
Phoca (=Pusa) hispida ladogensis	Ringed seal	Phocidae	Endangered
Phoca (=Pusa) hispida ochotensis	Ringed Seal	Phocidae	Threatened
Phoca largha	Spotted Seal	Phocidae	Threatened
Phoebastria (=Diomedea) albatrus	Short-tailed albatross	Diomedeidae	Endangered
Phoxinus cumberlandensis	Blackside dace	Cyprinidae	Threatened
Phyllanthus saffordii	No common name	Phyllanthaceae	Endangered
Phyllostegia bracteata	No common name	Lamiaceae	Endangered

Scientific Name	Common Name	Family	Federal Listing Status
Phyllostegia brevidens	No common name	Lamiaceae	Endangered
Phyllostegia floribunda	No common name	Lamiaceae	Endangered
Phyllostegia glabra var. lanaiensis	No common name	Lamiaceae	Endangered
Phyllostegia haliakalae	No common name	Lamiaceae	Endangered
Phyllostegia helleri	No common name	Lamiaceae	Endangered
Phyllostegia hirsuta	No common name	Lamiaceae	Endangered
Phyllostegia hispida	No common name	Lamiaceae	Endangered
Phyllostegia kaalaensis	No common name	Lamiaceae	Endangered
Phyllostegia knudsenii	No common name	Lamiaceae	Endangered
Phyllostegia mannii	No common name	Lamiaceae	Endangered
Phyllostegia mollis	No common name	Lamiaceae	Endangered
Phyllostegia parviflora	No common name	Lamiaceae	Endangered
Phyllostegia pilosa	No common name	Lamiaceae	Endangered
Phyllostegia racemosa	Kiponapona	Lamiaceae	Endangered
Phyllostegia renovans	No common name	Lamiaceae	Endangered
Phyllostegia stachyoides	No common name	Lamiaceae	Endangered
Phyllostegia velutina	No common name	Lamiaceae	Endangered
Phyllostegia waimeae	No common name	Lamiaceae	Endangered
Phyllostegia warshaueri	No common name	Lamiaceae	Endangered
Phyllostegia wawrana	No common name	Lamiaceae	Endangered
Physa natricina	Snake River physa snail	Physidae	Endangered
Physaria douglasii ssp. tuplashensis	White Bluffs bladderpod	Brassicaceae	Threatened
Physaria filiformis	Missouri bladderpod	Brassicaceae	Threatened
Physaria globosa	Short's bladderpod	Brassicaceae	Endangered
Physaria obcordata	Dudley Bluffs twinpod	Brassicaceae	Threatened
Physeter catodon (=macrocephalus)	Sperm whale	Physeteridae	Endangered
Picoides borealis	Red-cockaded woodpecker	Picidae	Endangered

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Pilosocereus robinii	Key tree cactus	Cactaceae	Endangered
Pinguicula ionantha	Godfrey's butterwort	Lentibulariaceae	Threatened
Piperia yadonii	Yadon's piperia	Orchidaceae	Endangered
Pipilo crissalis eremophilus	Inyo California towhee	Emberizidae	Threatened
Pittosporum halophilum	Hoawa	Pittosporaceae	Endangered
Pittosporum hawaiiense	Hoawa	Pittosporaceae	Endangered
Pittosporum napaliense	Ho`awa	Pittosporaceae	Endangered
Pituophis melanoleucus lodingi	Black pine snake	Colubridae	Threatened
Pituophis ruthveni	Louisiana pinesnake	Colubridae	Threatened
Pityopsis ruthii	Ruth's golden aster	Asteraceae	Endangered
Plagiobothrys hirtus	rough popcornflower	Boraginaceae	Endangered
Plagiobothrys strictus	Calistoga allocarya	Boraginaceae	Endangered
Plagopterus argentissimus	Woundfin	Cyprinidae	Endangered
Plantago hawaiensis	Kuahiwi laukahi	Plantaginaceae	Endangered
Plantago princeps	Kuahiwi laukahi	Plantaginaceae	Endangered
Platanthera holochila	No common name	Orchidaceae	Endangered
Platanthera integrilabia	White fringeless orchid	Orchidaceae	Threatened
Platanthera leucophaea	Eastern prairie fringed orchid	Orchidaceae	Threatened
Platanthera praeclara	Western prairie fringed Orchid	Orchidaceae	Threatened
Platydesma cornuta var. cornuta	No common name	Rutaceae	Endangered
Platydesma cornuta var. decurrens	No common name	Rutaceae	Endangered
Platydesma remyi	No common name	Rutaceae	Endangered
Platydesma rostrata	Pilo kea lau li`i	Rutaceae	Endangered
Pleodendron macranthum	Chupacallos	Canellaceae	Endangered
Pleomele fernaldii	Hala pepe	Agavaceae	Endangered
Pleomele forbesii	Hala pepe	Agavaceae	Endangered

Scientific Name	Common Name	Family	Federal Listing Status
Pleomele hawaiiensis	Hala pepe	Asparagaceae	Endangered
Plethobasus cicatricosus	White wartyback (pearlymussel)	Unionidae	Endangered
Plethobasus cooperianus	Orangefoot pimpleback (pearlymussel)	Unionidae	Endangered
Plethobasus cyphyus	Sheepnose Mussel	Unionidae	Endangered
Plethodon neomexicanus	Jemez Mountains salamander	Plethodontidae	Endangered
Plethodon nettingi	Cheat Mountain salamander	Plethodontidae	Threatened
Plethodon shenandoah	Shenandoah salamander	Plethodontidae	Endangered
Pleurobema athearni	Canoe Creek Clubshell	Unionidae	Proposed Endangered
Pleurobema clava	Clubshell	Unionidae	Endangered
Pleurobema collina	James spinymussel	Unionidae	Endangered
Pleurobema curtum	Black clubshell	Unionidae	Endangered
Pleurobema decisum	Southern clubshell	Unionidae	Endangered
Pleurobema furvum	Dark pigtoe	Unionidae	Endangered
Pleurobema georgianum	Southern pigtoe	Unionidae	Endangered
Pleurobema gibberum	Cumberland pigtoe	Unionidae	Endangered
Pleurobema hanleyianum	Georgia pigtoe	Unionidae	Endangered
Pleurobema marshalli	Flat pigtoe	Unionidae	Endangered
Pleurobema perovatum	Ovate clubshell	Unionidae	Endangered
Pleurobema plenum	Rough pigtoe	Unionidae	Endangered
Pleurobema pyriforme	Oval pigtoe	Unionidae	Endangered
Pleurobema strodeanum	Fuzzy pigtoe	Unionidae	Threatened
Pleurobema taitianum	Heavy pigtoe	Unionidae	Endangered
Pleurocera foremani	Rough hornsnail	Pleuroceridae	Endangered
Pleuronaia dolabelloides	Slabside Pearlymussel	Unionidae	Endangered
Poa atropurpurea	San Bernardino bluegrass	Poaceae	Endangered
Poa mannii	Mann's bluegrass	Poaceae	Endangered
Poa napensis	Napa bluegrass	Poaceae	Endangered

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Poa sandvicensis	Hawaiian bluegrass	Poaceae	Endangered
Poa siphonoglossa	No common name	Poaceae	Endangered
Poeciliopsis occidentalis	Gila topminnow (incl. Yaqui)	Poeciliidae	Endangered
Pogogyne abramsii	San Diego mesa-mint	Lamiaceae	Endangered
Pogogyne nudiuscula	Otay mesa-mint	Lamiaceae	Endangered
Polioptila californica californica	Coastal California gnatcatcher	Muscicapidae	Threatened
Polyborus plancus audubonii	Audubon's crested caracara	Falconidae	Threatened
Polygala lewtonii	Lewton's polygala	Polygalaceae	Endangered
Polygala smallii	Tiny polygala	Polygalaceae	Endangered
Polygonella basiramia	Wireweed	Polygonaceae	Endangered
Polygonella myriophylla	Sandlace	Polygonaceae	Endangered
Polygonum hickmanii	Scotts Valley Polygonum	Polygonaceae	Endangered
Polygyriscus virginianus	Virginia fringed mountain snail	Helicodiscidae	Endangered
Polyphylla barbata	Mount Hermon June beetle	Scarabaeidae	Endangered
Polyscias bisattenuata	No common name	Araliaceae	Endangered
Polyscias flynnii	No common name	Araliaceae	Endangered
Polyscias gymnocarpa	`Ohe`ohe	Araliaceae	Endangered
Polyscias lydgatei	No common name	Araliaceae	Endangered
Polyscias racemosa	No common name	Araliaceae	Endangered
Polystichum aleuticum	Aleutian shield fern	Dryopteridaceae	Endangered
Polystichum calderonense	No common name	Dryopteridaceae	Endangered
Polysticta stelleri	Steller's Eider	Anatidae	Threatened
Popenaias popeii	Texas Hornshell	Unionidae	Endangered
Portulaca sclerocarpa	Po`e	Portulacaceae	Endangered
Portulaca villosa	Ihi	Portulacaceae	Endangered
Potamilus capax	Fat pocketbook	Unionidae	Endangered
Potamilus inflatus	Inflated heelsplitter	Unionidae	Threatened

Scientific Name	Common Name	Family	Federal Listing Status
Potamogeton clystocarpus	Little Aguja (=Creek) Pondweed	Potamogetonaceae	Endangered
Potentilla hickmanii	Hickman's potentilla	Rosaceae	Endangered
Primula maguirei	Maguire primrose	Primulaceae	Threatened
Pristis clavata	Dwarf sawfish	Pristidae	Endangered
Pristis pectinata	Smalltooth sawfish	Pristidae	Endangered
Pristis pristis	Largetooth Sawfish	Pristidae	Endangered
Pritchardia aylmer-robinsonii	Wahane	Arecaceae	Endangered
Pritchardia bakeri	Baker's Loulu	Arecaceae	Endangered
Pritchardia hardyi	Lo`ulu	Asteraceae	Endangered
Pritchardia kaalae	Lo`ulu	Arecaceae	Endangered
Pritchardia lanigera	Lo`ulu	Arecaceae	Endangered
Pritchardia maideniana	Lo`ulu	Arecaceae	Endangered
Pritchardia munroi	Lo`ulu	Arecaceae	Endangered
Pritchardia napaliensis	Lo`ulu	Arecaceae	Endangered
Pritchardia remota	Lo`ulu	Arecaceae	Endangered
Pritchardia schattaueri	Lo`ulu	Arecaceae	Endangered
Pritchardia viscosa	Lo`ulu	Arecaceae	Endangered
Procambarus econfinae	Panama City crayfish	Cambaridae	Proposed Threatened
Procaris hawaiana	Anchialine pool Shrimp	Procarididae	Endangered
Prunus geniculata	Scrub plum	Rosaceae	Endangered
Pseudemys alabamensis	Alabama red-bellied turtle	Emydidae	Endangered
Pseudemys rubriventris bangsi	Plymouth Redbelly Turtle	Emydidae	Endangered
Pseudobahia bahiifolia	Hartweg's golden sunburst	Asteraceae	Endangered
Pseudobahia peirsonii	San Joaquin adobe sunburst	Asteraceae	Threatened
Pseudocopaeodes eunus obscurus	Carson wandering skipper	Hesperiidae	Endangered
Pseudognaphalium sandwicensium var. molokaiense	`Ena`ena	Asteraceae	Endangered

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Pseudonestor xanthophrys	Maui parrotbill (Kiwikiu)	Drepanidinae	Endangered
Pseudorca crassidens	false killer whale	Delphinidae	Endangered
Pseudotryonia adamantina	Diamond Tryonia	Hydrobiidae	Endangered
Psittirostra psittacea	`O`u (honeycreeper)	Drepanidinae	Endangered
Psychotria grandiflora	Kopiko	Rubiaceae	Endangered
Psychotria hexandra ssp. oahuensis	Kopiko	Rubiaceae	Endangered
Psychotria hobdyi	Kopiko	Rubiaceae	Endangered
Psychotria malaspinae	Aplokating-palaoan	Rubiaceae	Endangered
Pteralyxia kauaiensis	Kaulu	Apocynaceae	Endangered
Pteralyxia macrocarpa	Kaulu	Apocynaceae	Endangered
Pteris lidgatei	No common name	Adiantaceae	Endangered
Pterodroma cahow	Bermuda petrel	Procellariidae	Endangered
Pterodroma hasitata	Black-capped petrel	Procellariidae	Proposed Threatened
Pterodroma sandwichensis	Hawaiian petrel	Procellariidae	Endangered
Pteropus mariannus mariannus	Mariana fruit Bat (=Mariana flying fox)	Pteropodidae	Threatened
Pteropus tokudae	Little Mariana fruit Bat	Pteropidae	Endangered
Ptilimnium nodosum	Harperella	Apiaceae	Endangered
Ptychobranchus greenii	Triangular Kidneyshell	Unionidae	Endangered
Ptychobranchus jonesi	Southern kidneyshell	Unionidae	Endangered
Ptychobranchus subtentus	Fluted kidneyshell	Unionidae	Endangered
Ptychocheilus lucius	Colorado pikeminnow (=squawfish)	Cyprinidae	Endangered
Puffinus auricularis newelli	Newell's Townsend's shearwater	Procellariidae	Threatened
Puma (=Felis) concolor coryi	Florida panther	Felidae	Endangered
Purshia (=Cowania) subintegra	Arizona Cliffrose	Rosaceae	Endangered
Pyrgulopsis (=Marstonia) pachyta	Armored snail	Hydrobiidae	Endangered

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Pyrgulopsis bernardina	San Bernardino springsnail	Hydrobiidae	Threatened
Pyrgulopsis bruneauensis	Bruneau Hot springsnail	Hydrobiidae	Endangered
Pyrgulopsis chupaderae	Chupadera springsnail	Hydrobiidae	Endangered
Pyrgulopsis neomexicana	Socorro springsnail	Hydrobiidae	Endangered
Pyrgulopsis ogmorhaphe	Royal marstonia (snail)	Hydrobiidae	Endangered
Pyrgulopsis roswellensis	Roswell springsnail	Hydrobiidae	Endangered
Pyrgulopsis texana	Phantom Springsnail	Hydrobiidae	Endangered
Pyrgulopsis trivialis	Three Forks Springsnail	Hydrobiidae	Endangered
Pyrgus ruralis lagunae	Laguna Mountains skipper	Hesperiidae	Endangered
Quadrula cylindrica cylindrica	Rabbitsfoot	Unionidae	Threatened
Quadrula cylindrica strigillata	Rough rabbitsfoot	Unionidae	Endangered
Quadrula fragosa	Winged Mapleleaf	Unionidae	Endangered
Quadrula intermedia	Cumberland monkeyface (pearlymussel)	Unionidae	Endangered
Quadrula sparsa	Appalachian monkeyface (pearlymussel)	Unionidae	Endangered
Quadrula stapes	Stirrupshell	Unionidae	Endangered
Quercus hinckleyi	Hinckley oak	Fagaceae	Threatened
Rallus longirostris levipes	Light-footed clapper rail	Rallidae	Endangered
Rallus longirostris obsoletus	California clapper rail	Rallidae	Endangered
Rallus obsoletus [=longirostris] yumanensis	Yuma Ridgways (clapper) rail	Rallidae	Endangered
Rallus owstoni	Guam rail	Rallidae	Endangered
Rana chiricahuensis	Chiricahua leopard frog	Ranidae	Threatened
Rana draytonii	California red-legged frog	Ranidae	Threatened
Rana muscosa	Mountain yellow-legged frog	Ranidae	Endangered
Rana pretiosa	Oregon spotted frog	Ranidae	Threatened
Rana sevosa	dusky gopher frog	Ranidae	Endangered
Rana sierrae	Sierra Nevada Yellow-legged Frog	Ranidae	Endangered

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Rangifer tarandus caribou	Woodland Caribou	Cervidae	Endangered
Ranunculus aestivalis (=acriformis)	Autumn Buttercup	Ranunculaceae	Endangered
Ranunculus hawaiensis	Makou	Ranunculaceae	Endangered
Ranunculus mauiensis	Makou	Ranunculaceae	Endangered
Reithrodontomys raviventris	Salt marsh harvest mouse	Cricetidae	Endangered
Remya kauaiensis	No common name	Asteraceae	Endangered
Remya mauiensis	Maui remya	Asteraceae	Endangered
Remya montgomeryi	No common name	Asteraceae	Endangered
Rhadine exilis	[no common name] Beetle	Carabidae	Endangered
Rhadine infernalis	[no common name] Beetle	Carabidae	Endangered
Rhadine persephone	Tooth Cave ground beetle	Carabidae	Endangered
Rhaphiomidas terminatus abdominalis	Delhi Sands flower-loving fly	Mydidae	Endangered
Rhinichthys osculus lethoporus	Independence Valley speckled dace	Cyprinidae	Endangered
Rhinichthys osculus nevadensis	Ash Meadows speckled dace	Cyprinidae	Endangered
Rhinichthys osculus oligoporus	Clover Valley speckled dace	Cyprinidae	Endangered
Rhinichthys osculus thermalis	Kendall Warm Springs dace	Cyprinidae	Endangered
Rhodiola integrifolia ssp. leedyi	Leedy's roseroot	Crassulaceae	Threatened
Rhododendron chapmanii	Chapman rhododendron	Ericaceae	Endangered
Rhus michauxii	Michaux's sumac	Anacardiaceae	Endangered
Rhynchopsitta pachyrhyncha	Thick-billed parrot	Psittacidae	Endangered
Rhynchospora knieskernii	Knieskern's Beaked-rush	Cyperaceae	Threatened
Ribes echinellum	Miccosukee gooseberry	Saxifragaceae	Threatened
Rorippa gambellii	Gambel's watercress	Brassicaceae	Endangered
Rostrhamus sociabilis plumbeus	Everglade snail kite	Accipitridae	Endangered

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Sagittaria fasciculata	Bunched arrowhead	Alismataceae	Endangered
Sagittaria secundifolia	Kral's water-plantain	Alismataceae	Threatened
Salmo salar	Atlantic salmon	Salmonidae	Endangered
Salvelinus confluentus	Bull Trout	Salmonidae	Threatened
Samoana fragilis	Fragile tree snail	Partulidae	Endangered
Sanicula mariversa	No common name	Apiaceae	Endangered
Sanicula purpurea	No common name	Apiaceae	Endangered
Sanicula sandwicensis	No common name	Apiaceae	Endangered
Santalum haleakalae var. lanaiense	Lanai sandalwood (=`iliahi)	Santalaceae	Endangered
Santalum involutum	No common name	Santalaceae	Endangered
Sarracenia oreophila	Green pitcher-plant	Sarraceniaceae	Endangered
Sarracenia rubra ssp. alabamensis	Alabama canebrake pitcher-plant	Sarraceniaceae	Endangered
Sarracenia rubra ssp. jonesii	Mountain sweet pitcher-plant	Sarraceniaceae	Endangered
Scaevola coriacea	Dwarf naupaka	Goodeniaceae	Endangered
Scaphirhynchus albus	Pallid sturgeon	Acipenseridae	Endangered
Scaphirhynchus suttkusi	Alabama sturgeon	Acipenseridae	Endangered
Schenkia sebaeoides	Awiwi	Gentianaceae	Endangered
Schiedea adamantis	Diamond Head schiedea	Caryophyllaceae	Endangered
Schiedea apokremnos	Ma`oli`oli	Caryophyllaceae	Endangered
Schiedea attenuata	No common name	Caryophyllaceae	Endangered
Schiedea diffusa ssp. macraei	No common name	Caryophyllaceae	Endangered
Schiedea diffusa subsp. diffusa	No common name	Caryophyllaceae	Endangered
Schiedea haleakalensis	No common name	Caryophyllaceae	Endangered
Schiedea hawaiiensis	Ma`oli`oli	Caryophyllaceae	Endangered
Schiedea helleri	No common name	Caryophyllaceae	Endangered
Schiedea hookeri	No common name	Caryophyllaceae	Endangered

Scientific Name	Common Name	Family	Federal Listing Status
Schiedea jacobii	No common name	Caryophyllaceae	Endangered
Schiedea kaalae	No common name	Caryophyllaceae	Endangered
Schiedea kauaiensis	No common name	Caryophyllaceae	Endangered
Schiedea kealiae	Ma`oli`oli	Caryophyllaceae	Endangered
Schiedea laui	No common name	Caryophyllaceae	Endangered
Schiedea lychnoides	Kuawawaenohu	Caryophyllaceae	Endangered
Schiedea lydgatei	No common name	Caryophyllaceae	Endangered
Schiedea membranacea	No common name	Caryophyllaceae	Endangered
Schiedea nuttallii	No common name	Caryophyllaceae	Endangered
Schiedea obovata	No common name	Caryophyllaceae	Endangered
Schiedea pubescens	Ma`oli`oli	Caryophyllaceae	Endangered
Schiedea salicaria	No common name	Caryophyllaceae	Endangered
Schiedea sarmentosa	No common name	Caryophyllaceae	Endangered
Schiedea spergulina var. leiopoda	No common name	Caryophyllaceae	Endangered
Schiedea spergulina var. spergulina	No common name	Caryophyllaceae	Threatened
Schiedea stellarioides	Laulihilihi	Caryophyllaceae	Endangered
Schiedea trinervis	No common name	Caryophyllaceae	Endangered
Schiedea verticillata	No common name	Caryophyllaceae	Endangered
Schiedea viscosa	No common name	Caryophyllaceae	Endangered
Schoenocrambe argillacea	Clay reed-mustard	Brassicaceae	Threatened
Schoenocrambe barnebyi	Barneby reed-mustard	Brassicaceae	Endangered
Schoenocrambe suffrutescens	Shrubby reed-mustard	Brassicaceae	Endangered
Schoepfia arenaria	No common name	Olacaceae	Threatened
Schwalbea americana	American chaffseed	Scrophulariaceae	Endangered
Scirpus ancistrochaetus	Northeastern bulrush	Cyperaceae	Endangered
Sclerocactus brevihamatus ssp. tobuschii	Tobusch fishhook cactus	Cactaceae	Threatened
Sclerocactus brevispinus	Pariette cactus	Cacatacea	Threatened

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Sclerocactus glaucus	Colorado hookless Cactus	Cactaceae	Threatened
Sclerocactus mesae-verdae	Mesa Verde cactus	Cactaceae	Threatened
Sclerocactus wetlandicus	Uinta Basin hookless cactus	Cactaceae	Threatened
Sclerocactus wrightiae	Wright fishhook cactus	Cactaceae	Endangered
Scutellaria floridana	Florida skullcap	Lamiaceae	Threatened
Scutellaria montana	Large-flowered skullcap	Lamiaceae	Threatened
Sebastes paucispinis	Bocaccio	Sebastidae	Endangered
Sebastes pinniger	canary rockfish	Sebastidae	Threatened
Sebastes ruberrimus	yelloweye rockfish	Sebastidae	Threatened
Senecio layneae	Layne's butterweed	Asteraceae	Threatened
Serianthes nelsonii	Hayun Iagu (=(Guam), Tronkon guafi (Rota))	Fabaceae	Endangered
Sesbania tomentosa	Ohai	Fabaceae	Endangered
Setophaga angelae	Elfin-woods warbler	Parulidae	Threatened
Sibara filifolia	Santa Cruz Island rockcress	Brassicaceae	Endangered
Sicyos albus	`Anunu	Cucurbitaceae	Endangered
Sicyos lanceoloideus	No common name	Cucurbitaceae	Endangered
Sicyos macrophyllus	`Anunu	Cucurbitaceae	Endangered
Sidalcea keckii	Keck's Checker-mallow	Malvaceae	Endangered
Sidalcea nelsoniana	Nelson's checker-mallow	Malvaceae	Threatened
Sidalcea oregana ssp. valida	Kenwood Marsh checker-mallow	Malvaceae	Endangered
Sidalcea oregana var. calva	Wenatchee Mountains checkermallow	Malvaceae	Endangered
Sidalcea pedata	Pedate checker-mallow	Malvaceae	Endangered
Sideroxylon reclinatum ssp. austrofloridense	Everglades bully	Sapotaceae	Threatened
Silene alexandri	No common name	Caryophyllaceae	Endangered
Silene hawaiiensis	No common name	Caryophyllaceae	Threatened
Silene lanceolata	No common name	Caryophyllaceae	Endangered

Scientific Name	Common Name	Family	Federal Listing Status
Silene perlmanii	No common name	Caryophyllaceae	Endangered
Silene polypetala	Fringed campion	Caryophyllaceae	Endangered
Silene spaldingii	Spalding's Catchfly	Caryophyllaceae	Threatened
Sistrurus catenatus	Eastern Massasauga (=rattlesnake)	Viperidae	Threatened
Sisyrinchium dichotomum	White irisette	Iridaceae	Endangered
Solanum conocarpum	Marron bacora	Solanaceae	Proposed Endangered
Solanum drymophilum	Erubia	Solanaceae	Endangered
Solanum guamense	Berenghenas halomtano	Solanaceae	Endangered
Solanum incompletum	Popolo ku mai	Solanaceae	Endangered
Solanum nelsonii	Popolo	Solanaceae	Endangered
Solanum sandwicense	`Aiakeakua, popolo	Solanaceae	Endangered
Solidago houghtonii	Houghton's goldenrod	Asteraceae	Threatened
Solidago shortii	Short's goldenrod	Asteraceae	Endangered
Solidago spithamaea	Blue Ridge goldenrod	Asteraceae	Threatened
Somateria fischeri	Spectacled eider	Anatidae	Threatened
Somatochlora hineana	Hine's emerald dragonfly	Corduliidae	Endangered
Sorex ornatus relictus	Buena Vista Lake ornate Shrew	Soricidae	Endangered
Spelaeorchestia koloana	Kauai cave amphipod	Talitridae	Endangered
Speoplatyrhinus poulsoni	Alabama cavefish	Amblyopsidae	Endangered
Spermolepis hawaiiensis	No common name	Apiaceae	Endangered
Speyeria callippe callippe	Callippe silverspot butterfly	Nymphalidae	Endangered
Speyeria zerene behrensii	Behren's silverspot butterfly	Nymphalidae	Endangered
Speyeria zerene hippolyta	Oregon silverspot butterfly	Nymphalidae	Threatened
Speyeria zerene myrtleae	Myrtle's silverspot butterfly	Nymphalidae	Endangered
Sphaeralcea gierischii	Gierisch mallow	malvaceae	Endangered
Sphyrna lewini	Scalloped Hammerhead Shark	Sphyrnidae	Endangered
Spigelia gentianoides	Gentian pinkroot	Loganiaceae	Endangered

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Spiraea virginiana	Virginia spiraea	Rosaceae	Threatened
Spiranthes delitescens	Canelo Hills ladies-tresses	Orchidaceae	Endangered
Spiranthes diluvialis	Ute ladies'-tresses	Orchidaceae	Threatened
Spiranthes parksii	Navasota ladies-tresses	Orchidaceae	Endangered
Stahlia monosperma	Cobana negra	Fabaceae	Threatened
Stenogyne angustifolia var. angustifolia	No common name	Lamiaceae	Endangered
Stenogyne bifida	No common name	Lamiaceae	Endangered
Stenogyne campanulata	No common name	Lamiaceae	Endangered
Stenogyne cranwelliae	No common name	Lamiaceae	Endangered
Stenogyne kaalae ssp. sherffii	No common name	Lamiaceae	Endangered
Stenogyne kanehoana	No common name	Lamiaceae	Endangered
Stenogyne kauaulaensis	No common name	Lamiaceae	Endangered
Stenogyne kealiae	No common name	Lamiaceae	Endangered
Stephanomeria malheurensis	Malheur wire-lettuce	Asteraceae	Endangered
Sterna antillarum	Least tern	Laridae	Endangered
Sterna antillarum browni	California least tern	Laridae	Endangered
Sterna dougallii dougallii	Roseate tern	Laridae	Endangered
Sterna dougallii dougallii	Roseate tern	Laridae	Threatened
Sternotherus depressus	Flattened musk turtle	Kinosternidae	Threatened
Streptanthus albidus ssp. albidus	Metcalf Canyon jewelflower	Brassicaceae	Endangered
Streptanthus niger	Tiburon jewelflower	Brassicaceae	Endangered
Streptocephalus woottoni	Riverside fairy shrimp	Branchinectidae	Endangered
Strix occidentalis caurina	Northern spotted owl	Strigidae	Threatened
Strix occidentalis lucida	Mexican spotted owl	Strigidae	Threatened
Strymon acis bartrami	Bartram's hairstreak Butterfly	Lycaenidae	Endangered
Stygobromus (=Stygonectes) pecki	Peck's cave amphipod	Crangonyctidae	Endangered

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Stygobromus hayi	Hay's Spring amphipod	Crangonyctidae	Endangered
Stygoparnus comalensis	Comal Springs dryopid beetle	Dryopidae	Endangered
Styrax portoricensis	Palo de jazmin	Styracaceae	Endangered
Styrax texanus	Texas snowbells	Styracaceae	Endangered
Suaeda californica	California seablite	Chenopodiaceae	Endangered
Succinea chittenangoensis	Chittenango ovate amber snail	Succineidae	Threatened
Swallenia alexandrae	Eureka Dune grass	Poaceae	Threatened
Sylvilagus bachmani riparius	Riparian brush rabbit	Leporidae	Endangered
Sylvilagus palustris hefneri	Lower Keys marsh rabbit	Leporidae	Endangered
Syncaris pacifica	California freshwater shrimp	Palaemonidae	Endangered
Tabernaemontana rotensis	No common name	Apocynaceae	Threatened
Tamiasciurus hudsonicus grahamensis	Mount Graham red squirrel	Sciuridae	Endangered
Taraxacum californicum	California taraxacum	Asteraceae	Endangered
Tartarocreagris texana	Tooth Cave pseudoscorpion	Neobisiidae	Endangered
Taylorconcha serpenticola	Bliss Rapids snail	Hydrobiidae	Threatened
Tectaria estremerana	No common name	Dryopteridaceae	Endangered
Telespyza cantans	Laysan finch (honeycreeper)	Drepanidinae	Endangered
Telespyza ultima	Nihoa finch (honeycreeper)	Drepanidinae	Endangered
Ternstroemia luquillensis	Palo colorado	Theaceae	Endangered
Ternstroemia subsessilis	No common name	Theaceae	Endangered
Tetramolopium arenarium	No common name	Asteraceae	Endangered
Tetramolopium capillare	Pamakani	Asteraceae	Endangered
Tetramolopium filiforme	No common name	Asteraceae	Endangered
Tetramolopium lepidotum ssp. lepidotum	No common name	Asteraceae	Endangered
Tetramolopium remyi	No common name	Asteraceae	Endangered
Tetramolopium rockii	No common name	Asteraceae	Threatened

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Texamaurops reddelli	Kretschmarr Cave mold beetle	Pselaphidae	Endangered
Texella cokendolpheri	Cokendolpher Cave Harvestman	Phalangodidae	Endangered
Texella reddelli	Bee Creek Cave harvestman	Phalangodidae	Endangered
Texella reyesi	Bone Cave harvestman	Phalangodidae	Endangered
Thaleichthys pacificus	Eulachon	Osmeridae	Threatened
Thalictrum cooleyi	Cooley's meadowrue	Ranunculaceae	Endangered
Thamnophis eques megalops	Northern Mexican gartersnake	Colubridae	Threatened
Thamnophis gigas	Giant garter snake	Colubridae	Threatened
Thamnophis rufipunctatus	Narrow-headed gartersnake	Colubridae	Threatened
Thamnophis sirtalis tetrataenia	San Francisco garter snake	Colubridae	Endangered
Thelypodium howellii ssp. spectabilis	Howell''s spectacular thelypody	Brassicaceae	Threatened
Thelypodium stenopetalum	Slender-petaled mustard	Brassicaceae	Endangered
Thelypteris inabonensis	No common name	Thelypteridaceae	Endangered
Thelypteris pilosa var. alabamensis	Alabama streak-sorus fern	Thelypteridaceae	Threatened
Thelypteris verecunda	No common name	Thelypteridaceae	Endangered
Thelypteris yaucoensis	No common name	Thelypteridaceae	Endangered
Thermosphaeroma thermophilus	Socorro isopod	Sphaeromatidae	Endangered
Thlaspi californicum	Kneeland Prairie penny-cress	Brassicaceae	Endangered
Thomomys mazama glacialis	Roy Prairie pocket gopher	Geomyidae	Threatened
Thomomys mazama pugetensis	Olympia pocket gopher	Geomyidae	Threatened
Thomomys mazama tumuli	Tenino pocket gopher	Geomyidae	Threatened
Thomomys mazama yelmensis	Yelm pocket gopher	Geomyidae	Threatened
Thymophylla tephroleuca	Ashy dogweed	Asteraceae	Endangered

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Thysanocarpus conchuliferus	Santa Cruz Island fringepod	Brassicaceae	Endangered
Tiaroga cobitis	Loach minnow	Cyprinidae	Endangered
Tinospora homosepala	No common name	Menispermaceae	Endangered
Torreya taxifolia	Florida torreya	Taxaceae	Endangered
Townsendia aprica	Last Chance townsendia	Asteraceae	Threatened
Toxolasma cylindrellus	Pale lilliput (pearlymussel)	Unionidae	Endangered
Trematolobelia singularis	No common name	Campanulaceae	Endangered
Trichechus manatus	West Indian Manatee	Trichechidae	Threatened
Trichilia triacantha	Bariaco	Meliaceae	Endangered
Trichomanes punctatum ssp. floridanum	Florida bristle fern	Hymenophyllaceae	Endangered
Trifolium amoenum	Showy Indian clover	Fabaceae	Endangered
Trifolium stoloniferum	Running buffalo clover	Fabaceae	Endangered
Trifolium trichocalyx	Monterey clover	Fabaceae	Endangered
Trillium persistens	Persistent trillium	Liliaceae	Endangered
Trillium reliquum	Relict trillium	Liliaceae	Endangered
Trimerotropis infantilis	Zayante band-winged grasshopper	Acrididae	Endangered
Triodopsis platysayoides	Flat-spired three-toothed Snail	Polygyridae	Threatened
Tryonia alamosae	Alamosa springsnail	Hydrobiidae	Endangered
Tryonia cheatumi	Phantom Tryonia	Hydrobiidae	Endangered
Tryonia circumstriata (=stocktonensis)	Gonzales tryonia	Hydrobiidae	Endangered
Tuberolabium guamense	No common name	Orchidaceae	Threatened
Tuctoria greenei	Greene's tuctoria	Poaceae	Endangered
Tuctoria mucronata	Solano grass	Poaceae	Endangered
Tulotoma magnifica	Tulotoma snail	Viviparidae	Threatened
Tympanuchus cupido attwateri	Attwater's greater prairie-chicken	Phasianidae	Endangered
Typhlomolge rathbuni	Texas blind salamander	Plethodontidae	Endangered

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Uma inornata	Coachella Valley fringe-toed lizard	Phrynosomatidae	Threatened
Urera kaalae	Opuhe	Urticaceae	Endangered
Urocitellus brunneus	Northern Idaho Ground Squirrel	Sciuridae	Threatened
Urocyon littoralis catalinae	Santa Catalina Island Fox	Canidae	Threatened
Ursus arctos horribilis	Grizzly bear	Ursidae	Threatened
Ursus maritimus	Polar bear	Ursidae	Threatened
Vagrans egistina	Mariana wandering butterfly	Nymphalidae	Endangered
Varronia rupicola	No common name	Boraginaceae	Threatened
Verbena californica	Red Hills vervain	Verbenaceae	Threatened
Verbesina dissita	Big-leaved crownbeard	Asteraceae	Threatened
Vermivora bachmanii	Bachman's warbler (=wood)	Emberizidae	Endangered
Vernonia proctorii	No common name	Asteraceae	Endangered
Vetericaris chaceorum	Anchialine pool shrimp	Procaridae	Endangered
Vicia menziesii	Hawaiian vetch	Fabaceae	Endangered
Vigna o-wahuensis	No common name	Fabaceae	Endangered
Villosa choctawensis	Choctaw bean	Unionidae	Endangered
Villosa fabalis	Rayed Bean	Unionidae	Endangered
Villosa perpurpurea	Purple bean	Unionidae	Endangered
Villosa trabalis	Cumberland bean (pearlymussel)	Unionidae	Endangered
Viola chamissoniana ssp. chamissoniana	Pamakani	Violaceae	Endangered
Viola helenae	No common name	Violaceae	Endangered
Viola kauaiensis var. wahiawaensis	Nani wai`ale`ale	Violaceae	Endangered
Viola lanaiensis	No common name	Violaceae	Endangered
Viola oahuensis	No common name	Violaceae	Endangered
Vireo bellii pusillus	Least Bell's vireo	Vireonidae	Endangered
Vulpes macrotis mutica	San Joaquin kit fox	Canidae	Endangered

Scientific Name	**Common Name**	**Family**	**Federal Listing Status**
Vulpes vulpes necator	Sierra Nevada red fox	Canidae	Proposed Endangered
Warea amplexifolia	Wide-leaf warea	Brassicaceae	Endangered
Warea carteri	Carter's mustard	Brassicaceae	Endangered
Wikstroemia skottsbergiana	No common name	Thymelaeaceae	Endangered
Wikstroemia villosa	No common name	Thymelaeaceae	Endangered
Wilkesia hobdyi	Dwarf iliau	Asteraceae	Endangered
Xylosma crenatum	No common name	Salicaceae	Endangered
Xyrauchen texanus	Razorback sucker	Catostomidae	Endangered
Xyris tennesseensis	Tennessee yellow-eyed grass	Xyridaceae	Endangered
Yermo xanthocephalus	Desert yellowhead	Asteraceae	Threatened
Zanthoxylum dipetalum var. tomentosum	A`e	Rutaceae	Endangered
Zanthoxylum hawaiiense	A`e	Rutaceae	Endangered
Zanthoxylum oahuense	A`e	Rutaceae	Endangered
Zanthoxylum thomasianum	St. Thomas prickly-ash	Rutaceae	Endangered
Zapada glacier	Western glacier stonefly	Nemouridae	Threatened
Zapus hudsonius luteus	New Mexico meadow jumping mouse	Zapodidae	Endangered
Zapus hudsonius preblei	Preble's meadow jumping mouse	Zapodidae	Threatened
Zizania texana	Texas wild-rice	Poaceae	Endangered
Ziziphus celata	Florida ziziphus	Rhamnaceae	Endangered
Zosterops conspicillatus conspicillatus	Bridled white-eye	Zosteropidae	Endangered
Zosterops rotensis	Rota bridled White-eye	Zosteropidae	Endangered