Monsanto Petitions (10-188-01p and 12-185-01p) for Determinations of Nonregulated Status for Dicamba-Resistant Soybean and Cotton Varieties

Draft Environmental Impact Statement - 2014

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Executive Summary

The U.S. Department of Agriculture (USDA), Animal and Plant Health Inspection Service (APHIS) received two requests (petitions) from Monsanto Company, St. Louis, MO (Monsanto) seeking determinations of nonregulated status for genetically engineered (GE) plant varieties referred to as MON 87708 soybean and MON 88701 cotton, that have been engineered to be resistant to the herbicide dicamba. These GE plant varieties are currently regulated by APHIS, and Monsanto requests that APHIS grant the petition so that these varieties can be grown without any APHIS regulatory oversight. Since these two GE plant varieties are currently under APHIS regulatory oversight, the Agency requires Monsanto to comply with a full range of safeguarding measures to ensure that these regulated GE plant varieties do not transfer or spread from their APHIS-approved outdoor planting sites. APHIS authorization is also required to move these regulated varieties interstate.

Once a developer of a genetically engineered (GE) plant has obtained sufficient information to conclude that its regulated GE plant is unlikely to cause injury, damage, or disease to plants or plant products (i.e., pose a plant pest risk), it may submit a petition to APHIS to no longer regulate the organism. This is referred to as seeking nonregulated status. If a petition for nonregulated status is approved by APHIS, permits or notifications are no longer required by the Agency to grow or ship the GE plant throughout the United States and its territories. If APHIS determines that nonregulated status is appropriate for one or both the Monsanto GE varieties, they will no longer be subject to any regulations pursuant to Part 340.

Regulatory Authority

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

Any party can petition APHIS for “nonregulated status” of a GE organism (that is, to discontinue regulating a GE organism that falls under its regulations) through the procedures described in 7 CFR § 340.6. APHIS regulates such a GE organism until a request for nonregulated status is made. The agency then evaluates whether it meets the PPA definition of a plant pest, and it concludes on the basis of scientific evidence that the GE organism is unlikely to pose a plant pest risk by determining that the potential for the GE organism to cause plant disease or damage is unlikely. The petitioner must provide data, including information obtained from confined field tests regulated by APHIS, to help inform Agency decisionmakers. APHIS analyzes the data from the petitioner, researches current scientific findings, and prepares a Plant Pest Risk Assessment (PPRA) that documents whether or not the GE organism is likely to cause disease or damage. If APHIS concludes that the GE organism does not pose plant pest risk, APHIS must then issue a regulatory decision of non-regulated status, since the Agency does not have regulatory authority to regulate organisms that are not plant pests. When a determination of nonregulated status has been issued, the GE organism may be introduced into the environment without APHIS regulatory oversight under Part 340. In the case of the GE soybean and cotton varieties that are the subject of this draft EIS, if nonregulated status is determined to be appropriate for them, Monsanto will be allowed to sell the GE seeds to farmers, and growers will be able to grow, harvest, and move their crop into commerce for food and feed without any authorization from APHIS.

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

The FDA's regulation of GE plants is based upon its authority to regulate food safety under the Federal Food, Drug, and Cosmetic Act (FFDCA) 21 U.S.C. §§ 301 – 399. The FDA implements a voluntary consultation process to ensure that human food and animal feed safety issues or other regulatory issues, such as labeling, are resolved before commercial distribution of food derived from GE products.

EPA regulates the use, sale, and labeling of pesticides pursuant to its authority under the Federal Insecticide, Fungicide, and Rodenticide Act ("FIFRA") (7 U.S.C. §§ 136–136y). EPA's actions under FIFRA directly affect the production methods used on herbicide-resistant (HR) GE plants. An herbicide must first be "registered" by the EPA before it can be distributed or sold in the U.S. (7 U.S.C. §§ 136a(a),136j(a)(2)(F)). The EPA registration process starts with the herbicide manufacturer providing the EPA with information about the herbicide (7 U.S.C. § 136a(c)(1)(C), (F)). The agency then evaluates the adverse effects it may have on humans and the environment in accordance with the proposed label. On the basis of this evaluation, the EPA then determines if it will allow use of the herbicide on a plant, and, if so, under what conditions and in what quantity. The EPA sets the conditions for herbicide use and places them in labeling instructions that a user must follow (*See* 7 U.S.C. 136j(a)(2)(G)). The EPA reevaluates all pesticides, which includes herbicides, every fifteen years (or shorter) to ensure they meet current standards for continued safe use (7 U.S.C.§ 136a(g)(1)(A)(iv)). Under FIFRA, the EPA also regulates plant-incorporated protectants (PIPs) which are pesticidal substances produced by plants and the genetic material necessary for the plant to produce the substance.

The varieties that are the subject of this draft Environmental Impact Statement (DEIS) (MON 87708 soybean and MON 88701 cotton) are resistant to the herbicide dicamba, and are being marketed by Monsanto under the name Xtend™ soybean and cotton. MON 88701 cotton is also resistant to the herbicide glufosinate. The EPA is currently reviewing proposed changes in the registered uses of dicamba on these soybean and cotton varieties. If approved by EPA, these label changes will allow for direct application of dicamba to Xtend soybean and cotton varieties (MON 87708 soybean and MON 88701 cotton). The herbicide formulation to be used on MON 87708 soybean and MON 88701 cotton will contain a diglycolamine (DGA) salt formulation of dicamba. These proposed label changes were requested by Monsanto based on the standard that the new uses of this herbicide would not cause any unreasonable adverse environmental effects and a reasonable certainty of no harm to humans, so long as it was applied in accordance with its labeling instructions. Monsanto is not requesting any changes to the current EPA-approved uses for glufosinate for MON 88701 cotton; thus, no new review of the label by EPA is required. EPA does not regulate MON 87708 soybean and MON 88701 cotton plants because these plants are not PIPs.

Purpose of MON 87708 Soybean and MON 88701 Cotton

Monsanto has developed these two GE plant varieties as alternatives to currently available GE HR soybean and cotton varieties (Monsanto, 2012a; 2012b). Many HR soybean and cotton varieties have been engineered over the past 20 years. These include HR varieties with resistance to the herbicide glyphosate (the active ingredient in the herbicide Roundup®); varieties resistant to the herbicide glufosinate (the active ingredient in the herbicide Liberty®); a class of herbicides known as sulfonylureas (the active ingredients in herbicides such as Glean®); and isoxaflutole (the active ingredient in herbicides such as Balance® and Prequel®). RoundupReady® crops greatly simplified weed management for growers and reduced their weed management costs. For example, most growers can effectively manage weeds in RoundupReady soybean by using only glyphosate. In contrast, three to four herbicides are needed for weed control in conventional soybeans. Therefore, RoundupReady crops were rapidly and widely adopted and continue to be planted by growers.

When weed control strategies remain unchanged for prolonged periods, weed populations tend to adapt and eventually become difficult to control. For example, the nearly exclusive reliance on glyphosate during the past 20 years has contributed to the selection of glyphosate-resistant (GR) weeds. When only one herbicide is used year after year 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. A review of the processes contributing to HR weed development, including those specific to GR weeds, was conducted for the DEIS. The findings of this review are presented in Appendix 6.

In cropland where GR weeds are widespread, the benefits of the RoundupReady system are diminishing and weed management has become more costly. To manage GR weeds, growers have reverted to applying other herbicides and to mechanical cultivation practices. Growers are also increasingly adopting glufosinate-resistant and other HR crops. Further details about the socioeconomic impacts of resistant weeds are presented in Section 5.7.1.

The primary purpose of MON 87708 soybean and MON 88701 cotton is to provide growers with an additional in-crop weed management option to manage GR broadleaf weed species. Each of these varieties has a trait that makes the plant resistant to dicamba, an active ingredient in many herbicide formulations. Those crops that do not contain this trait are sensitive to dicamba, so the herbicide can only be used on these crops prior to planting. MON 87708 soybean and MON 88701 cotton can be treated with dicamba after sprouting, killing competing weeds but not the developing soybean or cotton seedlings. MON 88701 cotton is also resistant to glufosinate, so both herbicides may be used on this cotton variety after planting. If Xtend varieties are no longer regulated they would also be available for cross-breeding with all other GE varieties that are no longer regulated by APHIS. For the technical details on these two GE plant cultivars, see the petitions submitted by Monsanto which are available on the APHIS website (USDA-APHIS, 2014c).

Purpose and Need for Agency Action

APHIS regulations require that APHIS make decisions on the petitions it receives for nonregulated status. The Agency can choose to approve a petition in whole or in part, or it can deny the petition. As previously mentioned, the APHIS decision is based on a PPRA for the GE plants that are the subject of the petition. Plant pest risks are those risks caused by plant pests that can cause injury, damage, or disease to plants or plant products. Consistent with the APHIS authority under the PPA, market acceptance of a product is not a plant pest risk.

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

In response to the receipt of the two Monsanto petitions, APHIS prepared PPRAs to assess the plant pest risk for each plant variety. In addition to the PPRAs, APHIS must also prepare an environmental analysis consistent with its obligations under the National Environmental Policy Act (NEPA). Under NEPA regulations, an agency conducts an Environmental Assessment (EA) to determine if a major Federal agency action will cause significant environmental impacts (40 CFR § 1501.4). If the agency concludes in its EA that its action will not significantly impact the environment, the agency issues a "Finding of No Significant Impact" (FONSI) and the agency can proceed with its proposed action without preparing a more thorough Environmental Impact Statement (EIS). If the EA concludes that the proposed action may significantly affect the environment, the agency must prepare an EIS. However, an agency may determine that significant impacts are possible without formally preparing an EA and proceed to the preparation of an EIS.

Public Involvement

APHIS sought comments for the petitions that are the subject of this DEIS in a *Federal Register* notice dated July 13, 2012. Comments received for the petitions were influential, though not the sole basis, for the Agency's decision to prepare this DEIS. In reviewing the petitions for determinations of nonregulated status of crop cultivars genetically engineered to be resistant to various herbicides, APHIS has identified the potential selection of herbicide resistant weeds as a potential environmental impact. As part of its scoping process to identify issues to address in this DEIS, APHIS also published a Notice of Intent (NOI) to prepare this DEIS and sought public input during a comment period (May 10 to July 17, 2013). Based on the input received during this comment period, APHIS determined that for the two Monsanto petitions it is appropriate to perform a comprehensive environmental analysis of the potential selection of dicamba-resistant weeds and other potential environmental impacts that may occur as a result of making determinations of nonregulated status for these plants, and report the findings in this DEIS.

Comments were submitted by individuals, academic researchers, non-government organizations (NGOs), and industry representatives. The majority of comments submitted by NGOs and individuals were opposed to determinations of nonregulated status for the petitions. The majority of comments submitted by industry and academia supported determinations of nonregulated status for MON 87708 soybean and MON 88701 cotton. These comments are summarized in Appendix 2.

In general, comments fell into three broad categories. A brief summary follows, accompanied by the APHIS response to each:

1) Many commenters expressed the concern that natural and biological resources would be adversely impacted by dicamba because of increased amounts of this herbicide being used on soybean and cotton, if MON 87708 soybean and MON 88701 cotton are no longer regulated by APHIS.

The APHIS response is that the direct and indirect impacts of herbicide use are outside the scope of this DEIS because the authority to regulate herbicide resides with the EPA under FIFRA and does not reside with USDA-APHIS. The USDA-APHIS authority comes from the PPA, which limits APHIS authority to the regulation of plant pests and noxious weeds. Under APHIS regulations, the Agency can only consider plant pest risks when making a determination of nonregulated status.

APHIS has no authority to regulate herbicide use or mitigate the impacts that may result from that use. The EPA registration process under FIFRA ensures that pesticides will be properly labeled, and that, if used in accordance with label specifications will meet the EPA's safety standards of no unreasonable adverse effect on the environment and a reasonable certainty of no harm to humans. More details about EPA regulatory responsibilities are provided in Section 1.5.2. The risk assessment process used by EPA is explained in Section 5.4.

2) Some commenters emphasized that growers need MON 87708 soybean and MON 88701 cotton to manage GR weeds already present on many U.S. farms.

APHIS considers the impacts of GR weeds in the No Action Alternative (Section 4.1.3). APHIS also considers possible cumulative impacts if it makes a determination to no longer regulate MON 87708 soybean and MON 88701 cotton, and the EPA makes a decision to allow the new registered uses of dicamba for these varieties in Chapter 5 of this DEIS.

3) Some commenters expressed concern that increased use of dicamba on MON 87708 soybean and MON 88701 cotton would promote selection of dicamba-resistant weeds.

APHIS notes that it has identified the possible selection of HR weeds resulting from the change in management practices associated with the adoption of MON 87708 soybean and MON 88701 cotton as a potential environmental impact. This impact is a cumulative impact (see Chapter 5) because it would only result if APHIS approves the petitions to no longer regulate the GE varieties that are the subject of this DEIS, and EPA allows registration of the proposed new uses of dicamba on them. If dicamba-resistant weeds were to develop as a result of these combined actions, growers who rely on dicamba for effective and inexpensive weed control might experience increased socioeconomic impacts by a need to rely on potentially more costly and restrictive weed control alternatives.

Alternatives Analyzed

In this DEIS, APHIS considers four alternatives regarding the possible deregulation of these two GE organisms. The four alternatives are: 1) No Action; 2) approve the petitions for nonregulated status of MON 87708 soybean and MON 88701 cotton; 3) approve the petition for nonregulated status only for MON 88701cotton; and 4) approve the petition for nonregulated status only for MON 87708 soybean.

Alternative 1: No Action Alternative—Continuation as Regulated Articles

Under the No Action Alternative, APHIS would deny the two petitions because the two varieties that are the subject of the petitions would present a plant pest risk and would continue to be regulated by APHIS. Permits issued or notifications acknowledged by APHIS would still be required for the introduction of MON 87708 soybean and MON 88701 cotton, and measures to ensure physical and reproductive confinement would continue to be implemented. This Alternative is not the Preferred Alternative because APHIS has concluded in its preliminary PPRAs that MON 87708 soybean and MON 88701 cotton are unlikely to pose plant pest risks (USDA-APHIS, 2014a; 2014b). Therefore, choosing this alternative would not satisfy the purpose and need of making the required regulatory determination that is consistent with the PPA and 7 CFR part 340.6.

Alternative 2: Determination of Nonregulated Status of MON 87708 Soybean and MON 88701 Cotton (Preferred Alternative)

Under this alternative, MON 87708 soybean and MON 88701cotton and their progeny would no longer be subject to APHIS biotechnology regulations (7 CFR part 340) as they have been determined unlikely to pose a plant risk. Permits issued or notifications acknowledged by APHIS would no longer be required for introductions of these varieties. This alternative meets the purpose and need to respond appropriately to the petitions (Monsanto, 2012a; 2012b) for nonregulated status, the requirements in 7 CFR part 340, and the Agency's regulatory authority under the plant pest provisions of the PPA, because APHIS has concluded in its preliminary PPRAs that these varieties are unlikely to pose plant pest risks (USDA-APHIS, 2014a; 2014b). Therefore, this is the Preferred Alternative because approving the petitions for nonregulated status for both varieties is consistent with the plant pest provisions of the PPA and the regulations codified in 7 CFR part 340.

Alternative 3: Approve the Petition for a Determination of Nonregulated Status Only for MON 88701 Cotton

Under this alternative, only MON 88701 cotton and progeny derived from its cultivation would no longer be subject to APHIS biotechnology regulations (7 CFR part 340) as it has been determined unlikely to pose a new plant pest risk or increase existing ones. Permits issued or notifications acknowledged by APHIS would no longer be required for this cotton variety and its progeny. This alternative meets the purpose and need to respond appropriately to the petition for nonregulated status for MON 88701 cotton (Monsanto, 2012b), the requirements in 7 CFR part 340 and the Agency's regulatory authority under the plant pest provisions of the PPA because APHIS has concluded in its preliminary PPRA that it is unlikely to pose a new plant pest risk or increase existing ones (USDA-APHIS, 2014b). Therefore, approving the petition for a determination of nonregulated status for MON 88701 cotton is consistent with the plant pest provisions of the PPA and the regulations codified in 7 CFR part 340. However, because APHIS has concluded in its preliminary PPRA that MON 87708 soybean is also unlikely to pose new plant pest risks or increase existing ones (USDA-APHIS, 2014a), choosing this alternative would not fully satisfy the purpose and need of making the required regulatory determination that is consistent with the PPA and 7 CFR part 340.6.

Alternative 4: Approve the Petition for a Determination of Nonregulated Status Only for MON 87708 Soybean

Under this alternative, only MON 87708 soybean and progeny derived from its cultivation would no longer be subject to the APHIS biotechnology regulations (7 CFR part 340) as it has been determined unlikely to pose a plant pest risk. Permits issued or notifications acknowledged by APHIS would no longer be required for its introduction and progeny derived from it. This alternative meets the purpose and need to respond appropriately to the petition for nonregulated status for MON 87708 soybean (Monsanto, 2012a), the requirements in 7 CFR part 340 and the Agency's regulatory authority under the plant pest provisions of the PPA, because APHIS has concluded in its preliminary PPRA that it is unlikely to pose plant pest risk (USDA-APHIS, 2014a). Therefore, approving the petition for a determination of nonregulated status for MON 87708 soybean is consistent with the plant pest provisions of the PPA and the regulations codified in 7 CFR part 340. However, because APHIS has concluded in its preliminary PPRA that MON 88701cotton is also unlikely to pose plant a plant pest risk (USDA-APHIS, 2014b), choosing this alternative would not fully satisfy the purpose and need of making the required regulatory determination that is consistent with the PPA and 7 CFR part 340.6.

Affected Environment

To determine the extent of the potential environmental impacts that could result from any APHIS decision related to the regulation of MON 87708 soybean and MON 88701cotton, APHIS used information provided by the USDA National Agricultural Statistics Service (USDA-NASS) to identify those regions of the country where soybeans and cotton are grown. To describe the ecological features of soybean and cotton regions, APHIS compared these growing areas to maps that group regions having similar ecological attributes such as soil, landform, or major vegetation types (CEC, 2009). These regions are termed ecoregions and are identified as regions A through M in this DEIS. To identify the types of land cover and crops grown in each region, APHIS analyzed information in the USDA-NASS online tool "Cropscape," an information source that compiles these data from satellite imagery.

Potential Environmental Consequences of Alternatives

Environmental issues are assessed individually in Chapter 4 (Potential Environmental Consequences). As stated previously, APHIS has regulatory authority over the MON 87708 soybean and MON 88701cotton cultivars; the EPA has regulatory authority over dicamba herbicide products and uses. The scope of this DEIS covers the direct and indirect impacts that would result from the cultivation and use of these varieties. EPA, in its registration process, is considering any direct and indirect impacts from the proposed new uses of dicamba on these varieties. APHIS is relying on EPA's authoritative assessments and will not duplicate the assessments prepared by EPA. However, in this DEIS, APHIS does consider (see Chapter 5) the potential cumulative impacts that could result in the event that it approves the petitions for nonregulated status of MON 87708 soybean and MON 88701 cotton and EPA registers the proposed new uses of dicamba on these crop varieties.

APHIS determined that the direct impacts on the environment from the cultivation of MON 87708 soybean and MON 88701 cotton would not differ from those caused by the cultivation of other soybean and cotton varieties, because these GE varieties are not agronomically different from non-GE soybean and cotton cultivars or other GE soybean or cotton cultivars that are no longer regulated by the Agency. These two GE plant varieties do not directly affect natural (e.g., soil, water, air) or biological (e.g., animal, insect, plant) resources. However, the agricultural management practices (e.g., tillage practices) associated with their cultivation may indirectly impact natural and biological resources. For example, the need for tillage, which may adversely affect soil, water, and air quality, and greenhouse gas emissions, is likely to decrease in conjunction with the weed management alternatives available in association with the cultivation of MON 87708 soybean and MON 88701 cotton.

The EPA regulates the use of herbicides under FIFRA and is making a separate decision which may or may not allow new uses of dicamba. While MON 87708 soybean and MON 88701 cotton are engineered to resist damage from the application of dicamba, selection of a particular alternative by APHIS does not allow the new uses of dicamba on these soybean and cotton varieties.

Potential Cumulative Impacts

Chapter 5 of this DEIS includes an environmental analysis of potential cumulative impacts, including how herbicide use may change, if APHIS approves the petitions for nonregulatory status of MON 87708 soybean and MON 88701 cotton and EPA approves the proposed registration changes for dicamba. As part of its analysis, APHIS considered the potential effects of the development of dicamba-resistant weeds if the EPA approves the new dicamba uses on MON 87708 soybean and MON 88701 cotton. In particular, the impacts of dicamba-resistant weeds on the cultivation of crops, other than soybean and cotton, on which dicamba is used currently were evaluated (see Appendix 4, Tables 4-8 and 4-12 for more details).

The availability of dicamba-resistant soybean and cotton in conjunction with EPA approval of new uses of dicamba on these new varieties would cause growers who adopt the varieties to change management practices. For instance, dicamba use may increase to levels greater than what might occur if these varieties were not available. Another anticipated change is that dicamba is expected to be used over a wider part of the growing season. Both changes in management practices can be expected to increase the pressure for selection of dicamba-resistant weeds. Growers themselves can influence this selection pressure by the management practices they choose. For example, rotating crops, rotating types of herbicides, using cover crops, scouting for weeds and using mechanical tillage to prevent weeds from flowering, are just some of the practices that can be followed to reduce or delay the selection of HR weeds. Groups such as the Weed Science Society of America (WSSA), university extension agents, crop consultants, and industry representatives, have made a concerted effort to increase grower awareness of best management practices for managing the development of HR weeds (see Section 5.7.2 for a detailed review of this topic). EPA has noted the increasing problems and economic issues growers are facing from the emergence of herbicide resistant weeds. As part of the proposed registration of Enlist Duo (a 2,4-D choline salt and glyphosate premix), EPA has included several management practices related to herbicide selection, crop selection and cultural practices that will appear on the product labeling for growers of Enlist crops to follow that are designed to help avoid initial occurrences of weed resistance. APHIS assumes that EPA will include similar requirements on a revised dicamba label for use on Xtend crops (US-EPA, 2014b) and growers will adhere to the EPA label requirements.

If dicamba-resistant weeds become more prevalent as a result of its use on MON 87708 soybean and MON 88701cotton, growers of other crops that rely on dicamba for weed control may need to modify management practices to control weeds that become resistant to dicamba. The management changes required could increase the complexity and cost of weed management programs for some of these growers. Because the use of dicamba on Xtend soybean and cotton does not require a single specific set of agronomic practices, the magnitude of the impacts would depend on the adoption rates of various practices by growers.

In the cumulative impact assessment, the selection pressure for dicamba-resistant weeds is expected to be greater under the Preferred Alternative, while the selection pressure for GR weeds is expected to be greater under the No Action Alternative. This is because the cropping systems that use dicamba potentially decrease grower reliance on glyphosate by including an additional type of herbicide in the weed management system. The continued emergence of GR weeds under the No Action Alternative will itself require modification of crop management practices to address these weeds.

Growers will likely continue to use glyphosate because it is still effective on hundreds of weed species. However, farmers are also expected to depend on additional chemical and non-chemical methods to control GR weeds. Changes in management practices are expected to include more use of non-glyphosate herbicides and adjustments to crop rotation and tillage practices (Owen et al., 2011). Use of herbicides that kill weeds by mechanisms (referred to as sites of action; see Appendix 3 for details) that differ from that of glyphosate are expected to increase as growers alter methods to manage GR weeds.

Selection for GR weeds is expected to continue where glyphosate is used. Areas where GR weeds are expected to remain a serious problem include the Southeast, Great Plains and Northern Crescent. These are regions where GR weeds have become widely prevalent. Weed resistance to other non-glyphosate herbicides has also become prevalent in many regions (see Appendix 6 for more details). As a result, herbicide options for weed management may become less attractive under the No Action Alternative and growers may be forced to return to more aggressive tillage systems to maintain productive soybean yields (Conley, 2013).

Under the Preferred Alternative, dicamba use is expected to increase relative to the No Action Alternative, if EPA approves proposed new uses of dicamba on these crops. However, increases in other herbicide sites of action under the Preferred Alternative are expected to be less than under the No Action Alternative because dicamba is expected to be preferentially adopted if approved for use on these crops by EPA. The availability of inexpensive and effective herbicides may delay the adoption of non-chemical management strategies under the Preferred Alternative. Fewer growers would be expected to adopt aggressive tillage when herbicides remain both cost effective and efficacious for weed control. Selection of weeds resistant to glyphosate, and non-glyphosate herbicides may still occur under the Preferred Alternative. The selection pressure for HR weeds under the Preferred Alternative relative to the No Action Alternative will depend on the management practices chosen and cannot be predicted.

Under the No Action Alternative, natural resources are expected to be negatively impacted by a return to more aggressive tillage practices. If conventional tillage increases to control GR/HR weeds, several negative impacts are likely: reduced soil quality from increased erosion; reduced air quality from increased air particulates and increased exhaust emissions from farm equipment; reduced water quality from the release and mobilization of sediments, nutrients, and other chemicals into surface and groundwater; increased greenhouse gases from burning additional fossil fuels and releases of sequestered carbon from disrupted soil; and reduced biodiversity from habitat loss. The total acreage that may be impacted by such an increase in tillage would be based on the extent of resistant weeds present in a field and the weed management strategy chosen by a grower. Adoption of MON 87708 soybean and MON 88701 cotton can provide growers with an alternative herbicide to glyphosate and could provide growers with an alternative to intensive tillage practices that may be used to manage HR weeds. However, the development of more resistant weed species to more types of herbicides could reduce the long-term use of dicamba and any associated benefits to natural resources. The magnitude of this impact is uncertain because of the difficulty of characterizing the variability of the decisions made by crop production managers and individual growers.

Table of Contents

Table of Figures

Table of Tables

List of Appendices

ACRONYMS and ABBREVIATIONS

§	section
2,4-D	2,4-dichlorophenoxyacetic acid
ACCase	acetyl CoA carboxylase
ae	acid equivalent
AHAS	acetohydroxyacid
a.i.	active ingredient
AIA	advanced informed agreement
AL	Alabama
ALS	acetolactate synthase
AMS	Agricultural Marketing Service (USDA)
APHIS	Animal and Plant Health Inspection Service (USDA)
AQI	Air Quality Index
AR	Arkansas
AREI	Agricultural Resources and Environmental Indicators
ARMS	Agricultural Resource Management Survey
ARS	Agricultural Research Service (USDA)
AZ	Arizona
bar	bialaphos resistance
BMPs	best management practices
BNF	biotechnology notification file
BRS	Biotechnology Regulatory Services (USDA)
Bt	*Bacillus thuringiensis*
°C	degrees Celsius
CA	California
CAA	Clean Air Act
CBD	Convention on Biological Diversity
CEC	Canada-Mexico-U.S. Commission for Environmental Cooperation
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CO	carbon monoxide
CO_2	carbon dioxide
CPWC	critical period of weed control
CWA	Clean Water Act
DAS	Dow AgroSciences
DCSA	3,6-dichlorosalicylic acid
DE	Delaware
DEIS	Draft Environmental Impact Statement
DGA	diglycolamine
DMA	dimethylamine
DMO	dicamba mono-oxygenase
DNA	deoxyribonucleic acid
DR	dicamba resistant
DRT	Drift Reduction Technology

DT_{50}	dissipation time needed for herbicide to degrade to half of its original concentration
EA	environmental assessment
EFED	Environmental Fate and Effects Division (EPA)
EIS	environmental impact statement
ELS	extra-long staple
EPA	U.S. Environmental Protection Agency
EPSPS	5-enolpyruvylshikimate-3-phosphate synthase
ER	environmental report
ERS	Economic Research Service (USDA)
ESA	Endangered Species Act
EU	European Union
EO	Executive Order
FAO	Food and Agriculture Organization of the United Nations
FDA	U.S. Food and Drug Administration
FFDCA	Federal Food, Drug, and Cosmetic Act
FFP	food, feed, or processing
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FL	Florida
fl oz/A	fluid ounces per acre
FQPA	Food Quality Protection Act
FR	Federal Register
FSANZ	Food Standards Australia New Zealand
GA	Georgia
GE	genetically engineered
GHG	greenhouse gases
GMO	genetically modified organism
GR	glyphosate resistant
GT	glyphosate tolerant
HED	Health Effects Division (EPA)
HPPD	4-hydroxyphenylpyruvate dioxygenase
HR	herbicide resistant
HRAC	Herbicide Resistance Action Committee
IA	Iowa
IL	Illinois
IN	Indiana
IPCC	Intergovernmental Panel on Climate Change
IPM	Integrated Pest Management
IPPC	International Plant Protection Convention
ISPM	International Standard for Phytosanitary Measure
IWM	integrated weed management
KY	Kentucky
KS	Kansas
LA	Louisiana

lb	pound(s)
lb ae	pounds acid equivalent
lb ai	pounds active ingredient
LMO	living modified organism
MD	Maryland
MI	Michigan
mm	millimeter(s)
MO	Missouri
MN	Minnesota
MGI	mesotrione, glufosinate, isoxaflutole
MOA	mode of action
MOU	memorandum of understanding
MCPA	(4-chloro-2-methylphenoxy) acetic acid/2-Methyl-4-chlorophenoxyacetic acid
MS	Mississippi
MT	Montana
MTSA	Monsanto Technology Stewardship Agreements
NAAQS	National Ambient Air Quality Standards
NABI	North American Biotechnology Initiative
NAPPO	North American Plant Protection Organization
NASS	National Agricultural Statistics Service (USDA)
NC	North Carolina
ND	North Dakota
NE	Nebraska
NEPA	National Environmental Policy Act
NGO	non-government organization
NHPA	National Historic Preservation Act
NJ	New Jersey
NLCD	National Land Cover Dataset
NMFS	National Marine Fisheries Service
NO_2	nitrogen dioxide
NOI	Notice of Intent
NOP	National Organic Program
NPS	nonpoint source
NRC	National Research Council
NRCS	Natural Resources Conservation Service
NTSR	non-target site-specific resistance
NY	New York
O_3	ozone
OECD	Organization for Economic Co-operation and Development
OH	Ohio
OK	Oklahoma
OPP	Office of Pesticide Programs (EPA)
OR	Oregon

PA	Pennsylvania
PAT	phosphinothricin acetyltransferase
Pb	lead
PIPs	plant-incorporated protectants
PM	particulate matter
$PM_{2.5}$	particulate matter with aerodynamic diameter of 2.5 micrometer or less
PM_{10}	particulate matter with aerodynamic diameter of 10 micrometer or less
POST	post-emergence in-crop use
PPA	Plant Protection Act
PPE	personal protective equipment
ppm	parts per million
PPO	protoporphyrinogen oxidase
PPRA	plant pest risk assessment
PRA	pest risk analysis
PRE	pre-plant/pre-emergence application to the crop
PSI	Photosystem I
PSII	Photosystem II
R1	corn reproductive growth stage 1: silking
R2	corn reproductive growth stage 2: full flowering stage
RBD	refined, bleached, and deodorized
RED	Reregistration Eligibility Decision
REI	Restricted Entry Intervals
RSPM	Regional Standards for Phytosanitary Measures
SC	South Carolina
SD	South Dakota
SO_2	sulfur dioxide
SOA	site of action
SOM	soil organic matter
STS	sulfonylurea resistant soybean
TES	threatened and endangered species
Tg CO_2 Eq	teragrams of CO_2 Equivalent
TN	Tennessee
TSCA	Toxic Substances Control Act
TSR	target site-specific resistance
TX	Texas
US	United States
USA	United States of America
USC	United States Code
USDA	U.S. Department of Agriculture
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
USSR	Union of Soviet Socialist Republics
VA	Virginia
WA	Washington

WHO	World Health Organization
WI	Wisconsin
WSSA	Weed Science Society of America
WY	Wyoming

1 PURPOSE AND NEED

This document is intended to ensure compliance with the National Environmental Policy Act (NEPA). NEPA requires that all actions implemented under the authority of the Federal government be examined and assessed if they have possible impacts on the environment. The United States Department of Agriculture (USDA) Animal and Plant Health Inspection Service (APHIS) is currently engaged in decisionmaking relevant to its statutory authority to regulate the plant as pest potential of two genetically engineered (GE) organisms. The Agency has determined that there are possible environmental impacts associated with whatever regulatory decision it renders. Therefore, this document has been prepared as part of this APHIS decisionmaking process.

1.1 Introduction

Summarized as "Protecting American Agriculture," the mission of USDA APHIS[1] is: "To protect the health and value of American agriculture and natural resources." To achieve its mission, APHIS regulates plant and animal health. It integrates these regulatory functions to protect and promote United States domestic agricultural production, commodities, and trade in agricultural products in a manner that prevents or minimizes impacts on the environment.

To implement its plant protection mission, the Agency establishes policies and measures to prevent the introduction of plant pests into the United States. It also promotes management of those plants, animals, and microorganisms that currently occur within the U.S. and cause economic losses to U.S. agriculture, including commercial and non-commercial production of crops and ornamental plants. Its mission encompasses all practices and technologies that have the potential to impact plant pest risks, either by increasing or reducing them.

One practice overseen by the APHIS plant protection mission is the use of genetic engineering to modify plant agronomic properties. The Agency has regulatory authority to ensure that applications of genetic engineering technology do not pose new plant pest risks or pose any greater ones than already exist.

Principles of biochemistry and molecular biology underlie the current understanding of genetic inheritance. The mechanisms involved provide the theoretical framework for modern biotechnology. Genetic engineering is one application of biotechnology. It enables the precise insertion of one or more selected genetic traits (genes) into the genome of an organism without sole dependence on the cross-breeding principles of classical Mendelian genetics of inheritance. As a result, modern biotechnology makes possible the transfer of highly specific, individual, beneficial genetic traits between unrelated species. As part of its statutory and regulatory authority to regulate plant pests, APHIS must examine and determine that all GE (genetically

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

engineered) products that are potential plant pests do not pose risks greater than those that already exist or create new ones.

The APHIS regulatory authority (see Section 1.2 for a general summary) over GE organisms is limited to those with the potential to be plant pests or to increase plant pest risks. The Agency performs extensive, science-based analyses to evaluate the plant pest potential of each GE organism it regulates. Results are documented in a Plant Pest Risk Assessment (PPRA). If the conclusion of the PPRA is that a GE organism is unlikely to pose or increase a plant pest risk itself, increase the plant pest risk of another existing plant pest(s), and/or create a new plant pest(s) risk, the Agency must determine that it does not regulate that organism as a plant pest.

Regardless of its decision (either not to regulate or continue regulating) for a particular article (i.e., organism) that has not been released previously into the environment, the Agency also assesses whether or not its decision is likely to cause an environmental impact(s), and if so, examines the environmental impacts of its determination to comply with regulations codified under the National Environmental Policy Act (NEPA). The results of the examination APHIS has performed, relevant to two new GE organisms it currently regulates, are the subject of this document.

1.2 APHIS Regulatory Authority

The Plant Protection Act of 2000 (PPA), as amended (7 U.S.C. §§ 7701–7772), provides the legal authorization for the APHIS plant protection mission. It authorizes the Agency to regulate the introduction of potential plant pests into the territorial boundaries of the U.S., and their interstate movement within U.S. boundaries by establishing quarantine, eradication and control programs. Implementing rules, regulations and guidelines for this enabling legislation (PPA) are codified in Title 7 of the U.S. Code of Federal Regulations (CFR). Rules that implement this authority specific to GE organisms have been published in 7 CFR part 340.

1.3 Requirement for This Document

When APHIS receives a petition for nonregulated status of an article currently regulated under its PPA authority codified in 7 CFR part 340, the Agency is required to make a decision. As a Federal agency, APHIS must also comply with applicable U.S. environmental laws and regulations because a decision on a petition for nonregulated status, whether positive or negative, is a final Agency action that might cause environmental impact(s).

This document addresses both of these requirements relevant to decisionmaking for two petitions submitted by Monsanto Company, St. Louis, Missouri (henceforth referred to as Monsanto): APHIS Petition 10-188-01p for MON 87708 soybean (Monsanto, 2012a) and APHIS Petition 12-185-01p for MON 88701 cotton (Monsanto, 2012b). Each petition seeks a determination of nonregulated status respectively for two new GE cultivars: a soybean and a cotton variety engineered for resistance[2] to certain herbicides. Monsanto has presented data in these petitions to support its claims that each variety is not a plant pest risk, so should not be regulated by APHIS under the PPA and 7 CFR part 340.

Both varieties described here are currently regulated under 7 CFR part 340. Interstate movement and field trials of each (MON 87708 soybean and MON 88701 cotton) were conducted under permits issued or notifications acknowledged by APHIS between 2005 and 2012. The field trials were conducted within selected growing areas in the U.S. (see Appendix 1 for a list of notifications and states approved for environmental releases for each of the petitions). Data from field trials of each variety are reported in the petitions (Monsanto, 2012a; 2012b) and analyzed in separate PPRAs prepared by APHIS (USDA-APHIS, 2014a; 2014b).

If APHIS makes a determination of nonregulated status for each of these GE varieties, they will cease to be subject to the PPA and regulations in 7 CFR part 340. Once they are no longer regulated, non-regulated status will extend to crosses, using methods based on the principles of classical Mendelian inheritance, between these varieties and conventional (non-GE) cultivars, and those GE varieties classified previously by APHIS as not subject to regulation as plant pests under the PPA and 7 CFR part 340.

1.4 Purpose of These Products

APHIS Petition 10-188-01p is for a GE soybean (*Glycine max*) variety designated as MON 87708 soybean. It is engineered for increased resistance to the broadleaf herbicide, dicamba (3,6-dichloro-2-methoxybenzoic acid). The active ingredient (a.i.) of dicamba is a plant hormone (auxin) modifier that suppresses development of susceptible weed species when applied at a sufficient concentration. MON 87708 soybean is resistant to the levels of exposure that effectively suppress the development of susceptible weeds, so it outcompetes weeds, which increases its productivity.

If the petitions for nonregulated status are granted, these herbicide-resistant (HR) varieties (MON 87708 soybean; MON 88701 cotton) will be alternatives to currently available GE HR cultivars (Monsanto, 2012a; 2012b). Most GE HR crops in the U.S. have historically included only a glyphosate-resistant (GR) trait for weed control. This has limited the diversity of herbicides used for weed management, and resulted in intense reliance on glyphosate. This has been accompanied by a corresponding increase in GR weeds that commonly occur in soybean,

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[2] "Resistance" is defined by the Herbicide Resistance Action Committee (HRAC) as the inherited ability of a plant population to survive and reproduce following repeated exposure to a dose of herbicide normally lethal to the wild type HRAC (2013).. Resistance may be induced by genetic engineering or selection of variants produced by tissue culture or mutagenesis HRAC, (2013).. HRAC applies a different meaning to the term "tolerance," defining it as the inherent ability of a plant to survive and reproduce after herbicide treatment. Survival of a tolerant plant implies that there was no selection or genetic manipulation to make it tolerant; it is naturally tolerant HRAC, (2013).. These terms are sometimes used interchangeably. For this document, the term "herbicide resistance" has been used consistent with that of HRAC. It can be construed as synonymous with the term "herbicide tolerance" as used in the petitioner's documents.

cotton, and other crops (USDA-APHIS, 2014a; 2014b). Each of these varieties (MON 87708 soybean; MON 88701 cotton) will increase weed-management options available to growers. This flexibility will result in more strategies to control HR weeds. More details about these new varieties follow.

1.4.1 MON 87708 Soybean

MON 87708 soybean contains a gene from *Stenotrophomonas maltophilia* (an aerobic gram-negative bacillus that is found in soil, water and plants) that expresses a mono-oxygenase enzyme that rapidly demethylates dicamba rendering it inactive, thereby conferring resistance to dicamba. This dicamba mono-oxygenase (DMO) protein rapidly demethylates dicamba to the herbicidally inactive metabolite 3,6-dichlorosalicylic acid (DCSA), a known soybean, soil, and livestock metabolite of dicamba. Its safety has been evaluated by the U.S. Environmental Protection Agency (EPA). DCSA, in addition to dicamba, is included in the current 10 parts per million (ppm) pesticide residue tolerance for soybean seed that supports the existing uses of dicamba on commercially produced soybean (40 CFR § 180.227).

Monsanto will request a registration from EPA for the expanded use pattern of dicamba described here for MON 87708 soybean (Monsanto, 2010a), an establishment of new tolerances for dicamba in soybean forage and hay and the inclusion of DCSA in the residue definitions for these. However, the rapid metabolism of dicamba results in residues in dicamba-treated MON 87708 soybean seed, including the DCSA metabolite, that are substantially below the currently established 10 ppm tolerance. Therefore, modification of the current soybean seed tolerance is not necessary.

MON 87708 soybean that is resistant to dicamba will offer growers a soybean variety that allows for expanded use of dicamba in soybean production from the current EPA-labeled preplant and preharvest uses. MON 87708 dicamba-resistant (DR) soybean will allow growers to make preemergence applications up to crop emergence. Postemergence applications through the early reproductive (R1/R2) growth stage will also be allowed.

Dicamba provides effective control of more than 95 annual and biennial weed species, and suppression of over 100 perennial broadleaf and woody plant species. Dicamba is efficacious on broadleaf weeds that are difficult to control with glyphosate (e.g., common lambsquarters, hemp sesbania, morning glory species, nightshade, Pennsylvania smartweed, prickly sida, velvetleaf, waterhemp and wild buckwheat). Hard-to-control weeds generally require a higher treatment rate and/or more frequent applications at a smaller growth stage in order to consistently achieve commercially acceptable control. See the Roundup WeatherMax® label (U.S. EPA Reg. No. 524-537) for a listing of these weeds.

Dicamba also provides effective control of HR weeds, including GR weeds such as marestail, common ragweed, giant ragweed, palmer pigweed, and waterhemp. HR weeds are those listed on the International Survey of Resistant Weeds website (www.weedscience.org).

As indicated in Section 1.3, if MON 87708 soybean is no longer regulated, non-regulated status will extend to crosses between MON 87708 soybean and conventional (non-GE) soybean cultivars, and those GE soybean varieties no longer subject to regulation as plant pests under the PPA and 7 CFR part 340. Monsanto has indicated it intends to cross MON 87708 soybean with MON 89788 (Roundup Ready 2 Yield soybean) utilizing traditional breeding techniques, producing a soybean variety with resistance to both dicamba and glyphosate (Monsanto, 2012a).

1.4.2 MON 88701 Cotton

APHIS Petition 12-185-01p is for a GE cotton (*Gossypium hirsutum*) variety designated as event MON 88701 cotton that is engineered for resistance to dicamba. It is also resistant to glufosinate, an herbicide that controls susceptible weeds by inhibition of photosynthesis, when applied at sufficient concentration to suppress susceptible weed species. The combined effects of these two traits enable MON 88701 cotton to outcompete weed species, which increases productivity of cotton fiber.

MON 88701 cotton will allow for expansion from the current EPA preplant cotton uses of dicamba. If the EPA approves the label for the new uses of dicamba on MON 88701 cotton (Monsanto, 2014b), in-crop applications of dicamba for control of broadleaf weeds would be allowed from preemergence to seven days preharvest. The use pattern and rate of glufosinate on MON 88701 cotton will follow the existing glufosinate-resistant cotton uses listed on current glufosinate herbicide labels. The glufosinate residues in MON 88701 cotton treated with commercial glufosinate rates are below the established pesticide residue tolerances for both cottonseed and gin by-products. No changes in the existing glufosinate label will be requested by Monsanto.

Monsanto will request a registration from EPA for the expanded uses of dicamba described here for MON 88701 cotton, an increase in the dicamba residue tolerance for cottonseed, the establishment of a tolerance for cotton gin by-products, and the inclusion of DCSA in the residue definitions for both cottonseed and gin by-products. No other revisions to the dicamba pesticide residue tolerances are necessary, including those for animal products such as meat, eggs, and milk.

Dicamba provides effective control of more than 95 annual and biennial weed species. It also suppresses more than 100 perennial broadleaf and woody plant species. Glufosinate, a broad-spectrum contact herbicide, provides nonselective control of approximately 120 broadleaf and grass weeds. When combined, dicamba and glufosinate provide control of HR weeds that include GR biotypes of Palmer amaranth (*Amaranthus palmeri*), marestail (*Conyza canadensis*), common ragweed (*Ambrosia artemisiifolia*), giant ragweed (*Ambrosia trifida*) and waterhemp (*Amaranthus tuberculatus*).

MON 88701 cotton contains a demethylase gene from *Stenotrophomonas maltophilia* that expresses a dicamba mono-oxygenase (DMO) protein to confer resistance to dicamba. The DMO protein rapidly demethylates dicamba to the herbicidally inactive metabolite 3,6-dichlorosalicylic acid (DCSA). DCSA has previously been identified as a metabolite of dicamba in cotton, soybean, livestock, and soil (Reeves and Weihrauch, 1979).

MON 88701 cotton also contains a bialaphos resistance (bar) gene from *Streptomyces hygroscopicus* that expresses the phosphinothricin N-acetyltransferase (PAT) protein to confer resistance to glufosinate. The PAT (bar1) protein acetylates the free amino group of glufosinate to produce non-herbicidal N-acetyl glufosinate. This metabolite occurs commonly in glufosinate-resistant plants. The use pattern and rate of glufosinate on MON 88701 cotton will follow the existing glufosinate-resistant cotton uses outlined on the EPA label for glufosinate. Glufosinate residues in MON 88701 cotton treated at commercial glufosinate rates are below the established pesticide residue tolerances for both cottonseed and gin by-products. Therefore, Monsanto will not seek any changes in tolerances associated with uses of glufosinate on MON 88701 cotton.

As indicated in Section 1.3, if MON 88701 cotton is no longer regulated, non-regulated status will extend to crosses between MON 88701 cotton and conventional (non-GE) cotton cultivars, and those GE cotton varieties no longer subject to regulation as plant pests under the PPA and 7 CFR part 340. Monsanto has indicated MON 88701 cotton will be stacked with Roundup Ready Flex Cotton and Bollgard II (MON 88913 and MON 15985) (Monsanto, 2013a). Roundup Ready Flex Cotton (MON 88913) is GE to exhibit resistance to glyphosate. Bollgard II (MON 15985) contains the Cry1Ac and Cry2Ab insecticidal proteins providing protection from feeding by a range of Lepidopteran species including: tobacco budworm (Heliothis virescens), pink bollworm (Pectinophora gossypiella), cotton bollworm (Helicoverpa zea), cabbage looper (Trichoplusia ni), saltmarsh caterpillar (Estigmene acrea), cotton leaf perforator (Bucculatrix thurbeiella), soybean looper (Pseudoplusia includens), beet armyworm (Spodoptera exigua), fall armyworm (Spodoptera frugiperda), yellowstriped armyworm (Spodoptera ornithogolli) and European corn borer (Ostrinia nubilalis) (Convention on Biological Diversity, 2014).

1.5 Coordinated Regulatory Framework for Genetically-Engineered Organisms

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

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

1) should define those transgenic organisms subject to review to the extent permitted by their respective statutory authorities;

2) are required to focus on the characteristics and risks of a biotechnology product, not the process by which it was created;

3) are intended to exercise oversight of GE organisms when there is evidence of "unreasonable" risk.

The Coordinated Framework explains the regulatory roles and authorities for the three major agencies involved in regulating GE organisms: USDA APHIS, the EPA, and the U.S. Food and Drug Administration (FDA). A summary of each role follows.

1.5.1 USDA-APHIS

As noted in Section 1.2, the PPA authorizes APHIS to regulate, manage and control plant pests. The PPA includes regulatory authority over the introduction (i.e., importation, interstate movement, or release into the environment) of certain GE organisms and products. A GE organism is considered a regulated article if the donor organism, recipient organism, vector, or vector agent used in engineering the organism belongs to one of the taxa listed in the regulation (7 CFR part 340.2) and is also considered a plant pest. A GE organism is also regulated under 7 CFR part 340, when APHIS has reason to believe that the GE organism may be a plant pest, or APHIS does not have sufficient information to determine if the GE organism is unlikely to be a plant pest risk. A GE organism is no longer subject to the plant pest provisions of the PPA or to the regulatory requirements of 7 CFR part 340, when APHIS determines that it is unlikely to pose a plant pest risk.

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

1.5.2 Environmental Protection Agency

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

Under FIFRA (7 U.S.C. 136 et seq.), the EPA requires registration of all pesticide products for all specific uses prior to distribution for sale. Before granting a registration, the EPA evaluates the following: toxicity of the ingredients of a pesticide product; the particular site or crop on which it is to be used; the amount, frequency, and timing of its use; storage and disposal requirements. Prior to registration for a new use for a new or previously registered pesticide, the

EPA must determine through specified test protocols conducted by the applicant that the pesticide does not cause unreasonable adverse effects on humans, the environment, and non-target species, when used in accordance with label instructions. The EPA is authorized under FIFRA to make these determinations on the basis of benefits exceeding associated risks of a pesticide. The EPA establishes restrictions that ensure that this test is met by approving specific language used on the pesticide label in accordance with 40 CFR part 158.

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

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

1.5.3 Food and Drug Administration

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

In June 2006, the FDA also published recommendations in “Guidance for Industry: Recommendations for the Early Food Safety Evaluation of New Non-Pesticidal Proteins Produced by New Plant Varieties Intended for Food Use” (US-FDA, 2014 (updated)). This establishes voluntary food safety evaluations for new non-pesticidal proteins produced by new plant varieties intended to be used as food, including GE plants. Early food safety evaluations help ensure that potential food safety issues related to a new protein in a new plant variety are addressed early in development. These evaluations are not intended as a replacement for a biotechnology consultation with the FDA, but the information may be used later in the biotechnology consultation.

1.6 Purpose and Need for this APHIS Action

APHIS is required to respond, consistent with its PPA authority and regulations at 7 CFR part 340.6, to two petitions submitted by Monsanto. As noted previously in Section 1.3, each petition is for a different GE HR event: APHIS Petition 10-188-01p for MON 87708 soybean (Monsanto, 2012a) and APHIS Petition 12-185-01p for MON 88701 cotton (Monsanto, 2012b).

In its submissions, the petitioner has provided information consistent with that described in §340.6(c)(4), which APHIS requires to inform it of the full range of biological and chemical properties of GE organisms, so the Agency can assess the plant pest risk(s) of each, and determine if they are unlikely to be a greater plant pest risk than the unmodified organisms from which they were derived. Therefore, APHIS must respond to the petitions from Monsanto that are the subject of this document. If the Agency determines that each GE-regulated article is unlikely to be a plant pest risk, it is no longer subject to the provisions of the PPA as implemented by the regulations of 7 CFR part 340.

As noted in Section 1.1, under the provisions of NEPA as amended (42 U.S.C. 4321 et seq), prior to implementation, Federal agencies must examine the potential impacts of proposed major actions that may significantly affect the quality of the human environment. In accordance with NEPA, regulations of the Council on Environmental Quality (CEQ) for implementing the procedural provisions of NEPA (40 CFR parts 1500-1508), USDA regulations implementing NEPA (7 CFR part 1 b), and the NEPA Implementing Procedures (7 CFR part 372) of APHIS, the Agency has considered how to properly examine the potential environmental impacts of its decisions for petitions for determination of nonregulated status.

For most petitions for a determination of nonregulated status of GE organisms that APHIS has evaluated previously, it has prepared an Environmental Assessment (EA) to provide the APHIS decisionmaker with a review and analysis that identifies whether there may be any significant environmental impacts. If the Agency makes a finding of no significant impact (FONSI), the NEPA process stops and a decision is issued. If significant environmental impacts are identified, the process continues with the preparation of an Environmental Impact Statement (EIS) before a determination is made.

However, preparation of a formal EA is not a requirement of the NEPA process when a pending Federal action is recognized as likely to have an environmental impact(s) if implemented. For MON 87708 soybean and MON 88701 cotton, APHIS made such a determination, and so has decided to prepare this draft EIS (DEIS) to provide Agency decisionmakers with a mechanism for examining the broad and cumulative impacts on the quality of the human environment[3] that may result from determinations of nonregulated status. APHIS has prepared this DEIS to be

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

consistent with NEPA/CEQ regulations and USDA-APHIS NEPA-implementing regulations and procedures (7 CFR part 1 b; 7 CFR part 372; 40 CFR parts 1500-1508).

1.7 Public Involvement

APHIS seeks public comment on petitions it receives that request a decision of non-regulatory status for GE organisms. When the Agency decides to prepare an EIS as part of its decisionmaking process for a petition, prior to preparation, it also seeks public comments as part of its advance scoping process. Details about the public involvement process for the petitions that are the subject of this document follow.

1.7.1 Public Comments for Petitions 10-188-01p and 12-185-01p

APHIS sought comments for the petitions that are the subject of this DEIS in a *Federal Register* notice dated July 13, 2012. Comments received for the petitions were influential, though not the sole basis, for the Agency's decision to prepare this DEIS. As part of its scoping process to identify issues to address in this DEIS, APHIS also published a Notice of Intent (NOI) to prepare this DEIS and sought public input during a comment period (May 10 to July 17, 2013).

Comments were submitted by individuals, academic researchers, non-government organizations (NGOs), and industry representatives. The majority of comments submitted by NGOs and individuals were opposed to determinations of nonregulated status for the petitions. The majority of comments submitted by industry and academia supported determinations of nonregulation for MON 87708 soybean and MON 88701 cotton.

Issues most frequently cited in public comments included the nature of agronomic inputs associated with these two new traits, potential impacts to plants from off-target herbicide drift, management of HR weeds, human health impacts of exposure to herbicides, and domestic and international economic impacts associated with the development and marketing of new HR products. A more detailed summary of these comments is provided in Appendix 2.

1.7.2 Issues Considered in This DEIS

The list of resource areas considered by APHIS in this document were identified in part from a review of: comments received for the petitions and the NOI; relevant concerns and issues cited in comments submitted by the public and various stakeholders in response to previous petitions and EAs for GE organisms; concerns identified in previous unrelated lawsuits. The following list includes the resource areas APHIS identified during this process, which are considered in this DEIS:

- Land Use
- Domestic Use of Soybeans and Cotton
- Exports of Soybeans and Cotton

- Food and Feed Safety
- Worker Safety
- Animal and Plant Communities
- Biodiversity
- Soil Quality
- Water Quality
- Air Quality
- Climate Change

2 ALTERNATIVES

This document analyzes the potential environmental consequences of a determination of nonregulated status of MON 87708 soybean and MON 88701 cotton. In responding to the petitions, APHIS must assess the plant pest risks associated with MON 87708 soybean and MON 88701 cotton. Based on its PPRAs (USDA-APHIS, 2014a; 2014b), APHIS has preliminarily concluded that MON 87708 soybean and MON 88701 cotton will not result in new plant pest risks or increase existing ones. Following the conclusion of the plant pest risk analysis process, APHIS considered possible alternatives and selected those appropriate for further evaluation in this DEIS.

2.1 Alternative Considered and Selected for Further Evaluation for This DEIS

APHIS evaluated four Alternatives in this DEIS: 1) No Action Alternative; 2) determination of nonregulated status of MON 87708 soybean and MON 88701 cotton (Preferred Alternative); 3) determination of nonregulated status only for MON 88701 cotton; 4) determination of nonregulated status only for MON 87708 soybean. APHIS has assessed the potential for environmental impacts for each Alternative in the Environmental Consequences chapter of this document.

2.1.1 Alternative 1: No Action Alternative - Continuation as Regulated Articles

Under the No Action Alternative, APHIS would deny the two petitions (Monsanto, 2012a; 2012b). MON 87708 soybean and MON 88701 cotton, and progeny derived from these event lines would continue to be regulated articles under the regulations at 7 CFR part 340. APHIS would still require permits or notifications for their introduction, and would continue to implement measures to ensure physical and reproductive confinement. APHIS could choose this Alternative if it determined that both of these cultivars were plant pests, or that there were insufficient data for APHIS to completely evaluate the potential plant pest risks associated with the unconfined cultivation of them. This Alternative is not the Preferred Alternative because APHIS evaluated the data and has preliminarily concluded in its PPRAs that MON 87708 soybean and MON 88701 cotton are unlikely to cause new, or increase plant pest risks (USDA-APHIS, 2014a; 2014b). Therefore, choosing this Alternative would be inconsistent with the purpose and need of making a determination based on scientific evidence about of plant pest risk status.

2.1.2 Alternative 2: Determination of Nonregulated Status of MON 87708 Soybean and MON 88701 Cotton (Preferred Alternative)

Under this Alternative, MON 87708 soybean and MON 88701 cotton and progeny derived from their cultivation would no longer be subject to APHIS biotechnology regulations. APHIS would no longer require permits or notifications for introductions of these varieties because they are unlikely to pose plant pest risks (USDA-APHIS, 2014a; 2014b). Therefore, this is the Preferred Alternative because a determination of nonregulated status for both varieties, MON 87708 soybean and MON 88701 cotton, would be consistent with the plant pest provisions of the PPA, the regulations codified in 7 CFR part 340, and the biotechnology regulatory policies in the Coordinated Framework.

2.1.3 Alternative 3: Determination of Nonregulated Status Only for MON 88701 Cotton

Under this Alternative, only MON 88701 cotton and progeny derived from its cultivation would no longer be subject to regulations. MON 87708 soybean would continue to be regulated as described under Alternative 1. APHIS would no longer require permits or notifications for introductions of MON 88701 cotton and progeny derived from this event because it is unlikely to cause new plant pest risks or increase existing ones (USDA-APHIS, 2014b). APHIS would choose this Alternative if it determined that MON 87708 soybean was a plant pest itself, increased existing plant pest risks, or that available data were not sufficient to complete an evaluation of potential plant pest risks associated with the unconfined cultivation of MON 87708 soybean. However, APHIS has preliminarily concluded as part of its plant pest risk assessment process that this variety is unlikely to pose a plant pest risk, or increase existing plant pest risks Therefore, such a choice would be inconsistent with the purpose and need of making a determination of plant pest risk status based on scientific evidence, the provisions the plant pest provisions of the PPA, and the regulations codified in 7 CFR part 340 and the biotechnology regulatory policies in the Coordinated Framework.

2.1.4 Alternative 4: Determination of Nonregulated Status Only for MON 87708 Soybean

Under this Alternative, only MON 87708 soybean, and progeny derived from its cultivation would no longer be subject to regulations. MON 88701 cotton would continue to be regulated as described under Alternative 1. APHIS would no longer require permits or notifications for introductions of MON 87708 soybean and progeny derived from this variety because it is unlikely that it poses a plant pest risk or increase existing ones (USDA-APHIS, 2014a). APHIS would choose this Alternative if it determined that MON 88701 cotton was a plant pest, increased existing plant pest risks, or that there was insufficient evidence to demonstrate the lack of plant pest risk from the unconfined cultivation of MON 88701 cotton. However, APHIS has preliminarily concluded as part of its plant pest risk assessment process that this variety is unlikely to pose a plant pest risk, or increase existing plant pest risks. Therefore, such a choice would be inconsistent with the purpose and need of making a determination of plant pest risk status based on scientific evidence, the plant pest provisions of the PPA, and the regulations codified in 7 CFR part 340 and the biotechnology regulatory policies in the Coordinated Framework.

2.2 Alternatives Considered but Not Selected for Further Evaluation

APHIS assembled a list of Alternatives considered for MON 87708 soybean and MON 88701 cotton. The Agency evaluated these Alternatives in accordance with its authority under the plant pest provisions of the PPA, and the regulations at 7 CFR part 340. In this evaluation APHIS considered environmental safety, efficacy, and practicality to identify those Alternatives the Agency would further consider for MON 87708 soybean and MON 88701 cotton. Based on this evaluation, APHIS rejected several Alternatives. These Alternatives are described briefly below with the specific reasons for rejecting each.

2.2.1 Prohibit Any MON 87708 Soybean and MON 88701 Cotton from Being Released

In response to public comments that stated a preference that no GE organisms enter the marketplace, APHIS considered prohibiting the release of MON 87708 soybean and MON 88701 cotton, including denial of any permits associated with field testing. APHIS determined that this Alternative is not appropriate because APHIS has preliminarily concluded that MON 87708 soybean and MON 88701 cotton are unlikely to pose new plant pest risks or increase the risks associated with existing ones (USDA-APHIS, 2014a; 2014b). Therefore, there is no basis in science for prohibiting the release of these varieties under the regulations at 7 CFR part 340.

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

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

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

Consistent with this guidance and based on the findings and scientific data evaluated for the PPRAs (USDA-APHIS, 2014a; 2014b), APHIS has preliminarily concluded that MON 87708 soybean and MON 88701 cotton are unlikely to pose a plant pest risk. Therefore, there is no basis in science for prohibiting the release of these varieties under the regulations at 7 CFR part 340.

2.2.2 Approve the Petition(s) in Part

The regulations at 7 CFR part 340.6(d)(3)(i) state that APHIS may "approve the petition in whole or in part." However, APHIS has preliminarily concluded that MON 87708 soybean and MON 88701 cotton are not likely to pose any new plant pest risks, nor increase any existing ones, so there is no basis in science for prohibiting the release of these varieties under the regulations at 7 CFR part 340.

2.2.3 Production/Geographical Restrictions to Isolate MON 87708 Soybean and MON 88701 Cotton from Non-GE Soybean or Cotton

In response to public concerns of gene movement between GE and non-GE plants, APHIS considered requiring isolation distances separating MON 87708 soybean and MON 88701 cotton from non-GE soybean or cotton production. However, because APHIS has preliminarily concluded that MON 87708 soybean and MON 88701 cotton are unlikely to pose plant pest risks (USDA-APHIS, 2014a; 2014b), an Alternative based on requiring isolation distances would be inconsistent with the Agency's statutory authority under the plant pest provisions of the PPA and regulations in 7 CFR part 340.

APHIS also considered geographically restricting the production of MON 87708 soybean and MON 88701 cotton based on the location of organic production systems of non-GE soybean and cotton, or production systems for GE-sensitive markets in response to public concerns regarding possible gene movement between GE and non-GE plants. However, as presented in the APHIS PPRA (USDA-APHIS, 2014a; 2014b), there are no geographic differences associated with any identifiable plant pest risks for MON 87708 soybean and MON 88701 cotton. This Alternative was not analyzed in detail because APHIS has preliminarily concluded that MON 87708 soybean and MON 88701 cotton are not likely to pose new plant pest risks, nor increase and exhibit a greater plant pest risk in any geographic area. Therefore, there is no basis in science for prohibiting the release of these varieties under the regulations at 7 CFR part 340.

Individuals might choose on their own to geographically isolate their non-GE soybean or cotton production systems from MON 87708 soybean and MON 88701 cotton, or to use isolation distances and other management practices to minimize gene movement between soybean and cotton fields. Information to assist growers in making informed management decisions to effectively isolate their crop varieties from other varieties (including MON 87708 soybean and MON 88701 cotton) is available from the American Organization of Seed Certifying Agencies (AOSCA, 2010).

2.2.4 Requirement of Testing for MON 87708 Soybean and MON 88701 Cotton

During the comment periods for other petitions for nonregulated status, some commenters requested that USDA require and provide testing for GE products in non-GE production systems. However, because APHIS has preliminarily concluded that MON 87708 soybean and MON 88701 cotton are not likely to pose new plant pest risks nor increase existing ones (USDA-APHIS, 2014a; 2014b), testing requirements are inconsistent with the plant pest provisions of the PPA, the regulations at 7 CFR part 340 and the biotechnology regulatory policies of the Coordinated Framework. Therefore, there is no scientific basis for prohibiting or regulating releases of these varieties under the regulations at 7 CFR part 340.

2.3 Comparison of Alternatives

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

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

Attribute/Measure	**Alternative 1: No Action (Deny Both Petitions)**	**Alternative 2: Preferred Alternative- Determination of Nonregulated Status for MON 87708 Soybean and MON 88701 Cotton**	**Alternative 3: Determination of Nonregulated Status Only for MON 88701 Cotton**	**Alternative 4: Determination of Nonregulated Status Only for MON 87708 Soybean**
Meets Purpose and Need	No	Yes	Partially	Partially
Land Use	Soybean plantings are anticipated to increase somewhat through 2020 (USDA-OCE, 2013). Cotton plantings are anticipated to fluctuate as market prices change. Locations of soybean and cotton production are not expected to change.	Plantings generally the same as Alternative 1. The deregulated varieties might replace other soybean or cotton varieties currently grown in the U.S. Locations of production unchanged.	Plantings generally the same as Alternative 1. The deregulated cotton variety might replace other varieties currently grown in the U.S. Locations of production unchanged.	Plantings generally the same as Alternative 1. The deregulated soybean variety might replace other varieties currently grown in the U.S. Locations of production unchanged.
Economic Aspects	The U.S. will continue to be an exporter of soybeans and cotton. It is the responsibility of food and feed manufacturers to ensure that the products they market are safe and labeled properly. The percentage of GE varieties in the market will not change.	Monsanto has submitted or is planning to submit requests for regulatory approvals in the main export markets for these varieties of soybean and cotton. These traits are not substantially different from what is already in commerce. Their presence in exported commodities will not affect trade differently than that of other currently approved GE traits in commerce.	Monsanto has submitted or is planning to submit requests for regulatory approvals in the main export markets for this variety of cotton. This trait is not substantially different from what is already in commerce. Its presence in exported commodities will not affect trade differently than that of other currently approved GE traits in commerce.	Monsanto has submitted or is planning to submit requests for regulatory approvals in the main export markets for this variety of soybean. This trait is not substantially different from what is already in commerce. Its presence in exported commodities will not affect trade differently than that of other currently approved GE traits in commerce. The percentage of

Attribute/Measure	Alternative 1: No Action (Deny Both Petitions)	Alternative 2: Preferred Alternative- Determination of Nonregulated Status for MON 87708 Soybean and MON 88701 Cotton	Alternative 3: Determination of Nonregulated Status Only for MON 88701 Cotton	Alternative 4: Determination of Nonregulated Status Only for MON 87708 Soybean
		The percentage of GE varieties in the market will not substantially change.	The percentage of GE varieties in the market will not substantially change.	GE varieties in the market will not substantially change.
Agronomic Practices	Weeds resistant to other herbicides will continue to increase. As HR weeds become more prevalent, growers are expected to shift to more costly alternative weed control measures or other weed-resistant crops that are economically viable. Conventional growers are likely to use additional herbicides and/or abandon conservation tillage practices and return to more aggressive conventional tillage systems to maintain yields.	Use of dicamba and glufosinate in soybean and cotton cropping systems is expected, but this is contingent on EPA's decision to label these herbicides for these crop varieties. More efficient weed control is expected to reduce the need for more aggressive tillage. Conventional growers are likely to use fewer herbicides and retain or increase conservation tillage practice, if resistant weeds do not develop over time.	Use of dicamba and glufosinate in cotton is expected, but this is contingent on EPA's decision to label these herbicides for this cotton variety. More efficient weed control is expected to reduce the need for more aggressive tillage. Conventional growers are likely to use fewer herbicides and retain or increase conservation tillage practice, if resistant weeds do not develop over time.	Use of dicamba in soybean is expected, but this is contingent on EPA's decision to label this herbicide for this soybean variety. More efficient weed control is expected to reduce the need for more aggressive tillage. Conventional growers are likely to use fewer herbicides and retain or increase conservation tillage practice, if resistant weeds do not develop over time.
Organic Production Systems	Planting of organic soybeans and cotton are not likely to change, but production could become more difficult if the abundance of HR weeds increases.	Planting of organic soybeans and cotton are not likely to change, but production could become more difficult if the abundance of HR weeds increases.	Planting of organic cotton is not likely to change, but production could become more difficult if the abundance of HR weeds increases.	Planting of organic soybeans is not likely to change, but production could become more difficult if the abundance of HR weeds increases.
Use of GE Crops:	Planting of GE HR	Planting of GE HR	Planting of GE HR	Planting of GE HR

Attribute/Measure	Alternative 1: No Action (Deny Both Petitions)	Alternative 2: Preferred Alternative-Determination of Nonregulated Status for MON 87708 Soybean and MON 88701 Cotton	Alternative 3: Determination of Nonregulated Status Only for MON 88701 Cotton	Alternative 4: Determination of Nonregulated Status Only for MON 87708 Soybean
Herbicide and Resistant Weed Aspects	crops is likely to increase as multiply-resistant weeds increase. However, organic growers do not use herbicides.	crops is likely to increase as multiply-resistant weeds increase. Organic growers do not use herbicides.	crops is likely to increase as multiply-resistant weeds increase. Organic growers do not use herbicides.	crops is likely to increase as multiply-resistant weeds increase. Organic growers do not use herbicides.
Human Health and Safety	Soybean and cotton varieties are associated with all the normal risks of agricultural production. EPA label use restrictions are designed to protect humans during herbicide use in soybean and cotton cropping systems to achieve a standard of a “reasonable certainty of no harm”.	These varieties do not present any additional risks to workers. The revised EPA label use restrictions for soybean and cotton are designed to achieve the same level of human health and safety as those that currently exists for non-GE varieties.	This variety does not present any additional risks to workers. The revised EPA label use restrictions for cotton are designed to achieve the same level of human health and safety as those that currently exists for non-GE varieties.	This variety does not present any additional risks to workers. The revised EPA label use restrictions for soybean are designed to achieve the same level of human health and safety as those that currently exists for non-GE varieties.
Biological Diversity	Cropping systems generally are not expected to change, so biodiversity in regions where soybean and cotton are produced will not change. Herbicide use may decrease weed prevalence or modify the weed species complex in some regions. These changes could modify the	Crop biodiversity is not substantially increased. Use of these varieties will allow for increased conservation tillage, which will not decrease biodiversity and might increase it. Use of these crops will require less overall herbicide use, which will not	Crop biodiversity is not substantially increased. Use of this cotton variety will allow for increased conservation tillage, which will not decrease biodiversity and might increase it. Use of this cotton variety will require less overall herbicide use,	Crop biodiversity is not substantially increased. Use of this soybean variety will allow for increased conservation tillage, which will not decrease biodiversity and might increase it. Use of this soybean variety will require less overall herbicide use, which

Attribute/Measure	Alternative 1: No Action (Deny Both Petitions)	Alternative 2: Preferred Alternative- Determination of Nonregulated Status for MON 87708 Soybean and MON 88701 Cotton	Alternative 3: Determination of Nonregulated Status Only for MON 88701 Cotton	Alternative 4: Determination of Nonregulated Status Only for MON 87708 Soybean
	species complex of organisms that rely on these weeds as a food source or habitat.	reduce biodiversity and might increase it. Selection pressure for dicamba and glufosinate resistance in weed populations may modify the weed species complex in some regions, which might modify the species complex of organisms that rely on these weeds as a food source or habitat.	which will not reduce biodiversity and might increase it. Selection pressure for dicamba and glufosinate resistance in weed populations may modify the weed species complex in some regions, which might modify the species complex of organisms that rely on these weeds as a food source or habitat.	will not reduce biodiversity and might increase it. Selection pressure for dicamba resistance in weed populations may modify the weed species complex in some regions, which might modify the species complex of organisms that rely on these weeds as a food source or habitat.
Animal Communities	Cultivated soybean and cotton currently provide limited food and habitat for wildlife in regular cropping situations.	Expected to be the same as Alternative 1 because toxicological studies and studies of allergenicity of the added traits did not reveal any impacts on animals.	Expected to be the same as Alternative 1 because toxicological studies and studies of allergenicity of the added trait did not reveal any impacts on animals.	Expected to be the same as Alternative 1 because toxicological studies and studies of allergenicity of the added trait did not reveal any impacts on animals.
Plant Communities / Weed Complexes	Currently cultivated soybean and cotton varieties are not potential plant pests because they do not compete with native plant species, so do not adversely impact natural plant communities. Selection pressure for HR weed	These varieties are not potential plant pests because they do not compete with native plant species and lack the potential to do so, so will not adversely impact natural plant communities. Selection pressure to develop dicamba and glufosinate resistance in weed	This variety is not a potential plant pests because it does do not compete with native plant species and lacks the potential to do so, so will not adversely impact natural plant communities. Selection pressure to develop dicamba and glufosinate	This variety is not a potential plant pests because it does do not compete with native plant species and lacks the potential to do so, so will not adversely impact natural plant communities. Selection pressure to develop dicamba resistance in weed populations will

Attribute/Measure	Alternative 1: No Action (Deny Both Petitions)	Alternative 2: Preferred Alternative- Determination of Nonregulated Status for MON 87708 Soybean and MON 88701 Cotton	Alternative 3: Determination of Nonregulated Status Only for MON 88701 Cotton	Alternative 4: Determination of Nonregulated Status Only for MON 87708 Soybean
	development will continue.	populations will increase, including the potential for development of weeds with multiple resistance to more than one herbicide mode of action.	resistance in weed populations will increase, including the potential for development of weeds with multiple resistance to more than one herbicide.	increase, including the potential for development of weeds with multiple resistance to more than one herbicide.
Soil Quality	Increased tillage to manage herbicide resistant weeds may occur in soybean and cotton cropping systems and cause decreased soil quality from increased soil erosion.	Decreased tillage accompanied by decreased soil erosion. These varieties are not expected to change the existing composition of soil microflora in cropping systems.	Decreased tillage accompanied by decreased soil erosion. This variety is not expected to change the existing composition of soil microflora in cropping systems.	Decreased tillage accompanied by decreased soil erosion. This variety is not expected to change the existing composition of soil microflora in cropping systems.
Water Quality	Increased tillage to manage HR weeds may occur in soybean and cotton cropping systems. This could increase evaporative water loss and demand on water resources for irrigation, and cause increased soil erosion accompanied by diminished water quality from sedimentation.	These varieties will promote continued or increased use of current conservation tillage practices in the short term. In the long term, development of more HR weeds may be accompanied by increased tillage with negative impacts (as described in the No Action Alternative).	This variety will promote continued or increased use of current conservation tillage practices in the short term. In the long term, development of more HR weeds may be accompanied by increased tillage with negative impacts (as described in the No Action Alternative).	This variety will promote continued or increased use of current conservation tillage practices in the short term. In the long term, development of more HR weeds may be accompanied by increased tillage with negative impacts (as described in the No Action Alternative).
Air Quality	Increased tillage to manage HR weeds may occur in soybean and cotton cropping systems. This could reduce	Use of these varieties is expected to decrease tillage. This will be accompanied by a reduction in	Use of this variety is expected to decrease tillage. This will be accompanied by a reduction in	Use of this variety is expected to decrease tillage. This will be accompanied by a reduction in airborne particulates and

Attribute/Measure	Alternative 1: No Action (Deny Both Petitions)	Alternative 2: Preferred Alternative- Determination of Nonregulated Status for MON 87708 Soybean and MON 88701 Cotton	Alternative 3: Determination of Nonregulated Status Only for MON 88701 Cotton	Alternative 4: Determination of Nonregulated Status Only for MON 87708 Soybean
	air quality from increased air particulates and exhaust from farm equipment. Increased use of herbicides may occur to manage HR weeds. This would increase drift from herbicides that would reduce air quality.	airborne particulates and exhaust emissions, which will increase air quality. Overall use of herbicides will remain the same or be reduced by better management of HR weeds. Drift from herbicides will remain the same or be reduced, resulting in no change or improved air quality.	airborne particulates and exhaust emissions, which will increase air quality. Overall use of herbicides will remain the same or be reduced by better management of HR weeds. Drift from herbicides will remain the same or be reduced, resulting in no change or improved air quality.	exhaust emissions, which will increase air quality. Overall use of herbicides will remain the same or be reduced by better management of HR weeds. Drift from herbicides will remain the same or be reduced, resulting in no change or improved air quality.
Climate Change	Increased tillage to manage HR weeds may occur in soybean and cotton cropping systems. This would Increase the release of GHGs (primarily CO_2 and methane).	Use of these varieties is expected to decrease tillage. This will be accompanied by a reduction in the release of GHGs (primarily CO_2 and methane).	Use of this variety is expected to decrease tillage. This will be accompanied by a reduction in the release of GHGs (primarily CO_2 and methane).	Use of this variety is expected to decrease tillage. This will be accompanied by a reduction in the release of GHGs (primarily CO_2 and methane).
Other U.S. Regulatory Approvals: FDA Consultations and EPA Registrations	Consultations with FDA and changes to EPA registrations would be unnecessary.	Monsanto completed consultations with FDA for MON 87708 soybean on October 11, 2011 (BNF No. 00125) and for MON 88701 cotton on April 24, 2013 (BNF No. 000135). The EPA	Monsanto completed consultations with FDA for MON 88701 cotton on April 24, 2013 (BNF No. 000135). The reregistration decision for dicamba was issued in 2006 (US-EPA, 2006). The EPA	Monsanto completed consultations with FDA for MON 87708 soybean on October 11, 2011 (BNF No. 00125). The reregistration decision for dicamba was issued in 2006 (US-EPA, 2006). The EPA concluded that dicamba and its

Attribute/Measure	Alternative 1: No Action (Deny Both Petitions)	Alternative 2: Preferred Alternative- Determination of Nonregulated Status for MON 87708 Soybean and MON 88701 Cotton	Alternative 3: Determination of Nonregulated Status Only for MON 88701 Cotton	Alternative 4: Determination of Nonregulated Status Only for MON 87708 Soybean
		reregistration decision for dicamba was issued in 2006 (US-EPA, 2006). EPA concluded that dicamba and its metabolites were below the Agency's level of concern for all registered uses of dicamba including soybean and cotton (US-EPA, 2009b). The registration decision for glufosinate was issued in 2000 for crop use (US-EPA, 2008). The EPA is currently evaluating the proposed new uses of dicamba for MON 87708 soybean and MON 88701 cotton.	concluded that dicamba and its metabolites were below the Agency's level of concern for all registered uses of dicamba including cotton (US-EPA, 2009b). The registration decision for glufosinate was issued in 2000 for crop use (US-EPA, 2008). The EPA is currently evaluating the proposed new uses of dicamba for MON 87708 soybean and MON 88701 cotton.	metabolites were below the Agency's level of concern for all registered uses of dicamba including soybean (US-EPA, 2009b). The registration decision for glufosinate was issued in 2000 for crop use (US-EPA, 2008). The EPA is currently evaluating the proposed new uses of dicamba for MON 87708 soybean and MON 88701 cotton.
Applicable U.S. Laws	Compliant	Compliant	Compliant	Compliant

3 AFFECTED ENVIRONMENT

Cotton and soybean production regions of the conterminous U.S. may be affected by a determination of nonregulated status for MON 87701 cotton and MON 88708 soybean. This chapter includes a review of the prevailing conditions in the human environment in those regions. Background information about the economics and production practices associated with cotton and soybean production is provided followed by descriptions of twelve major components of the human environment and how they might be affected if MON 87701 cotton and/or MON 88708 soybean were no longer regulated as plant pests.

Relevant components of the physical environment, biological resources, human health, animal feed, and socioeconomic resources are considered. They include soil, water and air quality, climate change, land cover and land uses, cotton and soybean production practices, animal communities, food and feed uses, worker safety and agricultural markets.

3.1 U.S. Cotton and Soybean Economics

The many and varied products derived from cotton and soybean are why these crops are important both domestically and as export commodities. This section describes some of the economics and production practices associated with these two crops.

3.1.1 U.S. Cotton Economics

Cotton (*Gossypium* spp.) is the world's most widely grown textile fiber crop, accounting for over 40% of fiber production in the world (Meyer et al., 2007). The major cotton by-products include an edible oil from seeds, as well as the use of chaff (hulls and linters), high-protein cake, and flour as livestock feed (OECD, 2008). The most commonly cultivated species in the U.S. is upland cotton (*G. hirsutum*), comprising 97% of the cotton crop, ranging in 17 states from Virginia to California (USDA-NASS, 2014a). Upland cotton is also known as short staple cotton based on the relative length of the cotton fibers (Rude, 1984). The remainder is Pima (extra-long staple [ELS] or Egyptian) cotton (*G. barbadense*) cultivated in Arizona, California, New Mexico, and Texas (Pleasants and Wendell, 2005; USDA-NASS, 2014a). The U.S. is the third largest producer of cotton after China and India (USDA-FAS, 2014).

Cotton is cultivated in tropical and subtropical zones (OECD, 2008). It is a perennial plant cultivated as an annual (Smith and Cothren, 1999; Boyd *et al.*, 2004b). It is geographically more limited than other major crops in the U.S. because its growth requires a minimum of 180 frost-free days per year (Rude, 1984; Smith and Cothren, 1999; OECD, 2008).

Cotton is generally grown in deep arable soils with good drainage and a high moisture-retention capacity (OECD, 2008). Ideal cotton production requires at least 500 millimeters (mm) rainfall during the growing season for non-irrigated upland crops. However, it is also grown as an irrigated crop, where careful timing of irrigation optimizes flowering and boll production (OECD, 2008).

Good cotton management allows the plant to produce a high yield at a reasonable cost by channeling energy into harvestable seed cotton within the limitations imposed by soil, length of season, and production cost (Rude, 1984). Particularly in upland varieties, boll maturation is dominant over vegetative growth and formation of new flower buds (called "squares"), once the plant begins to set bolls. If too few of the ovules are fertilized, the fruit drops within 10 days of flowering. During the post-harvest ginning process, longer cotton lint fibers are separated from the harvested seed cotton. Unfertilized ovules within a fruit that fully develops remain as contaminants or "motes" within the lint. Shorter fuzz fibers (called linters) remain attached to the seed after ginning (Rude, 1984; Boyd *et al.*, 2004b), and cottonseed oil processing begins with these materials.

The recent Agricultural Outlook Forum summarized recent economic aspects of cotton production (Johnson et al., 2014):

> *"U.S. all-cotton production in 2013/14 is estimated at 13.2 million bales, 24% lower than last season's crop. Cotton planted acreage decreased 15% (nearly 2 million acres) in 2013 as relative crop prices favored the planting of alternative crops. Cotton area this season was its lowest since 2009. Severe drought conditions continued for much of the Southwest in 2013, keeping U.S. abandonment near 25% for a second consecutive season, compared with the 10-year average of 14%. In 2013, the U.S. yield averaged 826 pounds per harvested acre, below 2012's record of 887 pounds but the second highest since 2007. Upland production is currently estimated at about 12.6 million bales—approximately 4 million below 2012—with an average yield of 807 pounds per harvested acre, well below 2012's 869-pound record. The extra-long staple (ELS) crop (also known as Pima cotton) also is estimated lower—at 636,000 bales—as smaller area and a lower yield reduced the crop to its smallest in three seasons.*
>
> *"Compared with last season, 2013/14 upland cotton production was lower in each of the Cotton Belt regions. Production decreased in the Southwest as lower area more than offset a higher yield. With 2013 Southwest cotton plantings at 6 million acres, the region accounted for 59% of the total U.S. upland plantings and the largest since 1980. Southwest harvested area approached 3.4 million acres, below the 5-year average, as above-average abandonment --- 44% --- occurred for the third consecutive season. As a result, the Southwest upland crop reached 4.5 million bales in 2013/14, accounting for 36% of upland production. "For the Southeast, planted acreage in 2013 was about unchanged at nearly 2.7 million acres. A yield of 811 pounds per harvested acre is considerably lower than 2012's record yield of 1,033 pounds. The 2013/14 Southeast crop only approached 4.5 million bales, the lowest in three seasons. For the Delta, 2013 planted area decreased to a record low of 1.2 million acres, 39% below 2012. Although a record yield of 1,085 pounds per harvested acre helped offset some of the area decline, the 2013/14 Delta crop of 2.7 million bales was the second lowest in three decades.*
>
> *"In the West, 2013 upland area declined to 292,000 acres, the second lowest behind the 2009 season. With an average yield of 1,470 pounds per harvested acre, upland*

production in the West decreased to 870,000 bales, one of the lowest on record. The ELS crop remains concentrated in the West, and with ELS production at 636,000 bales, total cotton production in the West region reached 1.5 million bales."

U.S. Cotton Area, Abandonment, Yield, and Production					
	2009/10	**2010/11**	**2011/12**	**2012/13**	**2013/14**
Planted acres (million acres)	9.2	11.0	14.7	12.3	10.4
Harvested acres (million acres)	7.5	10.7	9.5	9.4	7.7
Abandonment rate (percent)	17.7	2.5	35.8	23.9	26.4
Yield (lb/acre harvested)	777	812	790	887	826
Production (millions of bales)	12.2	18.1	15.6	17.3	13.2

According to the 2007 Census of Agriculture, upland cotton was harvested in 631 U.S. counties or county equivalents (20%) (USDA-NASS, 2009d) (Figure 1). Production occurs in Alabama, Arizona, Arkansas, California, Florida, Georgia, Kansas, Kentucky, Louisiana, Mississippi, Missouri, New Mexico, North Carolina, South Carolina, Tennessee, Texas, and Virginia (USDA-NASS, 2009d). Five of these states (Texas, Georgia, Arkansas, North Carolina, and Mississippi) account for approximately 75% of the total U.S. crop (USDA-NASS, 2009d). Limited cotton production also occurs in Puerto Rico for breeding and as a seed crop (Monsanto, 2004; Bayer, 2006). Naturalized or feral populations of cotton grow in Florida, Hawaii, Puerto Rico, and the Virgin Islands (Fryxell 1984; Bates, 1990; Coile and Garland, 2003; Wunderlin and Hansen, 2008; USDA-NRCS, 2012c).

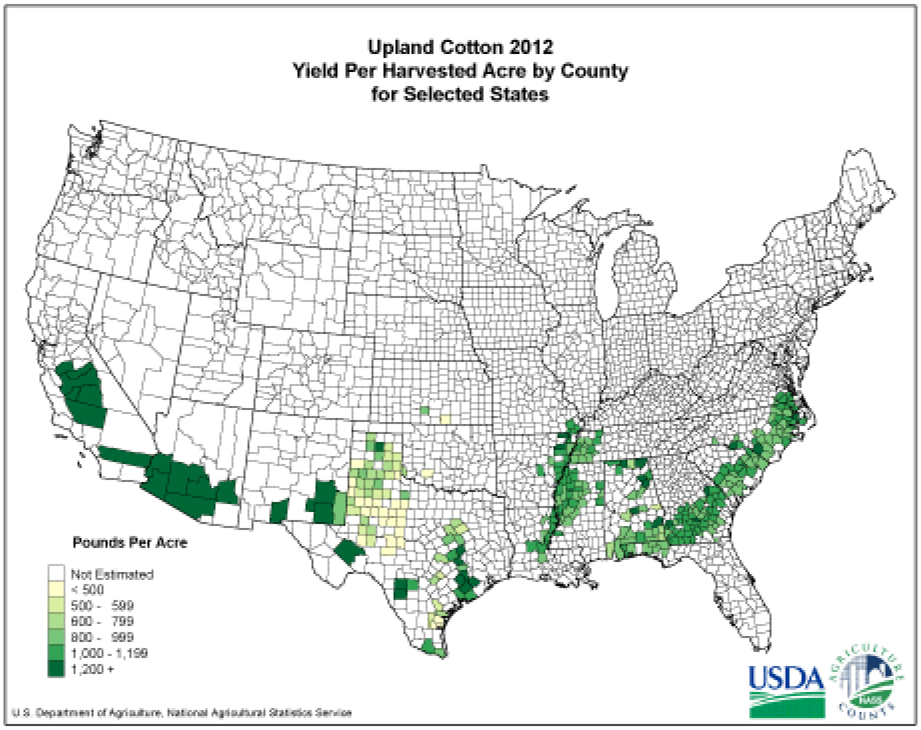


Figure 1. Upland Cotton 2012 Yield per Harvested Acre by County for Selected States.
Source: (USDA-NASS, 2013h)

3.1.2 U.S. Soybean Economics

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

According to the 2007 Census of Agriculture, soybeans were harvested in 2,039 U.S. counties or county equivalents (66%) (USDA-NASS, 2009d). U.S. soybean production totaled 3.29 billion bushels in 2013, an increase of 8% from 2012. This is the third largest yield on record (USDA-NASS, 2014a). The average yield per acre is estimated at 43.3 bushels, which is 3.5 bushels more than the 2012 yield (USDA-NASS, 2014a). The harvested area of 85.9 million acres, although the fourth highest on record, was slightly less than 2012 acreage (USDA-NASS, 2014a).

The value of U.S. soybean production for beans exceeded $43 billion in 2012 (USDA-NASS, 2013e), which was 23% of the total value of field and miscellaneous crops in 2012. The U.S. heartland (Illinois, Indiana, Iowa, Kentucky, Minnesota, Missouri, and Ohio) accounted for more than 58% of the total U.S. crop value in 2012. There is significant variation in yields and costs across soybean production regions.

Soybean exports in the form of bulk beans, meal, and oil are a major share of the total agricultural exports for the U.S., representing 16.1% of the total value of U.S. agricultural exports. Bulk soybeans accounted for $17.59 billion of the total U.S. agricultural exports ($136 billion in 2011) (USDA-ERS, 2013b),, ranking first among all agricultural commodities. Soybean meal ($3.2 billion) and soybean oil ($1.3 billion), ranked 11th and 22nd, respectively (USDA-ERS, 2012c). As a percentage of global exports, the U.S. accounted for 38% of bulk soybeans, 13% of soybean meal, and 11% of soybean oil in 2011/12 (USDA-ERS, 2012c).

In 2011/12 soybean meal represented 67% of the protein meal produced worldwide, although soybean oil ranked behind palm oil in terms of worldwide vegetable oil production (USDA-ERS, 2012c). In terms of consumption, soybeans yielded the largest share of protein meal consumed worldwide, mainly as animal feed. As a vegetable oil source, soybean oil consumption was second only to palm oil (USDA-FAS, 2013b).

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

From 1990-2013, U.S. acreage planted with soybeans increased from 59 million to more than 77 million acres (Figure 2). It is now the second most widely planted crop in the U.S. after corn. The increase in soybean acreage is related to strong prices, the absence of acreage set-aside programs, increased types of crop rotation strategies, and optimum soybean planting conditions. The top five soybean producing states (Iowa, Illinois, Minnesota, Indiana, and Nebraska) accounted for more than half of the total U.S. crop in 2012 (USDA-NASS, 2013e).

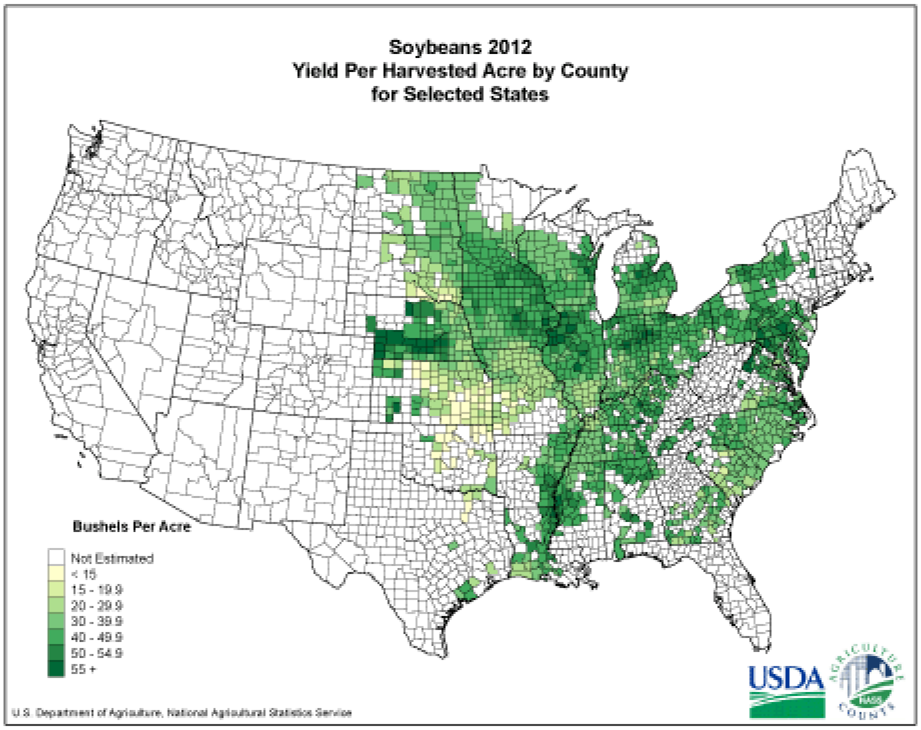


Figure 2. Soybeans 2012 Yield per Harvested Acre by County for Selected States.
Source: (USDA-NASS, 2013g)

Soybeans yield both solid (meal) and liquid (oil) products. Soybean meal is high in protein and is used for products such as tofu, soymilk, meat replacements, and protein powder. It also provides a natural source of dietary fiber (USB, 2009). Nearly 98% of soybean meal produced in the U.S. is used as animal feed. Less than 2% is used to produce soybean flour and proteins for human consumption (Soyatech, 2011). Poultry consume more than 45% of domestic soybean meal (about 590 million bushels of the U.S. crop). Soybean oil is used increasingly to replace animal fats and oils in broiler diets (USB, 2011). Soybean can be the dominant component of livestock diets (e.g., about 66% of protein in poultry diets is derived from soybeans (Waldroup and Smith, No Date)).

Other animals fed domestic soybean (by crop volumes consumed) include swine (26%), beef cattle (12%), dairy cattle (9%), farm-raised fish (3%), and household pets (2%) (Soy Stats, 2010; USB, 2011). Soybean plant material is also used as forage, hay, and silage for livestock (Blount et al., 2009). Specific varieties of soybean exist for grazing and hay, but the whole plant has feeding value (Weiderholt and Albrecht, 2003)Specific varieties of soybean exist for grazing and hay, but the whole plant has feeding value (Weiderholt and Albrecht, 2003).

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

3.2 U.S. Cotton and Soybean Production

Most U.S. soybean acreage is located in the Midwest and along the east coast. Cotton is confined to the southern tier of the country.

3.2.1 Major U.S. Cotton and Soybean Production Regions

Major cotton- and soybean-growing regions in the continental U.S are shown in Figure 1and 2, respectively. Little or no cotton and/or soybean production occurs in Hawaii, Alaska, and the U.S. territories, so these regions are not included in the figures (Figure 1and Figure 2). The data in Figure 1and 2 were used to identify the criteria described in Section 3.2.2 and define the ecoregions of the affected environment (Figure 3). The primary locations of cotton and soybean cultivation within Regions A to M are described in Table 2. For each of these cotton or soybean producing regions, the corresponding Level I ecoregion is used to describe the physical terrain and climate. These are broad descriptions based on the ecoregion’s characteristics, and demonstrate the wide range of soil types, land, and climatic features.

3.2.2 Ecoregions of the Affected Environment

The 13 regions (A-M) of the affected environment (Figure 3) reviewed in this document represent the principal U.S. cotton- and soybean-growing areas. The Regions (A-M; Figure 3) are based on the identification of contiguous groups of counties that exceed a threshold. The threshold used to determine if a county was included in a region was the number of cotton or soybean acres (USDA-NASS, 2009d) multiplied by a constant (100) and the percentage of total cropland in that county that the crop covers. If the result exceeded 100,000 and the county was contiguous with another county that exceeded the100-thousand threshold, then the county was included as part of the affected environment reviewed in this document. Idle cropland was excluded from the calculations.

For example, if 20,000 acres of cotton were harvested in a county, and this represented 6% of the total cropland in that county, the index number is 120 thousand. If the county was contiguous with another county with an index exceeding 100 thousand, then the county was included as part of the affected environment reviewed in this document.

Using this method, over 90% of the total soybean and cotton acreage harvested in 2007 (USDA-NASS, 2009d) was included in the regions identified in Figure 3 and considered as part of the affected environment here.

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

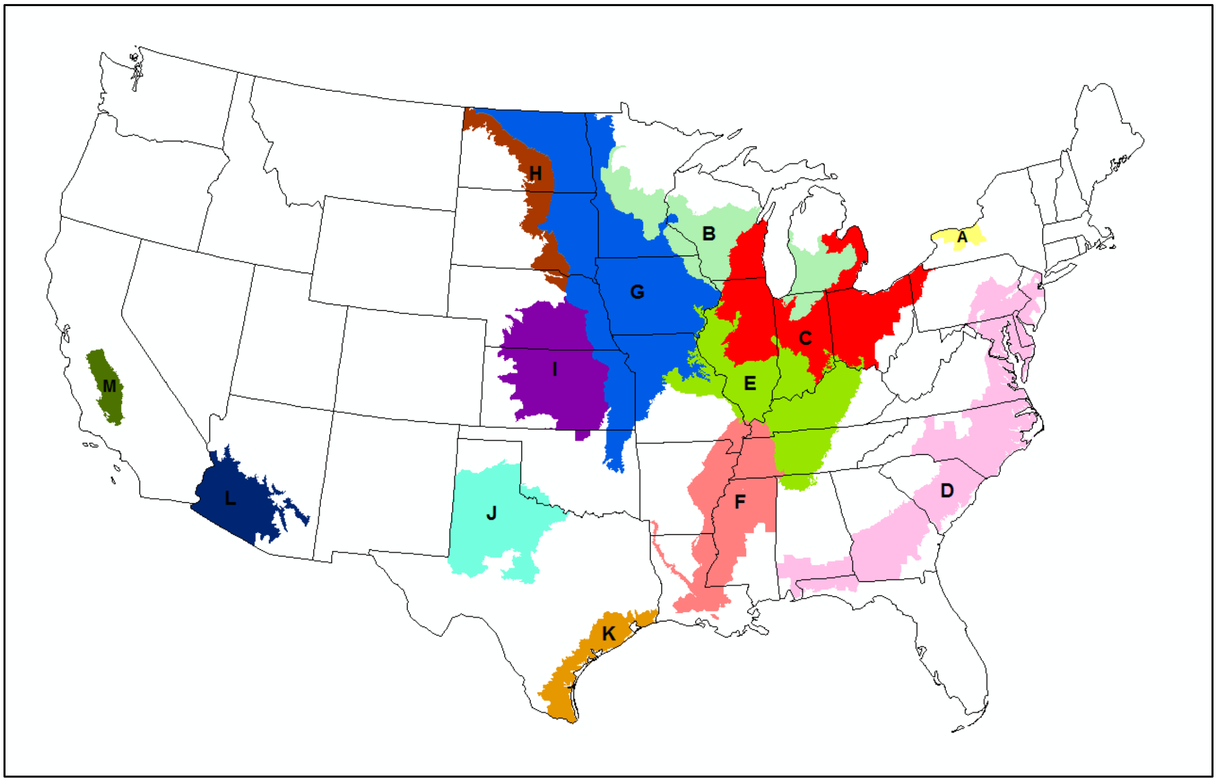


Figure 3. Major Soybean and Cotton Cultivation Regions in the United States.

Commercial cotton or soybean production occurs in the 13 regions (labeled A-M) of the affected environment in the conterminous U.S. Most are in Level I ecoregions (i.e., EPA/CEC Ecoregions 8 [Eastern Temperate Forests] and 9 [Great Plains]). Ecoregion 8 covers most of the eastern half of the conterminous U.S. and is distinguished by its moderate to mildly humid climate, diverse forest cover, and high density of human inhabitants, industry, and agriculture. Ecoregion 9 covers most of the central conterminous U.S. and is distinguished by its sub-humid to semiarid climate, grasslands with little topographic relief, high density of agriculture and much lower (than Ecoregion 8) density of human inhabitants. Ecoregion 9 is among the largest farming and ranching areas in the world.

For cotton, a small portion of the affected environment also occurs in Level I ecoregion 10 (North American Deserts) and 11 (Mediterranean California). Although these two ecoregions combined account for only about 4% of total U.S. upland cotton cultivation, cotton production is locally important in both regions. Within the continental U.S., the regions of soybean and cotton cultivation are non-overlapping with the exceptions of the Mississippi River Valley and the Southeast (see Table 2; Figure 1and Figure 2).

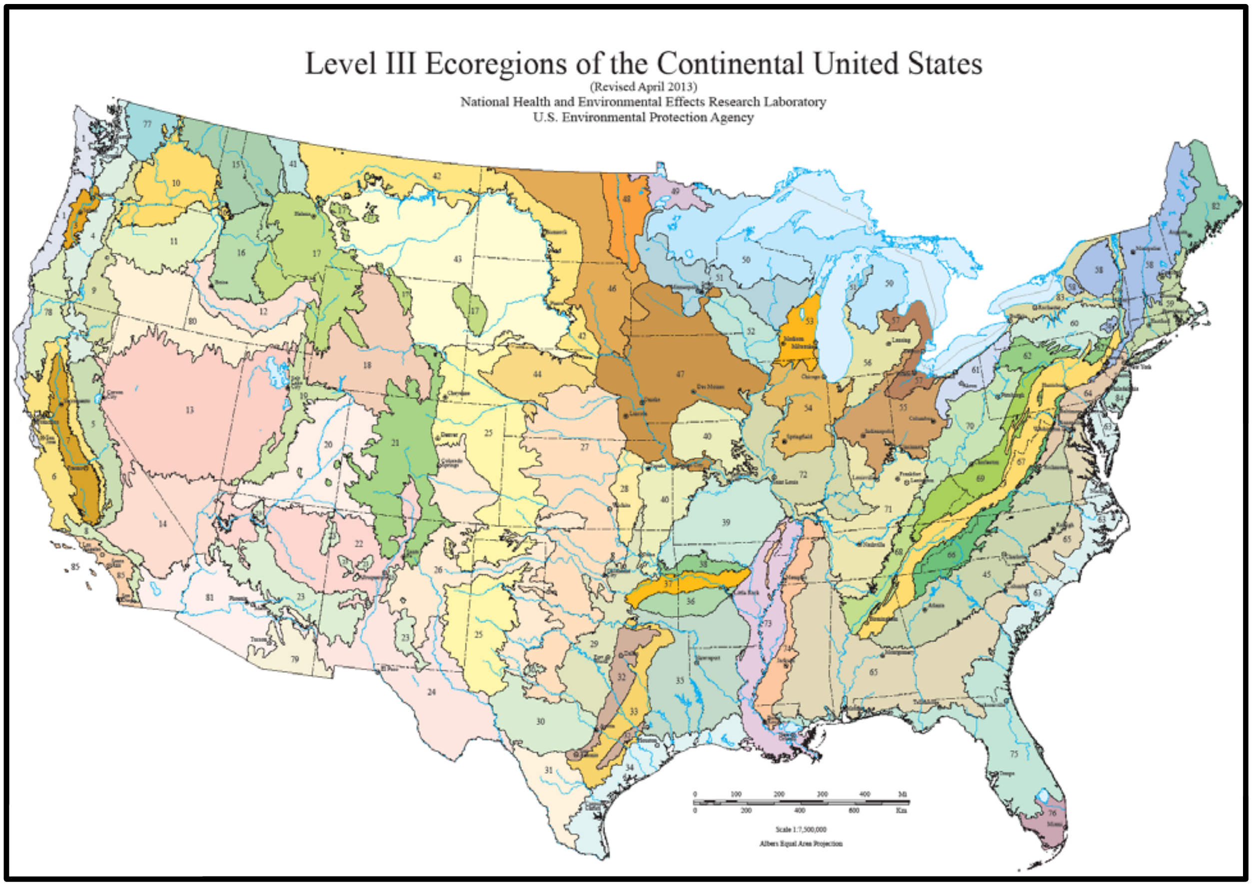


Figure 4. Ecoregions of the Conterminous United States
Source: (CEC, 2006)

The general descriptions of the physical and biological environments for each region that follow are based on the CEC combined with U.S. EPA Level III descriptions for ecoregions. These are supplemented by the U.S. EPA Level IV descriptions, unless otherwise cited (US-EPA, 2010a; CEC, 2011).

3.3 Physical Environment

The physical environment is defined for the purposes of this document as the location and physical terrain within each region, its soil and water resources, air quality, and climate. The locations of cotton and soybean cultivation within Regions A-M are described in Table 2.

3.3.1 Physical Terrain and Climate

For each of these cotton or soybean producing regions, the corresponding Level I ecoregion is used to describe the physical terrain and climate. These are broad descriptions based on the ecoregion characteristics that include soil type, land and climatic features.

Table 2. Location of Major Cotton and Soybean Production Areas.

Region	CEC/EPA Ecoregion	Location of Soybean and Cotton Cultivation	Area (sq. miles)	Percent of U.S. Harvest[1]	
				Soybean	Cotton
A **(Mixed Wood Plains, central portion)**	8.1.1/83 8.1.3/60	Upstate NY	5,184	0.3%	0%
B **(Mixed Wood Plains, western portion)**	8.1.4/51 8.1.5/52 8.1.6/56	Northwestern IL Northern IN Northeastern IA Central and southern MI Central MN Central and western WI	60,802	5.2%	0%
C **(Central USA Plains; Erie Drift Plain)**	8.2.1/53 8.2.2/57 8.2.3/54 8.2.4/55 8.1.10/61 8.4.3/70 (northwestern)	Northern and central IL Eastern, central and northwestern IN Eastern MI OH (most) Northwestern PA Southeastern WI	102,899	18.4%	0%
D **(Southeastern USA Plains,**	8.3.1/64 8.3.4/45	Southern AL DE	133,875	5.4%	19.7%

Region	CEC/EPA Ecoregion	Location of Soybean and Cotton Cultivation	Area (sq. miles)	Percent of U.S. Harvest[1]	
				Soybean	Cotton
eastern and southern portion; Appalachian Forests, northeastern portion; Southeast USA Coastal Plains)	(east-central) 8.3.5/65 (eastern, south-central) 8.4.1/67 (northern) 8.5.1/63 8.5.3/75 (northwestern) 8.5.4/84 (southern)	Northwestern FL panhandle Southern and east-central GA MD (most) Central and southwestern NJ Eastern and central NC Southeastern PA Northeast to southwest SC Eastern VA			
E **(Southeastern USA Plains, northwestern portion)**	8.3.2/71 8.3.3/72 8.4.5/40 (northern, along 8.3.2 border)	North-central AL Western and southern IL Southwestern IN Southeastern edge IA Central and western KY Eastern edge and central MO Southwestern edge OH North-central and south-central TN	97,017	9.4%	0.7%
F **(Mississippi Alluvial Plains; Southeastern USA Plains, western portion)**	8.3.5/65 (northwestern) 8.3.6/74 8.3.7/35 (Red River only)	Eastern and southwestern AR Western KY Northeastern, northwestern and central LA Western and northern MS	78,430	11.7%	15.3%

Region	CEC/EPA Ecoregion	Location of Soybean and Cotton Cultivation	Area (sq. miles)	Percent of U.S. Harvest[1]	
				Soybean	Cotton
	8.5.2/73 9.5.1/34 (eastern)	Southeastern MO Western TN			
G **(Temperate Prairies)**	9.2.1/46 9.2.2/48 9.2.3/47 9.2.4/40	IA (most) Eastern KS Western and southern MN Northern and western MO Eastern NE Eastern and north-central ND Northeastern OK Eastern SD	201,400	38.7%	0%
H **(West-Central Semi-Arid Prairies, eastern portion)**	9.3.1/42	North-central NE (small area) Central and south-central ND Central SD	30,487	2.3%	0%
I **(South-Central Semi-Arid Prairies, northeastern portion)**	9.4.2/27 (northern) 9.4.4/28	Central KS South-central NB North-central OK	70,597	5.8%	0.2%
J **(South-Central Semi-Arid Prairies, south-**	9.4.1/25 (southern) 9.4.2/27 (southern) 9.4.3/26 (south-	Southwestern OK Northwestern TX	63,765	0%	47.1%

Region	CEC/EPA Ecoregion	Location of Soybean and Cotton Cultivation	Area (sq. miles)	Percent of U.S. Harvest[1]	
				Soybean	Cotton
central portion)	eastern)				
K **(Western Gulf Coastal Plain)**	9.5.1/34	Central Gulf Coast of TX	22,863	0%	5.2%
L **Warm Deserts (central portion)**	10.2.2/81 10.2.4/24 (AZ only)	Southwestern AZ	35,352	0%	1.5%
M **(Central California Valley)**	11.1.2/7 (southern)	San Joaquin Valley CA	10,270	0%	2.8%[2]

CEC = Canada-Mexico-E.S. Commission for Environmental Cooperation (CEC)
EPA = U.S. Environmental Protection Agency
[1] Based on USDA-NASS CropScape land cover data for 2012 (USDA-NASS, 2013i). Upland cotton represented more than 97% of total cotton acreage harvested from 2007-2012 (USDA-NASS, 2009d; 2013f).
[2] CropScape does not distinguish between upland and Pima cotton, so the percentage listed for Region M includes Pima cotton production. Pima cotton averaged 60% of the harvested cotton acreage in California (USDA-NASS, 2013f). 90% of the harvested Pima cotton acreage in the U.S. came from California in 2007-2012.

Region A is characterized by level to rolling terrain and open valleys with a variety of deep glacial and marine deposits, and some bedrock outcrops. It has a mid-latitude humid continental climate marked by warm summers and cold, snowy winters with a mean annual temperature of 5-9 degrees Celsius (°C). The frost-free period ranges from 130 to 200 days. Annual precipitation ranges from 720 mm to 1,200 mm. Locations that are in closer proximity to the Great Lakes experience a longer growing season, more winter cloudiness, and greater snowfall.

Region B is characterized by rolling plains formed by glacial outwash and deposits. Some are complex deposits of drift, rolling to hilly moraines, deeply dissected plateaus, lacustrine basins, and meltwater channels. It has a mid-latitude, humid continental climate, and winters with no dry season. The mean annual temperature ranges from 5-10°C with a frost-free period of 130-200 days. Annual precipitation is 600-990 mm.

Region C is characterized by flat to rolling glacial plains, with some clay plains, outwash plains, sand dunes, and moraines, with areas of wetlands. The southeastern edge in Ohio was not covered by a glacier, so it has the form of a dissected plateau with some rugged hills. It has a mid-latitude, humid continental climate with mean annual temperatures of 7-13°C. The frost-free period ranges from 140-200 days. Annual precipitation is 700-1150 mm, increasing from north to south.

Region D is characterized by features, ranging from low rounded or irregular hills, ridges, irregular plains and rolling or open valleys in the north and west (CEC/EPA Ecoregions 8.3.1, 8.3.4, northern 8.4.1), and flatter, rolling to smooth coastal plains to the south and east (CEC/EPA Ecoregions 8.3.5 and 8.5.1). It has a mild mid-latitude humid subtropical climate with hot humid summers and mild winters, except for the northern areas (CEC/EPA Ecoregions 8.3.1 and northern 8.4.1), which have severe mid-latitude climates or are transitional areas and have cold winters. Mean annual temperatures range from 8-19°C. The frost-free period ranges from 145-300 days, increasing from north to south and west to east. Annual precipitation ranges from 900-1650 mm, generally increasing from north to south and west to east.

Region E is characterized by wide, flat-bottomed terraced valleys, valley slopes, and river bluffs to the north and west (CEC/EPA Ecoregion 8.3.2), with dissected glacial till plains in Illinois and Indiana, and by a broader variety of landforms to the east and south (CEC/EPA Ecoregion 8.3.3), including gently sloping, rolling and irregular plains, dissected plateaus, and tablelands and open hills. The climate also varies from a severe mid-latitude humid continental climate with hot summers and cold winters in the north and west to a mild mid-latitude humid subtropical climate with hot summers and mild winters with no pronounced dry season in the south and east. Mean annual temperatures range from 10-16°C and the frost-free period ranges from 160-220 days. Annual precipitation ranges from 850-1470 mm, with noticeably more precipitation to the south and east.

Region F is characterized by a variety of landforms, from a mostly broad and flat alluvial plain with river floodplains, terraces, swales, levees, oxbow lakes, and back swamps to the west (CEC/EPA Ecoregions 8.5.2 and 8.3.7), to irregular plains with some gently rolling hills to the east (CEC/EPA Ecoregions 8.3.6 and northwestern 8.3.5). Thick deposits of sandy to clayey alluvium occur in the west, thick deposits of loess in the central part of the region, and fine-textured clayey sand and some loess to the east and north. The region has a mild mid-latitude humid subtropical climate with hot and humid summers and mild winters. Mean annual temperatures range from 13°C in the north to 21°C in the south, while the frost-free ranges from 200-300 days, but approaches 350 days near the Gulf of Mexico. Annual precipitation ranges from 1140 mm to 1650 mm, increasing from north to south, and is fairly evenly distributed throughout the year.

Region G is characterized by flat to gently rolling glacial till plains with thick beds of lake sediments on top, and by hilly loess plains with thick layers of loess. The southernmost part of the region is topographically hillier than the rest. The region has a severe, mid-latitude, humid continental climate, with a milder humid subtropical climate in the southernmost area (CEC/EPA Ecoregion 9.2.4). It is marked by short warm summers and long cold winters with nearly continuous snow cover to the north, and by longer hot summers and cold to mild winters further south. The mean annual temperature ranges from 3°C in the north to 16°C in the south, and the frost-free period ranges from 90 to 225 days. Annual precipitation ranges from 400- 1145 mm, increasing from northwest to southeast, with most precipitation occurring during the growing season.

Region H is characterized by rolling hills and gentle plains mantled almost entirely by moraine, outwash, and glaciolacustrine sediments. It has a dry, mid-latitude steppe climate with warm to hot summers and cold winters. The mean annual temperature ranges from 3°C in the north to 9°C in the south, and the frost-free period ranges from 100 to 160 days. Annual precipitation ranges from 250 mm to 550 mm.

Region I is primarily characterized by smooth and level to slightly irregular plains, with broad alluvial valleys and some hillier dissected plains in the central part of the region (CEC/EPA Ecoregion 9.4.2), rolling hills, and relatively narrow steep valleys to the east (CEC/EPA Ecoregion 9.4.4). The climate varies both north to south and west to east. The west has a mid-latitude steppe climate while the east has a mid-latitude humid continental climate. Summers are hot and winters are cold in the north becoming milder moving south. Mean annual temperatures range from 10°C in the north to 15°C in the south, with 135 - 200 frost-free days. Annual precipitation ranges from 450 mm to 1000 mm and is much higher in the easternmost part of the region (CEC/EPA Ecoregion 9.4.4) than elsewhere.

Region J is characterized by nearly level to irregular plains that are lightly to moderately dissected. It has a mild mid-latitude humid to dry steppe climate moving from east to west, marked by hot summers and mild winters. The mean annual temperature ranges from 13°C to 18°C and the frost-free period is 190 to 260 days (USDA-NRCS, 2006b). Annual precipitation ranges from 300 to 660 mm, increasing from west to east (USDA-NRCS, 2006b).

Region K is characterized by flat to gently sloping coastal plains in the agricultural areas, with sediments of marine sand, silt, and clay. It has a mild, mid-latitude, humid subtropical climate marked by hot summers and mild winters. The mean annual temperature ranges from 20°C to 25°C, with a frost-free period of 270 – 365 days. The mean annual precipitation ranges from 600 mm to 1625 mm, increasing rapidly from southwest to northeast.

Region L is characterized by mountain ranges to the north, scattered low mountains, and alluvial fans and valleys. It has a dry, subtropical desert climate marked by hot summers and mild winters. The mean annual temperature ranges from 15°C to 23°C. The frost-free period ranges from 200 - 365 days, decreasing in length with increasing elevations. Mean annual precipitation ranges from 75 mm to 500 mm, with winter rainfall decreasing from west to east and summer rainfall decreasing from east to west. Evaporation rates are high.

Region M is characterized by flat fluvial plains filled with deep and well-drained loamy or clayey soils formed by deposits washed down from the surrounding mountains. It has a warm and mild Mediterranean climate, with long, hot dry summers and mild, slightly wet winters. The mean annual temperature ranges from 15°C to 20°C, with a frost-free period of 280 to 365 days, decreasing with increasing elevation and latitude. The mean annual precipitation ranges from 125 mm in the south to 300 mm in the northern margins.

3.3.2 Soil Resources

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

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

Table 3. Dominant and Major Secondary Soil Types by Region.

Soil Order	Description	Region
Alfisols	A dark surface horizon mineral soil, similar to mollisols however, lacking the same level of fertility and more acidic.	A, B, C, D, E, F, G, I, J, K, M
Aridisols	These soils are found in the arid regions of the US. Typically high in calcium, Magnesium, potassium and sodium. The soils have an alkaline pH.	J, L, M
Entisols	This soil order is relatively un-weathered. These soils have no diagnostic horizon development. Often found on floodplains, glacial outwash areas and other areas receiving alluvial materials.	B, C, D, E, F, H, I, J, L, M
Histosols	Dominated by organic soil materials, some consist of a thin layer of organic materials over a root-limiting layer or fragmental materials; commonly called bogs, peats, mucks	B
Inceptisols	Soils of the humid and sub humid region. Weathering has created minimal diagnostic differentiation in the soil column.	B, C, D, E, F, J
Mollisols	Dark colored mineral soils developed under grassland conditions. Rich in nutrients, very fertile. Associated with the	B, C, E, G, H, I, J, M

Soil Order	Description	Region
	corn belt.	
Ultisols	Highly weathered soils found in hot, moist regions. Typically acidic and low in available nutrients.	D, E, F
Vertisols	Soils having significant amounts of expanding clay content. Soils typically crack when dry and swell when wet.	F, G, H, J, K, M

Source: (USDA-NRCS, 1999b)

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

Soil erosion is a naturally occurring event and the erosion rates are relatively slow; however, human activity can greatly accelerate the rate of erosion. In general, wind and/or water erosion are important soil resource concerns along with wetness and maintenance of organic matter content in the U.S. cotton- and soybean-growing regions (USDA-FSA, 2010). Figure 5 is a map of erosion exceeding the soil loss tolerance rate on cropland in the United States (USDA-NRCS, 2011). Excessively eroding cropland soils are concentrated in the Midwest and the Southern High Plains of Texas (Regions G and J) (Figure 5). From 1980-2011, the reported total soil erosion in U.S. cotton production areas decreased by 42%, and decreased in soybean production areas by 28% (Field to Market, 2012).

Cotton can be produced in a wide variety of soil types, provided sufficient nutrition and moisture is available throughout the growing season. In general, loam and clay loam soils are more productive where annual rainfall is less than 20 inches per year, because these soil types are able to store more water, in comparison to coarse-textured soils that provide better internal drainage and are more productive where rainfall exceeds 30 inches per year (Graneto et al., 2013). Soybean production is best suited to fertile, well-drained, medium-textured loam soils, yet they can also be grown in a wide range of soil types (Berglund and Helms, 2003; NSRL, No Date).

3.3.3 Water Resources

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

Surface water in rivers, streams, creeks, lakes, and reservoirs provides water for drinking and bathing, irrigation, industrial, and recreational uses. About 66% of water used in the U.S. in

2005 (about 410 billion gallons per day) was from fresh surface water sources (USDA-FSA, 2010). Surface runoff from rain, snowmelt, or irrigation can affect water quality by depositing sediment, minerals, and contaminants into streams, rivers, lakes, wetlands, and coastal waters. The amount of surface runoff is influenced by meteorological factors (such as rainfall intensity and duration), and physical factors (such as vegetation, soil type, and topography).

Groundwater flows underground, substantially contributes water to streams and rivers, is stored in natural geologic formations called aquifers, and sustains ecosystems by releasing a constant supply of water. In 2005, groundwater contributed about 19% of the freshwater used in the U.S. (USDA-FSA, 2010). Approximately 47% of the U.S. population depends on groundwater for its drinking water supply (McCray, 2009). Both groundwater and surface water can be used for irrigation, which accounted for approximately 28% of withdrawals from fresh surface water sources (USDA-FSA, 2010).

Based on 2005 data, the largest use of groundwater in the U.S. is irrigation, representing approximately 67% of all the groundwater pumped each day (McCray, 2009; USDA-FSA, 2010). More than 90% of the areas irrigated in Mississippi and Missouri used groundwater (USDA-FSA, 2010). Wells replenished from groundwater often are the only source of irrigation in many locations in the Great Plains (US-EPA, 2012a). Groundwater sources are especially important for irrigation in Arizona, Arkansas, California, Nebraska, and Texas, accounting for nearly 60% of total groundwater withdrawals for irrigation in 2005. In three of these states (Arkansas, Nebraska, and Texas) fresh groundwater accounted for 75% - 96% of all irrigation water. Irrigation maintains adequate moisture for a crop, so it contributes to agriculture by increasing yields per acre, and by making more acreage (i.e., dry lands) usable. Irrigation also moderates fluctuations in product and seed quality. This is because moisture requirements for most crops tend to vary during development, and an adequate water supply allows crop growth during critical periods of the growing cycle. In this way, irrigation can optimize both quality and yield (US-EPA, 2012a). A variety of irrigation technologies are available (Figure 5) (Barnes and O'Leary, 2006). Efficient irrigation can reduce runoff and deep percolation (leaching) losses (TAMU, 2014). In addition to irrigation, water is used in agriculture for pesticide and fertilizer applications, crop cooling (e.g., light irrigation), and frost control (US-CDC, 2013).

Figure 5. Examples of Cotton Irrigation Systems: A=furrow, B=drip method, C=low energy precision application.
Source: (Barnes and O'Leary, 2006)

Irrigation is especially important to agriculture in the western U.S. and the Mississippi River Valley (Figure 6). Most irrigation in California (Region M) is used for alfalfa, cotton, orchards, and vegetables (USDA-NASS, 2009a). Nationally, less than 10% of soybean acres and approximately 40% of cotton acres are irrigated. However, soybean accounts for about 25% of irrigated acres in the eastern 31 states, particularly in the Mississippi River Valley (Region F) (USDA-NASS, 2009b; 2009c; Schaible and Aillery, 2012). Cotton is heavily irrigated in California, Arizona, western Texas, Georgia, and the Mississippi River Valley (Regions D, F, J, L, and M). Soybean is heavily irrigated in central Nebraska (Region I) (USDA-NASS, 2009b; 2009c) (Figure 7).

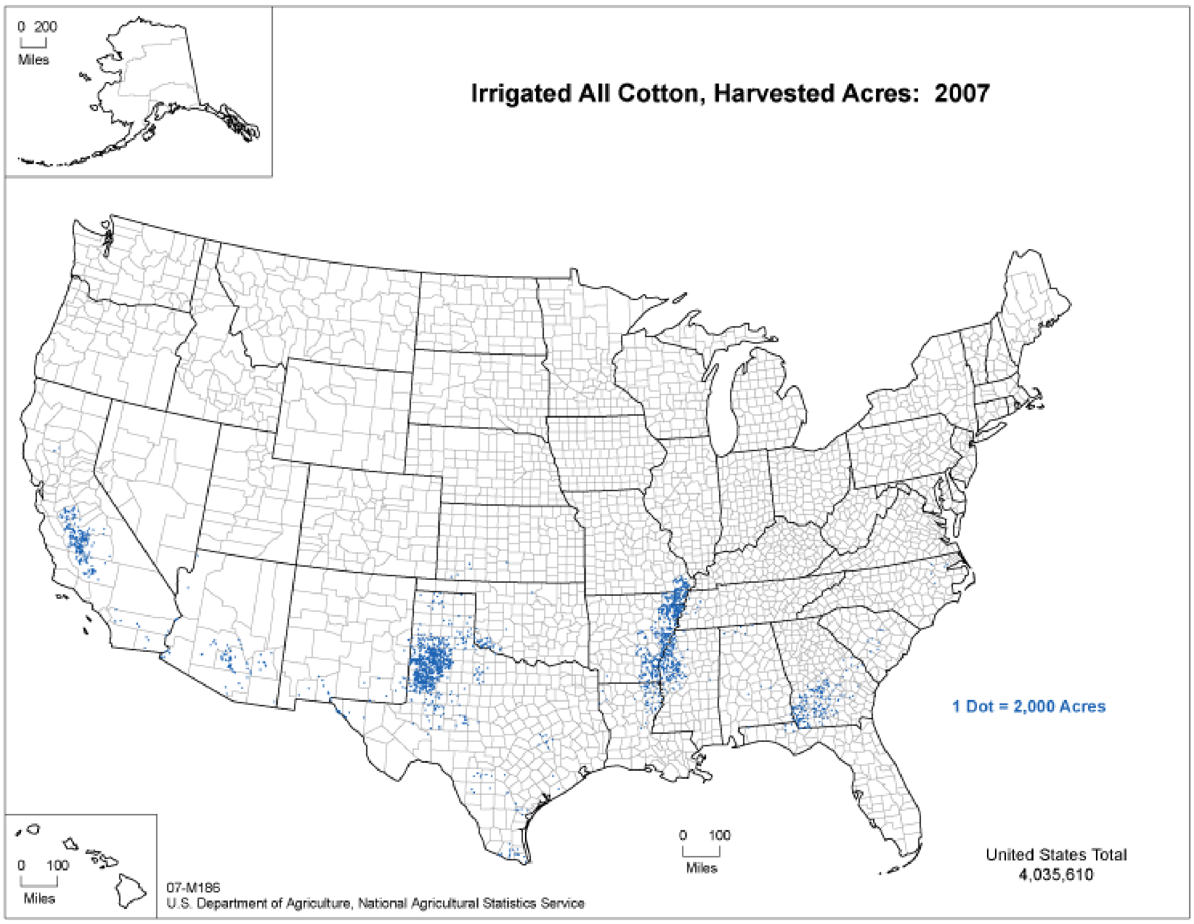


Figure 6. Irrigated Cotton Acreage in the United States in 2007.
Source: USDA National Agricultural Statistics Service Map # 07-M080 (USDA-NASS, 2007b).

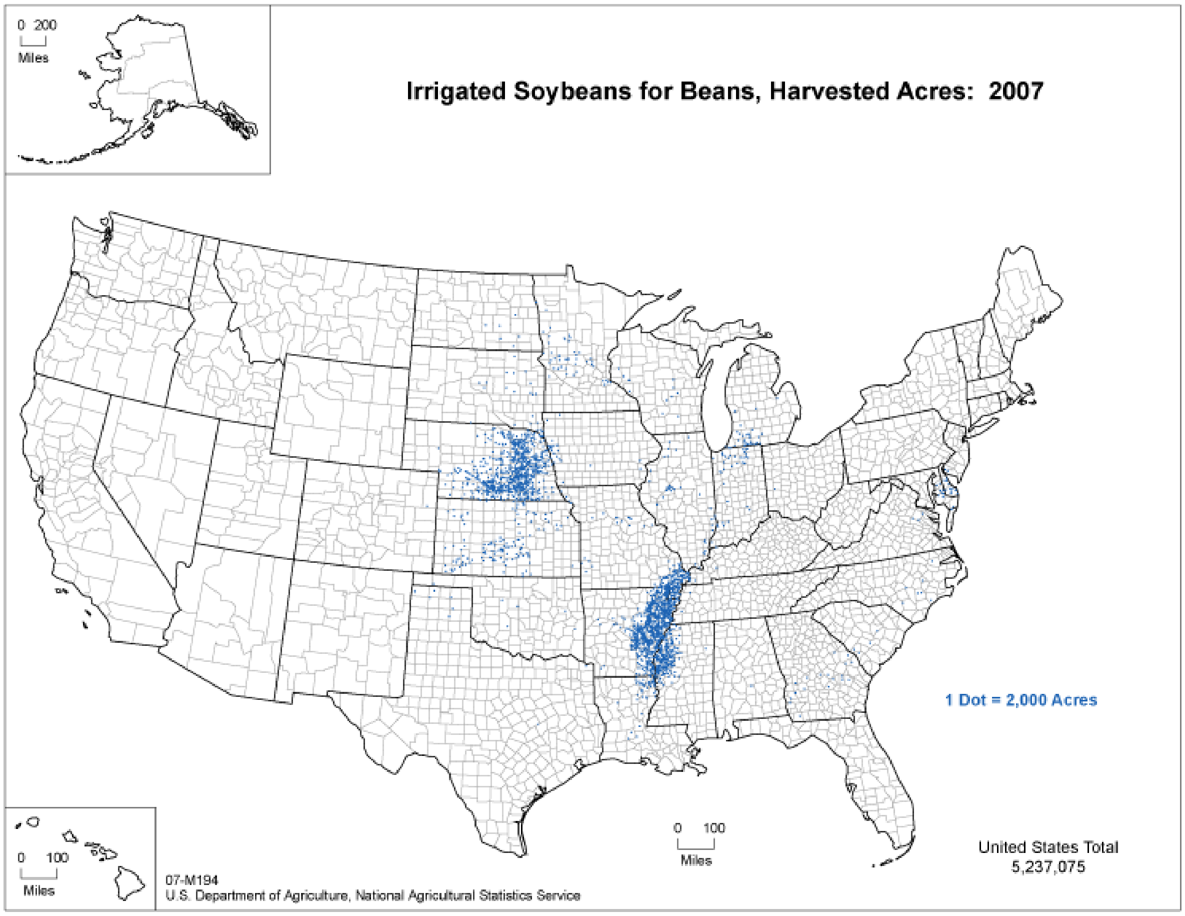


Figure 7. Irrigated Soybean Acreage in the United States in 2007.
Source: USDA National Agricultural Statistics Service Map #07-M194 (USDA-NASS, 2007c).

Information from the U.S. Geological Survey (Konikow, 2013; USGS, 2013b) is combined with the Level III and Level IV Ecoregion descriptions to further describe the water resources in the regions identified as the Affected Environment:

Region A contains perennial streams, Lake Ontario, the Finger Lakes and some smaller lakes, and abundant wetlands in some areas.

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

Region C has a low to medium density of perennial streams, which are often intermittent in the more southern portions of the region. Some areas have lakes and abundant groundwater, which serve as the major source of irrigation water in Illinois and Wisconsin, and wetlands are abundant in the east (CEC/EPA Ecoregion 8.1.10). Drainage has been greatly modified in CEC/EPA Ecoregions 8.2.2 and 8.2.3, and stream chemistry, turbidity, and habitat have been affected by agriculture.

Region D has a moderate to dense network of streams and rivers, with few natural lakes but some reservoirs to the north and numerous swamps and marshes to the south. The Roanoke, Savannah, and Susquehanna Rivers, among others, run through the region.

Region E has numerous perennial streams and rivers in CEC/EPA Ecoregion 8.3.2, with silt and sand dominating lowland channels while upland streams are rockier. There are both perennial and intermittent streams and numerous springs in CEC/EPA Ecoregion 8.3.3, with higher nutrient, alkalinity and hardness levels than the streams in CEC/EPA Ecoregion 8.3.2. In the Western Pennyroyal region of Kentucky and Tennessee there are also many sinkholes, ponds and well developed underground drainage such that soils are quick to dry. The Illinois, Missouri, Mississippi, Ohio, Tennessee and Wabash Rivers all run through the region.

Region F is dominated by the Mississippi River and used to contain one of the largest continuous wetland systems in North America. However, extensive areas have now been modified by channelization and navigation and flood control engineering. The Red River also runs through the region, and oxbow lakes, backswamps, and ponds occur. To the east there is a moderate to dense network of perennial and intermittent streams and rivers, including the Tombigbee River, but few lakes. Groundwater from the Mississippi Alluvial Valley alluvial aquifer is the major source for irrigation water in this region (USDA-FSA, 2010). Water withdrawals from the aquifer greatly exceed recharge from surface waters (Konikow, 2013).

Region G has a low density of rivers and intermittent and perennial streams through most of the region, with a higher density and several large rivers in the south, including the Des Moines, Kansas, and Missouri Rivers. The Minnesota River and the Red River of the North are the major rivers in the north. Many streams and rivers have been channelized. Abundant temporary and seasonal wetlands occur in the north, creating favorable conditions for waterfowl nesting and migration, and a few large reservoirs occur to the south. Groundwater is highly mineralized in some areas and surface and groundwater contamination from fertilizer and pesticide applications as well as from concentrated livestock production is a regional issue in the central portions of this region (CEC/EPA Ecoregion 9.2.3).

Region H has mostly intermittent streams, with some perennial streams and larger rivers, most notably the Missouri River which runs along the western boundary of most of the region. In some areas a high concentration of semi-permanent and seasonal wetlands can be found.

Region I has mostly intermittent and ephemeral streams to the west and intermittent and perennial steams to the east. There are a few larger rivers (Arkansas, Platte, and Kansas and its tributaries) and some springs, but few lakes. The Ogallala Aquifer underlies large portions of the ecoregion and is the major source for irrigation water in this region (USDA-FSA, 2010). Water withdrawals from the aquifer greatly exceed recharge from surface waters (Konikow, 2013; Steward *et al.*, 2013).

Region J has few to no streams. Surface water occurs in numerous ephemeral pools or playas which serve as recharge areas for the Ogallala Aquifer, which is essential for cultivated agriculture in the region. However, water withdrawals from the aquifer usually exceed recharge.

Region K has intermittent and perennial streams, some of which are channelized. There are numerous wetlands in the eastern part of the region.

Region L has ephemeral and intermittent streams, with few surface waters other than the Colorado River, which has a mountainous, distant source. Some springs and a few reservoirs are present. Water resource use is intense, both from rivers and ground water.

Region M the San Joaquin flows through the region. Streams are mostly intermittent and dry during the summer months. The region has an extensive network of water diversions, channelization, and drainage, and irrigation water management is a priority (USDA-NRCS, 2006c). Groundwater from the Central Valley Aquifer is a major source of irrigation water, though secondary to surface water for this purpose, and groundwater withdrawals exceed recharge rates (Konikow, 2013). Groundwater contamination from heavy use of agricultural chemicals is a concern. Water in lowland streams is often degraded by sediments and salts from agricultural irrigation and drainage and municipal and industrial waste discharges.

3.3.4 Water Quality

Natural features (i.e., the physical and chemical properties) of the land surrounding a water body have the greatest impact on quality. The topography, soil type, vegetative cover, minerals, and climate also influence water quality. Regions of the U.S. identified as part of the Affected Environment continue to experience diminished water quality. For example, in Region C, drainage has become greatly modified, while in Region F, extensive areas are modified by channelization, navigation, and flood control engineering. Further, in Region G, groundwater is highly mineralized in some areas and there is groundwater contamination from fertilizer and pesticide applications. Finally, in Region M, groundwater contamination from heavy use of agricultural chemicals is a concern. Water in lowland streams can be degraded by sediments and salts from agricultural irrigation, drainage, municipal, and industrial waste discharges.

Sediments flowing into water bodies can affect the health of fish, aquatic invertebrates, and other wildlife. Sediments reduce light penetration into water, which can adversely impact aquatic plant growth and survival. Fertilizer runoff can contribute to chemical and mineral toxicity, higher water turbidity, algal blooms, and oxygen depletion in water resources. Soil erosion-mediated sedimentation can increase fertilizer runoff causing similar impacts (US-EPA, 2005; TAMU, 2014).

Major sources of pollutants include storage tanks, septic systems, hazardous waste sites, and landfills. Widespread use of road salts, fertilizers, pesticides and other agricultural chemicals are also important sources. All surface water pollutants have the potential to be transported into groundwater. According to an EPA Report on the Environment for 2008, groundwater also was seriously affected by various nutrients and pesticides (USDA-FSA, 2010).

Agricultural pollution is the leading source of impacts on surveyed rivers and lakes. It is also the third largest source of impairment of water quality in estuaries, and a major source of contamination of groundwater and wetlands (USDA-NRCS, 2011). The most common types of agricultural pollutants include excess sediment, fertilizers, animal manure, pesticides and herbicides. Management practices that contribute to water contamination include the type of crop cultivated, plowing and tillage, and irrigation. Safe and appropriate storage, handling, and application of agricultural chemicals and wastes reduce the risks of water contamination (TAMU, 2014). Irrigation depletes available water and reduces quality by increasing erosion and sedimentation, nutrients dissolved in runoff, and chemicals adsorbed onto soil particulates washed into surface water. Some of these pollutants eventually contaminate groundwater by leaching.

Pesticide use introduces chemicals into water through spray drift, the cleaning of pesticide application equipment, soil erosion, and subsequent filtration through soil into groundwater (US-EPA, 2012c). Consequently, fertilizers and pesticides are in excess in many water bodies in the U.S. (USDA-FSA, 2010). The EPA documented over 3 million acres of water bodies and over 75,000 miles of rivers and streams, large areas of bays and wetlands with excess levels of nitrogen and phosphorus. Excess of these two nutrients create harmful blooms of algae and other aquatic flora which deplete oxygen that can result in many detrimental effects including fish kills.

Nonpoint source (NPS) pollution comes from many diffuse sources. NPS pollution accumulates as runoff from rainfall or snowmelt moves over the ground, picks up, and then carries natural and human-made pollutants. NPS pollution increases sedimentation in surface waters following soil erosion by surface runoff. These pollutants may eventually be transported into various types of permanent water resources, such as streams, rivers, and lakes. This is in contrast to a point source of pollution which has a discernible, confined, and discrete source.

In addition to conservation tillage that leaves crop residue to absorb water, two other important agronomic methods of controlling runoff include furrow diking and use of center-pivot irrigation systems. The mechanical tillage operation called furrow diking prevents runoff by placing mounds of soil at intervals across the furrow between crop rows to form small water storage basins. Rainfall or irrigation water is trapped and stored in the basins until it soaks into the soil, rather than running off. Center pivot systems irrigate in a circular pattern that can improve water distribution. In these systems, runoff is reduced by changing the speed to adapt the precipitation rate to the soil infiltration rate (New and Fipps, 2000).

3.3.5 Air Quality

The Clean Air Act (CAA) (amended in 1990) requires States to comply with the National Ambient Air Quality Standards (NAAQSs) established by the EPA for six principal pollutants, called criteria pollutants. The intention of these standards is to protect public health and the environment from these pollutants. The six criteria pollutants are: ozone (O_3), nitrogen dioxide (NO_2), carbon monoxide (CO), sulfur dioxide (SO_2), lead (Pb), and inhalable particulate matter (PM). There are three subgroups of particulates based on particle size (Cambra-Lopez et al., 2010). They are PM (coarse particulate matter greater than 10 µm [micrometers]), PM_{10} (particulates 2.5-10 µm), and $PM_{2.5}$, (fine particles less than 2.5 µm)(US-EPA, 2013c).

Air quality monitoring data is collected and reviewed by EPA, state, and local regulatory agencies, and is available to the public. This data is often published with respect to a local air quality index (AQI). The AQI is a measurement (from zero to 500) of the level of criteria pollutants in the atmosphere. An AQI above 100 indicates that air quality conditions may be unhealthy for certain sensitive groups of people. An AQI over 300 represents air quality that is hazardous to everyone. AQI values below 100 indicate pollutant levels are at satisfactory levels (AirNow, 2013).

Agricultural operations can affect air quality by releasing particulates, gases, and other chemicals into the air. Particulates may be released through a variety of cropping practices including the burning of crop residues or animal carcasses (Yang and Sheng, 2003; Lemieux et al., 2004). Burning releases smoke, exhaust from motorized equipment may release criteria pollutants, and cropping activities (such as planting, tillage, and harvesting) generate airborne soil particulates when growers use motorized equipment (Lemieux et al., 2004). Gases, such as carbon dioxide (CO_2), hydrocarbons, other volatile organic compounds, and methane, are released through equipment exhaust (particularly diesel exhaust), disturbance of the soil inducing population changes among the microbial flora, and animal production facilities, while fertilizer applications are associated with release of oxides of nitrogen, particularly during their manufacture (USDA-NRCS, 2006a; Zhao, 2007; Aneja *et al.*, 2009; Cambra-Lopez *et al.*, 2010; US-EPA, 2011b). Burning releases smoke, exhaust from motorized equipment may release criteria pollutants, and cropping activities (such as planting, tillage, and harvesting) generate airborne soil particulates when growers use motorized equipment (Lemieux et al., 2004). Gases, such as carbon dioxide (CO_2), hydrocarbons, other volatile organic compounds, and methane, are released through equipment exhaust (particularly diesel exhaust), disturbance of the soil inducing population changes among the microbial flora, and animal production facilities, while fertilizer applications are associated with release of oxides of nitrogen, particularly during their manufacture (USDA-NRCS, 2006a; Zhao, 2007; Aneja et al., 2009; Cambra-Lopez et al., 2010; US-EPA, 2011b).

Aerosols from herbicide, pesticide and fertilizer applications to crops are another source of molecules that impact air quality. The effects of aerosols are complex because these various molecules can: (1) drift from the target site, (2) volatilize to increase the area impacted, and (3) adsorb onto soil particles (Felsot, 2005; Hernandez-Soriano et al., 2007). Tillage and wind-induced erosion may lead to suspended soil particles in the air and adsorbed aerosols becoming airborne (Felsot, 2005; Hernandez-Soriano et al., 2007). Vapor aerosol particles contribute to the formation of haze and decrease visibility (Zhao, 2007).

Cotton and soybean fields typically are tilled just prior to planting (Albers and Reinbott, 1994). Tillage releases particulate matter into the air (Madden et al., 2009) as soil is disturbed. Reductions in tillage generate fewer suspended particulates (dust) and lower rates of soil wind erosion (Towery and Werblow, 2010).

Tillage also is associated with increased emissions from farm equipment burning fossil fuels. Reducing the number of times tillage is done through a growing season reduces these vehicle emissions. Both of these benefits to air quality are variable and are affected by factors such as soil moisture and the specific tillage regime employed. The ability of reduced tillage to minimize the burning of fossil fuels is illustrated in Table 4, based on the Natural Resource Conservation Service (NRCS) Energy Estimator: Tillage Tool (USDA-NRCS, 2013a). This tool estimates potential fuel savings of 3,010 gallons or 60% savings per year based upon producing 1,000 acres of no-till soybean compared to conventional till soybean in the Urbana, Illinois, postal code.[4] NRCS is careful to note that this estimate is only approximate because many variables affect an individual operation's actual savings. This example, however, illustrates the magnitude of the contribution of minimum tillage to reducing the impact of agriculture on air quality.

Table 4. Total Farm Diesel Fuel Consumption Estimate.

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

Source: (USDA-NRCS, 2013a)

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 is likely occurring only as a pre-planting option, based on individual farm characteristics.

Growers typically apply pesticides and herbicides to conventionally grown cotton and soybean by ground spray equipment or aircraft. Both may affect air quality through drift and volatilization to the atmosphere (Owen, 2008). Drift is defined by EPA as, "the movement of pesticide through air at the time of application or soon thereafter, to any site other than that intended for application" (Kiely et al., 2004). Small, lightweight droplets are produced by equipment nozzles; many droplets are small enough to remain suspended in air for long periods of time allowing them to be moved by air currents, until they adhere to a surface or drop to the ground. The amount of drift varies widely and is influenced by a range of factors, including weather conditions, topography, the crop or area being sprayed, application equipment and methods, and other practices followed by the applicator (Kiely et al., 2004). For example, the

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

fine droplet size of pesticides applied through center-pivot irrigation systems can lead to evaporation and drift unless minimized by addition of Low Elevation Spray Application applicators or Low Energy Precision Application irrigation methods (New and Fipps, 2000).

The EPA defines volatilization as the point "when pesticide surface residues change from a solid or liquid to a gas or vapor after an application of a pesticide has occurred." (http://www.epa.gov/pesticides/about/intheworks/volatilization.htm). Volatilization of herbicides and pesticides from soil and plant surfaces introduces these chemicals into the air.

A long-term USDA Agricultural Research Service (ARS) study to identify factors that affect pesticide levels in the Chesapeake Bay Region airshed (USDA-ARS, 2011) has determined that volatilization is highly dependent on exposure of disturbed loose and unstratified (unconsolidated) soils, and variability in measured compound levels is correlated with temperature and wind conditions. Another ARS study of volatilization of certain herbicides after application to fields has found moisture in dew and soils in higher temperature regimes significantly increases volatilization rates (USDA-ARS, 2011).

The EPA's Office of Pesticide Programs (OPP), which regulates the use of pesticides and herbicides in the U.S., introduced initiatives to help pesticide applicators minimize off-target drift. Currently, EPA-OPP is evaluating new regulations for pesticide drift labeling, and developing voluntary best management practices (BMPs) to aid in reducing drift, as well as identifying scientific issues surrounding field volatility of conventional pesticides (US-EPA, 2010b). Additional information on off-target movement of pesticides is included in Appendix 7.

Other conservation practices may allow growers to qualify for crop insurance, federal loans, and other beneficial programs (USDA-ERS, 2009). Using conservation practices can effectively reduce crop production impacts to air quality through the deployment of windbreaks, shelterbelts, reduced tillage, and cover crops that promote soil protection on highly erodible lands.

The aspects of air quality discussed in this section, and water in Section 3.3.4, focused on the relatively small-scale activities occurring in and around cotton and soybean fields. We combine issues related to water and air with a broader, long-term perspective in the next section by examining aspects of climate change.

3.3.6 Climate Change

Climate change represents a statistical change in global climate conditions, including shifts in the frequency of extreme weather (Cook et al., 2008). Agriculture is estimated to contribute roughly six% of all human-induced greenhouse gases (GHG) in the U.S.(US-EPA, 2011b). Some GHG are released during fertilizer production, transport, and application, while others are released during pesticide production and application (West and Marland, 2002). Between 1980 and 2011, total GHG are reported to have increased by 10% for cotton, and 13% for soybeans (Field to Market, 2012). The EPA identified CO_2, methane, and nitrous oxide as the key GHGs affecting climate change (US-EPA, 2011c).

Agricultural practices are associated with the production and sequestration of GHG. Emissions of GHG released during the use of agricultural equipment (e.g., irrigation pumps and tractors) include carbon monoxide, nitrogen oxides, methane, reactive organic gases, particulate matter, and sulfur oxides (US-EPA, 2011b). Additional emissions arise from the production and delivery of fuels to farms (West and Marland, 2002). Nitrogen-based fertilizers are the largest source of U.S. nitrous oxide emissions (US-EPA, 2011b). Nitrous oxide is naturally produced in soils through microbial nitrification and denitrification, and it can be dramatically influenced by fertilization, grazing animals, cultivation of nitrogen-fixing crops and forage (e.g., alfalfa), retention of crop residues (i.e., no-till conservation), irrigation, and the fallowing of land (US-EPA, 2011b). These same agricultural practices can influence the decomposition of carbon-containing organic matter sequestered in soil, resulting in conversion to carbon dioxide and subsequent loss to the atmosphere (US-EPA, 2011b). Agricultural sources of methane emissions are associated primarily with enteric emissions of gas from cattle and manure management. The conversion of cropland to pasture increases carbon and nitrogen sequestration in soils (US-EPA, 2011c). Agricultural lands afford great opportunities for sequestering carbon (reducing carbon dioxide levels) and reducing or mitigating emissions of other GHGs. To a great extent, the contribution of agricultural activities to climate change depends on the production practices employed to grow various commodities, the region in which the commodities are grown, and the individual choices made by growers.

There are three generally recognized sources of carbon emissions relative to tillage practices. First is use of machinery for cultivating the land, second is the application of fertilizers and pesticides. The third source is the soil organic carbon that is oxidized following soil disturbance (West and Marland, 2002).

Tillage contributes to GHG emissions by releasing CO_2 previously sequestered in soil. Disruption and exposure of soil also promotes CO_2 production by the oxidation of soil organic matter (Baker et al., 2005). The carbon footprint for any crop is directly affected by the associated cultivation practices. For example, cotton cultivation is estimated to produce higher total CO_2 emissions than soybeans (Nelson et al., 2009). On-site emissions can be reduced by half for some crops by replacing conventional with no-till systems agriculture (Nelson et al., 2009). In general, conservation tillage may decrease the rate of loss of soil organic carbon, however, carbon emitted during pesticide and fertilizer inputs may negate the increased carbon sequestered in soils (West and Marland, 2002). The uncertainty inherent in these comparisons arises from industry-wide estimates based on production being juxtaposed against estimates based on grower-reported practices.

The EPA identified regional differences in GHG emissions associated with agricultural practices on different soil types, noting that carbon emission rates differ between mineral soils and organic soils (US-EPA, 2011b). Mineral soils contain from 1 to 6% organic carbon by weight in their natural state, but organic soils may contain as much as 20% carbon by weight (US-EPA, 2011b). Up to 50% of the soil organic carbon in mineral soils can be released to the atmosphere when land is initially converted to crop production. Over time, the soil establishes a new equilibrium that reflects a balance between carbon from decaying plant matter and organic amendments, and carbon released by microbial decomposition. On-site emissions can be reduced by half for some crops by replacing conventional with no-till systems agriculture (Nelson et al., 2009). In general, conservation tillage may decrease the rate of loss of soil organic carbon, however, carbon emitted during pesticide and fertilizer inputs may negate the increased carbon sequestered in soils (West and Marland, 2002).(US-EPA, 2011b).

Organic soils continue to release carbon to the atmosphere for a longer period of time than mineral-based soils (US-EPA, 2011b). Mineral soils contain from 1 to 6% organic carbon by weight in their natural state, but organic soils may contain as much as 20% carbon by weight (US-EPA, 2011b). EPA estimated that mineral soil-based cropland areas sequestered over 45.7 Tg CO_2 Eq[5] in 2008. Carbon emissions from croplands with organic soils were estimated to be 27.7 Tg CO_2 Eq (US-EPA, 2011b). The highest rates of carbon sequestration occurred under conservation tillage, particularly in Midwest regions where mineral-based soils prevail (US-EPA, 2011b).

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

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

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

American production is expected to adapt with improved cultivars and responsive farm management (IPCC, 2007).

Climate change may have a positive impact on agriculture. However, the extent of positive effects on agriculture from climate change is highly speculative, and will not be observed in all growing regions. For example, the IPCC indicates that certain regions of the U.S. will be negatively impacted by a significant decline in available water resources. The IPCC also predicts potential climate change in North America may increase crop yields by 5-20% during the current century (Field *et al.*, 2007).

3.3.7 Land Resources

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

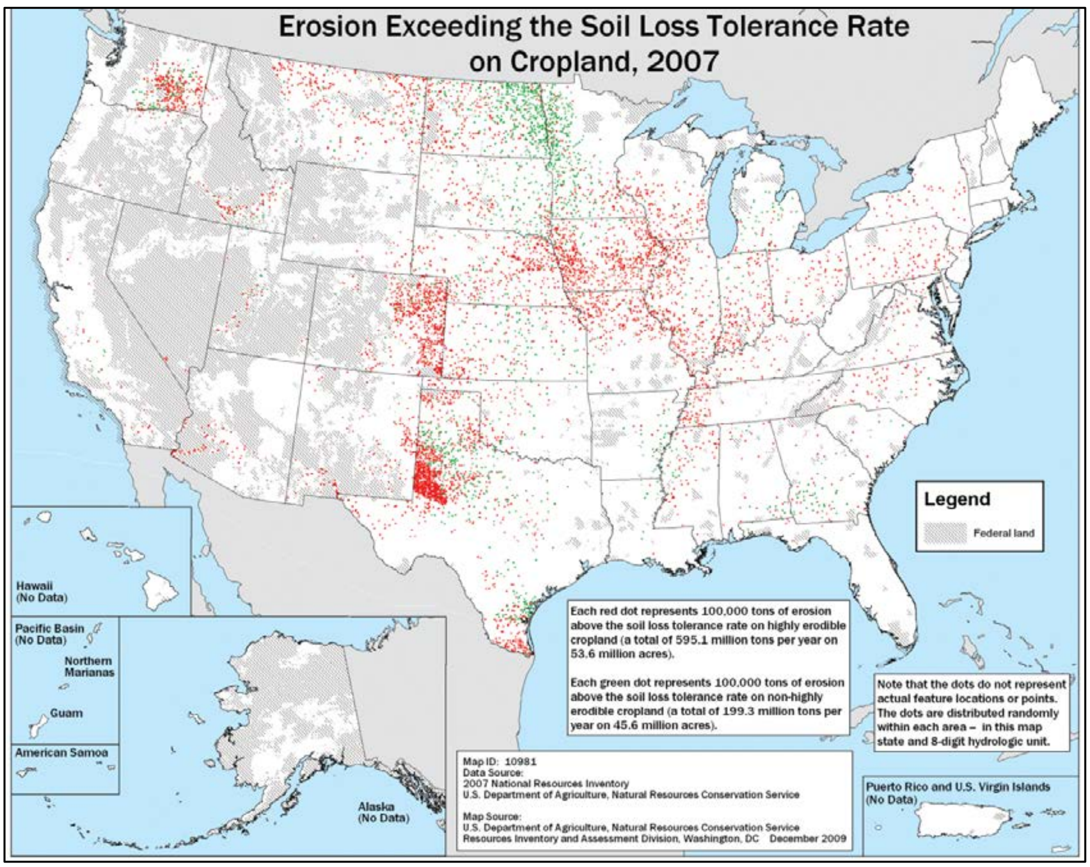


Figure 8. U.S. Croplands with High Erosion Rates.
Source: (USDA-NRCS, 2011)

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

Land cover data were obtained for each Level III ecoregion using USDA-NASS CropScape (USDA-NASS, 2013i). The statistical estimates for acreage as generated by CropScape are considered as raw numbers requiring a correction factor to account for statistical bias (USDA-NASS, 2013i). However, the bias in estimates of area for different land covers is proportionately equal, enabling comparisons of the area of different land cover classes relative to each other.

USDA-NASS uses the 2006 USGS National Land Cover Dataset (USGS-NLCD, 2006) to help identify non-agricultural land cover (USDA-NASS, 2013i). Table 5 compares the land cover groups and classes used by the National Land Cover Dataset to those used in this analysis, and lists the class number used in each categorization. Definitions of land classes can be found in NLCD, 2013 (NLCD, 2014).

Table 5. Comparison of NLCD 2006 Land Cover Groups with Classes in This Document.

National Land Cover Dataset (NLCD 2006)	This Document
Water: Open water (11) Perennial ice/snow (12)	Water (1) Water (1)
Developed: Open space (21) Low Intensity (22) Medium Intensity (23) High Intensity (24)	 Developed (2) Developed (2)
Barren (31)	Barren (3)
Forest: Deciduous (41) Evergreen (42) Mixed (43)	Forest: Deciduous (4a) Evergreen (4b) Mixed (4c)
Shrubland (52)	Shrubland (5)
Herbaceous: Grassland/Herbaceous (71)	Herbaceous: Grassland/Herbaceous (6)
_____	Pasture and Hay (7) (excluding alfalfa)

National Land Cover Dataset (NLCD 2006)	This Document
Planted/Cultivated: Pasture/Hay (81) (including alfalfa) Cultivated Crops (82) (including orchards; vineyards)	Cropland: Orchards/Vineyards (8a) Row crops (8b) (including alfalfa; non- forestry trees) Fallow (8c)
Wetlands: Woody (90) Herbaceous (95)	Wetlands (9)

Dominant vegetation types vary throughout the United States; these are described by region in the summary that follows:

Region A: cropland and forest are co-dominant, accounting for one-third of land cover each, followed by pasture/hay and developed land at roughly 10% each.

Region B: cropland is dominant, accounting for one-third of land cover, forest covers 27%, and pasture/hay, developed land, and wetlands each cover about 10%.

Region C: cropland is dominant, accounting for more than 50% of land cover, with roughly equal amounts of forest and developed land (15%), followed by pasture/hay at 11%.

Region D: forest is dominant, accounting for nearly 40% of land cover, followed by cropland and wetlands at approximately 15% each and developed land at 11%.

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

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

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

Region H: grassland and cropland dominate land cover, accounting for more than 40% each.

Region I: cropland is dominant, accounting for about 45% of land cover, while pasture/hay accounts for 30% and grassland for about 15%.

Region J: shrubland is slightly dominant, accounting for slightly more than 35% of land cover, followed closely by cropland at slightly more than 30% and grassland at 25%.

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

Region L: Desert shrubland is overwhelmingly dominant, accounting for 85% of land cover, while developed land accounts for 5% and cropland for about 3%.

Region M: Cropland is dominant, accounting for 70% of land cover, followed by grassland at about 20% of land cover.

Land cover composition varies across the affected environment (Table 6). For example, developed land ranges from 5 to 15% of land cover among the regions, accounting for 10% or more of the land cover in Regions A, B, C, D, and K. Central plains Regions H, I, J, and L in the Central Plains, Texas, and Arizona have much lower amounts of developed land. Wetlands account for 17% of the Mississippi Alluvial (Region F), and 16% of coastal Region D, and 13% of coastal Region K, but are present in much lower amounts in all other regions.

Table 6. Land Cover Composition by Region.

Land Cover Composition	Percent* Composition by Region												
	Region												
	A	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**
1. Water	3	3	1	2	2	3	2	4	1	<1	2	<1	<1
2. Developed	10	10	15	11	8	6	7	4	5	5	13	5	9
3. Barren	<1	<1	<1	<1	<1	<1	<1	<<1	<<1	<1	1	2	1
4a. Deciduous	26	26	16	15	38	13	7	1	3	1	2	<<1	<<1
4b. Evergreen	1	1	<1	22	1	5	<<1	<<1	<<1	1	1	<<1	<<1
4c. Mixed	2	<1	<<1	2	<1	2	<1	<<1	<<1	<<1	<1	<<1	<<1
5. Shrubland	5	<1	<<1	5	<1	5	<<1	<<1	<<1	37	12	85	<1
6. Grassland	0	5	1	4	1	<1	11	43	13	25	11	1	18
7. Pasture/hay	10	11	11	6	23	11	13	6	31	<<1	23	<1	<1
8a. Orchards	1	<1	<<1	<1	<<1	<1	<<1	<<1	<<1	<<1	<1	<1	27
8b. Row crops	33	33	53	15	25	34	56	40	43	30	18	3	30

8c. Fallow	1	<1	<<1	3	<<1	4	<1	1	3	2	5	2	13
9. Wetlands	7	9	2	16	1	17	4	2	1	<<1	13	1	2

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

The major land uses of the affected environment are agriculture (including crop cultivation, pasture and rangeland, animal production, forestry and logging), industrial, housing/residential (including urban, suburban and rural), and recreational and tourism. Wildlife habitat loss and urban sprawl are environmental concerns throughout the country. The relative proportions of major land uses vary between and within regions, as described below and in Table 7. Data on animal production is from the 2007 Census of Agriculture (USDA-NASS, 2009d).

Region A: Principal crops include corn, soybean, and alfalfa. Grain production is primarily for dairy cattle. Hay and alfalfa cultivation are roughly equivalent. Orchards, vineyards and vegetable farming (particularly cabbage) are also important in New York. Other significant land uses include urban development, industry, recreation, and tourism.

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

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

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

Region E: Land use in the north and west is dominated by cropland agriculture and pasture. The east and south tends to have a higher diversity of land uses that includes cropland, pasture, forest, and woodlots with some expanding urban areas. Corn and soybean are the predominant crops.

Wheat is also an important crop in the region, and tobacco is a significant crop in Kentucky. Livestock production, poultry farming, and egg production are also common. Mineral extraction is important in some parts of the region. This includes some oil and gas production in the south and east. Surface and underground coal mining are important industries in western Kentucky, southern Illinois and Indiana (USGS, 2013a), and these areas are associated with significantly degraded downstream wetland habitat and water quality.

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

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

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

Region I: Cropland (dryland and irrigated) and rangeland for cattle grazing are the principal land uses. Wheat and corn are the primary crops. Soybean and sorghum are also important. Livestock cattle production also is common.

Region J: Most of the region is devoted to cropland, pasture, and rangeland. Major crops include wheat and cotton. Other major crops are corn and sorghum. Oil and gas production are prominent in the southwest portion of the region, largely non-overlapping with crop cultivation, and concentrated animal feeding operations (primarily cattle) are also economically important (USDA-NRCS, 2006c).

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

Region L: Multiple areas of intensive, irrigated cropland are dominated by alfalfa, cotton, and wheat production. The region is also a major producer of lettuce, celery, melons, and greens despite being highly susceptible to droughts. Much of the land is federally owned, either as military lands or national parks, monuments, and wildlife refuges. Rapid urbanization around the larger communities is greatly reducing cropland acreage.

<u>Region M</u>: Land use is dominated by agriculture. Nearly half the land in the region is cropland. Three quarters of it is irrigated. A very wide variety of crops are grown. The major crops by land area are almonds, wheat, alfalfa, cotton, corn, and grapes. Other major crops, often constituting more than 50% of U.S. production, include walnuts and pistachios, pomegranates, nectarines, garlic, tomatoes, camelina, melons, lettuce, and olives. Cattle and dairy production is largely feedlot based. Urban areas and oil and gas production are also important.

Table 7. Major Cultivated Crops by Region in 2012[1].

Region	Crop	Cropland	
		As a Percent of Total Cropland Acreage in the Region[2]	In Region As a Percent of Total U.S. Acreage
A	Corn	48%	1%
	Soybean	18%	<1%
	Alfalfa	18%	1%
	Wheat	6%	<1%
	Apples	3%	8%
	Cabbage	1%	38%
B	Corn	53%	8%
	Soybean	26%	5%
	Alfalfa	15%	13%
	Wheat	3%	1%
	Potatoes	1%	10%
	Asparagus	<1%	35%
	Cucumbers	<1%	
	Celery	<1%	29%
C	Corn	53%	19%
	Soybean	40%	18%
	Wheat	3%	2%
	Alfalfa	3%	6%
	Dry beans	1%	11%
	Cucumbers	<1%	47%
	Gourds	<1%	39%
	Pumpkins	<1%	33%

Region	Crop	Cropland	
		As a Percent of Total Cropland Acreage in the Region[2]	In Region As a Percent of Total U.S. Acreage
D	Soybean	32%	5%
	Corn	28%	4%
	Cotton	21%	20%
	Wheat	15%	3%
	Peanuts	10%	79%
	Tobacco	1%	76%
	Pecans	2%	63%
	Sweet Potatoes	<1%	45%
	Peaches	<1%	42%
	Watermelon	<1%	32%
E	Corn	52%	8%
	Soybean	46%	9%
	Wheat	7%	2%
	Cotton	1%	1%
	Alfalfa	<1%	<1%
	Gourds	<1%	59%
F	Soybean	51%	12%
	Corn	20%	4%
	Cotton	12%	15%
	Rice	11%	70%
	Wheat	10%	3%
	Sweet Potatoes	<1%	36%
	Sugarcane	1%	22%
G	Corn	45%	34%
	Soybean	40%	39%
	Wheat	8%	11%
	Alfalfa	2%	8%
	Canola	1%	61%
	Sugarbeets	1%	54%
	Dry beans	1%	41%
	Flaxseed	<1%	37%
H	Wheat	34%	5%
	Corn	26%	2%
	Soybean	20%	2%
	Sunflower	6%	29%
	Alfalfa	3%	2%
	Flaxseed	2%	47%
	Lentils	1%	28%

Region	Crop	Cropland	
		As a Percent of Total Cropland Acreage in the Region[2]	In Region As a Percent of Total U.S. Acreage
I	Wheat	33%	12%
	Corn	34%	7%
	Soybean	23%	6%
	Sorghum	9%	26%
	Alfalfa	3%	4%
J	Cotton	54%	47%
	Wheat	39%	8%
	Sorghum	6%	11%
	Corn	2%	<1%
	Peanuts	<1%	2%
K	Sorghum	48%	19%
	Cotton	26%	5%
	Corn	13%	<1%
	Rice	6%	6%
	Citrus	6%	9%
L	Alfalfa	40%	2%
	Cotton	25%	2%
	Wheat	12%	<1%
	Lettuce	6%	65%
	Barley	6%	2%
	Celery	<1%	59%
	Misc.	2%	30%
	Fruit/Vegetable	<1%	30%
	Honeydew melons	1%	25%
	Greens		

Region	Crop	Cropland	
		As a Percent of Total Cropland Acreage in the Region[2]	In Region As a Percent of Total U.S. Acreage
M	Almonds	21%	69%
	Wheat	14%	1%
	Alfalfa	13%	3%
	Grapes	13%	42%
	Cotton	10%	3%
	Corn	9%	<1%
	Pomegranates	1%	97%
	Pistachios	5%	94%
	Nectarines	<1%	85%
	Garlic	<1%	84%
	Tomatoes	5%	53%
	Camelina	3%	52%
	Cantaloupes	<1%	45%
	Walnuts	2%	43%
	Honeydew	<1%	36%
	Melons	<1%	32%
	Lettuce	1%	25%
	Olives		

[1]Statistics for hay not included.

[2]Some regional totals may be less than or more than 100% because of rounding errors or double cropping practices.

By identifying land uses and the underlying soil parameters within the affected environment we can understand how to manipulate these environmental features to produce crops. Growers must use the land resources available to them and modify that environment to successfully produce crops. In Section 3.5, we review major agronomic methods important for cotton and soybean production. These include aspects of tillage, crop rotation, and agronomic inputs such as pesticides.

3.4 Biological Resources

Biological resources include the animal and plant communities associated with the major cotton and soybean cultivation areas within Regions A-M, as described in Table 2. Soil microorganisms are also reviewed in this section.

3.4.1 Animal Communities

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

The environment surrounding soybean and cotton fields may serve as important food sources and habitat for mammals, birds, fish, and insects. Soybean fields may be bordered by other soybean fields, or they may be surrounded by other agricultural crops, woods, pasture/grassland, or aquatic environments. Regardless of the agricultural operation, animals and insects in adjacent environments have the potential to be impacted directly by fertilizers, pesticides, and erosion or indirectly from the effects on the habitat surrounding the agricultural fields.

There are several crop management strategies that can increase the value of crop fields to wildlife. These strategies include conservation tillage and no-till practices (Towery and Werblow, 2010). Conservation tillage practices benefit biodiversity on agricultural land due to decreased soil erosion, improved surface water quality, retention of vegetative cover, increased food sources from crop residues, and increased populations of invertebrates (Landis et al., 2005; Sharpe, 2010b). Crop rotations also can reduce the likelihood of crop disease, insect and weed pests, and pesticide use which can benefit wildlife (University of California, 2008).

<u>Birds, Mammals, and Reptiles</u>

Agricultural fields have the potential to provide food, water, and habitat for birds but each landowner's farming practices and the crop type determines the value of these lands to wildlife. In the Cotton Belt, birds generally avoid cotton fields, although some generalist species (geese, egrets, gulls, and blackbirds) may periodically be observed in cotton fields (Butcher et al., 2007). Geese (Canada [*Branta canadensis*], snow [*Chen caerulescens*], and greater white-fronted [*Anser albifrons*] geese} and the northern pintail (*Anas acuta*) have been observed foraging in fallow or disked cotton fields that were flooded to enhance habitat for nonbreeding waterfowl during the fall or winter (Fleskes et al., 2003; Butcher et al., 2007). Cattle egrets (*Bubulcus ibis*) use cotton fields in the summer, which could be in response to increased invertebrate densities (Mora, 1997).

Waterbirds (e.g., geese, cranes, and shorebirds) and landbirds (e.g., red-winged blackbirds (*Agelaius phoeniceus*), purple martins (*Progne subis*), and bank swallows (*Riparia riparia*) are common visitors to soybean fields. Migratory birds have been observed feeding on spilled soybeans following crop harvest (Galle et al., 2009). However, the energy value of soybeans is low, so most birds only use soybeans to supplement their diet. Preferred diets include the consumption of nearby agricultural crops, especially corn and sunflower seeds, and the consumption of invertebrates and weed seeds in the soybean fields (Butcher et al., 2007). Migratory birds may be present in soybean fields year-round.

Some birds occurring within the affected environment that tend to be more localized include:

- Region A: wild turkey, waterfowl, ruffed grouse, woodpecker, warbler, screech owl
- Region B: wild turkey, turkey vulture
- Region C: Canada goose, sandpiper, sparrow
- Region D: wild turkey, herons, cardinal
- Region E: cardinal, bobwhite quail, Carolina chickadee
- Region F: wild turkey, migratory waterfowl, mourning dove, Carolina wren, wood thrush, cormorants, egrets, herons (widespread loss of forest and wetland habitat, has reduced bird populations but this region remains a major migratory flyway)
- Region G: Canada goose, bobwhite quail, sharp-tailed grouse, pheasants (this region is a major breeding habitat for waterfowl and other birds)
- Region H: golden eagle, ferruginous hawk, sage grouse
- Region I: numerous waterfowl (this is a major migratory flyway)
- Region J: turkey vulture
- Region K: waterfowl, geese, oriole, prairie chicken
- Region L: migratory waterfowl, chickadee, falcon, raven, thrasher
- Region M: wintering waterfowl, Nuttall's woodpecker, yellow-billed magpie

Rodents, such as mice or squirrels, may seasonally feed on soybean seeds. During the winter months, leftover and unharvested soybeans provide a food source for wildlife. White-tailed deer and groundhogs (*Marmota monax*) feed on soybeans and cause soybean damage, while eastern cottontail (*Sylvilagus floridanus*), raccoon (*Procyon lotor*), squirrels, and other rodents (such as ground squirrels) also feed on soybeans, but their damage is less significant (MacGowan et al., 2006). Deer may cause damage by browsing in soybean fields for forage, and in some areas, the state may issue licenses to kill deer outside the hunting season to reduce crop damage (Garrison and Lewis, 1987; Berk A, 2008). Deer also may feed on seed left after harvest. In Georgia, feral hogs (*Sus scrofa*) have damaged soybean fields through rooting and feeding (GDNR, 2003). Several mammals are widespread through many or most of the affected environment. These include white-tailed deer (Regions A-I; K), mule deer (Regions L and M), coyotes (Regions A-C; G-M), foxes (Regions A-G; I), raccoons (Regions A-G; J), red and/or gray squirrels (Regions A-D; F-H), bobcats (Regions C-F; H-L), and cottontail rabbits and/or jackrabbits (Regions D; G-J, M).

Some mammals occurring within the affected environment that tend to be more localized include:

- Region A: black bear, chipmunk, woodchuck, wolf in northern areas, beaver in the south
- Region B: beaver, otter, mink
- Region D: black bear, chipmunk
- Region E: badger, weasel in the north and west
- Region G: badger and skunk in southern areas
- Region H: pronghorn antelope and prairie dogs
- Region I: pronghorn antelope
- Region J: ringtail cat, armadillo, skunk, gopher

- Region K: ringtail cat, armadillo, ocelots
- Region L: pronghorn antelope, elk, cougar, chipmunk, pika, bats
- Region M: pronghorn antelope, elk, kit fox, ground squirrels, kangaroo rat

Some reptiles occurring within the affected environment that tend to be more localized include:

- Region D: box turtle, garter snake, rattlesnake
- Region E: snapping and box turtles, rattlesnake, copperbelly water snake
- Region G: this region is a major breeding habitat for waterfowl and other birds, including Canada goose, bobwhite quail, sharp-tailed grouse, and pheasants
- Region H: rattlesnakes
- Region J: Texas horned lizard
- Region K: alligator
- Region M: giant garter snake

<u>Invertebrates</u>

Invertebrate communities in agricultural fields represent a diverse assemblage of feeding strategies including predators, crop-feeders, saprophages, parasites, and polyphages (Stevenson et al., 2002). Numerous insects and related arthropods perform valuable functions: they pollinate plants, contribute to the decay and processing of organic matter, reduce weed seed populations through predation, cycle soil nutrients, and attack other insects and mites that are considered to be pests. Although many arthropods in agricultural settings are considered pests, there are many beneficial arthropods which are natural enemies of both weeds and insect pests (Landis et al., 2005). Terrestrial invertebrate food sources are likely impacted by insecticides used in soybean fields (including nontarget invertebrates). However, crop insect pests are considered less problematic than weeds in U.S. soybean production (USDA-NASS, 2009e).

For the purposes of environmental risk assessment, some high-profile or representative invertebrate species, such as honey bees, earthworms, and butterflies, are generally studied more thoroughly than others. Risk is a function of the toxicity of the compound to a given species and its exposure to the compound.

In order of importance, the most damaging arthropod pests in soybean in 2012 in the southern U.S. were corn earworm, soybean looper, and stink bugs (Musser *et al.*, 2013). The soybean cyst nematode is a roundworm which is an important pest of soybean fields in several states, especially Nebraska and Minnesota (Extension, 2011). Major arthropod insect pests of soybean and the states in which they are distributed are shown in Table 8.

Table 8. Major Arthropod Pests of Soybean.

Pest	Scientific Name	States
Armyworm, beet	*Spodoptera exigua*	AR, NC, SC, TX, VA
Armyworm, fall	*Spodoptera frugiperda*	AR, SC, TN, VA
Armyworm, southern	*Persectania ewengii*	AR

Pest	Scientific Name	States
Armyworm, yellowstriped	*Spodoptera ornithogallii*	AR, NC, VA
Armyworms	Noctuidae	MI, ND
Beetle, bean leaf	*Cerotoma trifurcata*	AR, IA, IL, IN, KS, KY, MI, MN, MO, NC, ND, NE, OH, SC, SD, TN, VA
Beetle, Japanese	*Popillia japonica*	IA, IL, IN, KY, MN, MO, NY, OH, PA, SC, TN
Beetle, Mexican bean	*Epilachna varivestris*	IL, IN, KY, MO, NC, OH, PA, TN, VA
Beetle, seed corn	*Stenolophus lecontei*	IN, KS
Beetle, spotted cucumber	*Diabrotica undecimpunctata*	AR
Beetles, blister	*Epicauta* spp.	AR, IA, IL, KS, MO, TN, VA
Beetles, Colaspis	*Colaspis* spp.	AR, IA, MO, NC
Beetles, flea	Chrysomelidae	KS, ND
Borer, common stalk	*Busseola fusca*	VA
Borer, lesser cornstalk	*Elasmopalpus lignosellus*	NC, SC, TX
Borer, soybean stem	*Dectes texanus*	AR, IA, KS, NC, NE, SC, TX, VA
Bug, kudzu bug	*Megacopta cribraria*	VA
Bug, tarnished plant	*Lygus lineolaris*	ND
Bugs, stink	*Pentatomidae*	AR, IA, IN, KY, MO, NC, NE, SC, TN, TX, VA
Caterpillar, alfalfa	*Colias eurytheme*	AR, NE
Caterpillar, saltmarsh	*Estigmene acrea*	AR, MN, NC, TX, VA
Caterpillar, thistle	*Vanessa cardui*	AR, IA, MN, ND, NE
Caterpillar, velvetbean	*Anticarsia gemmatalis*	NC, ND, SC
Caterpillar, woolly bear	*Pyrrharctia isabella*	MN, TX, VA
Caterpillar, yellow woolly bear	*Spilosoma virgnica*	NE
Corn earworm	*Helicoverpa zea*	AR, IL, MO, NC, SC, TN, TX, VA
Cutworms	Noctuidae	AR, IA, IL, IN, KY, MI, MN, ND, TN, TX, VA
Grasshoppers	Acrididae	AR, IL, IN, KY, MI, MN, MO, NC, ND, OH, SC, SD, TN, VA

Pest	Scientific Name	States
Green cloverworm	*Hypena scabra*	AR, IN, KY, MI, MN, MO, NC, ND, NE, OH, PA, SC, TN, VA
Imported longhorn weevil	*Calomycterus setarius*	NE
Looper, cabbage	*Trichoplusia ni*	MO, ND, NE
Looper, soybean	*Pseudoplusia includens*	AR, IA, KY, MI, NC, SC, TN, VA
Potato leafhopper	*Empoasca fabae*	IL, IN, MN, ND, NE, VA
Seed corn maggot	*Delia platura*	IA, IN, KS, KY, MI, MN, MO, ND, NY, PA, VA
Silverspotted skipper	*Epargyreus clarus*	NC, VA
Soybean aphid	*Aphis glycines*	IA, IL, IN: KS, KY, MI, MN, ND, NE, NY, OH, SD, TN, VA
Soybean leaf miner	*Odontota horni*	IA, NE
Spider mites	Tetranychidae	IA,IL, IN, KY, MI, MN, MO, ND, NE, NY, OH, SC, SD, VA
Threecornered alfalfa hopper	*Spissitulus festinus*	AR, KY, SC, TN, TX, VA
Thrips, especially soybean thrips	Thysanoptera	IN, MO, NC, NE, SD, VA
Tobacco budworm	*Heliothis virescens*	SC
Variegated leafroller	*Platynota flavedana*	AR
Webworm, alfalfa	*Loxostege commixtalis*	ND
Webworm, garden	*Achyra rantalis*	AR, MN, MO
White grubs	Larvae of Scarabaeidae	AR, IN,MN, MO, NC
Whiteflies	Aleyrodidae	NE
Wireworms	Elateridae	IN, MI, ND

Sources: (Thomas, 1993), (Station, No Date), (Moechnig *et al.*, 2013), (Nebraska, 2013),(University of Kentucky), (Service, 1999), (Extension, 2004), (Knodel *et al.*, 2013), (Tennessee, 2014), (Herbert *et al.*, No Date), (Whitworth *et al.*, 2014), (Service, No Date), (Greene, 2014b), (Gouge *et al.*, No Date), (Akin, 2009b); (Extension, 2013); (Gesell and Calvin, 2000); (Hammond *et al.*, 2009)

The most damaging arthropod pests in cotton fields in the United States in 2012 were:

1. Thrips (>8 million acres infested);
2. Bollworms and budworms (>6 million acres infested);
3. *Lygus* spp. (>5 million acres infested):
4. Aphids (> 5 million acres infested);
5. Cotton fleahopper (> 4 million acres infested) (Mississippi State University, 2013).

Major arthropod pests of cotton and the states in which they are distributed are shown in Table 9.

Table 9. Major Arthropod Pests of Cotton.

Pests	Scientific name	States
Aphid, cotton	*Aphis gossypii*	AR, AL, CA, FL, LA, MO, MS, NM, OK, SC, TX
Aphid, cowpea	*Aphis craccivora*	AZ, CA, NC
Armyworm, Beet	*Spodoptera exigua*	AR, AL, CA, GA, LA, MO, MS, NC, NM, OK, SC, TX
Armyworm, fall	*Spodoptera frugiperda*	AR, AL, GA, LA, MO, MS, NC, SC, TX
Armyworm, southern	*Spodoptera eridania*	AR
Armyworm, yellowstriped	*Spodoptera ornithogalli*	AR, AL, MO, MS, NC, TX
Boll weevil	*Athonomus grandis grandis*	AL, GA, MS, NC, OK, TX
Bollworms	*Helicoverpa punctigera*, *Helicoverpa armigera*	AR, GA, KS, LA, MO, MS, NC, NM, OK, TX
Common stalk borer	*Papaipema nebris*	AL
Corn earworm	*Helicoverpa zea*	AL, GA, SC
Cotton fleahopper	*Pseudatomoscelis seriatus*	KS, LA, MO, OK, SC, TX
Cotton leaf perforator	*Bucculatrix thurberiella*	TX
Cotton square borer	*Strymon melinus*	TX
Cotton stainer	*Dysdercus suterellus*	TX
Cutworms	*Agrotis* spp.	AL, GA, LA, MO, MS, NC, TX
European corn borer	*Ostrinia nubilalis*	AL, MO, MS
Flea beetles	Chrysomelidae	AZ, MO
Grasshoppers	*Brachystola magna*, *Melanoplus* spp.	AR, NM, OK, TX
Leafroller, omnivorous	*Platynota stultana*	TX
Leafroller, variegated	*Platynota flavedana*	MO
Leafworm, Brown Cotton	*Acontia dacia*	TX
Leafworm, cotton	*Alabama argillacea*	AL, TX

Pests	Scientific name	States
Loopers	Geometridae	AR, AL, GA, LA, MO, MS, NC, OK
Pink bollworm	*Pectinophora gossypiella*	CA, MS, TX
Plant bug, clouded	*Neuroculpus nubilus*	AR, TX
Plant bug, tarnished	*Lygus lineolaris*	AR, AL, AZ, CA, FL, GA, KS, LA, MO, MS, NC, NM, OK, SC, TX
Saltmarsh caterpillar	*Estigmene acrea*	AR, MO, TX
Spider mites	Tetranychidae	AR, AL, CA, GA, LA, MO, MS, NC, OK, SC, TX
Stink bugs	Reduviidae	AR, AL, CA, LA, MO, MS, NM: SC, TX
Thrips	*Frankliniella fusca*, others	AR, AL, CA, GA, KS, LA, MO, NC, NM, OK, SC, TX
Tobacco budworm	*Heliothis virescens*	AL, LA, MO, MS, NC, NM, OK, SC, TX
Vegetable weevil	*Listroderes costrirostris obliquus*	AR
Whiteflies	*Bemisia tabaci*, others	AZ, AL, CA, GA, LA, MO, MS, NM, SC, TX
Whitefringed beetles	*Naupactus* spp.	FL

Sources: (Akin, 2009a), (Bohmfalk *et al.*, 2011a), (Carlson and LaForest, 2010), (Extension, 1994), (Mossler, 2013), (Williams, 2013b), (Extension, 2001), (Schowalter, 2014); (Entomology, No Date); (Greene, 2014a); (Boyd *et al.*, 2004a); (Freeman, 2012); (Franke *et al.*, No Date)

Insect pests are managed during the growth and development of both crops to enhance yield (Higley and Boethel, 1994; Aref and Pike, 1998). This includes scouting for pests, establishing action thresholds beyond which treatment is required, and spraying with insecticides. In 2013, approximately 77% of acreage planted in cotton was sprayed with insecticide (Williams, 2013a).

Insects and other invertebrates can be beneficial to soybean and cotton production, providing services such as nutrient cycling and preying on plant pests. Table 10 lists the major beneficial arthropods in soybean and cotton fields.

Table 10. Major Beneficial Arthropods in Soybean and Cotton

Cotton		Soybeans	
Species or family	**Controls**	**Species or family**	**Controls**
Honey bee (*Apis mellifera)*	Pollinator		

Cotton		Soybeans	
Species or family	**Controls**	**Species or family**	**Controls**
Predators		**Predators**	
Ants (Formicidae)	Bollworm eggs and larvae	Ground beetles (Carabidae)	Aphids
Ambush and assassin bugs (Reduviidae)	Aphids, bollworm eggs, larvae	Mite (*Phytoseiulus persimilis*)	Spider mites
Bigeyed bugs (*Geocoris* spp.)	Aphids, bollworm eggs, larvae	Spined soldier bug (*Podisus maculiventris)*	Mexican bean beetle
Pirate bugs (Anthocoridae)	Aphids, bollworm eggs, larvae, thrips, whiteflies, spider mites	Pirate bugs (Anthocoridae)	Aphids
Damsel bugs (Nabidae)	Aphids, bollworm eggs, larvae		
Lacewing larvae (Chyrsopidae)	Aphids, bollworm eggs, larvae	Lacewings (Chrysopidae)	Aphids
Ladybird beetles (Coccinellidae)	Aphids, spider mites, bollworm eggs, budworm eggs	Ladybird beetles (Coccinellidae)	Aphids
Ant, Fire (*Solenopsis* spp)	Immature boll weevils, bollworm eggs, budworm eggs		
Cotton fleahopper	Bollworm eggs, budworm eggs		
Spiders			
Parasitoids		**Parasitoids**	.
Parasitic wasps *(Trichogramma* spp.)	Bollworm eggs	Hover flies (Syrphidae)	Aphids
Parasitic wasps (*Cardiochiles* spp.)	Budworm eggs	Braconid wasp (*Meteorus communis)*	Aphids
		Braconid wasp (*Glyptapanteles militari)*	Aphids

Source:(Bohmfalk *et al.*, 2011b);(Herbert et al.);(Mississippi State University, 2014)

<u>Aquatic Animal Communities</u>

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

Common fish found in each region include:

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

3.4.2 Plant Communities

Plant communities vary by region. In a previous section (3.3.7) land cover in each of the 13 regions of the affected environment was reviewed. Dominant vegetation types among the regions were summarized in Section 3.3.7. The vegetation types can include forest, shrubland, cropland, pastures, and grasslands. Table 6 and Table 7 provide descriptions of land cover in each of the regions.

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

In addition to the generally described land cover in an area, plant communities in agricultural fields include a range of weeds that influence and are influenced by agricultural practices. For example, cotton planted at too high a density forces the plants to compete for sunlight, water, and nutrients which limits each plant’s production (Rude, 1984), even though a high density of crop plants also reduces competition from weeds. Common weeds growing in the regions of the affected environment are identified in Appendix 5.

3.4.3 Microorganisms

The ability of animals to move in and out of fields can reduce their exposure to the crop production system. In contrast, soil microorganisms and plants living within cotton and soybean fields are simultaneously exposed to all of the agronomic practices affecting the crops. This section is a brief review of microbial components of the affected environment.

Inorganic and organic matter in soil supports a diversity of fungi, bacteria, and arthropods that are important components of the growth medium for terrestrial plant life (USDA-NRCS, 2004). Soil microorganisms are critical for soil structure formation, decomposition of organic matter, toxin removal, nutrient cycling, and most biochemical soil processes (Young and Ritz, 2000; Jasinski et al., 2003; Garbeva et al., 2004). They also suppress soil-borne plant diseases and promote plant growth (Doran et al., 1996). Soil resilience considers the capability of the soil to return to a pre-perturbation condition, and not as an intrinsic capacity to resist displacement from an initial equilibrium state (Welbaum et al., 2004).

Soil resilience is affected by the main factors affecting microbial population size and diversity. These include plant type (providers of specific carbon and energy sources into the soil), soil type (texture, structure, organic matter, aggregate stability, pH, and nutrient content), and agricultural management practices (crop rotation, tillage, herbicide and fertilizer application, and irrigation) (Young and Ritz, 2000; Garbeva et al., 2004). Plant roots release a variety of compounds into the soil that create a unique environment for microorganisms in the rhizosphere (Garbeva et al., 2004). Reduced-tillage practices enhance soil stability and reduce erosion in comparison to conventional tillage systems. All of these effects enhance soil microbial diversity. Although the total species diversity in the soil appears constant, organic matter decomposition continues to occur. This leads to the sequential colonization of niche specialists using different substrates as they present themselves over time. Consequently, changes in the relative abundance of a soil species is juxtaposed with aggregate variability in the overall abundance and biomass of the microbial community (Welbaum et al., 2004).

The soil microflora includes mycorrhizal fungi, nitrogen-fixing bacteria, and some free-living microbes that evolved together with plants to supply nutrients to the plant while obtaining food from their plant hosts (USDA-NRCS, 2004). This extensive microbial diversity in the rhizosphere differs from the microbial community in the bulk soil (Garbeva et al., 2004) because the root-specific exudates are the food sources used by these organisms to maintain and increase their populations. Tillage accelerates succession among microorganisms, and crop rotation can change soil conditions to favor different microbial communities (Papendick and Moldenhauer, 1995).

Inoculants are used to ensure adequate populations of “rhizobia” or *Bradyrhizobium japonicum* establish in soybean fields. This bacterium, in association with soybean roots, fixes atmospheric nitrogen into forms (ammonia or ammonium) the plant can use for growth and development (Alberton et al., 2006). Successful inoculation leads to nodulation on the soybean root, and excess fixed nitrogen remains in the soil to become available for subsequent crops or weeds (Alberton et al., 2006). Growers inoculating soybean fields can improve soybean yield by an average of 1 bushel/acre (Conley and Christmas, 2005). This organism can be added to fields in many forms including: non-sterile peat powder applied to the seed at planting, sterile carriers, inoculants with adhesives to stick to seed, liquid carriers, concentrated frozen products, pre-inoculants, and inoculants with extended biofertilizer and biopesticidal properties (Jawson et al., 1989; Conley and Christmas, 2005).

Another group of soil microorganisms that can affect soil quality, resilience, and crop growth are nematodes. These microscopic worms also can be pathogens that feed on the roots of various plants, including both cotton and soybeans. Many nematode species are difficult to control because it is difficult to find suitable molecules that can penetrate the soil, kill the microscopic pests, and not persist or have deleterious effects on other organisms.

3.5 Agronomic Practices in Cotton and Soybean Production

Modern agriculture coordinates a wide variety of ecosystem inputs to maximize crop yield and wisely use the land, vegetation, and environmental resources. Cotton and soybean production uses specific equipment for each crop's activities from preplant soil preparation to harvest and ginning (Weersink et al., 1992; Mitchell et al., 2012). For example, cotton may be harvested with spindle pickers, roller gins, or saw ginning depending on the variety (Rude, 1984; Anonymous, 2007). Tillage, crop rotation, and inputs such as pesticides are selected from a range of options by each grower to achieve their desired outcomes of yield and environmental stewardship.

3.5.1 Tillage

Prior to planting, soil is typically prepared by eliminating weeds that would otherwise compete with the crop for space, water, and nutrients. Field preparation often is accomplished through a variety of tillage systems, with each system defined by the remaining plant residue on the field (USDA-ARS, 1995).

Crop residues are materials left in an agricultural field after the crop has been harvested, including stubble (stems), leaves, and seed (USDA-NRCS, 2005). These residues aid in conserving soil moisture and reduce wind and water-induced soil erosion (Papendick and Moldenhauer, 1995; USDA-ERS, 1997; USDA-NRCS, 2005; Heatherly *et al.*, 2009). Residue on the soil surface breaks the impact of raindrops, improves water infiltration into the soil, and reduces evaporation and runoff (TAMU, 2014).

Conventional tillage is associated with intensive plowing and leaving less than 15% crop residue in the field (US-EPA, 2010b). In contrast, conservation and reduced tillage practices include: mulch-till, eco-fallow, strip-till, ridge-till, zero-till, and no-till (IPM, 2007). Reduced tillage is associated with 15-30% crop residue. Conservation tillage, including no-till practices requiring herbicide application on the plant residue from the previous season, is associated with at least 30% crop residue and substantially less soil erosion than other tillage practices (US-EPA, 2010b). Additionally, a number of different tillage and planting systems are used in soybean production, including primary and/or secondary tillage (IPM, 2007). Preplant tillage activities in cotton may include smoothing the soil or creating raised ridges for permanent or semi-permanent beds (Rude, 1984; Albers and Reinbott, 1994; Mitchell et al., 2012). Increases in total acres dedicated to conservation tillage were facilitated in part by an increased use of herbicide-resistant GE crops, reducing the need for mechanical weed control (USDA-NRCS, 2006b; Towery and Werblow, 2010; USDA-NRCS, 2010b).

Land management practices for crop cultivation also affect soil quality. Soil quality is related to its suitability for chosen uses (Welbaum et al., 2004). Tillage can affect soil properties after cultivation depending on the soil type (Papendick and Moldenhauer, 1995). Several concerns relating to soil and agricultural practices include increased erosion, soil compaction, degradation of soil structure, nutrient loss, increased salinity, change in pH, and reduced biological activity (USDA-NRCS, 2010b). Conventional tillage removes essentially all plant residues and weeds from the soil surface prior to planting. Conventional tillage practices may continue cultivation as the crop develops to control late emerging weeds (NCGA, 2007) particularly in cotton crops (Frans and Chandler, 1989). This practice increases the potential for soil loss from wind and water erosion (NCGA, 2007). Additionally, soil compaction associated with tillage machinery moving across fields may damage young, developing cotton crops (Rude, 1984; Mitchell et al., 2012). The act of mixing soil during tillage increases seed bed homogeneity while simultaneously destroying the diversity of microsites in the soil profile, consequently, tillage reduces both structural and functional diversity of the soil microbial community (Welbaum *et al.*, 2004).

In general, soil conservation practices, such as conservation tillage, reduce field tillage and corresponding soil loss (Tyler et al., 1994; Papendick and Moldenhauer, 1995; USDA-NRCS, 2006b). Conservation tillage relies on methods that result in less soil disruption and leaves at least 30% of crop residue on the surface in soybeans (Peet, 2001). No-till farming only disturbs the soil between crops. The new crop is planted into residue or in narrow strips of tilled soil (Peet, 2001), which results in less soil disruption. Under no-till practices, there is no turning of the soil to break up compacted areas (USDA-NRCS, 1996). Reducing tillage may also enhance conditions for development of economically significant pest populations that normally are efficiently managed with conventional tillage practices (NRC, 2010). For example, cotton aphids migrate into fields using conservation tillage and consistently reach peak population densities more rapidly than in conventionally tilled fields (Leonard, 2007).

Conservation tillage is highly valued as a means to enhance soil quality and preserve soil moisture, but it also presents potential challenges for disease and pest management (Rude, 1984; Tyler et al., 1994; Papendick and Moldenhauer, 1995). The surface residues may serve as an inoculum source for certain disease-causing organisms (Robertson et al., 2009). This can become problematic for growers using crop rotation schemes with minimal tillage (Robertson et al., 2009).

Cotton production systems generally rely on multiple-pass tillage, which is costly in labor, time, maintenance of specialized equipment, and fuel (El-Zik et al., 1989; Frans and Chandler, 1989; Albers and Reinbott, 1994; Mitchell et al., 2012). Despite incentives to reduce tillage, such as the USDA NRCS Environmental Quality Incentives Program, most cotton continues to be produced under traditional, multiple-pass tillage practices (Mitchell et al., 2012).

In traditional cotton cultivation, after the prior crop is harvested, the surface material is shredded and roots are undercut and mixed with the soil (Albers and Reinbott, 1994; Mitchell et al., 2012). A series of diskings provides a host-free period that is usually needed to reduce pink bollworm. There may be more than five field operations prior to seeding the cotton crop (plow under weeds, incorporate herbicides, break-up soil clods, shape the uniform planting beds, prepare for furrow irrigation and/or dry mulch) (Albers and Reinbott, 1994; Mitchell et al., 2012). Shallow cultivation using rolling harrow implements can kill weeds and even out surface soil moisture. Soil types prone to compaction can be loosened or fractured to reduce root restriction in hard soil layers (Mitchell et al., 2012). Since the 1990s, tractor traffic zones were separated from crop growth zones to create strip and vertical tillage systems where only the crop seed line is tilled. Improvements in equipment reduced tractor traffic, energy costs, and the soil compaction by combining tillage tools onto a single frame. Reducing the number of tillage passes reduces time, fuel use, the amount of dust generated (soil erosion), and can improve various aspects of water quality (Tyler *et al.*, 1994; Mitchell *et al.*, 2012).

Effective pink bollworm and nematode control in cotton require tillage operations to reduce soil-borne populations of these pests (Kirkpatrick and Thomas; Mitchell et al., 2012). These pests and others overwinter in the soil, and then infect or infest the new crop. Disease control measures include cultivation of resistant hybrids, crop rotation, and careful balancing of conservation tillage with residue management (Robertson et al., 2009).

Information provided by Monsanto on the trends in tillage practices for cotton showed variation across the country in the last five years (Monsanto, 2013c). According to the survey data, growers in the Western U.S. did not tend to increase use of conventional tillage practices, in contrast to those in the Mid-South. The survey revealed that growers adopt specific tillage practices based on the cost of production, commodity price, need for seed bed preparation, and to manage excessive crop residue or weeds (see Appendix 9).

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

Introduction of improved herbicides and planters in the mid-1980s facilitated better weed control and good seed placement in no-tillage systems, which some farmers began to adopt at that time (Randall *et al.*, 2002; Owen *et al.*, 2011). Adoption of conservation tillage systems in general accelerated in the 1990s after soil conservation policy was incorporated into the Food Security Act of 1985 (NRC, 2010). The introduction of GR soybeans in 1996 fit into the ongoing trend of increasing adoption of conservation tillage by allowing growers to control weeds without the need for tillage (Carpenter and Gianessi, 1999; NRC, 2010).

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

3.5.2 Crop Rotation

Crop rotation is the successive planting of different crops in the same field over a specific number of years. Goals of crop rotation include maximizing economic returns and sustaining the productivity of the agricultural system (Hoeft et al., 2000). Sustaining the agricultural system is achieved by rotating crops that may improve soil health and fertility with more commercially beneficial “cash crops.” Because soybeans fix nitrogen in soil, the yield of some crops following a soybean crop, such as corn or wheat, may increase (Berglund and Helms, 2003). Moreover, the rotation of crops can effectively reduce disease, pest incidence, weediness, and selection pressure for weed resistance to herbicides (USDA-ERS, 1997; Berglund and Helms, 2003). Crop rotation may also include fallow periods, or sowing with cover crops to prevent soil erosion and to provide livestock forage between cash crops (Hoeft et al., 2000; USDA-NRCS, 2010a). Maximizing economic returns is realized by rotating crops in a sequence that efficiently produces the most net returns for a producer over a single- or multi-year period.

Many factors at the individual farm level affect the crop rotation system chosen, including the soil type present in an individual field, the expected commodity price, the need to hire labor, the price of fuel, the availability of funding to buy seed, and the price of agricultural inputs (Langemeier, 1997; Hoeft et al., 2000; Duffy, 2011). Figure 9 shows the cropping patterns of soybeans and cotton in the U.S. The benefits of rotation to soybean (Al-Kaisi et al., 2003) include:

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

Crop rotation is not commonly used for cotton in the Cotton Belt, where over 60% of the planted acres are commonly described as a cotton monoculture (Hake et al., 1991; USDA-ERS, 2011a). The remaining acreage generally is planted to a rotation with small grains / sorghum or other crops (El-Zik et al., 1989; USDA-ERS, 2011a). For example, cotton-tomato rotations are successfully used in California when irrigation is available to set the transplants after planting (Mitchell et al., 2012). Preceding or following cotton with crops such as wheat or triticale may work well in conservation tillage systems, if seeding operations ensure adequate stands. Rotational sequences with sorghum, soybean, or alfalfa are reported to reduce the incidence of some soil-borne diseases (El-Zik et al., 1989). Silage corn, which leaves relatively few soil residues, may be suitable for crop rotation with cotton (Mitchell et al., 2012).

Since 2000, an increasing percentage of land cropped to cotton was left fallow (USDA-ERS, 2011a) . A dry fallow rotation can control perennial weeds such as field bindweed, bermudagrass, Johnsongrass, and nutsedges while providing increased water for irrigation on other fields (Hake et al., 1991). Regardless of which crop is grown, sustained conservation tillage production systems require detailed planning to avoid causing soil compaction (Mitchell et al., 2012).

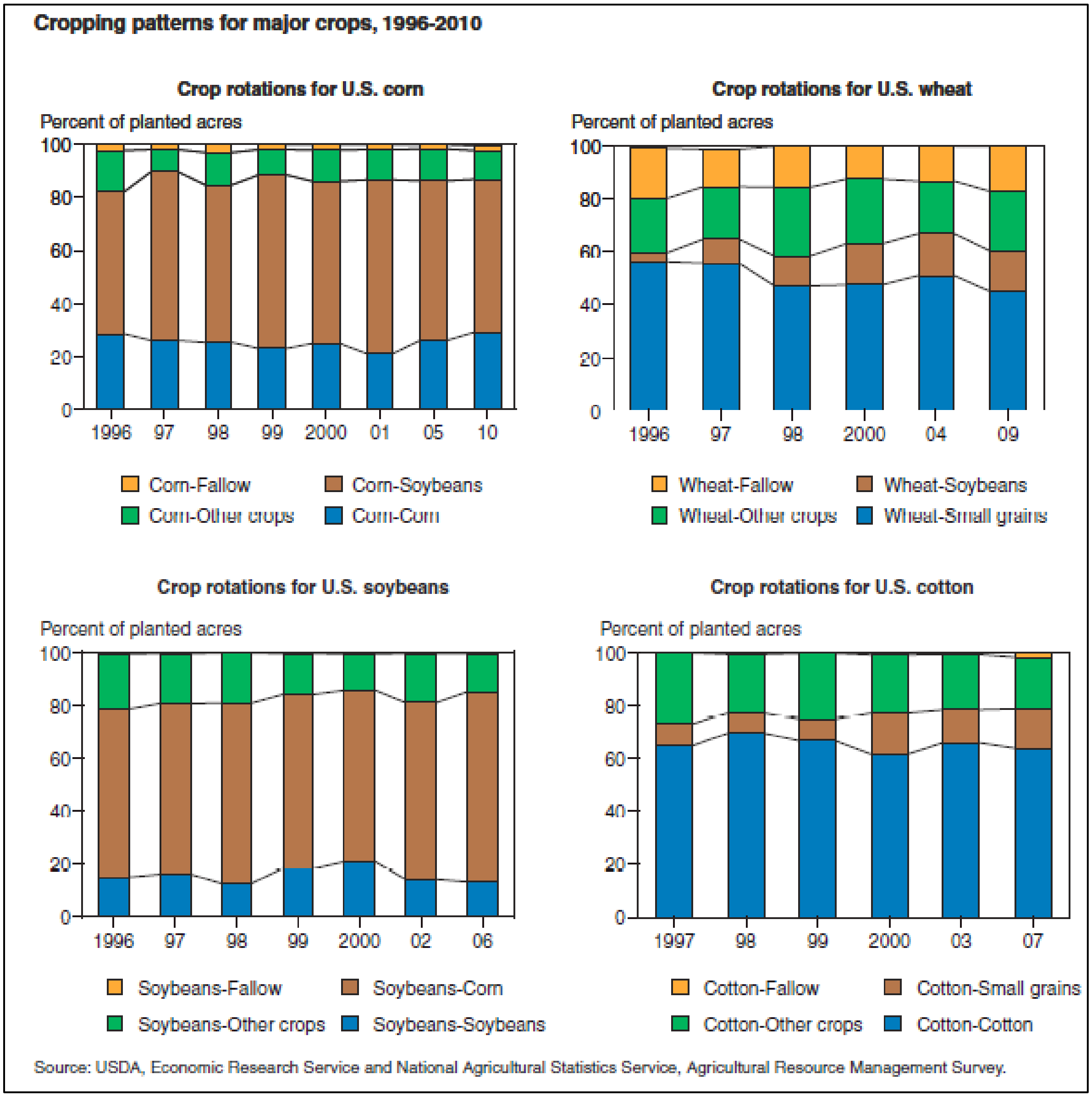


Figure 9. Cropping Patterns for Soybeans and Cotton in the United States.
Source: (USDA-ERS, 2011a)

Where it could be grown, cotton became a dominant crop because continuous monoculture of cotton provided more income per acre than soybeans, corn, rice, and wheat (Hake et al., 1991). Cover crop rotations typically consist of planting a winter cereal or legume in the fall followed by cotton next spring. These rotations create an economic control strategy for soilborne diseases, interacting nematodes, and resistant weeds. Typically, cover crop rotations provide erosion control, improved soil tilth, and suppress diseases. Diversification increases economic stability when profitable crops are rotated with cotton, but rotation out of monoculture may not be needed if pests can be otherwise managed (Hake et al., 1991). Growers must carefully adhere to label use requirements because some herbicides used in cotton production may leave soil residues that can injure subsequent rotation crops, and many cotton varieties are sensitive to pesticides used in other crops (Rude, 1984).

After over 100 years of continuous planting on Pacolet fine sandy loam soil, the oldest continuous cotton experiment in Alabama demonstrated cotton lint yield nearly three times higher when cotton is rotated with legumes as opposed to un-rotated plots (AUDAS, 2004).

Yet cotton lint yield response to crop rotation is relatively small in comparison to other crops. Rotation with wheat-soybean shows the largest benefit from crop rotation (Hake et al., 1991). But most of this benefit is attributed to decreasing disease and nematode populations in the soil, as opposed to supplying nutritional needs. Cotton's relatively low nutritional needs are attributed to its deep root system, associations with soil microorganisms, and warm season growth habit. Consequently, when cotton is grown in rotations it is the needs of the other crops that determine the amounts of phosphorus, potassium and micronutrients that must be added (Hake et al., 1991).

Effective nematode and disease suppression through crop rotation is a long-term management strategy that depends on the host range of the pathogen, the type of rotational crop used, and the length of the rotation. The goal of the rotation is to reduce pathogen populations below their threshold level by not planting crops that are susceptible to the disease present in the field (Kirkpatrick and Thomas; Hake et al., 1991). For example, rotation to a monocot crop can suppress seedling diseases in subsequently planted cotton, but rotation to a legume cover crop is not likely to reduce cotton seedling disease (Hake et al., 1991). Intercropping alfalfa as a trap crop for lygus bugs was attempted, instead of a rotation, but found impractical (El-Zik et al., 1989). An effective rotational management strategy must be economically feasible, practical, and compatible with herbicide programs (Kirkpatrick and Thomas).

Crop rotation is a common practice on U.S. soybean fields. Soybeans are often rotated with such crops as corn, winter wheat, spring cereals, and dry beans (OECD, 2000), the selection of which varies regionally. Corn is the most commonly rotated crop with soybeans. USDA Agricultural Resource Management Survey (ARMS) results for corn and soybean indicate a small increase in corn in rotation and continuous corn over the past decade (Ebel, 2012).

Soybean itself may be a cover crop in short rotations for its ability to contribute nitrogen to subsequent crops (Hoorman et al., 2009). Continuous soybean production is sometimes practiced, but yield can be reduced the second or later years, and pest and disease incidence may increase (Pedersen *et al.*, 2001; Monsanto, 2010b).

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

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

3.5.3 Agronomic Inputs

Crop production typically involves the extensive use of agronomic inputs to maximize yield (Ritchie et al., 2008). In general, agronomic inputs include fertilizers to supplement available nutrients in the soil; pesticides to reduce weed, insect, microbial, and nematode populations, and water to ensure normal plant growth and development (Rude, 1984; El-Zik et al., 1989; Ellington et al., 2007).

Fertilizer:

Commercially available fertilizers usually contain a mixture of the macronutrients nitrogen, phosphorus, and potassium which are essential for plant growth (Vitosh, 1996). To fill specific crop needs in soils that are deficient, various concentrations of micronutrients may be included in fertilizer formulations (Jones and Jacobsen, 2003). Fertility needs also can be met by applying organic matter which may alter the soil's naturally occurring level of nutrients that are available for plant growth (Jones and Jacobsen, 2003). Nevertheless, about half of the nitrogen applied in a chemical form is not taken up by plants but is lost to the atmosphere and to above- and below-ground water supplies (Ellington et al., 2007). Nevertheless, about half of the nitrogen applied in a chemical form is not taken up by plants but is lost to the atmosphere and to above- and below-ground water supplies (Ellington et al., 2007).

The nutritional needs for cotton are generally recognized as lower than other major crops. Nevertheless, the nutrients needed in the largest amounts are nitrogen, phosphorus, potassium, calcium, magnesium, and sulfur (Rude, 1984). Other essential nutrients needed in very small amounts are iron, boron, manganese, zinc, molybdenum, copper, and chlorine (Rude, 1984). Increased cotton growth and yield under higher nitrogen regimes can be offset in value by increased populations of pest insects leading to reduced lint quality (El-Zik et al., 1989; Ellington et al., 2007). Efficient fertilizer use in cotton requires there to be no excessive nitrogen at the end of the season because nitrogen applied too late triggers the need for extra applications of defoliants (Rude, 1984; El-Zik et al., 1989). Cotton plants produce more flowers than can be grown to maturity, so they typically shed excess squares and bolls when under carbohydrate stress (Rude, 1984).

Efficient fertilizer use in cotton requires there to be no excessive nitrogen at the end of the season because nitrogen applied too late triggers the need for extra applications of defoliants (Rude, 1984; El-Zik et al., 1989). Cotton plants produce more flowers than can be grown to maturity, so they typically shed excess squares and bolls when under carbohydrate stress (Rude, 1984).

Nitrogen is not frequently added to soybean fields because the plants have a microbial relationship that fixes atmospheric nitrogen into a form the plant can use for growth (Alberton et al., 2006). A 2006 survey reported by USDA National Agricultural Statistics Service (NASS) (USDA-NASS, 2009d) found that among 19 select states, nitrogen was applied to 18% of the planted soybean acreage in those states at an average rate of 16 pounds (lb)/acre per year, and phosphate was applied to 23% of the planted acres at an annual average rate of 46 lb/acre. Potash was applied to 25% of the planted acreage at an average annual rate of 80 lb/acre, and sulfur was applied to 3% of the planted acres at an average annual rate of 11 lb/acre (USDA-NASS, 2009d). Other micronutrient supplements such as zinc, iron, and magnesium were applied as needed to soybean production (Whitney, 1997; USDA-NASS, 2007a; NSRL, No Date).

Insecticides:

Pesticides that kill inhibit, or control insect populations are called insecticides. While insecticides are used to improve crop yields and quality, they can alter wildlife habitat and harm species. Wildlife is directly exposed to insecticides, when it consumes plants, seeds, or carcasses contaminated with insecticide residues. Wildlife that is located in fields during insecticide application inhale vapors and get residues on their fur or in their eyes. Wildlife also is indirectly exposed when they eat insects or other non-target animals killed by insecticides. Heavy rains can harm aquatic wildlife by washing chemicals into waterways (Fuchs et al., 2014).

A wide variety of insecticides are registered for use in cotton, but growers typically scout for pests and apply insecticides only when economic thresholds are met (Rude, 1984; Higgins, 1997) (Benedict et al., 1989). Some of the currently registered insecticides for use in cotton are listed in Table 11, however, this listing is provided for comparison purposes and should not be construed as a recommendation.

Table 11. Commonly Used Insecticides for Cotton Pests.

Cotton Pest	Insecticidal Products[1]
Aphids	acetamiprid, clothianidin, flonicamid, imidacloprid, and thiamethoxam
Beet and Fall Armyworms	chlorantraniliprole, emamectin benzoate (R), flubendiamide, indoxacarb, methomyl (R), methoxyfenozide, novaluron, spinosad, and thiodicarb
Bollworm	Bifenthrin (R), chlorantraniliprole, cyfluthrin (R), *beta*- cyfluthrin (R), *gamma*-cyhalothrin, *lambda*-cyhalothrin (R), cypermethrin (R), *zeta*-cypermethrin, *zeta*-cypermethrin / bifenthrin, emamectin benzoate (R), esfenvalerate (R), flubendiamide, indoxacarb, methomyl (R), novaluron, profenofos, spinosad, and thiodicarb
Tobacco Budworm (in Varieties Containing Bt Genes)[2]	chlorantraniliprole, emamectin benzoate (R), flubendiamide, indoxacarb, methomyl (R), novaluron, profenofos, spinosad, and thiodicarb
Cutworms	acephate, bifenthrin, chlorpyrifos, cyfluthrin, *lambda*-cyhalothrin, gamma-cyhalothrin, cypermethrin, zeta-cypermethrin, *zeta*-

Cotton Pest	Insecticidal Products[1]
	cypermethrin / bifenthrin, and esfenvalerate
Cotton Fleahopper and Tarnished Plant Bug	acephate, clothianidin, dicrotophos (R), flonicamid, imidacloprid, novaluron, oxamyl (R), and thiamethoxam
Soybean Looper and Cabbage Looper	emamectin benzoate (R), flubendiamide, indoxacarb, methoxyfenozide, novaluron, spinosad, and thiodicarb
Spider Mites	abamectin, bifenthrin (R), chlorpyrifos, dicofol, etoxazole, fepyroximate, propargite, and spiromesifen
Stink Bugs	Non-pyrethroids: acephate, dicrotophos, methyl parathion, novaluron, and oxamyl. Pyrethroids: bifenthrin (R), cyfluthrin (R), *beta*-cyfluthrin (R), *lambda*-cyhalothrin (R), *gamma*-cyhalothrin (R), cypermethrin (R), *zeta*-cypermethrin (R), *zeta*-cypermethrin / bifenthrin (R), and esfenvalerate (R)
Thrips (at Planting)	aldicarb (R), imidacloprid, and thiamethoxam
Thrips (Foliar Sprays)	acephate, dicrotophos (R), and dimethoate
Whiteflies	acephate, acetamiprid, imidacloprid, pyriproxyfen, and thiamethoxam

[1] (R) means restricted use. Pre-mixed or co-packaged products also may be available when there are multiple pests requiring simultaneous treatment.
[2] Bt - Insect resistant crops (Bt crops) contain a gene from a soil bacterium, *Bacillus thuringiensis* (Bt), which produces a protein that is toxic to specific lepidopteran insects.
Source: (Green, 2012).

Insect injury in soybean seldom reaches levels that cause significant economic loss, as indicated by the low percentage (18 percent) of soybean acreage that receive insecticide treatments (USDA-NASS, 2012b). Insect infestation levels indicate when insecticide applications are actually necessary (Higgins, 1997). When insect infestations found in field sampling surveys and/or during standard defoliation exceed specific levels, the thresholds are met. The National Information System of the Regional Integrated Pest Management Centers in pest management strategic plans provide a number of insect thresholds (USDA-AMS, 2011a). A 2006 survey (USDA-NASS, 2009d) found insecticides were applied to 16% of the 72.9 million soybean acres planted in surveyed states in 2006. Of the 12 reported insecticides, the three most common—lambda-cyhalothrin, chlorpyrifos, and esfenvalerate—were applied to 6%, 5%, and 3% of the planted acres, respectively (USDA-NASS, 2009d). Other methods of addressing insect infestations include the introduction of beneficial pests that prey on targeted insects obtained from commercial suppliers, as well as crop rotation and tillage.

A wide variety of pests hinder crop production, and many require applications of agricultural pesticides to keep pest populations below economic thresholds. The development of pest populations with resistance to various classes of insecticides requires growers to wisely coordinate the compounds used at various times during the production of a crop. For example, insecticide seed treatments that increase planting efficiency in cotton may use neonicotinoids and over-the-top foliar sprays used later in the season may include non-selective organophosphates. Many cotton aphid populations are resistant to these chemistries, so while other pests are controlled, the cotton aphid populations increase (Leonard, 2007). Several groups and types of insects feed on foliage, seed pods, and/or roots of the soybean plant leading to reductions in yield if these pests are not adequately controlled (Lorenz et al., 2006; Whitworth et al., 2011).

Pesticides can alter bird habitat and harm species that are directly exposed to the chemicals. Exposure occurs when birds consume plants or seeds contaminated by chemical residues. Birds located in fields during pesticide application can inhale vapors and get pesticides on their feathers or in their eyes. Birds can be indirectly exposed when they eat insects or non-target animals killed by the pesticides (Fuchs et al., 2014).

Herbicides:

The following section provides a brief background of herbicide use in cotton and soybeans in the U.S. It is provided to give the context for the analyses related to HR weed selection. Further information is presented in Appendices 3-8.

In selecting an herbicide, a grower must consider, among other factors, whether it can be used on the crop (herbicides are registered by the EPA for specific uses/crops), the potential adverse effects on the crop, residual effects that can limit crops that can be grown in rotation, effectiveness on expected weeds, and cost. Herbicides have different ways of acting on plant physiology (i.e., modes of action) to affect the health of a given plant (see Appendix 3). Some common modes of herbicide action include: auxin growth regulators like 2,4-D; amino acid inhibitors such as glyphosate; photosynthesis inhibitors such as atrazine; lipid biosynthesis inhibitors like quizalofop; glutamine synthase inhibitors such as glufosinate (UW-NPMP, No Date) (see Appendix 3).

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

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

Herbicide use varies with each crop based on both the types of herbicides used and the variety of herbicide sites of action[6] (see Appendix 3). Cotton establishment takes longer to close the canopy than soybeans, so cotton becomes more susceptible to competition by early season weeds (Frans and Chandler, 1989). Cotton may be planted in wider rows than soybeans, and the resulting light penetration into an unclosed canopy allows weed germination and growth over a longer period of time than in soybeans (Frans and Chandler, 1989). For these reasons, post-emergent applications of herbicides are more common in cotton crops than in soybeans, but there may be fewer herbicide options.

To obtain the best cotton yields, growers manage weeds with a diversification of weed control strategies ranging from mechanical choppers and cross-cultivation to hand-labor and modern herbicides (Frans and Chandler, 1989). The rotation of combinations of herbicide treatments can reduce the undesirable ecological shifts to new weed species or herbicide- resistant weed species (Frans and Chandler, 1989). Herbicide residues from organic arsenicals have been a concern in cotton seed, particularly if applications occurred during early reproductive growth stages (Frans and Chandler, 1989). Cotton is particularly sensitive to drift from phenoxy herbicides used on nearby crops (Frans and Chandler, 1989).

Until recently, soybean growers relied almost exclusively on glyphosate for weed control. Prior to the adoption of GR soybean, growers relied heavily on herbicides with a mode of action called "acetolactate synthase (ALS) inhibitors" or "acetohydroxyacid synthase (AHAS) inhibitors". With the adoption of GR soybean, glyphosate was used on greater than 95% of soybean acreage and for 75% of soybean growers, glyphosate represented the only herbicide mode of action used. As GR weeds have become more prevalent, the trend among soybean growers is to use more modes of action including 2,4-D, chloroacetamides, protoporphyrinogen oxidase (PPO), and ALS inhibitors.

Growers choose pesticides based on weed, insect and disease pressures, cost of seed and other inputs, technology fees, human safety, potential for crop injury, and ease and flexibility of the production system (Heiniger, 2000; Farnham, 2001). The continued emergence of GR weeds will likely require modifications of crop management practices to address these weeds. Herbicide use may increase to meet the need for additional integrated weed management tactics to mitigate HR weeds in different cropping systems (Owen and Zelaya, 2005; Culpepper, 2008; Heap, 2014c).

In selecting an herbicide, a grower must consider, among other factors, whether an herbicide can be used on the crop (herbicides are registered by the EPA for specific uses/crops), the potential adverse effects on the crop, residual effects that can limit crops that can be grown in rotation, effectiveness on expected weeds, and cost. Herbicides have different ways of acting on plant physiology (i.e., modes of action) to affect the health of a given plant (see Appendix 3). Some common modes of herbicide action include auxin growth regulators like 2,4-D; amino acid inhibitors such as glyphosate; photosynthesis inhibitors such as atrazine; lipid biosynthesis

[6] The sure if action is the location within the plant where the herbicide impacts the development process.

inhibitors like quizalofop; and glutamine synthase inhibitors such as glufosinate (UW-NPMP,No Date) (see Appendix 3). Applications of herbicides to a crop may occur pre-plant (i.e., burndown), pre-emergence, or post-emergence (Schneider and Strittmatter, 2003).

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

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

HR crops have become adopted widely since their introduction in the mid-late 1990s for several reasons. Increased selection pressure caused by wide-spread adoption of HR crops and reduction in the use of other herbicides and weed management practices, resulted in both weed population shifts and growing numbers of HR individuals among some weed populations (Owen, 2008; Duke and Powles, 2009). Figure 10 depicts states reported to have dicamba-, 2,4-D-, and glufosinate-resistant weeds.

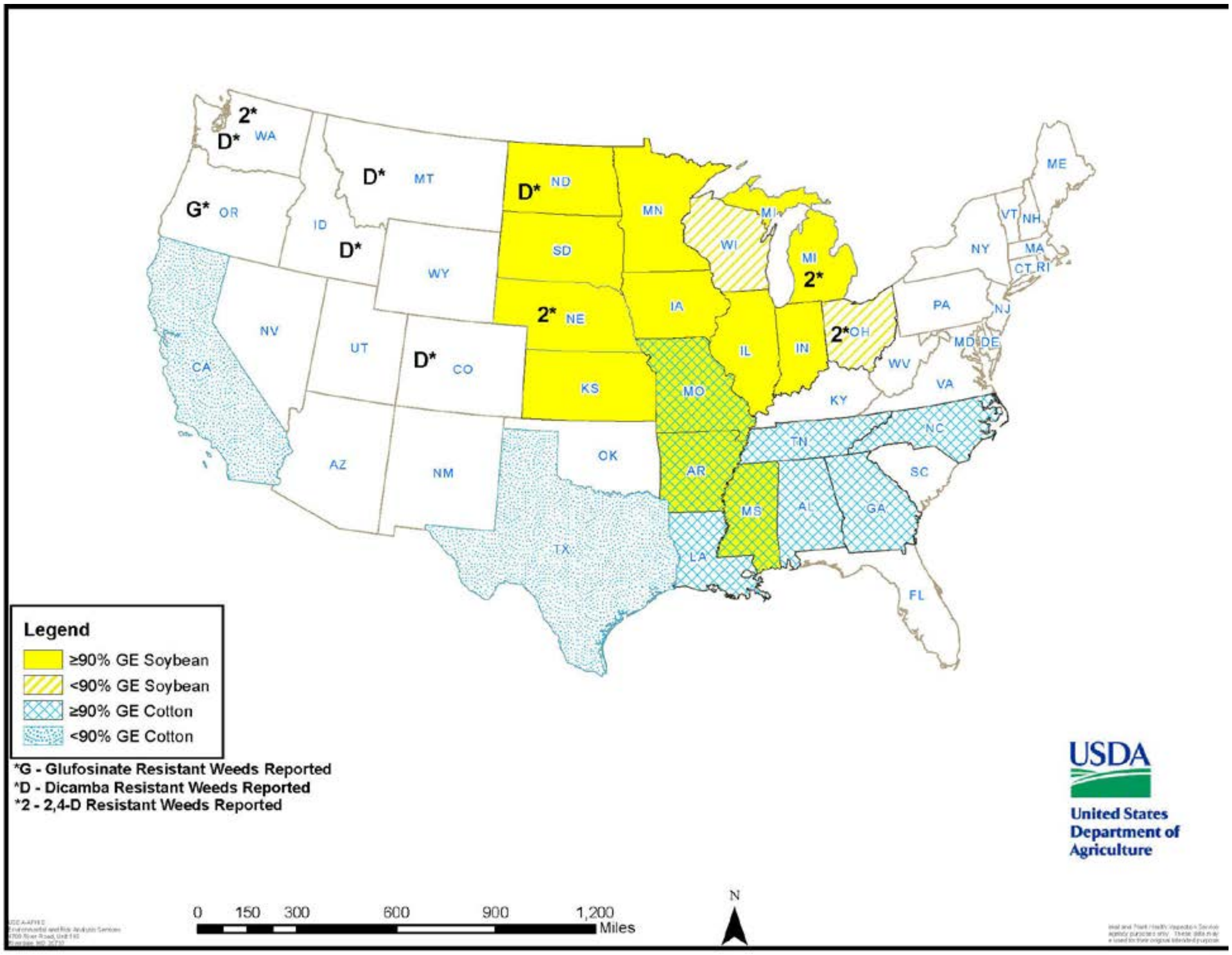


Figure 10. States of the United States Reported to Have Populations of Dicamba-, 2,4-D-, and Glufosinate-Resistant Weeds.
Source: (Heap, 2014c)

As HR weeds increase in prevalence, costs of weed control may also increase if additional compounds, applications, or equipment must be used. Growers may be able to control HR weeds without increasing costs if less expensive chemicals or multi-chemical formulations are available.

Extension weed scientists estimated the increased cost of the additional herbicides needed to control glyphosate-resistant weeds in soybean to be as much as $42/acre (for Palmer amaranth in Tennessee), with most estimates of the increased costs falling in the range of up to $20 to $30/acre (Carpenter et al., 2002). These costs will vary depending on the specific weed species present in any particular field. However, as resistance to glyphosate and other herbicides has developed and spread in weed populations, these costs may have increased since these estimates were made. For example, there are waterhemp populations in Iowa corn and soybean production fields with resistance to five herbicide sites of action (Owen, 2012).

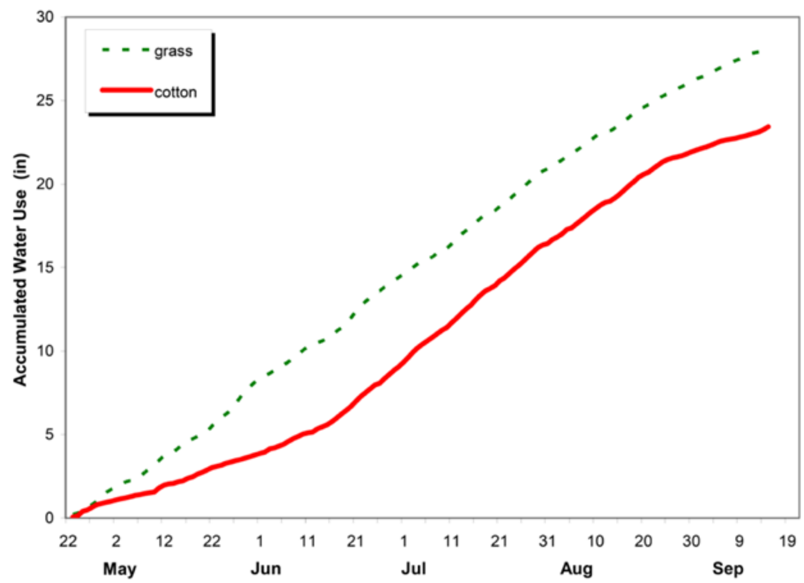
Growers choose certain pesticides based on weed, insect and disease pressures, cost of seed and other inputs, technology fees, human safety, potential for crop injury, and ease and flexibility of the production system (Heiniger, 2000; Farnham, 2001; University of California, 2008). Growers have traditionally used multiple herbicides for weed control. For pre-plant application herbicides that have residual activity are typically used (see Appendix 3). For more details about herbicides used for cotton and soybean production see Appendix.

Agronomic production methods change over time. One of the seemingly old, yet at the same time new methods of production is organic farming. While land producing crops under organic certification in the U.S. remains small in total acreage, the needs and demands to enter this niche market and remain profitable ensure that growers make wise decisions about how they manage their resources. In the next section, we briefly discuss organic production as related to cotton and soybean in this country.

Water Use in Cotton and Soybean Production

Soil is the storage site for water available to plants, the primary factors in determining water-holding capacity are soil texture and root zone depth (TAMU, 2014). Roots grow in moist soil, not in saturated or dry soil (TAMU, 2014). Several factors can affect soil moisture variability, including soil type and intrinsic heterogeneity, plant growth variation, rainfall interception, reduced application efficiency and uniformity in irrigation (Muñoz-Carpena et al., 2006).

Cotton varieties are now bred to be a relatively drought tolerant plants (see Figure 11), so the majority of U.S. cotton uses supplemental irrigation to optimize production (TAMU, 2014). From 1980 to 2011, the proportion of irrigated cotton acreage remained relatively constant at approximately 32% (Field to Market, 2012), even though the total irrigated acreage increased because of the increase in total land used for cotton production during that interval. Between 1980 and 2011, total irrigation water applied for U.S. cotton decreased 35% (1.4% compound annually); total water use was 95.5 million acre inches in 1980 and 62.9 million acre inches in 2011 (Field to Market, 2012). On average worldwide, at least 500 mm of rainfall (about 20 inches) is required during the growing season for dryland (non-irrigated) cotton crops (OECD, 2008).



Crop	Water Use Efficiency	
	lb/acre-in	L/kg
Maize	408	556
Wheat	247	917
Rice	247	917
Cotton - Seed + Lint	199	1136
Seed	147	1538
Lint	52	4348

Figure 11. Cotton Water Use and Average Water Use Efficiency Compared to Other Crops, 2003/2004.

The "water use efficiency" is calculated from the marketable crop yield divided by crop water use. Source: (Barnes and O'Leary, 2006)

The water supply for cotton germination and seedling development can be met either by preplant irrigation or by "irrigating up" after planting (Rude, 1984; El-Zik et al., 1989). The amount of water depends on rainfall and the nature of the soil profile (Rude, 1984). The need for water increases dramatically from less than 1 inch per week at emergence to 2 inches per week at first bloom. The critical period to avoid water stress is during flowering and boll development when peak water use occurs. Drought during this interval causes the plant to shed small squares first. Continued water stress leads to larger squares and then bolls being shed (Rude, 1984; TAMU, 2014). The need to avoid water stress during the flowering period must be balanced against the likelihood of boll rot epidemics (Rude, 1984). Proper timing for the final irrigation provides adequate moisture for the last harvestable bolls to mature even though the plant's water needs dropped considerably by harvest (TAMU, 2014). Irrigating too late can delay the opening of mature bolls, may increase lodging, and complicated defoliation by promoting late season growth and regrowth (Rude, 1984). An over-supply of water and/or nitrogen is associated with lanky or "rank" growth with excessive foliage and stems and reduced yield (Rude, 1984). Cotton will continue to grow and fruit until weather conditions are no longer favorable for growth (Barnes and O'Leary, 2006).

Established cotton plants metabolically adapt to cope with periods of water loss, but water stress can cause the shedding of leaves, flowers, and bolls; upset osmosis regulators; and reduce photosynthesis in cotton plants (El-Zik et al., 1989). As water stress increases, cotton plants put more biomass into reproductive growth, and this sequence can be manipulated by growers to increase yield (El-Zik et al., 1989; Gibbs et al., 2005). In certain cotton varieties, stem color is an indicator of water stress. Crops treated by a growth regulator may exhibit different stem coloring; plant wilting or flowering at their tops also can be used to identify water stress (IPM, 1984; McGuire, 2006).

Ongoing drought in the U.S. limits water allotment for agricultural use (Figure 12). Increasing costs of irrigation and labor also are incentives for growers to seek efficient ways to conserve and reuse water. Water availability for cotton crops can be improved with conservation tillage (TAMU, 2014). Conservation tillage must be carefully managed in cotton production because crop residues on cotton fields after harvest can provide a source for pest spread and volunteer cotton over a large surrounding area (McGuire, 2006). A prompt, thorough plowdown is essential for cotton crops. Plowdown involves the shredding and burial of all crop debris immediately after harvest, to a depth of 6 inches (IPM, 1984; Rude, 1984).

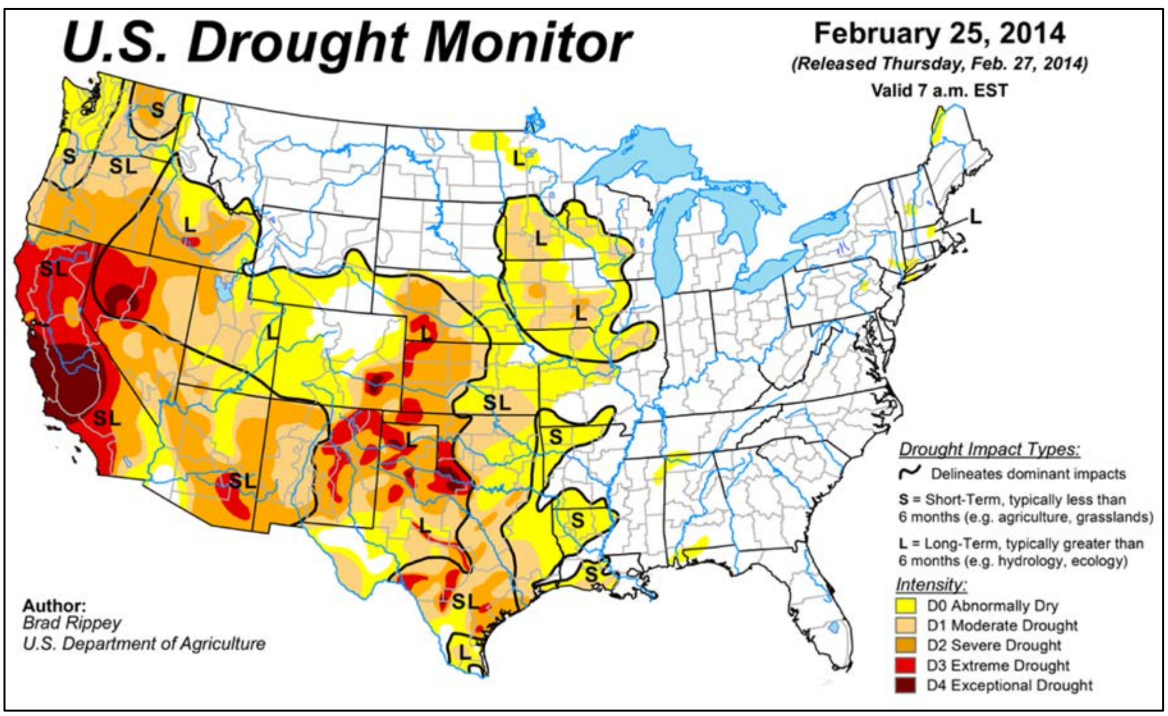


Figure 12. A Recent Compilation of Drought Affected Areas in the United States.
Source: (Rippey, 2004)

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

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

Many residual herbicides require adequate rainfall or irrigation water to be activated (Hager et al., 2011). In 2012, only 90% control of palmer amaranth was achieved under both furrow and sprinkler irrigation systems using residual herbicides, leading to recommendations that residual herbicides should be applied every 2 to 3 weeks until canopy formation to minimize the number of escapes that must be removed using other weed control measures (Riar *et al.*, 2012).

3.5.4 Organic Cotton and Soybean Production

<u>National Organic Program and Organic Soybean Farming</u>

In the U.S., only products produced using specific methods and certified under the USDA's Agricultural Marketing Service (AMS) National Organic Program (NOP) definition of organic farming can be marketed and labeled as "organic" (USDA-AMS, 2010). Organic certification is a process-based certification, not a certification of the end product; the certification process specifies and audits the methods and procedures by which the product is produced.

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

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

> To be sold or labeled as "100 percent organic," "organic," or "made with organic (specified ingredients or group(s))," the product must be produced and handled without the use of:

(a) Synthetic substances and ingredients,…
(e) Excluded methods,…

Excluded methods are then defined at 7 CFR §205.2 as—

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

The NOP has recognized the feasibility of protecting organically-produced crops from accidental contamination by GE crops by requiring that organic production plans include practical methods to protect organically produced crops—

> Organic crops must be protected from contamination by prohibited substances used on adjoining lands (for example, drifting pesticides, fertilizer-laden runoff water, and pollen drift from genetically engineered crops …)(NCAT, 2003).

Organic farming operations, as described by the NOP, require organic production operations to have distinct, defined boundaries and buffer zones to prevent unintended contact with excluded methods from adjoining land that is not under organic management. Organic production operations also must develop and maintain an organic production system plan approved by their accredited certifying agent. This plan enables the production operation to achieve and document compliance with the National Organic Standards, including the prohibition on the use of excluded methods. In NOP organic systems, the use of GE crops is excluded (USDA-AMS, 2010).

Most EPA-registered synthetic pesticides are prohibited in organic production; however, there is the potential for inadvertent or indirect contact from neighboring conventional farms or shared handling facilities. As long as the operator has not directly applied prohibited pesticides and has documented efforts to minimize exposure to them, the USDA organic regulations allow for residues of prohibited pesticides at or below 5 percent of the EPA tolerance (USDA-AMS, 2012).

Although the National Organic Standards preclude the use of excluded methods, they do not require testing of inputs or products for the presence of excluded methods. The presence of a detectable residue of a product of excluded methods alone does not necessarily constitute a violation of the National Organic Standards (USDA-AMS, 2011b). The current NOP regulations do not specify an acceptable threshold level for the adventitious presence of GE materials in an organic-labeled product. The unintentional presence of the products of excluded methods will not affect the status of an organic product or operation when the operation has not used excluded methods and has taken reasonable steps to avoid contact with the products of excluded methods as detailed in their approved organic system plan (USDA-AMS, 2011b).

U.S. Organic Cotton Production

Cotton grown without synthetic chemicals such as pesticides and fertilizers is referred to as "organic" (OTA, 2010; Babu et al., 2013) and is certified under the National Organics Program (TOCMC, 2014). Production of organic cotton includes the use of natural defoliants; beneficial insects for pest control; compost, manure, and crop rotations for fertilizers; hand-weeding; mechanical cultivation; cover crops and mulching for weed control. A comparison of conventional cotton and organic fibers showed that morphologically and chemically, the two types of cotton are similar (Babu et al., 2013).

Organic cotton has been produced in the U.S. since 1991 (Funtanilla et al., 2009). In 2012, the majority of the U.S. organic cotton crop was planted to upland cotton, with pima cotton representing fewer than 1,000 planted acres (OTA, 2014). Acreage planted in organic cotton increased 36% from 2009 to 2010 (OTA, 2014). According to USDA, in 2011, approximately 12,000 acres of certified organic cotton were planted; this acreage represents 0.08 percent of cotton acreage in the United States (USDA-ERS, 2013a). Organic cotton production is centered in West Texas with additional acreage in Arizona, California, New Mexico, and North Carolina (USDA-AMS, 2013). The Organic Trade Association, projects a two percent increase in organic cotton acreage or approximately 16,406 acres for 2012. A total of 16,716 acres of organic cotton, representing an additional two percent gain over the next five years, is forecasted to be planted (OTA, 2014). Limitations on the growth of the U.S. organic cotton industry are tied to challenges also faced by growers of conventional cotton, including weather, geography, weeds, drought, and pests. Also, there is reported to be a limited availability of organic seeds and not much work dedicated to improving cottonseed by traditional breeding techniques (OTA, 2014).

One of the main organic production regions is the South Plains area of Texas (TOCMC, 2011). Organic cotton production in this area benefits from winter temperatures that are cold enough to limit insect pressure and to provide a hard freeze to defoliate the cotton plants prior to harvesting, as well as a sunny climate and quick-drying soils to facilitate timely mechanical weed control. As many of these farmers do not irrigate, yields are heavily dependent upon rainfall (TOCMC, 2011).

American organic cotton typically commands premium prices over conventionally grown cotton; organic cotton growers indicated they received \$1.40 per pound for organic upland cotton and \$2.15 for organic pima cotton in 2012 (OTA, 2014). These prices are slightly lower than those from previous years due to global competition and weather-related quality issues with the 2012 crop (OTA, 2014). According to USDA's Agricultural Marketing Service, prices for organic cottonseed ranged from \$500 to \$650 per ton, while conventional cottonseed is \$210 to \$320 per ton. Most of the cottonseed is sold to organic dairies, with some saved for replanting (USDA-AMS, 2013).

However, organic cotton production is typically about 50% more expensive than conventional cotton production (ATTRA, 2003). Higher production costs are due to factors such as hand hoeing and weeding labor (ATTRA, 2003; TOCMC, 2014); gins and mills must be operated separately for organic cotton; higher dyestuff costs; small run penalties (TOCMC, 2014); more seed used/acre; higher energy costs due to more water typically used in organic cotton fields; loss in production for three years while converting conventional fields to organic fields (Funtanilla et al., 2009); crop loss due to defoliation; and costs of organically acceptable disease and insect management (ATTRA, 2003). In addition to higher production costs, organic cotton yields are typically lower than conventional cotton yields (Funtanilla et al., 2009; Chaudhry and Truscott, 2012; TOCMC, 2014), as much as 30% lower (Funtanilla *et al.*, 2009).

Most U.S. organic cotton growers sell their cotton products through a marketing cooperative, the largest of which is the Texas Organic Cotton Marketing Cooperative (TOCMC), with approximately 30 members (TOCMC, 2011; OTA, 2012). Cottonseed is marketed to organic dairies for feed (TOCMC, 2011). According to a survey conducted by OTA, organic cotton growers' biggest barriers to planting more organic cotton are finding a market willing to pay the added costs of organic products, production challenges such as weed and insect control, and labor costs. Growers have indicated challenges due to competition from international organic cotton producers, as well as the cost of transition to organic (OTA, 2010).

Organic cotton represents about 1.1% of global cotton production, and world production and sales have increased steadily, with world sales rising from $4 billion in 2009 to $5.3 billion in 2010 (Memon, 2012). As of 2012, the United States was the sixth-ranking producer of organic cotton in the world, behind India, Syria, Turkey, China, and Tanzania (Memon, 2012).

U.S. Organic Soybean Production

In 2011, U.S. acreage in organic soybeans totaled 132,411 acres. The states with the most acreage, in descending order, were Minnesota, Iowa, Michigan, Arkansas, Missouri, New York, Wisconsin, Nebraska and Ohio (USDA-ERS, 2011b). U.S. acreage has increased steadily since 1995, when 47,200 acres were dedicated to organic soybean (USDA-ERS, 2011b).

Typically, two types of organic soybeans are grown in the U.S.: food-grade, used for products such as tofu, miso, and soymilk, and feed-grade, for livestock (Delate, 2003; University of Minnesota, 2003). Many organic food-grade soybean products are for export to Japan and other countries (Delate, 2003).

Because of significant price premiums paid for organic soybean (Place et al., 2009), it can be profitable for growers to produce organic rather than conventional soybeans (ATTRA, 2003). For example, in 2006, a bushel of organic soybeans sold for about $9 more than a bushel of conventional soybeans (McBride and Green, 2008), and in 2013, the projected price for organic soybean was $19.73/bushel compared with $9.73/bushel for conventional soybeans (Clark and Alexander, 2010). For the week of March 7-15, 2014, the price range of organic soybean was $26.50-29.71/bushel; for organic feed-grade soybeans it was $24.00-26.50/bushel (USDA Livestock, 2014). However, without price premiums, organic soybeans had net market returns about the same as for conventional soybeans (McBride and Green, 2008). With a high dependence on fertilizers and pesticides, conventional soybean growers spend more money on chemicals than do organic soybean growers, but organic growers dedicate more operating funds to fuel and labor than do conventional soybean growers (McBride and Green, 2008). Operating costs for organic soybean production are about $0.82/bushel higher than for conventional soybean production (McBride and Green, 2008). In addition, crop yields for organic soybeans are generally lower than for conventional soybeans (University of Kentucky; McBride and Green, 2008; Place et al., 2009; Baldock *et al.*, 2012), as much as 15% lower (Clark and Alexander, 2010). Organic soybeans are more likely to be grown on smaller, family-owned farms (McBride and Green, 2008).

To grow organic soybeans, growers need to be certified by the USDA National Organic Program (NOP) (Delate, 2003), and must use only organic seed (University of Minnesota, 2003). Organic soybeans need to be segregated from conventional soybeans during all aspects of planting, harvesting, and storage (Delate, 2003). Highest premiums are obtained by planting Clear-Hilum food-grade seed (Delate, 2003). Growers of organic soybean may utilize various risk management strategies to compensate for the lack of chemical control. For example, most organic growers tend to plant 1-2 weeks after conventional growers to reduce weed populations; however, this may then lead to lower yields (University of Minnesota, 2003). In order to provide better competition with weeds which can significantly depress yields (Place et al., 2009), organic growers frequently use higher seeding rates than conventional growers: from 175,000 to 200,000 seeds/acre for organic fields compared with 100,000 seeds/acre for conventional fields (Delate, 2003; University of Minnesota, 2003; Place et al., 2009). More soybean seedlings/acre may help with shading out weeds (Place et al., 2009). Increasing row space to accommodate cultivators and other machinery to control weeds is also used frequently by organic soybean growers, but may also reduce yield (Baldock et al., 2012).

Organic soybean producers use production practices designed to prevent commingling of their value-added crop with neighboring crops treated with herbicides and other pesticides or that may be using plant varieties produced by excluded methods. Additionally, well-established practices help avoid spray drift from neighboring fields, including isolation zones, use of buffer rows surrounding the organic crop, adjusted planting dates, and varietal selection (Kuepper, 2006).

The efficacy of management practices utilized to avoid pollen movement from a GE crop to organic soybean production operations is facilitated by the nature of soybean pollination. Soybean is a highly self-pollinated species and exhibits a very low level of outcrossing. Outcrossing most commonly results from cross-pollination. Since soybean is highly self-pollinating, organic or conventional soybean producers can and have effectively implemented practices (e.g., isolation during the growing season, equipment cleaning during harvest, and post-harvest separation of harvested seed) that allow them to reasonably avoid GE soybean and maintain organic or conventional production status (Brookes and Barfoot, 2004).

3.5.5 GE Cotton and Soybean

Growers can choose from a large number of cotton and soybean hybrids generated either from traditional breeding or GE systems. Large-scale field testing of GE crops began in the 1980s, but it was not until ten years later the first generation of GE soybean varieties became commercially available.

As of 2006, Acala varieties of upland cotton approved for use in the San Joaquin Valley (SJV) included Roundup Ready® varieties, but Flex Acalas that would allow glyphosate applications almost to harvest time were not yet approved (Anonymous, 2006; 2007). The Summit variety was accepted as the new industry standard for SJV Acala cotton in 2006 (Anonymous, 2006). After the USDA stopped its cotton breeding program, Delta and Pine Land Co., Stoneville, and Fiber Max commercially bred Acala cottons for seed in the SJV, producing more varieties of upland cotton (Anonymous, 2007).

Plantings of GE HR cotton expanded from about 10% of U.S. acreage in 1997 to 82% in 2013 (USDA-ERS, 2014a). Plantings of insect-resistant cotton also expanded rapidly, from 15% of U.S. cotton acreage in 1997 to 75% in 2013 (USDA-ERS, 2014a). Adoption of cotton varieties stacked with both traits has accelerated in recent years. Adoption of all GE cotton, taking into account the acreage with either or both HR and Bt traits, reached 90% of cotton acreage in 2013 (USDA-ERS, 2014a).

Since GE soybeans' initial commercial availability in 1996, their use has expanded to greater than 90% of the total U.S. soybean acreage. Although other varieties are available for selection by growers, the Roundup Ready®, GR varieties continue to dominate the market (see, e.g., (Tarter, 2011)). Other cultivated HR soybeans include the LibertyLink® soybean varieties (a GE soybean that is resistant to glufosinate ammonium herbicide and was granted nonregulated status in 1996) and STS (a conventionally bred sulfonylurea- resistant soybean first introduced in 1993). As of 2012, 3.9% of U.S. soybean acres planted were glufosinate- resistant (DAS, 2013a). Additional GE traits, such as lepidopteran resistance, high oleic acid content, improved fatty acid profile, and increased stearidonic acid have nonregulated status (USDA-APHIS, 2014c). Of these, at this time, only high oleic acid content soybean has been commercialized, in a limited launch. Other GE traits with nonregulated status may be made available for commercial production in the future.

GR soybeans were first commercialized in 1996, and adoption by growers was rapid, reaching 54% already by 2000 and more than 90% by 2007 (USDA-NASS, 2013c). While some potential herbicide cost savings may have driven adoption, early studies recognized the primary reason that growers adopted the technology as the simplicity and flexibility of a weed control program that relied heavily on a single herbicide to control a broad spectrum of weeds without crop injury or crop rotation restrictions. The increased cost of GE HR seed was outweighed by the often lower cost of glyphosate-based weed control programs, although this cost advantage was quickly eroded by reductions in the prices of other conventional herbicides. The glyphosate-resistant soybean weed control program reinforced on-going trends towards post-emergence weed control and the adoption of conservation tillage programs (Carpenter and Gianessi, 1999). For 1997, USDA estimated that herbicide-resistant soybeans led to a 3% increase in yields and a reduction in weed control costs (including, application, scouting, cultivation, herbicides, and technology fees) of $3.50/acre (10.65%) in the Heartland (Price et al., 2003).

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

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

GR crops have been widely adopted because of the benefits they provide to growers, but the increasing prevalence of GR weeds threatens the sustainability of these benefits. HR weeds can reduce yields and increase weed control costs. In any given state there is no more than a single resistant species, and these biotypes are not widespread (Heap, 2014c). There is one species resistant to glufosinate in the United States and it occurs in Oregon (Heap, 2014e). HR weeds are discussed more fully in Appendix 6. Genetically modified crops are a part of mainstream agriculture in the United States., and are regularly consumed by humans and livestock. In this country, people rely on a network of legal and procedural requirements designed to reduce risk to acceptable levels and assure the health and safety of themselves and their livestock. In the next section, we discuss health and safety issues related to cotton and soybean production with a focus on worker safety and public health.

3.6 3.6 Human and Livestock Health and Safety

Cotton seed and associated linters are processed to produce cottonseed oil and cottonseed meal which is used for human food and animal feed. In the U.S., cottonseed oil annual production averages more than 1 billion pounds, ranking behind soybean and corn oil in volume, and representing about 5 to 6% of the total domestic fat and oil supply (NCPA, 2002). Cottonseed oil is primarily used as a salad or cooking oil. It is among the most unsaturated of food oils, and is rich in natural antioxidants called tocopherols (NCPA, 2002). Others, however, view cottonseed oil as unhealthy because they consider it too high in saturated fat and too low in monounsaturated fat (Weil, 2008). They believe it may contain natural toxins and unacceptably high levels of pesticide residues (Weil, 2008).

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

Soybean liquids produce salad and cooking oils, baking and frying fat, and margarine. Soybean oil is low in saturated fats, high in poly- and monounsaturated fats, and contains essential omega-3 fatty acids. Soybean oil comprises nearly 70% of the oils consumed in U.S. households (Soy Stats, 2010). Soybeans comprise about 90% of U.S. oilseed production, while other oilseeds (peanuts, sunflower seed, canola, and flax) make up the remainder 10% (USDA-ERS, 2014d).

Although the current soybean market is dominated by seed production, soybean has a long history as nutritious grazing forage, hay, and silage 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 produced in the beginning of the pod stage (Owen et al., 2011). For silage, harvesting should be at maturity before leaf loss. Then the soybean matter should be mixed with a carbohydrate source, such as corn, for optimal fermentation characteristics (Blount et al., 2009). There are varieties of soybean specifically developed for grazing and hay, but use of the standard grain varieties often is recommended because of the whole plant feeding value (Weiderholt and Albrecht, 2003).

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

Food safety reviews frequently compare the compositional characteristics of the GE crop with non-transgenic, conventional varieties of that crop (see e.g., (Aumaitre et al., 2002; FAO, 2009)). Moreover, this comparison also evaluates the composition of the modified crop under actual agronomic conditions, including various agronomic inputs (Monsanto, 2012a; 2012b). 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 anti-nutrients (Monsanto, 2012a; 2012b).

Anti-nutrients represent an important element of food safety comparisons that follow US-FDA's guidelines (DAS, 2013a). Anti-nutrients are compounds produced by a plant that interfere with the absorption and metabolism of the consumed vegetable as well as other foods in the digestive tract (Cordain, 1999). Anti-nutrients commonly found in raw soybean include trypsin inhibitors and lectins (US-FDA, 2011b).

Some plant constituents are toxins, such as gossypol. Except for varieties bred to suppress the trait, it is produced in glands on cotton stems, true leaves, bolls, and other plant parts. Gossypol is toxic to humans, pigs, chickens, and some other animals, so its presence reduces the value of cottonseed for food and feed. Gossypol-producing varieties have been shown to reduce rabbit and rodent feeding on cotton (Rude, 1984).

There are multiple ways in which organisms can be genetically modified through human intervention. Traditional methods include breeding or crossing an organism to elicit the expression of a desired trait, while more contemporary approaches include the use of biotechnology such as genetic engineering to produce new organisms (NRC, 2004). As noted by the National Research Council (NRC), unexpected and unintended compositional changes arise with all forms of genetic modification, including both conventional hybridizing and genetic engineering (NRC, 2004). The NRC also noted in its 2004 report that no adverse human health effects attributed to genetic engineering have been documented. Reviews on the nutritional quality of GE foods generally have concluded that there are no biologically meaningful nutritional differences in conventional versus GE plants for food or animal feed (Aumaitre *et al.*, 2002; Faust, 2002; Van Deynze et al., 2005).

More recently, the NRC found the cultivation of GE crops resulted in changes in pesticide application practices (NRC, 2010). For example, this included applications of fewer pesticides or using pesticides with lower environmental toxicity. Consequently the cultivation of HR crops is advantageous because of their superior efficacy in pest control and concomitant economic, environmental, and presumed personal health advantages (NRC, 2010).

Human health topics associated with GE crops include the potential toxicity of the introduced genes and their products, the expression of new antigenic proteins, and altered levels of existing allergens (Malarkey, 2003; Dona and Arvanitoyannis, 2009). Under the FFDCA, it is the responsibility of food and feed manufacturers to ensure that the products they market are safe and labeled properly. Food and feed derived from GE organisms must be in compliance with all applicable legal and regulatory requirements. GE organisms for food and feed may undergo a voluntary consultation process with the FDA prior to release onto the market. The PAT protein, conferring resistance to glufosinate, has already been evaluated by FDA; soybeans (and other crops) containing the pat gene are already in commerce.

Monsanto provided the FDA with information on the identity, function, and characterization of the genes for MON 88701 cotton and MON 87708 soybean. Monsanto completed consultations with the FDA for these varieties in 2013 (US-FDA, 2011b; 2013).

3.6.1 Worker Safety

Agriculture is one of the most hazardous industries for U.S. workers because of the risk of pesticide exposure to field workers. Pesticides, which typically include herbicides, are used on most U.S. cotton and soybean fields to manage weeds and pests. Agricultural workers, including pesticide applicators, may be exposed to pesticides through mixing, loading, or applying chemicals, or by entering a previously treated field. All pesticides sold or distributed in the U.S. must be registered by the EPA under FIFRA (US-EPA, 2014a), and used in accordance with label instructions.

The EPA Worker Protection Standard (WPS) (40 CFR Part 170) provides occupational protections to over 2 million agricultural workers and pesticide applicators at more than 600,000 agricultural establishments (farms, forests, nurseries and greenhouses) (US-EPA, 2014c). The WPS requires on pesticide safety training, notification of pesticide applications, use of personal protective equipment (PPE), restricted entry intervals (REI) following pesticide application, decontamination supplies, and emergency medical assistance. Under the WPS, the EPA requires the pesticide label to specify PPE and REI that will provide an appropriate level of protection, based on the properties of the product.

On February 20, 2014, the US-EPA announced proposed changes to the agricultural WPS to increase protections from pesticide exposure for agricultural workers and their families.[7] . EPA is proposing to strengthen the protections provided to agricultural workers and handlers under the WPS by improving elements of the existing regulation, such as training, notification, communication materials, use of personal protective equipment, and decontamination supplies. The proposed changes to the current WPS requirements, specifically improved training on reducing pesticide residues brought from the treated area to the home on workers and handlers' clothing and bodies and establishing a minimum age for handlers and early entry workers, other than those covered by the immediate family exemption, mitigate the potential for children to be exposed to pesticides directly and indirectly. EPA expects the revisions, once final, to prevent unreasonable adverse effects from exposure to pesticides among agricultural workers and pesticide handlers; vulnerable groups, such as minority and low-income populations, child farmworkers, and farmworker families; and the general public.

To register a pesticide product, the EPA evaluates the potential risks to humans and the environment using various scientific studies designed to determine whether a potential product has the potential to cause adverse effects on wildlife, fish, humans (including acute, chronic, reproductive, and carcinogenic risk), and plants (including endangered species and other non-

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

target organisms). The EPA requires reregistration of products with active ingredients registered prior to November 1, 1984, under the amended FIFRA in 1988. During the reregistration and registration renewal processes, the EPA thoroughly reviews the scientific databases underlying registrations for pesticides to ensure consistency with current scientific and regulatory standards.

To determine the risks to workers from dicamba and glufosinate, the EPA evaluated exposure data in occupational worker safety evaluations and risk assessments. For dicamba, the EPA completed the reregistration process and a Registration Eligibility Decision (RED) was issued in 2006. It was subsequently amended in 2008 and 2009 (US-EPA, 2009). The EPA concluded current dicamba uses were eligible for reregistration based on findings in three areas. First, the available data is adequate to support the continued registration of dicamba products and uses. Second, the worker exposure to dicamba for all registered agricultural uses, including exposures associated with the current preemergence cotton uses, meets the "no unreasonable adverse effects" criteria of FIFRA. Third, there is a reasonable certainty that no harm will result to the general population, or to infants and children, as a result of aggregate exposure to dicamba residues (US-EPA, 2009a).

The EPA assessed the safety of using glufosinate (as an active ingredient) to control broadleaf weeds on many crops, including cotton and soybeans, in a 2003 human health risk assessment in support of registration review (US-EPA, 2003). The EPA performed a second human health risk assessment for registration of glufosinate use on citrus, pome, and stone fruits, olives and sweet corn (US-EPA, 2012b). In 2013, the EPA updated their occupational assessment for glufosinate to include: (1) handler exposure and risk estimates for spot/directed treatments to citrus, pome, stone fruits, and olives, (2) handler exposure and risk estimates for the representative crops of corn, cotton, sorghum, and canola, and (3) a new summary of estimated post-application risks for various crops (US-EPA, 2013b). Based on the most recent EPA review, glufosinate is currently registered for use on apples, berries, canola, citrus, corn, cotton, currants, grapes, grass grown for seed, olives, pome fruit, potatoes, rice, soybeans, stone fruit, sugar beets, and tree nuts with preplant and post-emergent applications (US-EPA, 2013a).

The EPA pesticide registration process involves the development of use restrictions that protect worker health regardless of changes in acreage, crops, farming practices, the amounts and types of pesticides, and concomitant risks to workers. Growers are required to use pesticides in a manner consistent with the application instructions as provided on the EPA-approved pesticide labels. Worker safety precautions and use restrictions are clearly noted on pesticide registration labels. These restrictions provide instructions for the appropriate levels of personal protection required for agricultural workers to use herbicides. These instructions may include requirements for personal protective equipment, specific handling requirements, and field reentry procedures. Used in accordance with the EPA label, registered herbicides are determined to not present a health risk to workers (US-EPA, 2009a; 2013b).

The current labels for both dicamba and glufosinate include label use restrictions intended to protect humans, including PPE to be worn during mixing, loading, applications and handling; equipment specifications to control pesticide application; and reentry periods that establish a safe duration between pesticide application and exposure to the pesticide in the field. Used in accordance with the EPA label, these herbicides are determined to not present a health risk to humans (US-EPA, 2013b).

The greatest risk to human safety in agriculture is associated with physical injuries. These typically occur during maintenance and use of farm machinery. Cuts, bruises, loss of fingers and limbs are examples of injuries resulting from mechanical hazards.

3.6.2 Public Health

Health effects to the general public, including children in the vicinity of the cotton and soybean fields may arise from pesticide exposures via incidental ingestion, inhalation, and dermal contact. Pesticide exposures may occur from drift or accidental entry to the field during pesticide application. Adverse health effects to the general public, however, are not anticipated because of the pesticide label directions and restrictions, USEPA required agricultural workers trainings on proper pesticides uses, and restricted entry signage.

Health effects to consumers may arise from pesticide exposure through the consumption of harvested cotton and soybean food products. Consumers of cottonseed oil and/or processed soybeans may become exposed to residual levels of pesticides in these processed products or in animal-based food products. The FDA controls pesticide residue limits (known as tolerances) in both cotton and soybean harvested food products, while the EPA established tolerances (the maximum pesticide residue levels can remain on food and feed products or commodities) protect consumers from harmful levels of pesticides on food. For example, the EPA-established dicamba residue tolerance of 0.2 ppm for cottonseed supporting the current uses of dicamba on cotton is the result of combining residue tolerances for both the parent dicamba and its metabolite 5-hydroxy dicamba (40 CFR § 180.227). The EPA-established glufosinate residue tolerances are 4.0 ppm and 15.0 ppm for cottonseed and gin by-products, respectively (40 CFR § 180.473). Both of these tolerances include the combined residues of parent glufosinate and its metabolites N-acetyl glufosinate and 3-methylphosphinico-propionic acid. Any adverse health effects from exposure to pesticide residues for cottonseed oil and processed soybean consumers are minimized by FDA residue monitoring and EPA tolerance requirements.

A variety of opinions exist on the human health safety of genetically modified foods. The American Association for the Advancement of Science concluded that consuming food containing ingredients derived from genetically modified crops is not riskier than consuming the same food containing ingredients from crops modified by conventional plant breeding techniques. The NRC (NRC, 2004) found that no adverse health effects attributed to genetic engineering had been documented in the human population. They also indicated the contribution of genetically engineered food to the genetic vulnerability of some individuals to some compounds is unclear (NRC, 2004).

A European Union- (EU) funded GMO research (European Commission, 2010) concluded at least equal assurance of the safety of GM foods compared to conventional counterparts. The World Health Organization concluded that GM foods currently available on the international market are not likely to present risks for human health based on risk assessment results. These risk assessments evaluate five types of direct health effects: (1) any tendencies to provoke allergic reactions, (2) specific components thought to have nutritional or toxic properties, (3) the stability of the inserted gene, (4) nutritional effects associated with genetic modification, and (5) any unintended effects resulting from the gene insertion (WHO, 2014). Conversely, others raise concerns on the potential health hazard associated with allergenicity, gene transfer with changes in the natural functioning of a plant's DNA, and the GM protein may have unintended characteristics that may be harmful (Lendman, 2014).

GE organisms used for food or feed purposes undergo a voluntary consultation process with the FDA prior to release to the U.S. market (US-FDA, 2001). The FDA established this voluntary consultation process to review the safety of foods and feeds derived from GE crops for human and animal consumptions. During the consultation, FDA evaluates the scientific and regulatory assessment summary of the food and feed safety of a product submitted by a developer, and responds to the developer by letter (US-FDA, 2014). Developers intending to commercialize a bioengineered food meet with the FDA to identify and discuss relevant safety, nutritional, or other regulatory issues regarding the bioengineered food. They submit a summary of their scientific and regulatory assessment of the food including: (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 genetically engineered MON 88701 cotton and MON 87708 soybean completed the FDA consultation process with no further questions (US-FDA, 2011b; 2013).

3.7 Cotton and Soybean Production as Related to the Affected Environment

Some of the trends in U.S. cotton and soybean production from 1980 to 2011 are summarized in Table 12 (Field to Market, 2012). The cotton information was derived by combining seed and lint information at the percentages of production (83% lint and 17% seed). The total production for both crops increased through 2011. While soybean production continues to increase, cotton production decreased in the past few years (USDA-OCE, 2014a). From 1980 to 2011, the land use trends showed an increase in efficiency based on the increased yield combined with reductions in the acres per unit of production. Soil erosion and irrigation efficiency increased during the interval, probably as a result of the adoption of conservation tillage and improved irrigation technologies by growers. While overall CO_2 emission equivalents increased, the concomitant decreases in emissions per unit of production suggest awareness of agricultural contributions to GHG may be leading to conservation efforts.

Table 12. Summary of Trends in U.S. Cotton and Soybean Production, Resource Use and Impact from 1980-2011.

	Soybean				Cotton			
	Indicator	Percent Change[1]			Indicator	Percent Change		
		Trend Direction[2]	Entire Period	Compound Annual		Trend Direction	Entire Period	Compound Annual
Crop Yield	Total Production	↑	96	2.2	Total Production	↑	55	1.4
Land Use	Total Planted Acres	↑	24	0.7	Total Planted Acres	↑	11	0.3
	Acres per Bushel	↓	(35)	(1.4)	Acres per Pound	↓	(30)	(1.2)
Soil Eroded	Total Tons	↓	(28)	(1.0)	Total Tons	↓	(42)	(1.7)
	Tons per Bushel	↓	(66)	(3.5)	Tons per Pound	↓	(68)	(3.6)
Irrigate Water	Total Volume	↑	271	4.3	Total Volume	↓	(35)	(1.4)
	Volume per Bushel	↓	(42)	(1.8)	Volume per Pound	↓	(75)	(4.4)
GHG: CO_2	Total Pounds	↑	13	0.4	Total Pounds	↑	10	0.3
	Pounds per Bushel	↓	(41)	(1.7)	Pounds per Pound	↓	(30)	(1.1)

[1]Percent change results are based on a least squares trends analyses from 1980-2011.
Source: (Field to Market, 2012)citing: (1) USDA, NASS, Census of Agriculture, Farm and Ranch Irrigation Survey http://www.agcensus.usda.gov/Publications/index.php. (2) USDA, Economic Research Service (ERS), Agricultural Resource Management Survey (ARMS) http://www.ers.usda.gov/Briefing/ARMS/Access.htm; (3) USDA, National Resources Conservation Service (NRCS), National Resource Inventory (NRI) Reports http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/technical/nra/nri
[2]Trend direction: ↑= Increasing, ↓ = Decreasing.
creasing, ↓ = Decreasing.

4 POTENTIAL ENVIRONMENTAL CONSEQUENCES

This chapter examines the environmental effects associated with the alternatives on the affected environment (as identified in Chapter 2). In this chapter, APHIS only examines the direct and indirect effects of its decision regarding the regulatory status of MON 88701 cotton and MON 87708 soybean. While the Agency recognizes that these varieties were engineered to be resistant to applications of the herbicide dicamba, EPA has the regulatory authority to approve new uses of all pesticides, including those for dicamba on MON 88701 cotton and MON 87708 soybean. The EPA is currently evaluating the proposed new uses of dicamba for these varieties, and is the Federal agency which determines possible human health and environmental consequences of dicamba use in agriculture. EPA registers herbicide use when consistent with a conclusion of no unreasonable environmental impacts. In this chapter, we assume that any use of dicamba should be discussed as a cumulative effect of APHIS' action combined with future actions that may be taken by EPA or other agencies. Thus, the analysis of these possible cumulative effects is discussed in Section 5 of the EIS.

4.1 No Action Alternative

Under the No Action Alternative, APHIS would not approve the petitions for deregulation. This alternative represents the status quo, or the situation that would occur if APHIS denies the petitions. This section describes the effects of cotton and soybean production on the human environment that are occurring and are anticipated to continue to occur if APHIS selects the No Action Alternative. The analysis examines the effects of cotton and soybean production on physical, natural and biological resources to allow meaningful comparison to the other alternatives reviewed in this document.

4.1.1 Land Use and Acreage

Cotton

In the U.S., cotton is grown exclusively in the southern states because this is the only U.S. region with a growing season long enough for cotton to mature. During the past 10 years, total U.S. cotton acreage has varied from approximately 9.15 to 15.77 million acres, with the lowest acreage recorded in 2009 and the highest in 2001 (See Figure 13) (USDA-NASS, 2014a). In 2013, the harvested acreage for all types of cotton was 7.66 million acres, a reduction of 18 percent from the previous year (USDA-NASS, 2014a).

The most recent USDA projections for cotton anticipate an increase to 11 million acres in 2014 (USDA-OCE, 2014b). Prices for competing crops are projected to fall more than cotton prices, making cotton cultivation more favorable. The trend for cotton acreage plantings over the projection period shows a decrease to 10 million acres in 2015 and remains near that level for the remainder of the projection period, as a result of projected world and U.S. cotton prices below the recent 5-year average (USDA-OCE, 2014b). Under the No Action Alternative, the projected acreage of cotton production is not expected to change over the next decade.

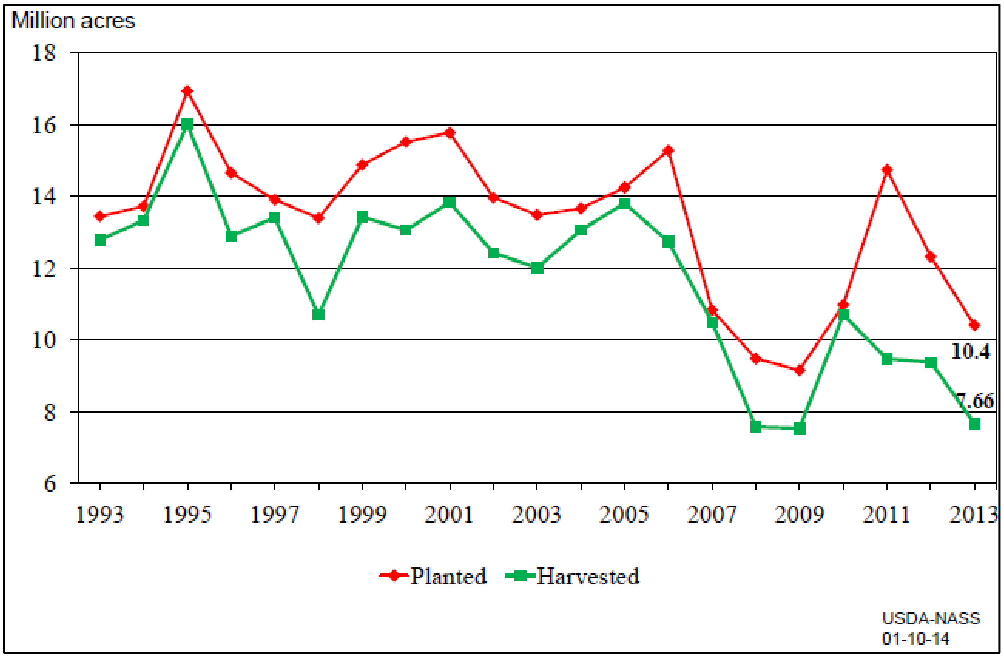


Figure 13. Acres of Upland and Pima Cotton Planted and Harvested from 1993 to 2013.
Source: (USDA-NASS, 2014d)

<u>Soybean</u>

During the last two decades, the number of acres planted to soybeans increased because of favorable prices (USDA-ERS, 2012a) (see Figure 14). This increase in soybean production was accompanied by decreases in other crops, including upland cotton, corn grown for silage, spring and specialty wheat, and oats (USDA-ERS, 2011c). In 2013, 75.9 million acres of soybeans were harvested in the U.S., a slight decrease from the 75.9 million acres harvested in 2012. However, the 2013 soybean harvest was the fourth highest on record, and production was up 8 percent from 2012 (USDA-NASS, 2014a).

The most recent USDA projections are for U.S. soybean plantings to remain near 78 million acres through 2023 (USDA-OCE, 2014b). The expected growth in the demands for soybean for domestic use and export will result in price increases, allowing soybeans to compete with corn and other crops for land use (USDA-OCE, 2014b). Under the No Action Alternative, the projected acreage of soybean production is not expected to change over the next decade.

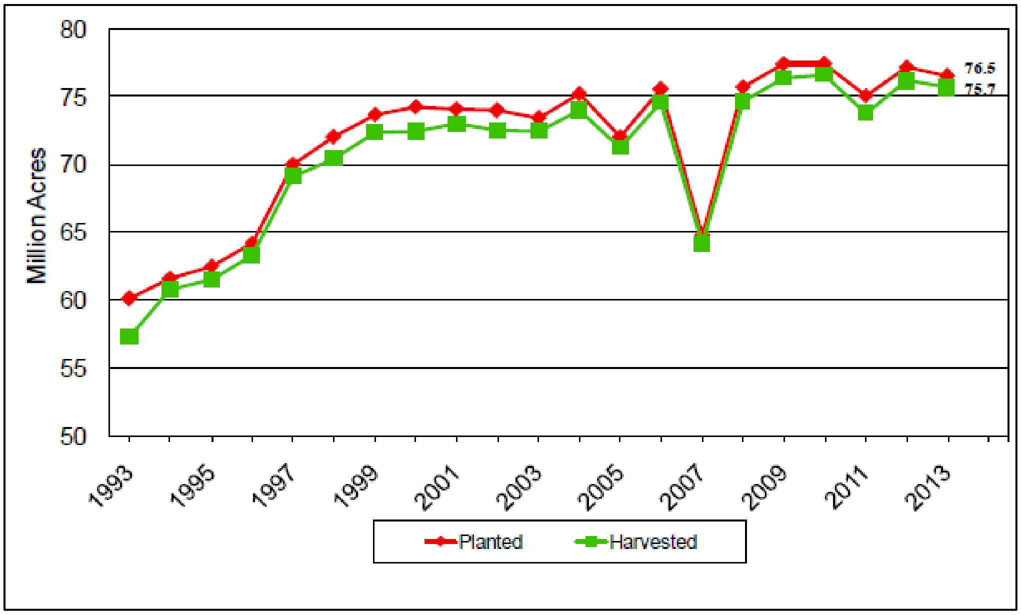


Figure 14. Acres of Soybeans Planted and Harvested from 1993 to 2013.
Source: (USDA-NASS, 2014d)

Genetically Engineered Cotton and Soybean

Under the No Action Alternative, the current trend of adoption of GE cotton and soybean varieties by U.S. farmers is likely to continue. However, continued adoption in the future will depend on whether growers continue to derive benefits from GE crops and will be dependent on the ability of farmers to adopt best management practices to avoid resistance issues, the ability of biotech companies to develop new GE varieties, and consumer acceptance of products from GE sources (Fernandez-Cornejo *et al.*, 2014b).

Growers can choose from a large number of cotton or soybean hybrids produced from conventional breeding or GE practices. Like other major commodities, GE varieties of cotton and soybean have been adopted during the past decade. Large-scale field testing of GE crops began in the 1980s, but it was not until 10 years later that the first generation of GE varieties became commercially available (Fernandez-Cornejo and Caswell, 2006). Since commercial introduction in 2000, GE cotton has expanded to approximately 90 percent of U.S. cotton acreage in 2011 (USDA-ERS, 2014a). Of that number, 15 percent of the U.S. cotton crop was GE HR, 17 percent was insect-resistant, and 58 percent was stacked with both GE herbicide resistance and insect resistance (USDA-ERS, 2014a).

Since GE soybeans became commercially available in 1996, their use has expanded to greater than 90 percent of the total U.S. soybean acreage (USDA-ERS, 2014a). Although other varieties are available for selection by growers, the Roundup Ready®, GR varieties continue to dominate the market (Tarter, 2011). Other cultivated HR soybeans include the LibertyLink® soybean varieties (a GE soybean that is resistant to glufosinate ammonium herbicide and was granted nonregulated status in 1996) and STS (a conventionally bred sulfonylurea-resistant soybean first introduced in 1993). As of 2012, 3.9 percent of U.S. soybean acres planted were glufosinate-resistant (DAS, 2013a). Varieties with other GE traits, such as lepidopteran resistance, high oleic acid content, improved fatty acid profile, and increased stearidonic acid have since been granted nonregulated status (USDA-APHIS, 2014c). Of these, at this time, only high oleic acid content soybean has been commercialized.

4.1.2 Socioeconomics

Domestic Cotton and Soybean Production

Under the No Action Alternative, MON 88701 cotton and MON 87708 soybean will continue to be regulated articles under 7 CFR Part 340. Growers and other parties who are involved in production, handling, processing, or consumption of cotton and soybean will continue to have access to nonregulated GE and non-GE cotton and soybean varieties. Domestic growers will continue to utilize GE and non-GE cotton and soybean varieties based upon availability and market demand.

Management practices associated with cotton and soybean production, including uses of agronomic inputs, vary from grower to grower, and would not be affected under the No Action Alternative. Farm income is positively impacted by GE cotton and soybean by reducing production costs (e.g., reduced tillage for weed management and, potentially, reduced herbicide use). While growers are expected to continue benefiting from the adoption and cultivation of currently deregulated GE crops, growers in some U.S. regions with HR weed problems may incur increased costs because of the increased need for more pesticide treatments and/or increased tillage. These trends are unaffected under the No Action Alternative.

In 2014, the area planted for all cotton is expected to total 11.1 million acres, 7 percent above 2013 acreage (USDA-NASS, 2014b). This increase is anticipated because of the lower prices expected for competing crops as compared to cotton prices (USDA-OCE, 2014b). Upland cotton area is expected to total 10.9 million acres, up 7 percent from 2013; Pima cotton area is expected to total 158,000 acres, a 21 percent decrease from 2013 (USDA-NASS, 2014b). Cotton acreage in 2015 is projected to fall to 10 million and remain near that level through 2023 with both world and U.S. cotton prices projected below the recent 5-year average (USDA-OCE, 2014b).

In 2013, all cotton production in the U.S. is estimated at 13.2 million 480-pound bales, a decrease of 24 percent from 2012. Cotton yield is estimated at 826 pounds per acre, 61 pounds per acre less than last year (USDA-NASS, 2014b). As a result of both higher planted acreage and expected lower abandonment, the U.S. cotton crop is projected to rise sharply to 16.3 million bales in 2014/15 (Johnson et al., 2014).

U.S. mill use fell to a low of 3.3 million bales in 2011, but has moved higher and is estimated at 3.7 million bales for 2014 (NCCA, 2014). U.S. mill use of upland cotton is projected to rise moderately, while cotton exports appear likely to remain level after 2016/17 (USDA-OCE, 2013) (Figure 15). With the help of the Economic Adjustment Assistance Program that began with the 2008 Farm Bill, and is continued under the 2014 Farm Bill, new investments and expansions within the U.S. cotton industry are reported with companies upgrading existing facilities and/or building new facilities. New plants are scheduled to open beginning in early 2015 (NCCA, 2014). The 2014/15 marketing year average price received by U.S. cotton producers is projected to range between 65 and 70 cents per pound, which is below the 2013/14 mid-point estimate of

76 cents per pound. Supporting the lower price projections are December 2014 cotton futures, which as of early February, were around 77 cents per pound (Johnson et al., 2014).

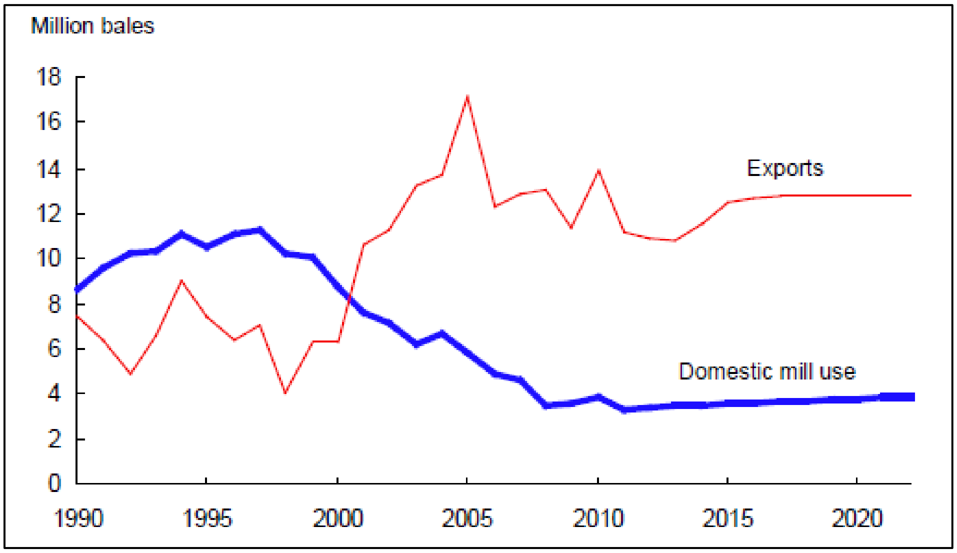


Figure 15. Domestic Mill Use and Exports of U.S. Upland Cotton with Projections Through 2022.
Source: (USDA-OCE, 2013)

U.S. soybean production in 2013 totaled 3.29 billion bushels, an 8 percent increase from 2012 and the third largest on record (USDA-NASS, 2014a). According to USDA-NASS, the average yield per acre for 2013 is estimated at 43.3 bushels, 3.5 bushels per acre more than 2012 yield (USDA-NASS, 2014a). USDA forecasts an increase in soybean planted area for 2014 at a record high of 81.5 million acres, a 6 percent increase from 2013 (USDA-NASS, 2014b). Projections for U.S. soybean plantings through 2023 indicate plantings remaining near 78 million acres over most of the projection period (USDA-OCE, 2014b).

Soybean prices are expected to increase from growth in both domestic use and export demand (see Figure 16), and are projected to remain historically high (above pre-2007 levels) (USDA-OCE, 2014b). The average U.S. on-farm market price for soybeans for the 2012-13 marketing year increased to $14.40 per bushel, compared to $12.50 per bushel for the 2011-12 and $11.30 per bushel for the 2010-11. On-farm soybean market prices for the 2013-14 marketing year are estimated by USDA to fall from the previous year's high to an average $12.70 per bushel (Corn and Soybean Digest, 2014). Soybean prices are then estimated to rise moderately after 2015-16, as a result of increasing demand for soybeans and soybean products (USDA-OCE, 2014b).

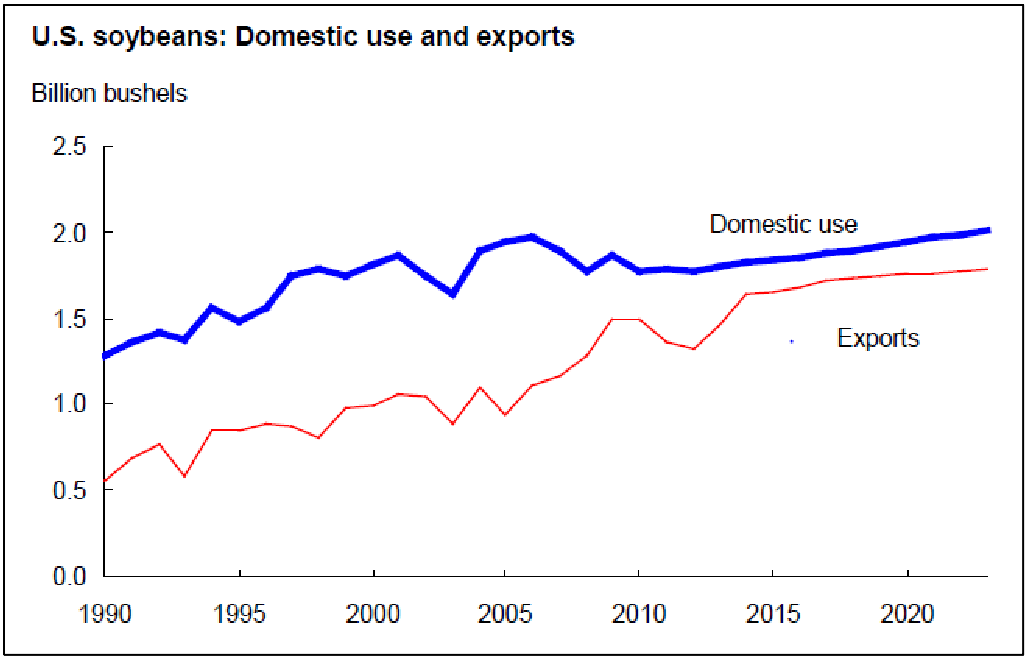


Figure 16. Projections of U.S. Soybean Domestic Use and Exports to 2023.
Source: (USDA-OCE, 2014b)

These trends in domestic production and uses for cotton and soybean are not expected to change under the No Action Alternative.

<u>Foreign Trade</u>

Under the No Action Alternative, the position of the U.S. as a major cotton and soybean exporting country is unlikely to change.

The USDA anticipates world cotton production will exceed consumption for the fifth consecutive season. Production throughout the world is expected to rise by less than 1 percent to 117.0 million bales, resulting from lower production in China, Brazil, and Australia being offset by an increase in U.S. production. Global 2013/14 cotton production is expected to fall 5 percent from the previous year to 116.7 million bales. The harvested area is estimated at 33.1 million hectares, down 3.5 percent from last year. World average yield is 766 kilograms (kg)/hectare, down 2 percent (Johnson *et al.*, 2014).

World trade is forecast down 18 percent from last season, the large fall in imports by China masks strong demand elsewhere. Imports in the rest of the world are forecast to increase 7 percent (Johnson *et al.*, 2014). Improved textile demand and lower cotton price volatility is anticipated to support a slight recovery in cotton's fiber share (Johnson *et al.*, 2014). U.S. exports are forecast to rise in 2013/14 and appear likely to level off after 2016/17 (USDA-OCE, 2013) (Figure 15). Exports for most other major exporters will remain near 2013/14 levels (Johnson *et al.*, 2014). Overall, USDA projects that world cotton trade will trend upward at a growth rate of 3.8 percent between 2014/15 and 2023/24 (USDA-OCE, 2014b).

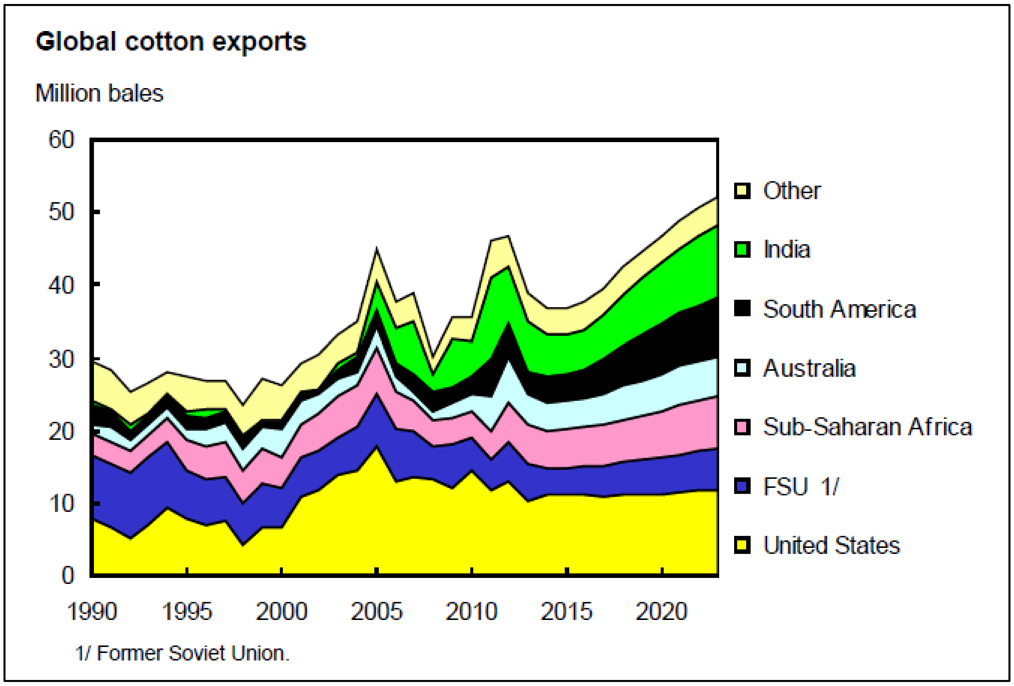


Figure 17. Projections of Global Cotton Exports to 2023.
Source:(USDA-OCE, 2014b)

An increase in U.S. cotton acreage coupled with high worldwide reserves is considered likely to reduce prices in the medium term, primarily due to the lag between cotton production and cotton demand (AgriMoney, 2014). World stocks more than doubled, mainly due to cotton policies in China. USDA projects that lower China domestic support levels, higher stocks outside of China, and falling grain and oilseed prices could reduce the world cotton price to a 5-year low (Johnson *et al.*, 2014). Higher world 'free' stocks and lower price projections for the 2014 corn and soybean crops will also affect U.S. cotton prices (Johnson *et al.*, 2014).

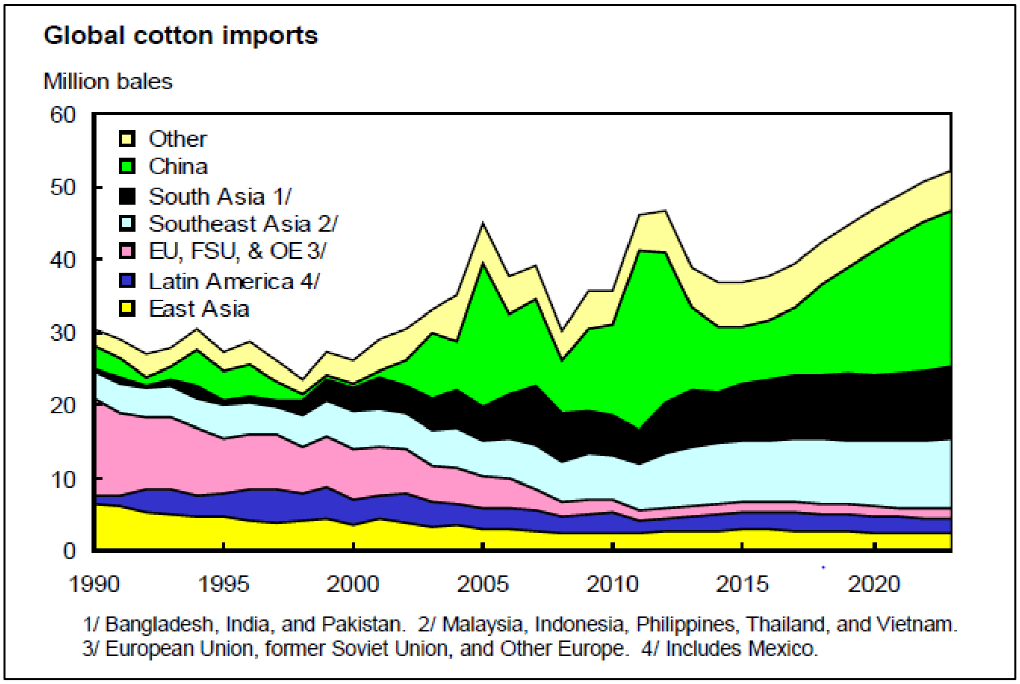


Figure 18. Projections of Global Cotton Imports to 2023.
Source: (USDA-OCE, 2014b)

Soybean exports in the form of bulk beans, meal, and oil are a major share of the total agricultural exports for the U.S. (Figure 19).The U.S. was responsible for 35 percent of world soybean production, 21 percent of world soybean meal production, and 21 percent of soybean oil production (USDA-FAS, 2013a). The U.S., Brazil, and Argentina are expected to continue to account for 88 percent of global exports of soybeans and soybean products (Figure 20). Underlying these projections is an assumption that China would continue to be heavily reliant on soybean imports (Figure 21), which are projected to rise 59 percent to 90 million tons in 2021/22 (USDA-OCE, 2013).

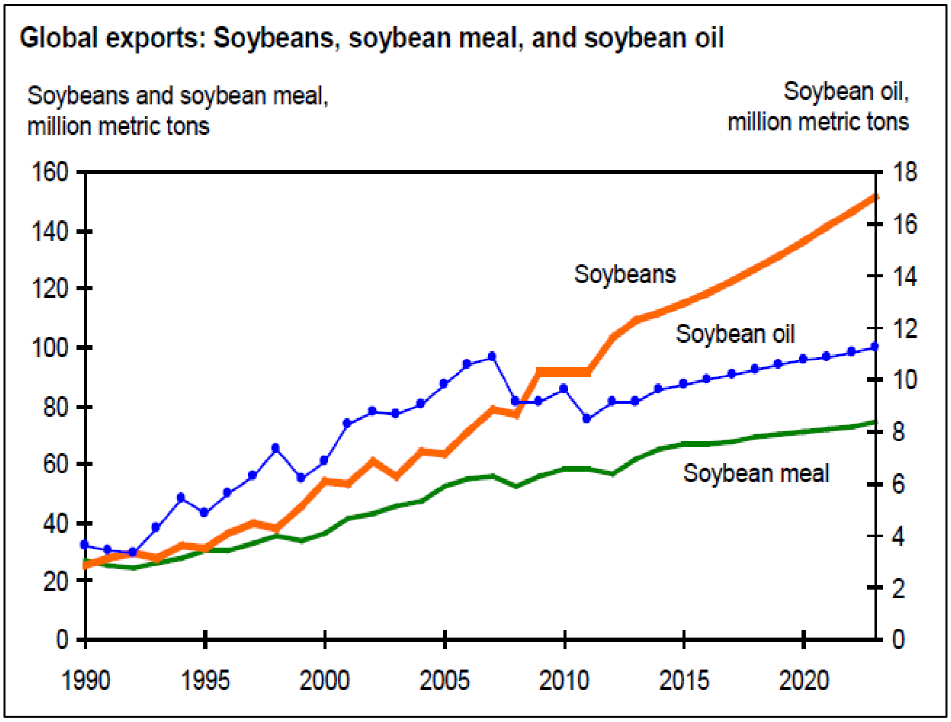


Figure 19. Projected U.S. Global Exports of Soybeans, Soybean Meal, and Soybean Oil.
Source: (USDA-OCE, 2014b)

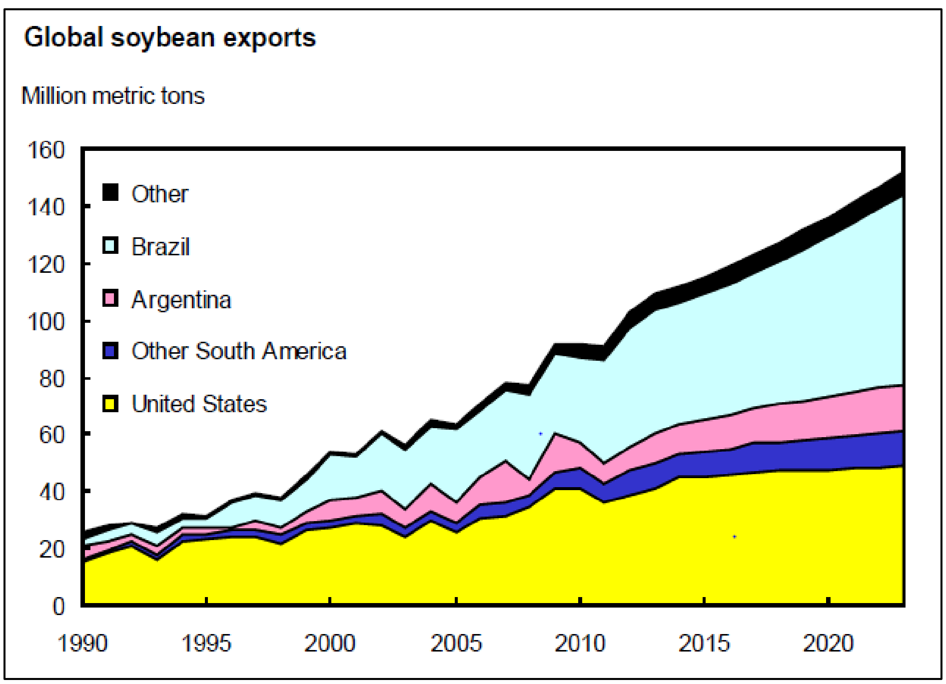


Figure 20. Projections of Global Soybean Exports to 2023.
Source: (USDA-OCE, 2014b)

China is the largest importer of U.S. soybeans and soybean products at 50 percent of the total value of U.S. soybean and soybean product exports, followed by Mexico (8.9 percent) and Japan

(4.2 percent) (USDA-FAS, 2013a). Over the next decade, global trade in soybeans is expected to increase by 31 percent, soybean meal by 17 percent, and soybean oil by 12 percent.

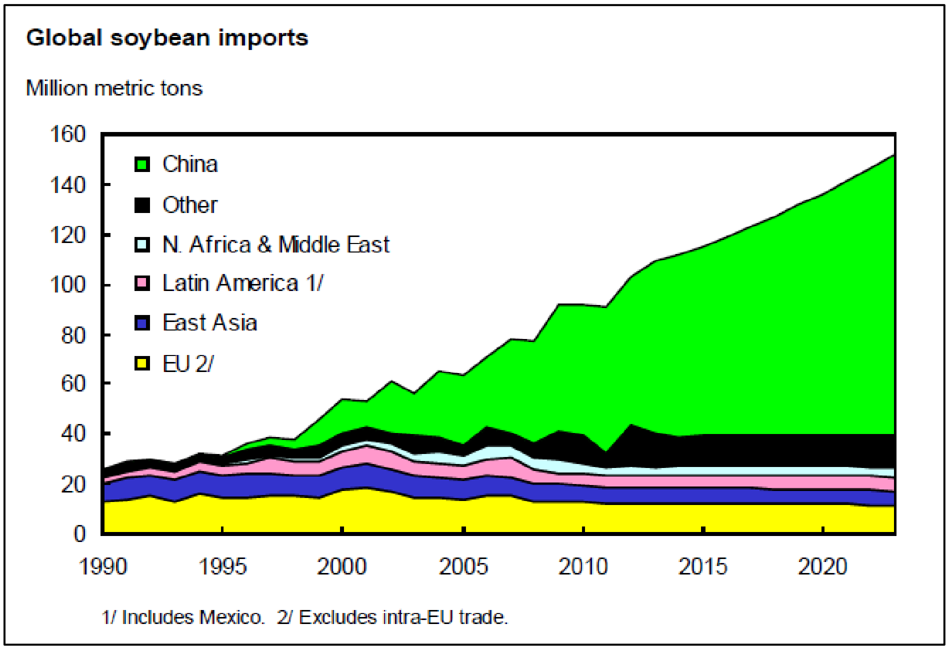


Figure 21. Projections of Global Soybean Imports to 2023.
Source: (USDA-OCE, 2014b)

Under the No Action Alternative, the U.S. is expected to continue to be a leading producer and exporter of cotton and soybean products.

4.1.3 Agronomic Practices in Cotton and Soybean Production

Under the No Action Alternative, MON 88701 cotton and MON 87708 soybean would continue to be regulated by APHIS. Current availability and usage of commercially-available (both GE and non-GE) cotton and soybean varieties are expected to remain the same under the No Action Alternative.

General agronomic practices such as planting and harvesting times, crop nutrition, use of plant growth regulators, and pre-harvest and harvest practices are expected to remain the same Specialized agronomic practices such as row spacing, the use of cover crops and crop rotation practices, as well as adoption of precision agriculture may change over time.

Tillage

Under the No Action Alternative, if hard-to-control and/or GR weeds continue to be problematic or to become a problem where they were not previously found, cotton and soybean growers may need to increase or revert to conventional tillage or hand-weeding. This may be a greater problem in soybean growing states because of the high prevalence of no-tillage used for soybean production.

Most growers are not expected to increase tillage in the short-term due to the economic (reduced fuel use, less time in the field) and environmental benefits (reduced soil erosion and better moisture retention) associated with these practices. The increase of GR weeds makes glyphosate use less attractive, although, glyphosate still controls large numbers of weeds (Monsanto, 2013a). Mid-South and possibly Southeastern states soybean growers who previously adopted no-till production are now replacing that with increasingly aggressive tillage in their management programs (see Cumulative Impacts: Cotton and Soybean Agronomic Practices and Costs of Production. Changes in Tillage). In parts of the Heartland, GR waterhemp and marestail are widespread (Bowman, 2013). No-till practices are being maintained in many areas, but the presence of HR weeds and rapidly increasing presence of GR weeds in particular, sometimes necessitate the inclusion of tillage in weed control strategies (Arbuckle and Lasley, 2013). An Iowa poll disclosed that farmers there used mechanical weed control (i.e., cultivation) 25 percent of the time, and 55 percent found it to be effective or very effective for weed control (Arbuckle and Lasley, 2013). Farmers apparently value soil cultivation for weed control, but practice it only to a limited extent (25 percent) at present.

The fact that tillage is increasing in soybean production suggests that this trend may continue under the No Action Alternative as herbicide-resistant weeds become more difficult to control with available herbicide chemistries. In an attempt to offset the increase in tillage that might otherwise result in the effort to manage herbicide resistant weeds, the Natural Resources Conservation Service (NRCS) is offering farmers technical and financial assistance to manage herbicide resistant weeds while maintaining conservation stewardship through two programs: the Conservation Security Program and the Environmental Quality Incentives Program.

In the majority of the states that produce cotton, conventional tillage is used (Table 13). However, Alabama, North Carolina, South Carolina, and Tennessee are cotton-producing states where no-till exceeds conventional tillage (Table 13). In these states, shifts toward conventional tillage may be more dramatic as GR weeds increase. Overall, conservation tillage is likely to decrease over time as GR weed populations continue to develop and spread. Under the No Action Alternative, an increase in the use of traditional tillage methods in states where GR weeds may be found could result in the potential loss of many of the benefits of conservation tillage. In areas where the NRCS had agreements with growers that restrict cultivation, an increasing number of variances are likely to be needed to accommodate grower needs.

Table 13. Tillage Practices by Crop, 2007.

Tillage Method	Soybean	Cotton
Acres in No-Till Exceeds Conventional Tillage	Illinois Indiana Kansas Kentucky Maryland Michigan Missouri North Carolina Ohio Pennsylvania	Alabama North Carolina South Carolina Tennessee

Tillage Method	Soybean	Cotton
	South Dakota Virginia Wisconsin	
Acres in Conventional Tillage Exceeds Other Types of Tillage	Arkansas Louisiana	Arkansas California Georgia Louisiana Mississippi Missouri Texas
Mulch Till Exceeds Other Types of Tillage	Iowa Minnesota Nebraska North Dakota New York	

Data derived from (USDA-ERS, 2014b).

Crop Rotation

Crop rotations are unlikely to change under the No Action Alternative, because existing varieties can be profitably produced by continuing to use current methods. This likely means continued reliance on producing cotton in a monoculture unless a cover or rotational crop can either reduce pests or soil compaction, or is needed to increase soil fertility. For soybeans, increased rotations are likely to continue as long as the crops can be profitably produced.

Cotton should be rotated with other crops on a regular basis to maintain soil productivity and reduce the incidence of various weeds, insect pests, or diseases (Hake *et al.*, 1996). However, because of economic factors including production costs, relative rate of return, and current market conditions, continuous cotton production has been and is likely to remain unchanged on the majority of U.S. cotton acres (Sandretto and Payne, 2006; USDA-ERS, 2006). By region, however, different patterns of rotation exist. Based on interviews conducted by Monsanto in 2010, approximately 54 percent of U.S. cotton acres are followed by cotton in the crop rotation sequence. By region, this percent is highest in the Southwest (61 percent) and lowest in the West (30 percent). Only in the West region is cotton rotated to another crop, wheat, on the majority of cotton acres. Corn (16 percent), wheat (9 percent), soybean (8 percent), sorghum (8 percent), and peanuts (4 percent) are the other crops most frequently rotated with cotton (Monsanto, 2013a). Based on recent state-specific information from interviews with university extension crop production specialists and extension weed control specialists, regional changes in crop rotation patterns on cotton fields may be occurring due to economic factors, including production costs related to GR weeds.

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

As described in the No Action Alternative analysis of tillage, tillage may increase as part of the effort to manage herbicide-resistant weeds. In an attempt to offset the increase in tillage that might otherwise result in the effort to manage herbicide resistant weeds, the Natural Resources Conservation Service (NRCS) is offering farmers technical and financial assistance to manage herbicide resistant weeds while maintaining conservation stewardship through two programs: the Conservation Security Program and the Environmental Quality Incentives Program. Among the practices that qualify for financial and technical incentives are the use of cover cropping and crop rotation. As a result, cover cropping and crop rotation, both of which have been shown to reduce weed pressure, are practices that are expected to increase under the No Action Alternative.

<u>Agronomic Inputs</u>

Nutrients/Fertilizer

Under the No Action Alternative, cotton and soybean fertilizer requirements for macronutrients (including nitrogen, phosphorus, and potassium) and micronutrients (such as zinc, iron, and magnesium) are not likely to change because fertilizer formulations will continue to be applied to existing varieties of cotton and soybeans.

With respect specifically to soybean, some growers will add microbial inoculants to the soil to facilitate the symbiotic relationship between nitrogen-fixing bacteria and soybean (Conley and Christmas, 2005). Industry has approximated that about one-third of U.S. soybean acreage was inoculated in 2009 (Seed Today, 2009). Under the No Action Alternative, the use of inoculates is unlikely to change from current use because of its benefits to soybean yield.

Insecticides

The use of insecticides on cotton and soybean crops is likely to continue so long as insecticide-resistant pest populations do not develop under the No Action Alternative.

In the U.S., the cotton industry has consistently relied heavily on insecticide use strategies to manage arthropod pests (Gianesi and Carpenter, 1999). Insecticides were applied to 66 percent of the cotton acreage in 2007 (USDA-NASS, 2008b). Of 30 listed insecticides, acephate was the most utilized insecticide, with 26 percent of the planted acreage being treated at an average rate of 0.900 pounds per acre per crop year (USDA-NASS, 2008b). Dicrotophos was the second most commonly utilized insecticide, applied to 21 percent of the acreage at an average rate of 0.565 pounds per year (USDA-NASS, 2008b). Other insecticides applied in the 2007 growing year included acetamiprid (6 percent of acreage), cyfluthrin (8 percent of acreage), cypermethrin (7 percent of acreage), imidacloprid (6 percent of acreage), lambda-cyhalothrin (5 percent of acreage), malathion (5 percent of acreage), and thiamethoxam (11 percent of acreage) (USDA-NASS, 2008b). Overall, insecticide use in cotton has decreased while the adoption of GE Bt cotton varieties has increased (Fernandez-Cornejo *et al.*, 2014b).

While insect management is important in soybean production, the crop is able to sustain a substantial amount of insect damage without loss of yield. This resiliency of soybean against insect damage is best represented by a 2006 survey (USDA-NASS, 2009e) that found that insecticides were applied to only 16 percent of the 72.9 million soybean acres planted in surveyed states in 2006. Of the 12 reported insecticides, the three most common—lambda-cyhalothrin, chlorpyrifos, and esfenvalerate—were applied to 6, 5, and 3 percent of the planted acres, respectively (USDA-NASS, 2009e).

If insecticide-resistant insect populations are selected for and reproduce unhindered, the use of a particular insecticide formulation is likely to diminish unless another MOA/chemistry becomes available. If new insecticidal chemistries become available, growers are likely to change to the novel insecticide until a resistant population arises. This pattern of insecticide use, followed by resistant pest populations developing and concomitant decease in use in the product is likely unless growers strategically deploy the use of existing insecticides. Integrated pest management (IPM) strategies currently in use seek to strategically use existing pesticides to ensure pesticide-resistant populations are less likely to develop and spread. Under the No Action Alternative, it is likely that the cost of insect control and the time spent managing insect pests in soybean will be similar to the current use levels. Under the No Action Alternative, insecticide use in cotton may increase if Bt-resistant insect pests continue to develop.

Herbicides

EPA-registered herbicides will continue to be used for weed management on GE cotton and soybean varieties no longer regulated by APHIS. The increase of GR weeds makes glyphosate use less attractive, although, glyphosate still controls large numbers of weeds (Monsanto, 2013a). From 2008 to 2011, acres to which glyphosate was applied were either stable or declined, but other herbicides (residuals applied to soil that persist for extended periods) applied increased by 177 percent (Monsanto, 2013a). To manage glyphosate resistance, growers are not using more glyphosate, but are using more sites of action in addition to glyphosate.

Dicamba is currently labeled for use in cotton only in pre-plant applications because cotton plants can be damaged by this herbicide (US-EPA, 2006; 2009b). Dicamba is limited to early pre-plant and late post-emergence (pre-harvest) applications in soybean. Under the No Action Alternative, the use of GR cotton and soybean is expected to continue, accompanied by an increasing use of additional herbicides to control other HR weeds. The use of pre-plant (less selective) residual herbicides is also increasing and is likely to continue to increase.

The following section provides a brief background of herbicide use in cotton and soybeans in the U.S. It is provided to give the context for the analyses related to HR weed selection (more information on these subjects is provided in Appendix 3: Weed Management and Herbicide Use; Appendix 4: Herbicide Use Trends in Cotton and Soybean; Appendix 5: Common Weeds in Cotton and Soybean; and Appendix 6: Herbicide Resistance).

Herbicide use in cotton differs substantially from that in soybean both in the types of herbicides used and the variety of herbicide sites of action (see Appendix 3 and 4). Cotton requires more time to develop a closed canopy than soybeans, so cotton becomes more susceptible to competition by early season weeds (Frans and Chandler, 1989). Cotton may be planted in wider rows than soybeans, and the resulting light penetration into an unclosed canopy allows weed germination and growth over a longer period of time than in soybeans (Frans and Chandler, 1989). For these reasons, post-emergent applications of herbicides are more common in cotton crops than in soybeans, but there may be fewer herbicide options.

In contrast, soybean growers have come to rely almost exclusively on glyphosate for weed control. Prior to the adoption of GR soybean, growers relied heavily on ALS and microtubule inhibitors. With the adoption of GR soybean, glyphosate was used on more than 95 percent of soybean acreage and by three quarters of soybean growers. Glyphosate represented the only herbicide site of action used. As GR weeds have become more prevalent, the trend among soybean growers is to use more sites of action including 2,4-D, chloroacetamides, PPO and ALS inhibitors (USDA-NASS, 2013b; Hartzler, 2014a; VanGessel, 2014b).

As described in more detail in Appendix 4, the trend to use more herbicides with different modes of action is observed for both cotton and soybean. Between 2009 and 2011, there was a 113 percent and 220 percent increase in pre- and post-application, respectively, of non-glyphosate treatments on GR cotton. From 2008 to 2011, there was also a 177 percent and 345 percent increase in the use of pre- and post-emergence herbicide application, respectively, of non-glyphosate herbicides on GR soybeans (Monsanto, 2013a). With respect to dicamba, however, after 1994, the use of dicamba steadily declined through 2006 to 17.4 million treated acres with 2.7 million pounds used because of competitive market introductions of sulfonylurea herbicides (chlorsulfuron, metsulfuron-methyl, and thifensulfuron-methyl) in wheat, new broadleaf herbicide active ingredients in corn, and GR corn. However, dicamba-treated acres have increased by as much as 4.0 million acres since 2006. Most of the increase in dicamba-treated acres has occurred in fallow, pastureland, sorghum, and cotton (Monsanto, 2013a). Dicamba-treated acres have increased in cotton, in particular, because it is a common pre-plant herbicide recommendation for GR marestail (horseweed) and Palmer amaranth in the Midsouth region (McClelland *et al.*, 2006). Approximately 25.3 million acres of crops were treated with dicamba in 2011 (see Table 8-1 in Appendix 8). Based on USDA-NASS (USDA-NASS, 2005b; 2007a; 2010b; 2011c; 2012d) statistics, dicamba application rates ranged from 0.07 to 0.24 pounds per acre with the average number of applications ranging from 1 to 1.9 applications per cropping season. Dicamba rates are lowest in barley, wheat and oats, where typically more than one application is made on these crops per cropping season.

Growers are also applying herbicides with different modes of action, and adopting other stewardship practices that reflect the recommendations for BMPs as outlined by the Weed Science Society of America and the National Science Foundation (WSSA, 2010; Ferrell, 2013). Heavily infested fields are being hand-weeded at a cost of up to $100 per acre (Ferrell, 2013). While these changes are positive in that they diversify weed control, the cost of these treatments poses a substantive threat to soybean production in this region.

In addition to increased tillage, growers are also using pre-plant burndown treatments with multiple herbicides on their minimum-till acres and are using residual herbicides more frequently

(Prince et al., 2012b). They also are moving to multiple herbicide applications, and are applying herbicides with several different sites of action at different times over the course of the season to eliminate weeds (including some HR biotypes). In an Iowa poll, farmers reported that 60 percent of the time, they used multiple herbicide modes of action (Arbuckle and Lasley, 2013). Increasingly, herbicide suppliers offer multiple herbicides as pre-mixes (Owen, 2014a). These might include both 2,4-D and glyphosate as recommended in these regions by extension herbicide specialists (Hartzler, 2014b).

Extension weed scientists estimated the increased cost of the additional herbicides needed to control glyphosate-resistant weeds in soybean to be as much as $42/acre (for Palmer amaranth in Tennessee), with most estimates of the increased costs falling in the range of $20 to $30/acre (Carpenter *et al.*, 2002). These costs will vary depending on the specific weed species present in any particular field. However, as resistance to glyphosate and other herbicides has developed and spread in weed populations, these costs may have increased since these estimates were made. For example, there are waterhemp populations in Iowa corn and soybean production fields with resistance to five herbicide sites of action (see (Owen, 2012)).

The continued selection of weeds resistant to glyphosate and other herbicides used will continue under the No Action Alternative. As such, crop management practices will require modifications to address these weeds. These include management practices including the use of alternative herbicides for weed control, as well as mechanical cultivation practices, and crop rotation (Benbrook, 2009; Norsworthy *et al.*, 2012). Under the No Action Alternative, it is likely that the cost of weed management and the time spent managing weeds will continue to increase.

4.1.4 Organic Production Systems

Under the No Action Alternative, the current availability of GE, non-GE, and organic cotton and soybean would remain unchanged from what it is currently in the U.S. Organic seed producers would continue to utilize the same methods as applied in certified seed production systems designed to maintain soybean and cotton seed identity and meet National Organic Standards as established by the NOP. Production costs associated with organic systems will also generally be higher than conventional systems, resulting in higher pricing for organic cotton compared to conventional cotton.

The USDA census of organic agriculture reported organic cotton farming on 30 farms in the U.S. in 2008, two in Arizona, three in New Mexico, four in California, and 21 in Texas (USDA-NASS, 2008a). Texas (66 percent) and New Mexico (20 percent) together accounted for approximately 86 percent of the production. Based on USDA Economic Research Service (ERS) data, between 1997 and 2008, organic cotton acreage ranged from 9,213 acres in 2004 to 15,377 acres in 2008 (USDA-ERS, 2008). In 2008 about 0.16 percent of the total 9.41 million acres of cotton was produced organically (USDA-ERS, 2008). In recent years, small and sporadic acreages of organic cotton production have been cultivated in other states, including Missouri, Illinois, Kansas, Tennessee, and Colorado (USDA-ERS, 2010). As of 2012, the U.S. was the sixth-ranking producer of organic cotton in the world, behind India, Syria, Turkey, China, and Tanzania (Memon, 2012). Based upon recent trend information, the presence of GE cotton varieties on the market has not affected the ability of organic production systems to maintain their market share. Between 2000 and 2008, although 11 GE cotton events were no longer subject to regulation under the PPA and 7 CFR part 340, the acreage of organic cotton production remained at approximately 15,000 acres(USDA-ERS, 2008; USDA-APHIS, 2014c).

Organic soybean production practices include crop rotation, use of cover crops, green and animal manures, application of rock minerals such as lime, other soil additives, mechanical weed control, biological control of pests, and disease control primarily through management practices (Kuepper, 2003; CAST, 2009; USDA-AMS, 2011b). Organic soybean was produced on 96,080 acres in 2011 and yielded 2.9 million bushels, equal to approximately 0.09 percent of U.S. soybean production (USDA-NASS, 2013d). The average yield was 30 bushels per acre. Major production states are Iowa, Minnesota, Michigan, New York, Illinois, Nebraska, and Wisconsin (USDA-NASS, 2012a). Based upon recent trend information, the presence of GE soybean varieties on the market has not affected the ability of organic production systems to maintain their market share.

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

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

4.1.5 Health and Safety Aspects for Livestock and Humans

Humans

Under the No Action Alternative, MON 88701 cotton and MON 87708 soybean would continue as a regulated article under APHIS. Grower exposure to these products would be limited to individuals involved in the cultivation under regulated conditions. Cotton and soybean growers and farm workers will continue to be exposed to existing traditional and GE cotton and soybean varieties and their respective cultivation practices.

Under the No Action Alternative, human exposure to existing traditional and GE cotton and soybean varieties and their products would not change. Ninety percent of cotton and 93 percent of soybean grown in the U.S. in 2013 was GE (USDA-ERS, 2014a). Human health concerns associated with GE crops include the potential toxicity of the introduced genes and their products, the expression of new antigenic proteins, and/or altered levels of existing allergens (Malarkey, 2003; Dona and Arvanitoyannis, 2009). Consumer consumption of GE cotton and soybean products is expected to continue to follow current levels in the future.

Under the FFDCA, it is the responsibility of food and feed manufacturers to ensure that the products they market are safe and labeled properly. Food and feed derived from GE organism must be in compliance with all applicable legal and regulatory requirements. GE organisms for food and feed may undergo a voluntary consultation process with the FDA prior to release onto the market. As described in Section 1.4.2, MON 88701 cotton contains the phosphinothricin N-acetyltransferase (PAT) protein, conferring resistance to glufosinate. FDA has previously reviewed submissions regarding the safety of food and feed derived from crops containing the *pat* gene (BNFs 000055 (soybean), 000073 (corn), 000081 (corn), 000085 (cotton), and 000092 (cotton)). The PAT protein is considered to be safe for consumption by humans and animals. Both cotton and soybean (and other crops) containing the *pat* gene are already in commerce and this exposure is expected to continue under the No Action Alternative.

The greatest risk to human (worker) safety in agriculture is associated with physical injuries usually occurring during the maintenance and use of farm machinery. Cuts, bruises, loss of fingers and limbs are examples of injuries resulting from mechanical hazards. Physical injuries resulting from maintenance and use of farm machinery are unlikely to change in frequency or severity if the No Action Alternative is adopted.

Cotton and soybean growers and farmworkers may be exposed to a variety of EPA-registered pesticides in both GE and non-GE production systems. Herbicide use may increase to meet the need for additional integrated weed management tactics to mitigate herbicide-resistant weeds in different cropping systems (Owen and Zelaya, 2005; Culpepper, 2008; Owen, 2008; Heap, 2014c). However, worker safety is taken into consideration when a pesticide label is developed during the EPA registration process. When use is consistent with the label, pesticides present minimal risk to the worker. No changes to current worker safety are anticipated under the No Action Alternative.

Animal Feed

Under the No Action Alternative, MON 88701 cotton and MON 87708 soybean would continue as regulated articles under APHIS. Under the No Action Alternative, livestock exposure to cotton and soybean would continue to be limited to currently-available varieties, including non-GE and GE varieties.

Processing of cotton generally provides cottonseed meal, cottonseed hulls, and whole cottonseed to be utilized in the animal feed industry as sources of protein, fiber and energy (NCPA, 2002; OECD, 2009). The value of cottonseed as animal feed represents a substantial portion of the grower's income from cotton (Blasi and Drouillard, 2002).

Cottonseed meal, which makes up over a third of the value of cottonseed, is an excellent source of protein for ruminant animals and is widely used in animal feed (Blasi and Drouillard, 2002; Calhoun, 2011). Cottonseed contains the anti-nutrients gossypol and cyclopropenoid fatty acids. Gossypol helps protect the cotton plant from pathogens, but is an anti-nutrient for which sensitivity is species-dependent. Gossypol is also toxic to some species (Gadberry, 2011).

The cottonseed hull is the tough, protective covering of the cottonseed that is removed prior to processing the seed for oil and meal. It is used as feed for livestock and can be an economical roughage that provides fiber, as well as serving as a good carrier for cottonseed meal and grain (NCPA, 2002). Gin by-products, the dried plant material cleaned from the fiber during ginning, is also used as a source of roughage for livestock feeds.

Cottonseed is typically fed to ruminants (i.e., cattle), because they have a relatively low sensitivity to gossypol and can tolerate moderate gossypol inclusion in their diets. Highly processed cottonseed meal is also fed to non-ruminant farm animals in limited quantities (OECD, 2009). Cyclopropenoid fatty acids interfere with the metabolism of saturated fats (Rolph *et al.*, 1990; Cao *et al.*, 1993) and reportedly have adverse effects on egg yolk discoloration and reduced hatchability in chickens (OECD, 2004; Lordelo *et al.*, 2007; OECD, 2008).

Soybeans yield both solid (meal) and liquid (oil) products. Soybean meal is high in protein and is used for products such as tofu, soymilk, meat replacements, and protein powder; it also provides a natural source of dietary fiber (USB, 2009). However, anti-nutrients commonly found in raw soybean also include trypsin inhibitors and lectins (US-FDA, 2011b). Routine processing in moist heat inactivates these anti-nutrients (US-FDA, 2011b).

Nearly 98 percent of soybean meal produced in the U.S. is used as animal feed (Soyatech, 2011). Poultry consume more than 45 percent of domestic soybean meal or 590 million bushels of the U.S. soybean crop, with soy oil increasingly replacing animal fats and oils in broiler diets (USB, 2011). Soybean can be the dominant component of livestock diets, such as in poultry, where upwards of 66 percent of their protein intake is derived from soy (Waldroup and Smith, No Date). Other animals fed domestic soybean (by crop volumes consumed) include swine (26 percent), beef cattle (12 percent), dairy cattle (9 percent), other (e.g., poultry, farm-raised fish) (3 percent), and household pets (2 percent) (Soy Stats, 2010; USB, 2011).

Although the soybean market is dominated by seed production, soybean has a long history in the U.S. as a nutritious grazing forage, hay, and silage crop for livestock (Blount *et al.*, 2009). Varieties of soybean have been developed specifically for grazing and hay, but use of the standard grain varieties is recommended by some because of the whole plant feeding value (Weiderholt and Albrecht, 2003).

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

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

GE organisms for food and feed typically undergo a voluntary consultation process with the FDA prior to release onto the market. Although a voluntary process, to date, all applicants proposing to commercialize a GE variety that would be included in the food supply have completed a consultation with the FDA. In a consultation, a developer who intends to commercialize a bioengineered food meets with the FDA to identify and discuss relevant safety, nutritional, or other regulatory issues regarding the bioengineered food and 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; 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.

Most of the cotton and soybean currently grown in the U.S. is GE (USDA-NASS, 2006), and this market share is expected to continue under the No Action Alternative. Livestock are routinely exposed to GE cotton and soybean in animal feed. All currently-available GE cotton and soybean varieties used in animal feed are considered safe for animal consumption and this is unlikely to change under the No Action Alternative.

4.1.6 Animal Communities

Under the No Action Alternative, MON 88701 cotton and MON 87708 soybean would continue to be regulated by APHIS. The current availability and use of commercially cultivated soybean and cotton, including conventional and GE varieties, would be unaffected under this alternative. Herbicide use may increase to meet the need for additional integrated weed management tactics to mitigate HR weeds in different cropping systems (Owen and Zelaya, 2005; Culpepper, 2008; Heap, 2014c), which may adversely impact wildlife and habitats. Most growers strive to cultivate a single plant species in a field while excluding all other plant species to maximize yield and increase ease in cultivation and harvesting. As a result, using herbicides in agricultural fields directly decreases plant biodiversity, and indirectly reduces the resources available to animals for habitat and food. Herbicides are used on 98 percent of soybean acreage (USDA-NASS, 2013b) and on greater than 99 percent of cotton acres (USDA-NASS, 2011b).

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

Additional integrated weed management tactics may impact the adoption of conservation tillage practices. Under the No Action Alternative, if tillage rates increase as a means of weed suppression, then increases in soil erosion are expected, and this could adversely impact wildlife habitat. In contrast, increased use of cover crops may create beneficial impacts on wildlife by providing habitat and food.

The widespread use of conservation tillage and no-till practices, especially in association with the planting of GE HR soybean varieties, benefitted wildlife through improved water quality, availability of waste grain, retention of cover in fields, and increased populations of invertebrates (Brady, 2007; Sharpe, 2010a). Conservation tillage practices that leave crop residue serve to increase the diversity and density of birds and mammals in agricultural fields (USDA-NRCS, 1999a). Increased residue also provides habitat for insects and other arthropods. This increases food sources for insect predators. Insects are important for many upland game birds and other birds during the spring and summer brood-rearing season because they provide a protein-rich diet for their fast-growing young A nutrient-rich diet also benefits migratory birds (USDA-NRCS, 2003). If growers abandon conservation tillage practices, then these benefits to wildlife may be lost.

Changes to crop management practices may create both beneficial and adverse effects on biological resources, but their net impact on biological resources under the No Action Alternative is unknown.

4.1.7 Plant Communities

Weeds are commonly found in cotton and soybean fields and if not controlled can significantly decrease yields. The most problematic weeds of each crop are shown in Appendix 5. Appendix 3 lists three categories of weeds: annual broadleaf weeds, annual grass weeds, and perennial weeds. In summary, common weeds in cotton fields include barnyardgrass, crabgrass, pigweed species (including Palmer amaranth), morning glory spp., common cocklebur, and common lambsquarters. These are common annual weed species in almost all cotton-growing regions. Johnsongrass, bermudagrass, and nutsedge are common perennial weed species.

Weeds in soybean include: foxtail, pigweed, velvetleaf, lambsquarters, and cocklebur, which are common weeds in Midwestern soybean fields. Certain growers in Indiana have reported giant ragweed, lambsquarters, Canada thistle, cocklebur, and velvetleaf to be difficult-to-control weeds in soybean (Nice and Johnson, 2005). Giant and/or common ragweed are also common and problematic in Minnesota, Missouri, Arkansas, Wisconsin and Illinois (Iowa State University, 2003; Andersen *et al.*, 2004; Boerboom, 2006). In a 2005-2006 survey of 1,200 growers of GR crops (e.g., soybean, corn and cotton) in six Midwestern and Southern states, growers classified these as most difficult to control (Kruger *et al.*, 2009). Waterhemp is also reported to be problematic in Minnesota, Indiana, Nebraska, Wisconsin and Missouri (Iowa State University, 2003; Andersen *et al.*, 2004; Boerboom, 2006; Kruger *et al.*, 2009; Legleiter *et al.*, 2009). Horseweed has been reported to be problematic in Ohio, Arkansas, Tennessee, Kansas, Wisconsin and Illinois (Mueller *et al.*, 2005; Boerboom, 2006; Peterson and Shoup, 2012).

Among these three categories, annual broadleaf weeds include the species that have become most difficult to control due to the selection of HR biotypes[8]. For example, velvetleaf and lambsquarters are both somewhat tolerant of glyphosate and for some species such as pigweed, waterhemp, ragweed, and kochia, GR biotypes have been selected (Heap, 2014c). Species such as waterhemp have developed resistance to as many as five different herbicide sites of action (Owen, 2012). Annual grass weeds that inhabit soybean fields are still largely controlled by glyphosate. Foxtail is an important weed actively managed on almost all acreage used for soybeans. Perennial weeds are particularly difficult to control because they can survive for more than two years and can regrow every year from rhizomes. Among the perennial weeds, biotypes of Johnsongrass have been selected for glyphosate resistance.

In 2012, the area of U.S. cropland infested with GR weeds expanded to 61 million acres, according to a survey conducted by Stratus Agri-Marketing (Farm Industry News, 2013). At present, dicamba-resistant and glufosinate-resistant weeds account for <1 percent and 0.5 percent of resistant biotypes, respectively (Heap, 2014a). No dicamba-resistant populations have been reported in the main soybean production areas, including the Midwest, the South and the East Coast of the U.S. Additional discussion of HR weeds can be found in Appendix 6.

Soybean is not listed as a weed in major weed references, nor is it present on the lists of noxious weed species distributed by the federal government (7 CFR part 360). Modern soybean harvesting equipment is efficient, so few seeds remain in soybean fields following harvest. Therefore, volunteer soybeans are typically not a problem in subsequent crops rotated with soybeans. Even when volunteer soybeans occur they do not compete well with other crops and are easily controlled with common agronomic practices. Volunteer soybeans are limited by the geography in which soybean is planted. Soybean requires specific environmental conditions to grow as a volunteer (OECD, 2000). Mature soybean seeds are sensitive to cold and rarely survive in freezing winter conditions (Raper Jr. and Kramer, 1987). Volunteer soybeans can occur in regions with warmer climates where temperature and moisture conditions are suitable for viability and germination can occur year-round, such as the Mississippi Delta and the southeast U.S. (Zapiola *et al.*, 2008). For volunteer soybean emerging after planting, shallow cultivation or use of another herbicide will control volunteers and effectively reduce competition with the crop. Several post-emergence herbicides are also available to control volunteer soybean (either conventional or herbicide-tolerant soybean) in each of the major soybean rotational crops (Monsanto, 2013a).

With regard to volunteer cotton, volunteer cotton populations are easily managed and feral populations occur rarely in the U.S. Cotton Belt (Wozniak, 2002). Cotton is not listed as a weed in major weed references, nor is it present on the lists of noxious weed species distributed by the federal government (7 CFR part 360). Cotton does not possess any of the attributes commonly

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[8] Plants of a given species are not identical, but are made up of “biotypes” with various genetic traits. Within a weed species, individuals may possess an inherent ability to withstand the effects of a particular herbicide. Repeated use of that herbicide in the absence of other weed control herbicides or practices has the potential to expose the weed population to a “selection pressure,” which may potentially lead to an increase in the number of surviving resistant biotypes in the population (HRAC, (2013)). Herbicide resistance is discussed in more detail in Appendix 6 of the DEIS.

associated with weeds, such as long persistence of the seed in the soil, ability to disperse, invade, or become a dominant species in new or diverse landscapes, or the ability to compete well with native vegetation. It is recognized that in some agricultural systems, cotton can volunteer in a subsequent rotational crop. However, volunteers are easily controlled through tillage or the use of appropriate herbicides with diverse modes-of-action (e.g., ALS inhibitor, chloroacetamide, 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS), PPO inhibitor, Photosystem I (PSI) disruption, Photosystem II (PSII) inhibitor, synthetic auxin, and tubulin inhibitor classes) (Monsanto, 2013a).

4.1.8 Soil Microorganisms

Under the No Action Alternative, MON 87708 soybean and MON 88701 cotton would continue to be regulated by APHIS. Agricultural practices such as pesticide applications and tillage are known to impact soil microbial populations, species composition, colonization, and associated biochemical processes. The use of these practices from what is currently practiced today is unlikely to change under the No Action Alternative.

Growers inoculating soybean fields with *Bradyrhizobium japonicum* bacteria experience increased yields (Conley and Christmas, 2005). In 2009, the industry estimated that one-third of U.S. soybean acreage was inoculated (Seed Today, 2009). Under the No Action Alternative, the use of inoculates is unlikely to change from the current use, unless new or improved strains become available.

4.1.9 Water

If drought conditions west of the Mississippi continue, then abandonment rates for cotton appear likely to increase. Cotton prices are expected to fall less than competing crops which makes planting cotton relatively more attractive to growers. Stronger soybean prices relative to corn should also favor soybean plantings in 2014 (USDA-OCE, 2014a). Corn and soybeans generally require less water than cotton (see Table 14 on comparative water needs) (Brouwer and Heibloem, 1986).

Table 14. Comparison of Water Needs and Drought Sensitivity for Some Globally Important Crops.

Crop	Minimum-maximum water (mm needed over total growing period)	Sensitivity to drought
Alfalfa	800-1600	low-medium
Citrus	900-1200	low-medium
Cotton	700-1300	low
Corn (Maize)	500-800	medium-high
Soybean	450-700	low-medium
Sugarbeet	550-750	low-medium
Sugarcane	1500-2500	high
Sunflower	600-1000	low-medium
Tomato	400-800	medium-high

Source: (Brouwer and Heibloem, 1986)

USDA projections indicate that demands on agricultural water supplies are likely to increase over time as alternative nonfarm uses of water continue to grow. Potential Native American water-right claims were estimated at nearly 46 million acre-feet annually and could impact the distribution and cost of irrigation water in the West. For many states, the scope of water demands for the environment have expanded from a minimum in-stream flow to an “environmental-flows” standard (i.e., a concept requiring water to meet the needs for water quality, but to also rehabilitate ecosystem habitats). Energy-sector growth is expected to significantly increase water demands for an expanding biofuels sector, utility-scale development of solar power, innovation in thermoelectric generating capacity, and commercial oil-shale and deep shale natural gas development (Schaible and Aillery, 2012).

Projected climate change—through warming temperatures, shifting precipitation patterns, and reduced snowpack—is expected to reduce water supplies and increase water demand across much of the West. These trends are placing greater pressure on existing water allocations, heightening the importance of U.S. water management and conservation for the sustainability of irrigated agriculture (Schaible and Aillery, 2012). Expansion in competing areas of national water demand may present U.S. cotton and soybean producers with more difficult farming decisions and fewer socioeconomic options (e.g., whether to purchase enough water for a crop, or to clear or even sell land).

Under the No Action Alternative, water allotment for agricultural use is expected to be restricted as demand for water increases globally. Pressure for the conservation of existing surface water and groundwater resources is expected to increase, as growers shift to produce more cotton and soybeans. In areas where increased tillage is used to control weeds and soil erosion, water may be more likely to be impacted by sediments in agricultural runoff (Fawcett and Towery).

4.1.10 Air Quality

Agricultural activities such as the use of tillage, pesticides, prescribed burning, and farm equipment can all effect air quality. Growers choose those activities that are most suited for their operations. To manage weeds growers may use a combination of activities including pesticide use. In some areas, tillage is increasing as growers use tillage to manage herbicide-resistant weeds. This activity affects air as particulate matter can increase with increasing tillage. Also conventional tillage can use more fossil fuels than conservation tillage methods, resulting in emission of air pollutants from fossil fuel combustion. Under the No Action Alternative, these potential emissions may cause some transient impacts to local air quality. These impacts are unlikely to affect areas with impaired air quality because of the potential for chemical dispersion in air currents and the relatively large distances from agricultural production areas to areas under air quality management plans, which generally encompass urban areas.

4.1.11 Climate Change

Under the No Action Alternative, cropping practices to manage weeds will likely increase in intensity. Increases in herbicide applications or the use of tillage would increase the contribution of cotton and soybean cultivation to GHG emissions. This increase would occur from the combustion of fossil fuels for equipment used to apply herbicides and to till fields. The manufacture of herbicides may also contribute to the release of greenhouse gases, but the overall contribution is likely to be minor. The magnitude of the effect will depend on the HR weed management practices that growers choose to use.

4.2 Preferred Alternative

Under the Preferred Alternative, MON 88701 cotton and MON 87708 soybean would not be regulated by APHIS. MON 88701 cotton has increased resistance to the herbicides dicamba and glufosinate. MON 87708 soybean has increased resistance to the herbicide dicamba. As with other deregulated GE crop varieties, if these Xtend varieties are no longer regulated they would also be available for cross-breeding with all other GE varieties that are no longer regulated by APHIS and non-GE cultivars. Monsanto intends to cross MON 87708 soybean with MON 89788 (Roundup Ready 2 Yield soybean) utilizing traditional breeding techniques, producing a soybean variety with resistance to both dicamba and glyphosate (Monsanto, 2012a) (see Section 1.4.1). Monsanto has indicated MON 88701 cotton will be stacked with Roundup Ready Flex Cotton and Bollgard II (MON 88913 and MON 15985), resulting in a cotton variety with resistance to dicamba, glufosinate, and glyphosate, as well as protection against feeding by a range of Lepidopteran species (see Section 1.4.2 for more details) (Monsanto, 2013a). More commercially available GE cotton and soybean varieties provide growers with more choices and additional tools for weed management. Growers may adopt these new varieties where HR weeds already are present. Continued use of commercially available GE cotton and soybean varieties is expected if the varieties meet grower needs.

4.2.1 Land Use

Under the Preferred Alternative there would be no direct or indirect effects on land use resulting from the decision to approve the petitions. The drivers of land used for cotton and soybean production include the price of cotton and soybean and the suitability of the land for this production. The decision to approve these petitions will not affect these factors.

In 2013, GE cotton and soybean, including stacked and herbicide-resistant varieties, covered approximately 82 and 94 percent, respectively, of the total acreage planted to cotton and soybean in the U.S. (USDA-ERS, 2014c). Under the Preferred Alternative, it is not anticipated that the availability of MON 88701 cotton and MON 87708 soybean will chance the acreage of GE cotton or GE soybean as compared to the No Action Alternative.

4.2.2 Socioeconomics

<u>Domestic Cotton and Soybean Production</u>

According to the petitions submitted by Monsanto, MON 88701 cotton and MON 87708 soybean are compositionally similar to currently available varieties of cotton and soybean, respectively. These events would be suitable for use in food, feed, and industrial applications of cotton and soybean products. Therefore, the use of these events in cotton or soybean processes would not change when compared to the No Action Alternative.

<u>Foreign Trade</u>

A determination of nonregulated status of MON 88701 cotton and MON 87708 soybean is not expected to adversely impact trade under the Preferred Alternative. Although the primary U.S. cotton and soybean export destinations do not present major barriers to trade in GE products, Monsanto would need to obtain approval of MON 88701 cotton and MON 87708 soybean in destination countries before commercialization to avoid adversely affecting current trade flows. As a result, Monsanto has requested import approval of MON 88701 cotton and MON 87708 soybean in key export markets of the U.S. that have functioning regulatory systems. These include, but are not limited to: Canada, Mexico, Japan, the EU, South Korea, and China (Monsanto, 2013a). The regulatory status of these events is summarized in Table 15 and Table 16.

Table 15. Status of Import Approvals of MON 88701 Cotton in Key U.S. Cotton Export Markets.

	MON 88701 Cotton		MON 88701 Cotton Stacks[1,2]	
Country	**Submission**	**Approval**	**Submission**	**Approval**
Canada	June 2012	In review	Not yet submitted	-
Mexico	May 2013	In review	Not yet submitted	-
Japan	November 2012	In review	June 2013	In review
Korea	October 2012	In review	Not yet submitted	-
Australia	January 2013	In review	NA	-
EU	February 2013	In review	Not yet submitted	-
China	Not yet submitted	-	NA	
Philippines	Not yet submitted	-	Not yet submitted	-

Source: (Monsanto, 2013a)
Definitions: EU = European Union; NA = Not Applicable
[1] MON 88701 cotton will be stacked with Roundup Ready Flex Cotton and Bollgard II (MON 88913 and MON 15985).
[2] Progeny (breeding stacks) of GE crops are not regulated by APHIS.

Table 16. Status of Import Approvals of MON 87708 Soybean in Key U.S. Soybean Export Markets.

	MON 87708 Soybean		MON 87708 Soybean Stack[1,2]	
Country	**Submission**	**Approval**	**Submission**	**Approval**
Canada	November 2010	October 2012	November 2012	January 2013
Mexico	November 2011	July 2012	June 2012	February 2013
Japan	March 2011	October 2013	September 2012	In review
Korea	February 2011	October 2013	January 2013	In review
Australia	May 2011	May 2012	NA	
EU	January 2011	In review	March 2012	In review
China	October 2012	In review	NA	
Taiwan	March 2011	April 2013	April 2013	In review

	MON 87708 Soybean		MON 87708 Soybean Stack[1,2]	
Country	**Submission**	**Approval**	**Submission**	**Approval**
India	April 2013	In review	NA	

Source: (Monsanto, 2013a)
Definitions: EU = European Union; NA = Not Applicable
[1] MON 87708 soybean will be stacked with Roundup Ready 2 Yield (MON 89788).
[2] Progeny (breeding stacks) of GE crops are not regulated by APHIS.

4.2.3 Agronomic Practices in Cotton and Soybean Production

Under the Preferred Alternative, there would be no direct or indirect effect on cotton or soybean agronomic practices or the cost of production as a result of deregulation of MON 88701 cotton and MON 87708 soybean. Under this alternative, growers would be able to plant MON 88701 cotton and MON 87708 soybean, but would not be able to make applications of dicamba other than currently approved by EPA. The new post-emergent use of dicamba on these cotton or soybean events is not permitted until EPA approves the new uses. Glufosinate use is allowed on GE cotton and soybean containing the LibertyLink® glufosinate-resistance traits. It is assumed that glufosinate will be able to be used on deregulated MON 88701 cotton varieties.

Therefore, the types of agronomic practices used to cultivate these cotton and soybean varieties, such as tillage, crop rotation, fertilization, and pesticide use, would be similar to those currently used. Growers would continue to manage weeds using a combination of chemical and cultural methods described in the No Action Alternative and Appendix 3. Under the Preferred Alternative, similar to the No Action Alternative, growers may continue to rely on glyphosate and glufosinate to manage weeds in cotton and soybean. Weed scientists will continue to encourage growers to use best management practices.

4.2.4 Organic Production Systems

Under the Preferred Alternative, there are no significant impacts anticipated to organic cotton or soybean production systems beyond what may be already occurring under the No Action Alternative.

Under the Preferred Alternative, MON 88701 cotton and MON 87708 soybean would not be regulated by APHIS and would be available for growers to adopt. Both MON 88701 cotton and MON 87708 soybean are not anticipated to increase acreage of GE cotton or GE soybean, as growers already cultivating GE cotton or soybean are the growers most likely to adopt MON 88701 cotton and MON 87708 soybean, respectively. GE GR soybean and cotton varieties are already extensively grown (93 percent of all soybean acres and 90 percent of all cotton acres (USDA-NASS, 2013c)), while organic soybean and cotton production represents a small percentage of the total U.S. soybean and cotton acreage. Similar to the No Action Alternative, combined organic soybean and cotton acreage is likely to remain small, regardless of whether new varieties of GE or non-GE cotton and soybean, including MON 88701 cotton and MON 87708 soybean, become available for commercial production.

When compared to other GE varieties of soybean and cotton, MON 88701 cotton and MON 87708 soybean should not present any new or different issues and impacts for organic and other specialty producers and consumers. Organic producers manage identity and preserve the integrity of organic production systems utilizing various measures (Guerena and Sullivan, 2003). Agronomic tests conducted by Monsanto found MON 88701 cotton and MON 87708 soybean to be substantially equivalent to the non-GE control variety. Therefore, pollination characteristics would be similar to other soybean varieties currently available to growers (USDA-APHIS, 2014a; 2014b). Because cotton and soybean are largely self-pollinating, there is limited pollen movement, so organic farmers are not expected to be affected by a determination of nonregulated status of MON 88701 cotton and MON 87708 soybean. Agronomic practices used in organic cotton and soybean production would remain unaffected by selection of the Preferred Alternative.

4.2.5 Health and Safety Aspects for Livestock and Humans

Worker Safety

APHIS has not identified any direct or indirect adverse effects on worker safety associated with the selection of the Preferred Alternative. Existing hazards to workers occurring through the various management practices that are used to grow cotton and soybean are expected to continue. Workers will continue to use farm equipment and agricultural chemicals. The decision to approve the two petitions does not authorize a change in herbicide use on these cotton or soybean varieties. The EPA regulates the use of herbicides under FIFRA and considers the effects on human health when approving the use of herbicides (See Appendix 8 for a summary of the EPA’s human health assessment of the proposed new uses of dicamba on these GE crop varieties).

Food and Feed

The direct and indirect effects on food and feed will not be different under the Preferred Alternative when compared to the No Action Alternative. People and livestock will continue to consume GE cotton and soy based-products, as well as animal products from livestock fed cotton and soy products. As described in the petition, MON 88701 cotton and MON 87708 soybean are compositionally similar to currently available varieties of cotton and soybean. Therefore, they are not expected to have different nutritional qualities than other available cotton or soybean varieties.

Monsanto provided the FDA with information on the identity, function, and characterization of the genes in MON 88701 cotton and MON 87708 soybean. The FDA evaluated the information in Monsanto’s submissions to ensure that regulatory and safety issues regarding the human food and animal feed from the new plant varieties have been resolved prior to commercial distribution. Consultations with the FDA for MON 88701 cotton (US-FDA, 2013) and MON 87708 soybean (US-FDA, 2011b) have been completed and the FDA has no further questions about food and feed derived from these cotton and soybean varieties.

No potential impacts to the safety of people and livestock are expected to result from exposure to the introduced dicamba mono-oxygenase (DMO) and PAT proteins in food and feed derived from MON 88701 cotton. Cottonseed, which is a by-product of fiber production, is used in human food, animal feed, and a range of industrial products. Food uses of cottonseed include cottonseed oil and, to a lesser degree, cotton linters (US-FDA, 2013). Cottonseed oil or refined, bleached, and deodorized (RBD) oil is highly refined to remove naturally occurring toxicants, gossypol, and cyclopropenoid fatty acids (Reeves and Weihrauch, 1979; US-FDA, 2013). Cottonseed oil is primarily consumed as a salad or cooking oil, for frying, in mayonnaise, and shortening. Cotton linters are short fibers that remain on cotton seeds after the long fibers have been removed at the ginning process for textile manufacturing (US-FDA, 2013). They are removed from the seeds and processed into pure cellulose, which is used in casings for bologna, sausages, and frankfurters and in ice cream and salad dressings (US-FDA, 2013).

Whole cottonseed, cottonseed meal, hulls, and cotton gin trash are used in animal feeds for cattle, sheep, goats, horses, poultry, swine, fish, and shrimp. Cottonseed meal is the product obtained after removal of oil from whole cottonseed flakes or cake and is used as a protein supplement in animal feed. Cottonseed hulls are used as a source of fiber in feeds (US-FDA, 2013).

RBD oil and linters are processed fractions that contain negligible amounts of total protein (Reeves and Weihrauch, 1979). The DMO and PAT proteins represents a very small portion of the total protein in the cottonseed of MON 88701 cotton; therefore, no exposure to MON 88701 DMO or PAT proteins is anticipated for food uses of MON 88701 cotton.

During the consultation process, the FDA reviewed information on the identity, function, and characterization of the inserted gens and a safety and nutritional assessment of the food and feed derived from MON 88701 cotton (US-FDA, 2013). Neither the DMO nor PAT proteins have relevant amino acid sequences similar to known allergens, toxins or other proteins that may have adverse effects on mammals. Furthermore, the DMO and PAT proteins in MON 88701 cotton are rapidly digested in simulated gastric and intestinal fluids, and these studies did not show any observable adverse effects in mouse acute oral toxicity analyses (Monsanto, 2013a). A compositional analysis of MON 88701 cotton demonstrates that it is comparable with currently-available cotton varieties, further indicating that there would be no negative impact on human or livestock health from consumption of MON 88701 cotton in food or feed (Monsanto, 2013a).

The PAT enzyme present in MON 88701 cotton is identical to the wild-type protein produced in *S. hygroscopicus* and is analogous to the PAT proteins in commercially available glufosinate-resistant products in several crops including cotton, corn, soybean, and canola (USDA-APHIS, 2014c). The Organization for Economic Co-operation and Development (OECD) recognizes PAT proteins produced from different genes to be equivalent with regard to function and safety (OECD, 1999). PAT proteins are structurally similar only to other acetyltransferases known to not cause adverse effects after consumption (Herouet *et al.*, 2005). In 1997, a tolerance exemption was issued for PAT proteins by the EPA (40 CFR part 180, 1997; CFR Part 180.1151, 2005). Additionally, the FDA has previously reviewed submissions regarding the safety of food and feed derived from crops containing the pat gene (BNFs 000055 (soybean), 000073 (corn), 000081 (corn), 000085 (cotton), and 000092 (cotton)). Because the PAT protein, expressed in MON 88701 cotton and in the crops noted above, has already been reviewed by the FDA and has been in commercially produced crops, there are not expected to be any effects on food and feed from MON 88701 cotton, when compared to the No Action Alternative.

With respect to MON 87708 soybean, no potential impacts to the safety of people and livestock are expected to result from exposure to the introduced DMO protein. Upon deregulation and commercialization, soybean and forage produced from MON 87708 soybean would enter the food and feed chain and would be consumed by humans and animals. During the consultation process on MON 87708 soybean, the FDA reviewed information submitted by Monsanto on the safety of the DMO protein, including a dietary risk assessment (US-FDA, 2011b). The DMO protein is rapidly digested in simulated gastric and intestinal fluids, and did not show any observable adverse effects in mouse acute oral toxicity analyses (Monsanto, 2013a). A compositional analysis of MON 87708 soybean demonstrated that it is comparable with currently-available soybean varieties, further indicating that there would be no negative impact on human or livestock health from consumption of MON 87708 soybean in food or feed (Monsanto, 2013a).

4.2.6 Animal Communities

Under the Preferred Alternative, the direct and indirect effects on wildlife from approving these petitions for deregulation would be similar to the effects under the No Action Alternative. Wildlife would continue to visit cotton fields on a limited basis with preferences for other agricultural fields, including soybean fields. As described in the No Action Alternative, animal populations could be indirectly impacted by changes in agricultural practices, such as tillage. Increases in tillage to control weeds can increase soil erosion and cause indirect impacts on wildlife.

Under the Preferred Alternative, cultivation of MON 88701 cotton or MON 87708 soybean will not result in any changes in current agricultural practices. Growers will continue to use cultural practices and herbicides to manage weeds, and biodiversity within a field is expected to remain unchanged. Agricultural production of cotton and soybean is expected to continue relying upon EPA-registered pesticides, including dicamba and glufosinate, for weed management.

Feed derived from GE soybean and cotton must comply with all applicable legal and regulatory requirements, which are designed to protect human health. Monsanto completed the biotechnology consultation process with the FDA for the safety and nutritional assessment of food and feed derived from MON 88708 soybean on October 11, 2011 (BNF No. 00125) and for MON 88701 cotton on April 24, 2013. MON 88701 cotton (US-FDA, 2013) and MON 87708 soybean (US-FDA, 2011b) are compositionally similar to other commercially available upland cotton and soybean varieties, and there are no known toxic properties associated with them.

Data submitted by Monsanto indicate that these proteins are unlikely to be a toxin or allergen in animal diets (Monsanto, 2013a). As a result, animals that may consume these cotton or soybean varieties are not expected to be affected from deregulation of MON 88701 cotton and MON 87708 soybean under the Preferred Alternative.

4.2.7 Plant Communities

Under the Preferred Alternative, the direct and indirect effects of approving these petitions on plant communities, including weed complexes, is expected to be the same as those under the No Action Alternative. Agronomic practices and inputs associated with MON 88701 cotton and

MON 87708 soybean would not be different than what is utilized on current commercially available GE cotton and soybean varieties. As a result, choosing the Preferred Alternative would not result in changes to the plant communities in or around cotton and soybean fields.

Weed communities within agricultural fields, including cotton and soybeans are impacted primarily by tillage practices and herbicide treatments (Owen and Zelaya, 2005). Non-target plant communities in areas surrounding production fields would be exposed to the effects associated with agricultural production, including exposure to various inputs, such as herbicides. Management practices such as herbicide use and mechanical cultivation can select for weeds that are adapted to these management practices.

MON 88701 cotton contains the PAT protein conferring resistant to the herbicide glufosinate. Both MON 88701 cotton and MON 87708 soybean will be combined with glyphosate-resistance traits utilizing traditional breeding techniques (Monsanto, 2013a). Other deregulated GE cotton and soybean varieties are available with resistance to each of these herbicides. Additionally, GE cotton varieties with resistance to both glufosinate and glyphosate are already available (e.g., GlyTol™ LibertyLink® and Widestrike™ Roundup Ready Flex™). Therefore, deregulation of MON 88701 cotton and MON 87708 soybean by APHIS under the Preferred Alternative is not expected to change current agronomic practices. Additionally, MON 88701 cotton and MON 87708 soybean have been shown to be phenotypically and agronomically similar to other commercially grown cotton and soybean varieties; therefore, agronomic practices associated with cotton and soybean cultivation, such as tillage, are not different than currently used. Therefore, there are no changes in effects to plant communities under the Preferred Alternative when compared to the No Action Alternative.

While MON 88701 cotton and MON 87708 soybean can resist applications of dicamba, deregulation by APHIS under the Preferred Alternative would not allow for the new (i.e., post-emergence) uses on these varieties. Pre-plant dicamba use on these and other cotton and soybean varieties could continue as permitted by the EPA. The EPA regulates the use of herbicides under FIFRA and is making a separate decision on the proposed new uses of dicamba; the potential cumulative impacts of the EPA's decision are reviewed in Chapter 5.

4.2.8 Soil Microorganisms

The potential effects on soil quality of choosing the Preferred Alternative are no different than the effects under the No Action Alternative. Soil microorganisms are affected by agricultural management practices, as described in the No Action analysis on soil microorganisms (Section 4.1.8). One factor that drives a grower's selection of agricultural practices is weed management. Another is the trend toward increased herbicide use to control HR weeds in different cropping systems (Owen and Zelaya, 2005; Culpepper, 2008; Owen, 2008; Heap, 2014c) and they will be similar under the No Action and the Preferred Alternative.

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

Growers inoculating soybean fields with *Bradyrhizobium japonicum* bacteria are likely to continue using this organism when additional plant varieties become available. This is because seed breeders have an ongoing interest in making their varieties compatible with existing cropping materials and practices. Under the preferred alternative, uses of inoculates is unlikely to change from current uses.

4.2.9 Water

Agricultural practices can affect water quality. Under the Preferred Alternative, the overall agricultural impacts on water quantity are likely to be the same as those described under the No Action Alternative. Choosing the Preferred Alternative does not change grower choices on how to grow cotton and soybeans or manage weeds in their fields. Any reduction in tillage compared to the amount of tillage occurring under the No Action Alternative would be associated with relatively less agricultural runoff and sedimentation. This would result in less water quality impacts. The converse is also true. In areas where tillage is used or increased to control weeds in cotton and soybean, water may be affected by sedimentation from surface runoff (Robertson *et al.*, 2009).

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

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

4.2.10 Air Quality

Agricultural activities, such as the use of tillage, pesticides, prescribed burning, and farm equipment, can all effect air quality. Growers choose those activities that are most suited for their operations. To manage weeds, growers may use a combination of activities, including pesticide use. In areas where HR weeds are increasing in prevalence, increased tillage is occurring in cotton and soybeans to combat these weeds. Increasing the frequency of tillage increases the release of air pollutants by releasing particulate matter and exhaust from the burning fossil fuels used to run tillage equipment.

MON 88701 cotton and MON 87708 soybean have been shown to be phenotypically and agronomically similar to other commercially grown cotton and soybean varieties; therefore, agronomic practices associated with cotton and soybean cultivation are not expected to change. Under the Preferred Alternative, any effects to air quality associated with deregulation of MON 88701 cotton and MON87708 soybean are likely to be similar to the No Action Alternative because agronomic practices are not expected to change.

Approving the petitions would allow MON 88701 cotton and MON 87708 soybean to be planted, but it does not allow for the additional new uses of dicamba. The use of herbicides is regulated by the EPA under FIFRA, and the EPA is making a separate decision on the proposed new uses of dicamba on these plants. APHIS considers the potential impacts on air quality of its decision combined with the EPA's decision in Chapter 5 (Cumulative Impacts).

4.2.11 Climate Change

Various environmental parameters are anticipated to be altered under the influence of continued climate change. Droughts, floods, and temperature changes are predicted to become more prevalent and more severe as climate change occurs. This requires faster crop improvement programs to develop climate-adapted varieties (James, 2013). The ongoing trend of a general increase in the current range of weeds and pests reflects one impact of climate change on agriculture. In general, North American production is expected to adapt to climate change impacts with improved cultivars and responsive farm management (Field *et al.*, 2007; IPCC, 2007).

The same types of agricultural activities that affect soil, water and air quality can contribute to climate change. Choosing the Preferred Alternative does not change these production practices. Therefore, the potential impacts on climate change are the same under the Preferred and the No Action Alternative.

4.3 Alternative 3

Under Alternative 3, Petition 12-185-01p for deregulation of MON 88701 cotton would be approved, but not Petition 10-188-01p (MON 87708 soybean). Approving the petition would allow MON 88701 cotton to be planted without an APHIS permit or acknowledged notification. MON 87708 soybean would continue to be regulated by APHIS. This decision does not allow for additional uses of herbicides on cotton or soybeans. The EPA regulates the use of herbicides under FIFRA and is making a separate decision which may or may not allow the new uses of dicamba on these plants. APHIS considers the potential cumulative impacts associated with its decision combined with the EPA's decision in Chapter 5.

Under the Preferred Alternative, neither of these two events (MON 88701 cotton and MON 87708 soybean), either individually or together, would have different effects on natural or biological resources than the No Action Alternative No direct or indirect effects associated with of growing MON 88701 cotton were identified in the Preferred Alternative (Alternative 2) when compared to the No Action Alternative. Therefore, approving Petition 12-185-01p for deregulation of MON 88701 cotton under Alternative 3 is also not expected to have different direct and indirect effects on those resource areas. In addition, APHIS does not expect

Alternative 3 to have different socioeconomic or human health-related effects than the No Action Alternative.

4.4 Alternative 4

Under Alternative 4, Petition 10-188-01p for deregulation of MON 87708 soybean would be approved, but not Petition 12-185-01p (MON 88701 cotton). By approving Petition 10-188-01p for deregulation, MON 87708 soybean could be planted without an APHIS permit or acknowledged notification. MON 88701 cotton would continue to be regulated by APHIS. APHIS' decision does not allow for additional uses of herbicides on cotton or soybeans. The EPA regulates the use of herbicides under FIFRA and is making a separate decision on the proposed new uses of dicamba on these plants. APHIS considers the potential cumulative impacts associated with its decision combined with the EPA's decision in Chapter 5.

Under the Preferred Alternative, neither of these two events (MON 88701 cotton and MON 87708 soybean), either individually or together, would have different effects on natural or biological resources than the No Action Alternative. No direct or indirect effects associated with of growing MON 87708 soybean were identified in the Preferred Alternative (Alternative 2) when compared to the No Action Alternative. Therefore, approving just Petition 10-188-01p for MON 87708 soybean is also not expected to have any different direct and indirect effects on those resource areas than the No Action Alternative. In addition, APHIS does not expect Alternative 4 to have different socioeconomic or human health-related effects than the No Action Alternative.

5 CUMULATIVE IMPACTS

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

Cumulative impacts are defined as the “impact on the environment, which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other actions” (40 CFR 1508.7).

Environmental consequences were assessed individually in Section 4. From those analyses, APHIS determined there are no direct or indirect impacts from the potential nonregulated status of MON 88701 cotton and MON 87708 soybean because these varieties are not phenotypically or agronomically different from other cotton or soybean cultivars.

This chapter includes a review and analysis of potential cumulative impacts associated with the Action Alternatives (see Section 2) combined with past, present and reasonably foreseeable future actions within the affected environment (described in Section 3). The first reasonably foreseeable future action considered is that EPA will approve the registration of the proposed new uses of dicamba formulation M1691 (U.S. EPA Reg. No. 524-582) on MON 88701 cotton and MON 87708 soybean. This herbicide product contains a diglycolamine (DGA) salt formulation of dicamba and is lower in volatility than the dimethlamine (DMA) or other formulations of dicamba currently in use. BASF is collaborating with Monsanto on a dicamba formulation with even lower volatility than the DGA M1691 formulation, which will be sold by Monsanto under the product name XtendiMax™ and by BASF under the name Engenia™. In addition, Monsanto will sell a premix of glyphosate and the new dicamba formulation under the product name of Roundup Xtend. As part of the EPA label restriction, only lower volatility dicamba formulations (e.g., M1691, XtendiMax, and Roundup Ready Xtend (glyphosate plus dicamba)) will be allowed to be used on these Xtend crops (Peterson and Thompson, 2013). In this Cumulative Impacts section we will assume that these proposed herbicide uses will be approved by EPA. A second reasonably foreseeable action is the expected determinations of nonregulated status for other HR crops, whose implications are noted later in this section.

This section analyzes the cumulative impacts related to changes in management practices that are likely to be associated with the adoption of MON 88701 cotton or MON 87708 soybean in the context of the impacts that agriculture has on these resources in the areas where cotton and soybeans are grown. In particular, one possible cumulative impact is an increased selection for dicamba-resistant weeds that would eventually occur resulting from the long-term increased use of Xtend herbicide applications. Because this impact would occur only if both APHIS (determines nonregulated status) and EPA (registers use of dicamba herbicides on Xtend crops) take the actions described here, APHIS has analyzed the potential cumulative impacts of both APHIS and EPA to combine and present the potential impacts that may include, for example, development of dicamba-resistant weeds.

Impacts on natural and biological resources are considered in the cumulative impacts analyses. Possible implications of how these impacts might affect the availability of those resources for human use and consumption are also analyzed. The initial step in this process was an analysis of the potential changes in management practices likely to occur if APHIS approves one or more of the Monsanto petitions and EPA approves the uses of dicamba on MON 88701 cotton and MON 87708 soybean. In the second phase of analysis, APHIS analyzed how changes in management practices might impact natural and biological resources. Possible impacts of an interaction with other APHIS actions (past and those currently pending) were also considered.

From those analyses, APHIS determined there are no direct or indirect impacts from the potential determining of nonegulated status of MON 88701 cotton or MON 87708 soybean because these varieties are not agronomically different from other GE cotton or soybean cultivars that are no longer regulated by the Agency. The action Monsanto requested of EPA, which is approval of the use of dicamba on cotton and corn, will be concurrent with a determination of nonregulated status for MON 88701 cotton and MON 87708 soybean. A reasonably foreseeable action is that EPA will approve registration of formulations of Xtendimax™ (dicamba registered with EPA as M1691). This herbicide product contains a diglycolamine (DGA) salt formulation of dicamba and would likely be offered as a premix with glyphosate as well (as Roundup Xtend™). Although the DGA formulation is not new, it is lower in volatility than dimethlamine (DMA) or other formulations, and will be required for use on the crops that are the subject of this DEIS, because only M1691 (XtendiMax (dicamba)) and Roundup Ready Xtend (glyphosate plus dicamba) will be labelled for use on these Xtend crops. BASF is collaborating with Monsanto on dicamba formulations with even lower volatility than the diglycolamine formulated M1691, and BASF with later EPA approval will sell another formulation of a dicamba product as Engenia™ (Peterson and Thompson, 2013).

For conventional cotton, the maximum seasonal application rate of dicamba is the same as that proposed for use on Xtend cotton. However, for Xtend cotton, if EPA approves Monsanto's petition (and APHIS makes the assumption that it will do so), additional acres of cotton may be treated with dicamba at later plant growth stages during the growing season compared to its current uses. Consequently, Monsanto estimates that at peak Xtend cotton use, which is about 50% of cotton acres, more frequent applications of dicamba will be made to cotton, since the trait allows new POST emergent exposure (Appendix Table A-40) (Monsanto, 2013a). For MON87708 or Xtend soybean, the new label would similarly allow for applications at later stages of plant growth than currently approved for dicamba use on soybean. At peak Xtend soybean use, Monsanto estimates that about 40% of acres will be planted with the technology. Again, more frequent application can be expected on soybean since POST emergent exposure is tolerated (Table A-2, A-3,A-5) (Monsanto, 2013a). Thus, more soybean acres are likely to be sprayed with dicamba on Xtend soybean than on present varieties, where it is used only as a burndown herbicide. For this summary, one possible cumulative impact is that more dicamba will be applied to cotton and soybean crops, which could result in increased selection for dicamba resistant weeds. Because this impact would occur only if both APHIS and EPA take the actions already described here, APHIS has analyzed in more detail the potential cumulative impacts of its action combined with potential Xtend herbicide applications in this section. This chapter includes a review and analysis of the cumulative impacts of weed resistance caused by long term use of dicamba. It includes a discussion of potential cumulative impacts associated with the Action Alternatives (see Section 2) combined with other past, present, and reasonably foreseeable future actions within the affected environment (described in Section 3).

5.1 Cumulative Impacts Methodology

For this analysis of cumulative impacts, Alternative 1, the No Action Alternative, was the baseline for comparisons. Under Alternative 1, MON 88701 cotton and MON 87708 soybean would not be determined as nonregulated and could only be grown under APHIS notifications or permits. Under this scenario, APHIS assumes that EPA would not approve the label for the dicamba new uses submitted by Monsanto for use on the GE varieties that are the subject of this DEIS. Existing EPA approved formulations of dicamba would continue to be available and currently available varieties of cotton and soybean would continue to be grown.

5.2 Geographic Boundaries for the Analysis of Cumulative Effects

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

5.3 Proposed New Dicamba Uses and EPA Risk Assessments

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

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

Results of environmental fate studies enable the EPA to determine where a pesticide and its degradates (byproducts) go in the environment (i.e., air, water, and soil), how long they persist, and in what quantities. This information is used by the EPA to develop estimated environmental concentrations (EECs) that can be compared to toxicity and ecotoxicology data as part of the risk assessment process. EEC values are based on the maximum allowable application rate for a pesticide, although typical application rates are usually lower than the maximum allowed. This approach, along with other factors such as the conditions on the farm field, result in “high-end” to “bounding” estimates of exposure. When these are compared to the most sensitive toxicological endpoints in human and ecological effects studies, the results are conservative risk estimates. If these estimates exceed concern levels, EPA will refine the exposure estimates using additional information or may perform a probabilistic assessment of risks.

The EPA is conducting an independent assessment of direct and indirect effects associated with the use of dicamba on MON 88701 cotton and MON 87708 soybean, concurrently with the development of this DEIS.

A summary of the EPA's human health and ecological risk assessments for the proposed new uses of dicamba on MON 88701 cotton and MON 87708 soybean is provided in Appendix 8 of this DEIS. These assessments provide the EPA with information needed to develop label use restrictions for the pesticide. Growers are required to use pesticides, such as dicamba, glyphosate, and glufosinate, consistent with the application instructions provided on EPA-approved pesticide label and any other applicable federal or state laws and regulations. Labels include restrictions on pesticide use/application, such as required personal protective equipment for applicators and requirements related to minimizing drift or exclusion distances from bodies of water when necessary. These label restrictions carry the weight of law and are enforced by the EPA and states (FIFRA 7 USC 136j (a)(2)(G) Unlawful Acts).

These direct effects of dicamba use are outside the scope of this DEIS. APHIS decisions regarding the regulated status of the petitions for these new GE varieties will be made independently of the results of the EPA assessments. One assumption of the APHIS analysis is that EPA will establish label restrictions that will ensure the safety standards for human health and the environment associated with the use of dicamba on these varieties. While the EPA is still evaluating Monsanto's application requesting the new uses of dicamba on MON 88701 cotton and MON 87708 soybean, APHIS sees as reasonably foreseeable that requirements similar to those imposed on Dow Agrosciences' (DAS) Enlist Duo containing glyphosate and the choline salt of 2,4-D related to weed resistance management will be imposed on Monsanto's registration of DGA formulated dicamba (M1691).

Because of the concern about the possibility that using Enlist Duo could result in the spread of weeds resistant to 2,4-D, the EPA is proposing requirements on the manufacturer to ensure that DAS successfully manages weed resistance problems. The proposed regulatory decision was made public on April 30, 2014, for Enlist Duo containing glyphosate and the choline salt of 2,4-D for use in controlling weeds in GE 2,4-D-resistant corn and soybeans (EPA docket EPA-HQ-OPP-2014-0195 at www.regulations.gov). These requirements include robust resistant weed monitoring and reporting to EPA, grower education and remediation, and would allow EPA to take swift action to impose additional restrictions on the manufacturer and the use of the herbicide if resistance develops (US-EPA, 2014b). The details of the EPA's new requirements related to weed resistance management for registration of Enlist Duo are provided in Appendix 10 of the DEIS.

These provisions would require DAS to conduct an active stewardship program including monitoring and swift steps as needed to remediate weed resistance. It would allow the EPA to modify the registration quickly and easily to impose additional measures to manage resistance when appropriate. The label would also contain information on resistance management consistent with the Weed Science Society of America's BMPs for comprehensive resistance management approaches (US-EPA, 2014b).

Because this approach to weed resistance management by the EPA is still in draft form, it is not known what the final requirements will be and how they may differ for Monsanto's registration (as compared to the registration of Enlist Duo). APHIS sees as reasonably foreseeable that these provisions will be generally useful for preventing or remediating the development of weed resistance. Nevertheless, APHIS' analysis in this section focuses on the cumulative impacts associated with these varieties, including possible development of HR weeds associated with application of EPA-approved herbicides, as well as changes in management practices resulting from their use

5.4 No Action Alternative. Current Management Practices Considered in the Analysis of Cumulative Impacts

This analysis addresses the potential impacts of the Alternatives on natural and biological resources and their interrelated socioeconomic impacts within the U.S. on APHIS' determination of nonregulated status for MON 88701 cotton and MON 87708 soybean. These varieties would not affect natural or biological resources directly, but rather the agricultural management practices (e.g., pesticide applications) associated with cultivation of these crops and its potential impact on natural and biological resources. The interaction of cultural and mechanical practices affect agricultural and natural resources, and these include crop rotations, and sequences of crops, selections of varieties and traits and tillage practices. Pest control practices are also relevant and include patterns, numbers and specific choices of applied herbicides or other pesticidal chemicals as well as mechanical and cultural controls. These management practices all accumulate specific outcomes for crop yield, and soil, water, or air impacts. Other consequences may include development of problem or herbicide resistant weeds, or adverse effects on successive crops planted on the same land. APHIS will discuss those selected issues which will or may potentially impact these agricultural and natural resources in the context of the Cumulative Impacts section, since as noted, EPA approval of new dicamba uses was a foreseeable event, rather than an already existing status.

5.4.1 Current Dicamba Use

The agronomic practices that are expected to be affected by nonregulated status for MON 88701 cotton and MON 87708 soybean are those that relate to the application of dicamba. The factors that would contribute to increased dicamba use on cotton and soybean include the application rate and the number of acres to which dicamba would be applied on these new GE plant varieties.

In 2012, the highest use of dicamba was on corn crops, with almost 12 million acres of corn treated. About 12% of corn acres received a dicamba application either alone or with another herbicide. The second crop most frequently treated with dicamba was fallow or idled cropland, with approximately 6.7 million acres treated. On spring and winter wheat, 1.8 and 3.6 million acres received dicamba applications or 14.6% and 8.4% of acres, respectively. Dicamba was used on 1.5 million cotton acres which represents 11.5% of the total U.S. cotton crop acreage (Monsanto, 2014a). Dicamba usage on additional crops is summarized in Table 17 and Appendix 8.

Table 17. Summary of Dicamba Use on U.S. Agricultural Crops.

U.S. Total	2012 Treated Acres			% Dicamba Only	Treated as % of Total U.S. Crop
	Total Dicamba Usage (Mixtures + Alone)	Dicamba Only	Dicamba Mixtures		
Corn	11,919,841	441,945	11,477,896	4%	12.4%
Fallow[1]	6,665,137	17,757	6,647,380	0.3%	17.9%
Winter Wheat	3,622,105	135,020	3,487,085	4%	8.4%
Pastureland	3,221,382	492,671	2,728,711	15%	8.9%
Spring Wheat	1,804,741	79,148	1,725,593	4%	14.6%
Sorghum	1,683,586	49,491	1,634,095	3%	14.6%
Cotton	1,455,312	79,093	1,376,219	5%	11.5%
Soybeans	1,055,926	3,215	1,052,711	0.3%	1.4%
Sugarcane	190,317	-	-	0%	26.9%

Source: BASF Corporation market research (Monsanto, 2014a)
[1] Total acreage is from cropland idled (USDA-ERS, 2011d).

For 2011, Monsanto proprietary and USDA-NASS data indicate that 10% of cotton crops received a single pre-plant application of dicamba (Tables A-2 and A-3 of the Monsanto ER) (Monsanto, 2013a). Monsanto proprietary data show that dicamba use on cotton has increased 2.4 times between 2006 to 2012 (Table 23). For 2011, 1.2% of soybean crops received a single application of dicamba, likely for burndown before planting. Because of the sensitivity of soybean to dicamba, application has been infrequent and accompanied by lengthy plant-back restrictions.

5.4.2 Current Tillage Patterns

The relationship of weed control to changes in tillage practices may be evident in different regions of soybean and cotton production. Surveys and studies of cotton and soybean management practices reveal some trends in a four-region tillage report, comprising West, Midwest, Mid-South and Southeast regions (Monsanto, 2013c). Conservation tillage practices increased, especially no till acres, at the expense of conventional tillage for cotton, corn and soybean in the 10 year period 1998 to 2007 but subsequently began to change (Appendix 9)(Monsanto, 2013c).

Recent tillage trends in cotton. Conventional tillage of cotton fields in the Mid-South increased from 2007 to 2012/2013, while conservation tillage substantially declined. In the Midwest and Southeast, no till declined, but appears to be replaced by reduced-till methods, since conventional tillage is flat but only trending toward an increase in both areas. The survey of experts from both Southern regions together showed that the first factor identified that led to the change in tillage practices was economics, the second reason was to manage existing weeds (Monsanto, 2013c); the first factor was likely a part of the second factor, which would be to solve important evolving weed problems using economically justifiable practices.

Recent tillage trends in soybean. During the five year period 2007-2012, soybean growers in the Mid-South (includes MS, LA, AR, and TN) increased conventional tillage and practiced less no-till, but did not change reduced-till efforts in the most recent period (Monsanto, 2013c). The first and second drivers behind the observed trend were stated as the same as those for cotton (economics and weed management), while the third driver was seed bed preparation, the fourth, managing soil moisture and the fifth as preventing weed resistance.. Some locations such as Tennessee, receive action recommendations from extension weed specialists to respond to severe Palmer amaranth with discing out the crop and replanting, unless they can find a chopping crew to selectively remove this weed (Steckel, 2013). Soybean production in Midwestern states (OH, MI, IN, IL, WI, MO, MN, IA, KY, KS, NE, ND, SD) also showed a two year trend towards increasing conventional tillage, with a significant decrease in no-till, but instead with an increase in reduced-till. Other regions such as the Southeast and East showed a two year trend toward increased conventional tillage, or no change, but no corresponding increase in reduced-till practices. Experts considered that economics and managing existing weeds were the third and fourth proximate reason for the changes in these states (Monsanto, 2013c), although the second reason, a need for better seed bed preparation, could also be related to weed management issues, since seed bed preparation controls early weed competitors of the crop (Gunsolus et al., 2010). A first reason for this grower response was a need to manage increased crop residue, which may be a consequence of newer varieties leaving increased stalk and crop detritus (Monsanto, 2013c). While all reasons for the tillage changes are not clear, and require further assessment, at least some of the changes were responses to weeds and weed resistance.

5.5 Magnitude of Potential Impacts on Resources

APHIS identified changes in management practices that could cause impacts on natural and biological resources. If approved for general use, the degree to which the GE crop varieties that are the subject of this DEIS are adopted will determine the magnitude of the impacts of the associated new management practices. Therefore, APHIS reviewed and analyzed here the range of possible management practices and their impacts. Because APHIS does not regulate production or management practices, the agency cannot control the choices growers make.

5.6 Assumptions

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

- The APHIS PPRAs did not identify any changes in MON 88701 cotton or MON 87708 soybean that would directly or indirectly affect natural or biological resources. These plants are compositionally similar to other cotton and soybean plants. The growth habits of these plants are also similar to other cotton and soybean plants. APHIS assumes that growers will choose management practices appropriate for the crops planted.
- APHIS used information available from extension services, trade journals, scientific journals, and public comments for petitions to identify common practices.
- Most of the U.S. cotton and soybean acreage is currently planted in HR varieties. APHIS assumes that HR cotton and soybean varieties will continue to be planted under all of the Alternatives.
- Under Alternatives 2, 3, and 4, when MON 88701 cotton and MON 87708 soybean, the Xtend crops are determined as nonregulated, could be crossed with any currently available varieties of these crops, including GE varieties no longer regulated by APHIS.

- APHIS considers that herbicide applications will conform to the EPA-registered uses for cotton and soybean.
- In addition to cotton and soybean, APHIS assumes that other approved dicamba uses (e.g. on pastures, wheat, oats, barley, millet, turf, sorghum, corn, sugarcane, asparagus) will conform to EPA-approved label requirements.
- APHIS assumes that the impacts associated with drift from dicamba and other pesticide applications will be mitigated to an acceptable level by the registration requirements established by EPA.
- APHIS assumes that dicamba treatments may or may not include glyphosate, although many treatments may be made with the Xtend dicamba formulation to cotton and soybean which could possibly include both as a premix; stewardship agreements (and herbicide labels with respect to Xtend-resistant crops) will include a requirement to use both dicamba and glyphosate and another herbicide in certain circumstances: "In fields where glyphosate-resistant broadleaf weeds are present or suspected, glyphosate plus dicamba will be recommended. In addition, Monsanto will recommend an additional herbicide with a 3rd mode-of-action that also has activity on the glyphosate-resistant broadleaf weed, thereby providing two effective modes-of-action to control glyphosate-resistant weeds" (Monsanto, 2013c).
- APHIS accepts as likely the Monsanto estimate of herbicide use for dicamba, glyphosate, and glufosinate for the four Alternatives, assuming approval of the new dicamba uses by EPA. The herbicide volume estimates are discussed in detail in Appendix 4. These estimates were based on the assumption that dicamba use on MON 88701 cotton and MON 87708 soybean will increase, while dicamba uses on turf, range, pasture, and industrial management will not change. In brief, dicamba use is expected to increase under the No Action and Action Alternatives (analysis by Monsanto of trends between 2011 and 2015 shows an expected 100% increase in use of non-glyphosate herbicides (Monsanto, 2013a)). Under the Action Alternatives, the increase in dicamba use is expected to be greater when compared to the No Action Alternative. Glyphosate use on cotton and soybean is not expected to increase under the No Action and Preferred Alternatives because of market saturation; between 2011 and 2013, HR soybean was planted on 93-94% of total acres and HR cotton was planted on 73%-82% of total acres (USDA-NASS, 2012c; 2013c). As of 2010, 98% of the corn acres, 99% of the cotton acres and 98% of the soybean acres are treated with herbicides (with glyphosate being the most commonly used)(USDA-NASS, 2011b; 2013b). APHIS understands that growers will be required to participate in Monsanto Technology Stewardship Agreements (MTSA) and Technology Use Guides (TUGs). The TUGs contain best management practices and requirements for growers who use MON 88701 cotton and MON 87708 soybean varieties, including weed resistance management practices (Monsanto, 2013a). Practices such as the use of an herbicide with a trait for a third mode of action in glyphosate resistant crops, and recommendations regarding the most effective rates and timing of applications for dicamba and glufosinate treatments will reduce the potential for weed communities in cotton and soybean fields to shift to more resistant weed species. EPA has specified such requirements be included on the label for the Enlist Duo™ herbicide as part of that proposed registration (US-EPA, 2014b) and is likely to specify similar requirements when considering approval of the label for the new dicamba uses.

5.7 Preferred Alternative: Cumulative Impact

Xtend crop commercialization and EPA approval of the new uses of dicamba on these crops are not likely to change overall agricultural acreage in the United States. If weed control costs become lower as a result of the availability of Xtend crops and new dicamba uses, and net returns on soybean are also higher, APHIS concludes that under the Preferred Alternative there may be basic economic reasons for growers to increase planted soybean acres in two of thirteen regions of soybean and cotton production.

5.7.1 Land Use and Acreage

Summary: Xtend crop commercialization and EPA approval of the new uses of dicamba on these crops are not likely to change overall agricultural acreage in the United States. If weed control costs become lower as a result of the availability of Xtend crops with the new allowable dicamba uses, and net returns on soybean or cotton are also higher, APHIS concludes that under the Preferred Alternative there may be potential economic reasons for growers to increase planted soybean and cotton acres in two each of thirteen regions of soybean or cotton production.

U.S. soybean acreage increased over the past two decades. The greatest increase occurred in the northern and western parts of the Region G and the Region H (USDA-NASS, 2013d). During the same period, wheat and small grain acreage decreased in these areas (USDA-NASS, 2013d). U.S. planted cotton acreage declined somewhat, and between1996 and 2004, averaged 14.4 million acres, while between 2005 and 2013, averaged 11.9 million acres (USDA-NASS, 2014c). Cotton acreage is expected to increase about 1 million acres in 2014, with subsequent moderate growth, reflecting falling values for other crops; soybean acreage will remain around 78 million acres until 2023, but both soybean and corn will compete for land use with other crops (USDA-OCE, 2014b).

An APHIS determination of nonregulated status of the two varieties and EPA registration for Xtend is not anticipated to change cotton and soybean acreage in Regions A-M because other factors such as cotton and soybean prices have a greater influence on planting decisions. Cotton and soybean acreage in Regions G and I is not likely to change unless the Xtend crops strategy for weed control reduces costs compared to the No Action Alternative. If the cost of production is sufficiently reduced to allow the net returns from growing dicamba-resistant soybeans to exceed that of other crops, growers may choose to plant more soybeans in these areas under this Alternative. Other factors such as changes in price of commodities and input costs are also variable and affect planting decisions. A final uncertainty is pricing of these products, and the utility to the growers of purchasing Xtend seeds; both are difficult to ascertain in advance. The potential contribution of MON 88701 cotton to expanding cotton acreage in Region D and J (70% of U.S. cotton acreage) and MON 87708 soybean in Region C and G (57% of U.S. soybean acreage) is not known. APHIS however, does not envision that the dicamba resistance trait will offer a substantially different property that will change the economics of soybean and cotton production, and so these crops are not likely to give rise to production on new or expanding acreage.

5.7.2 Changes in Herbicide Use

Summary: Currently, dicamba is used on only about 1% of soybean acres, and on average, once a season as a burndown or pre-plant herbicide. On Xtend soybean, Monsanto projects dicamba is likely to be used twice a year on no-till and GR weed infested fields, or once on conventional fields. While dicamba use is expected to increase if Xtend soybean is determined as nonregulated, APHIS agrees with analyses indicating that significant PRE non-glyphosate herbicide applications will likely be eliminated, as may more than half of POST non-glyphosate applications.

Currently, dicamba is used on about 12% of cotton acres, mainly as a pre-plant application once per season. Monsanto projects that about one half of the Xtend cotton acreage will receive two applications of dicamba per season and the other half of the acreage, three. Overall, the projected adoption of Xtend cotton will be about 50% of all cotton acres. The amount of dicamba that would be used on cotton may increase 14-fold, but APHIS agrees with estimates that the application of other herbicides would likely decrease on 2.6 million acres of cotton.

Glufosinate use on soybean and cotton has been increasing in recent years as a result of growers choosing to plant glufosinate-resistant varieties because of the increased prevalence of glyphosate-resistant weeds. APHIS concludes that total U.S. glufosinate use on soybean and cotton is expected to decrease because dicamba is a more versatile and efficacious herbicide, and use of dicamba as a POST application will likely be preferred on Xtend crops.

Glyphosate use is not expected to increase, since it is used on most soybean acreage already and on at least 83% of cotton, and also because of its efficacy in controlling many weed species. APHIS concludes that pressure to increase conventional tillage rates because of increasing weed resistance of some species to glyphosate can be alleviated with use of a new herbicide chemistry in addition to use of the existing effectiveness of glyphosate herbicide.

Non-glyphosate herbicide use in cotton and soybean during the period from 2008 to present has been steadily increasing in response to a need to control increasingly present glyphosate-resistant weeds. Some of the changes may also have come in response to advice from weed scientists for averting the development of herbicide-resistant weeds. It is likely that because PRE and POST application of dicamba (and co-application with glyphosate) will control certain herbicide resistant weeds, use of Xtend crops will allow for replacement of other herbicides. Similar results are likely in cotton as well. Under the Preferred Alternative the addition of POST-applied dicamba and residual herbicides will be parts of a coordinated herbicide use strategy with Xtend crops.

Changes in Dicamba Herbicide Use

Dicamba is currently registered for use on soybeans at application rates similar to those proposed for MON 87708 or Xtend soybean. However, the proposed EPA-approved label would allow for dicamba applications at later stages of plant growth than currently approved for soybean. At peak Xtend soybean use, Monsanto estimates that the technology will be adopted on about 40 percent of all soybean acres, compared to 2011 when only 1.2 percent of soybean growers used dicamba once per year for burndown or pre-plant weed control (Tables A-2, A-3, and A-5 of the Monsanto ER) (Monsanto, 2013a). Dicamba will likely be used on average twice per season on

Xtend soybean, on no-till and GR *Ameranthus*-infested fields, and once for conventional tillage fields (Table A-5 of the Monsanto ER) (Monsanto, 2013b; 2013a). Thus, more dicamba herbicide will be sprayed on Xtend soybean acres than are likely to be sprayed with dicamba on present varieties. Increased use of dicamba would however, result in a decrease of up to 21 percent of projected total area treated with PRE[9] non-glyphosate herbicide, and 56 percent of projected total area treated with POST[10] non-glyphosate herbicide, when peak use of Xtend soybean attains 40 percent of all soybean crops (Section A.3.6 of the Monsanto ER) Monsanto (Monsanto, 2013b). At peak extent of Xtend cotton adoption, 50% of US acres will be planted to the variety, and no-till cotton acres would be sprayed three times in W.TX, AZ, OK, NM, and KS and twice in conventional till acres and in all other cotton growing regions twice for no-till but once for conventional till (Monsanto, 2013b). Replacement of non-glyphosate PRE herbicides by Xtend dicamba will likely occur on 34% of cotton acres, and of POST herbicides on 37% of acres (Monsanto, 2013b). APHIS agrees that these values of herbicide reductions presented by Monsanto are consistent with other data made available to this agency.

If the Preferred Alternative is chosen, and the EPA approves use of Xtend herbicides (i.e., dicamba) for the crops, the increase in dicamba use on cotton acres with respect to the present use of dicamba on cotton would be an increase of 14.3 times more than that estimated under the No Action Alternative (Appendix 4, Table 4-9). The increased use of dicamba on soybean would be 88 times more than present, since it is so sparingly used in current practice. The use of dicamba on soybean with respect dicamba use on all other crops would present an increase of 5.4 times, and the increased use of dicamba in both crops compared to all dicamba uses would be 6.8 times. Dicamba at present can mainly be used as a pre-plant on cotton (if the maximum application rate is used, and the planting can come only 21 days after application (Clarity dicamba label). No application is permitted west of the Rocky Mountains. If dicamba is used on soybean in pre-plant applications under present label directions (at maximum application rate: planting not earlier than 28 days after application: Clarity dicamba label) relatively little is used because allowable exposure to the crop is limited.

Changes in Use of Glufosinate

Glufosinate use is expected to increase under the No Action Alternative as growers continue to increase their adoption of glufosinate-resistant crops. Under the Preferred Alternative, APHIS agrees that glufosinate use may decline, based on comparative efficacy data and the observation that dicamba is considered a more effective option for GR weed control compared to glufosinate (Monsanto, 2013a).

Changes in Use of Glyphosate

Glyphosate use on cotton and soybean is not expected to increase under the No Action or Preferred Alternatives because of market saturation; between 2011 and 2013, HR soybean was planted on 93-94% of total acres and HR cotton was planted on 73%-82% of total acres (USDA-NASS, 2012c; 2013c). As of 2010, 98% of the corn acres, 99% of the cotton acres and 98% of

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[9] PRE = pre-plant/pre-emergence application to the crop
[10] POST = post-emergence in-crop use

the soybean acres are treated with herbicides (with glyphosate being the most commonly used)(USDA-NASS, 2011b; 2013b).

Changes in Use of Non-glyphosate Herbicides

APHIS considered the question of whether some existing agronomic practices may facilitate new resistant weeds and more herbicide use. Mortensen et al. (2012) assert that the use of additional herbicide resistant crops, presumably including Xtend crops, will only increase the frequency of herbicide applications. The appearance of new herbicide resistant weeds then becomes an unavoidable consequence of more herbicide applications. Under that assertion, the availability of Xtend soybean and cotton could be accompanied first by first enhanced control, but followed by increasing weed resistance that required higher rates of herbicide applications to meet the increasing weed resistance. Using glyphosate, growers discovered that they could simplify weed control often with use of only glyphosate. In the absence of two-factor herbicide control, resistance to glyphosate easily developed and following that, non-glyphosate herbicide treatments expanded. While dicamba use will increase following determination of nonregulated status of Xtend soybean and cotton, the likelihood that use of other herbicides will decrease should also to be assessed. The larger tapestry of how existing herbicides will be used together is also a key part of the success of herbicides in directing sustainable weed control measures.

APHIS concludes that herbicides alone do not cause resistance, nor do HR crops, rather, the absence of diversity in herbicide use and in tactics for weed management is more relevant (Norsworthy et al., 2012; Shaner, 2014). While managing existing and future problem weeds with herbicides is a focus at present, APHIS agrees that this focus is not likely to provide for agronomic sustainability. New research into weed science and broader weed management practices might take new directions to improve the prognosis, but limited options may be available at present to deal sustainably with weeds (Shaner, 2014).

Soybean herbicide trends and replacement by Xtend. Some assert that new herbicide use on synthetic auxin-type resistant soybean will simply add to existing herbicide use. It is informative to measure how herbicide usage changed from the first availability of glyphosate resistant crops to the present. Mortensen et al. (2012) used data from 2007 and earlier from an 2010 NRC publication showing a decrease in use of the non-glyphosate herbicides. Using this, they postulated constant levels of non-glyphosate herbicide use until additional herbicide resistant crops were available. After these crops were adopted, these authors assumed highly increased herbicide usage rates. Using extensive market research data, Monsanto (Monsanto, 2013a) showed that total area treated PRE with non-glyphosate herbicides for 2002-2007 on soybean increased only 11% and treated POST decreased 7% ((Monsanto, 2013a), Appendix A, Herbicide use trends: Impact of DR soybean on future herbicide use; Table A-10 and A-11). In the more recent period 2008-2011, PRE applications increased 177% and POST 345% (Tables A-10 and A-11). From these it is clear that the present pattern of non-glyphosate herbicide applications is steadily increasing, even without any additional herbicide resistant crops. The factors which drive this increase are the development of glyphosate resistant weeds, and the advice of weed experts and extension personnel which advocate increased use of best management practices, often including multiple herbicides(Clemson-University-Extension, 2012; Norsworthy et al., 2012)

Data derived from market research on herbicide use by growers (Monsanto, 2013a) was subjected to regression analysis procedures, and assessment made of existing trends. From this, forecasts of how much herbicide would be used in future PRE and POST applications to soybean crops were made, based on weed management needs, acceptable weed control, and on costs of herbicide and mechanical tillage (ER, Herbicide use trends: Impact of DR soybean on future herbicide use (Monsanto, 2013a)). As noted in Figures A-1 and A-2 ((Monsanto, 2013a), Appendix A), beginning in about 2015, the increase in non-glyphosate herbicide use levels off because of the restraints of economics and efficiency of weed control.

As can be shown later in this section, the use of the dicamba and glyphosate tolerant Xtend crops will have advantages over many of the non-glyphosate herbicides presently being used on soybean ((Monsanto, 2013a), Appendix A, section A-4.2.2 and following). Under the Preferred Alternative, APHIS agrees that dicamba may displace substantial quantities of these herbicides, and potentially stabilize increases in the total herbicides that are applied to soybean. For example, dicamba and glyphosate resistant Xtend plants may lead to displacement of 60% of some of the PRE herbicides used in soybean production. These include synthetic auxins like 2,4-D, the PSI inhibitor paraquat or the glutamine synthase inhibitors, like glufosinate, because of improved efficacy, lack of a carryover effect, and for reasons of crop safety ((Monsanto, 2013a), Appendix A, Herbicide use trends: Impact of DT soybean on future herbicide use; Table A-15). For POST herbicides, various PPO herbicides such as fomesafen and chloransulam-methyl, various ALS inhibitors such as chlorimuron and imazamox, and a PSII inhibitor bentazone, are projected to be 80% displaced by dicamba/glyphosate used on herbicide-resistant soybean. Issues related to efficacy, carryover, crop safety and existing weed resistance to these herbicides will drive this displacement ((Monsanto, 2013a), Appendix A, Herbicide use trends: Impact of DT soybean on future herbicide use; Table A-16).

The PPOs are one of the few classes of effective POST herbicides for soybean, given that widespread weeds have both resistance to glyphosate and resistance to several classes of herbicide (Hager, 2013). Dicamba can replace the PPOs (some PPOs have less efficacy on GR waterhemp compared to other PPOs (fluthiacet) (Hager, 2013) while others are effective as residuals on GR and ALS resistant weeds (such as flumioxazin (VanGessel, 2014a)) but should be used cautiously to avoid new resistance (University of Illinois, 2013). In both situations, availability of Xtend soybean would be a useful tool to deal with GR weeds and to spare the use of effective PPOs. The usefulness of the PPO herbicide class could be prolonged by reducing overexposure of weeds to effective soybean herbicides.

Cotton herbicide trends and replacement by Xtend. A pattern of increasing use of non-glyphosate herbicides (see Table A-37 to A-39) on cotton can be discerned from grower surveys conducted by a contracting company for Monsanto in 2012 (Monsanto, 2013a). PRE herbicide use over the period 2002 to 2009 increased about 15%, with growers notably using 2,4-D and paraquat for burndown, fomesafen, trifluralin and fumioxazin as preplants with activity extending into post emergent growth, and pendimethalin as a preemergent ((Monsanto, 2013a), Appendix A, A.4.1.3. Analysis of Cotton Herbicide Use From 2002-2011). PRE non-glyphosate herbicide use in cotton increased more sharply between 2009 and 2011, rising 113% ((Monsanto, 2013a), Appendix A, Table A-37). To some extent, the totals reflect a decline in total cotton acres from 2002 and 2003 compared to 2009, and an increase in cotton acreage again by 2011 ((Monsanto, 2013a), Table A-39).

A 250% increase in non-glyphosate herbicide applications occurred between 2003 (30.2%) and 2011 (75.8%) when expressed as ratios of the acreage of non-glyphosate herbicides to total planted cotton acres (Table 18). Applications of non-glyphosate herbicide treatments increased in 2008 from 1.5 and in 2011 to almost 2.2 ((Monsanto, 2013a), Table A-38). Glyphosate-resistant cotton plantings declined 24% during the first period, then increased 68% from 2009 to 2011. The much larger increase in non-glyphosate herbicides applied was not correlated with GR cotton plantings, but with a rise in GR weed development, and the recommendations by weed scientists and extension personnel that growers should employ diversity in weed management practices to counteract the pattern of resistant weed development.

Table 18. Acres and Percentages of Cotton Acres Treated with Non-Glyphosate Herbicides.

Acreage (X1000)	Year				
	2003	2005	2007	2009	2011
Total Area Treated-Non-Glyphosate Herbicides	4,119	4,625	2,941	3,734	11,018
Total Planted Cotton Acres	13,626	14,024	10,732	9,042	14,533
Ratio of Treated Acres to Total Acres	30.2%	33.0%	27.4%	41.3%	75.8%

Data from ER, Appendix Table A-39 (Monsanto, 2013a)

For POST emergent non-glyphosate herbicide usage on GR cotton, a pattern of stasis and slight decline was seen between 2002 and 2009 based on grower survey data assembled by Monsanto ((Monsanto, 2013a), Appendix A, A. 4.1.4., Table A-39). For 2009 to 2011, the total acreage treated with non-glyphosate herbicides increased 220%. Just as was observed in the case of PRE herbicides, the amount of increased herbicide application was far greater than that caused by the large increase in planted GR cotton acres. Again, management of weed resistance, both that already present, and avoidance of future weed resistance was the likely cause of the observed increases ((Monsanto, 2013a), Appendix A, A.4.1.4., Analysis of Cotton Herbicide Use From 2002-2011). For both PRE and POST glyphosate applications, the average numbers per year remained relatively stable, about 1.2 for PRE and about 1.7 for POST applications ((Monsanto, 2013a), Table A-38). Just as observed for PRE applications of non-glyphosate herbicide to cotton, POST applications began rising from about 1.5 per season to around 2.2 ((Monsanto, 2013a), Tables A- 38 and A-40).

APHIS concludes that under the Preferred Alternative the determination of nonregulated status for the Monsanto Xtend crops will likely have considerable impacts on herbicide use patterns. Monsanto predicts that at peak adoption, 10.8 million acres will be planted with the Xtend cotton ((Monsanto, 2013a), Appendix A, A.4.1.5, Table A-40). The prediction is based on regional-specific patterns of treatments per acre, the differences between no-till (21%) and conventional tillage in herbicide treatments and with the assumption that 50% of growers will plant Xtend cotton. The consequences of this level of dicamba use for application of other herbicides on cotton were then assessed.

For PRE cotton herbicides, 100% displacement of diflufenzopyr was likely because of crop safety issues, 75% displacement of nine herbicides including paraquat, thifensulfuron, and carfentrazone because of crop safety issues, carryover, efficacy or grower preferences, and 50% displacement of seven herbicides including 2,4-D, fomesafen, and metolachlor for reasons of efficacy, crop safety, weed resistance and convenience ((Monsanto, 2013a), Table A-42). At peak adoption of Xtend cotton, 2.6 million acres will not receive these displaced herbicides with which these acres otherwise would have been treated. Among the likely displaced herbicides, the agronomic risk issues of these in comparison with dicamba shows that the displaced have between 2 and 5 issues in which they scored lower than dicamba in efficacy of the herbicide, Palmer amaranth resistance in the class, number of resistant weeds to the class, long rotational restrictions, or serious crop injury potential ((Monsanto, 2013a), Appendix, Table A-55). Among the herbicides that may be replaced, several can be used as both PRE residuals, and POST directed-spray herbicides, such as fluometuron, prometryn, and diuron (Steckel, 2014). Under the Preferred Alternative, Xtend crops will be available, and dicamba can be used to prolong the useful activities of these herbicides by providing a means for overlapping herbicidal control of problem and resistant weeds. It is more likely that weed resistance will not develop as quickly as under the No Action alternative. Under the Preferred Alternative, with this HR crop available, growers will be offered an opportunity to alternate herbicide resistance systems (such as glufosinate and HPPD inhibitor resistant cotton) in successive seasons.

<u>Dicamba Volatilization and Drift</u>

Summary: The EPA, which regulates use of herbicides on GE crops, will require that the DGA dicamba formulation (and future additional, even less volatile formulations) be exclusively used with Xtend crops, and will also specify application nozzle requirements. Consequently, if EPA registers herbicide uses for Xtend crops, volatilization and drift issues will not likely be substantially different for Xtend herbicides than for other herbicides on conventional crops following a determination of nonregulated status for these crops; EPA retains oversight and regulatory authority for all environmental impacts caused by herbicide drift or volatility.

An assumption in the No Action Alternative is that dicamba will be applied increasingly to cotton, corn and soybean, because dicamba can be used to control GR weeds. As a result, the acreage to which dicamba will be applied may likely increase from 1.4 to 40% of soybean cropland and from11.5% of cotton cropland to 50% (Monsanto, 2013b). Dicamba burndown applications on cotton and soybean have been steadily increasing since 2006 (*see* Table 23) since it has activity against several GR weeds, often when applied with 2,4-D (Monsanto, 2013a). Current use of dicamba for burndown applications in cotton and soybean are 10% and 12%, respectively (Monsanto, 2013a). The formulations used under the No Action Alternative are both the dimethylamine (DMA) formulation and the DGA and other formulations which are those currently available. The DGA formulation is about 10 times less volatile than for DMA. No additional stewardship agreements are expected to be announced by the developer to mitigate potential off-target movement of dicamba.

If Xtend crops are recognized as nonregulated, and EPA approves Xtend herbicides, Monsanto estimates that dicamba would replace about one-third of other non-glyphosate herbicides at maximum adoption rates, but the relative use on cotton would show an increase of 14.5-fold (Appendix 4, Table 4-12), and on soybean 88-fold (Appendix 4, Table 4-9). Potential for drift impacts of these other herbicides would thus decline.

Unlike the No Action Alternative, for the Action Alternatives, dicamba use is expected to be a required DGA (diglycolamine) salt formulation (M1691 as RoundupXtend, with "Vapor-Grip technology") which is 94% less volatile than DMA formulations (Egan and Mortensen, 2012). At a later date, XtendiMax and Bayer's Dicamba Engenia formulation will be available (Peterson and Thompson, 2013). The expected increase in dicamba use under the Preferred Alternative is not likely to result in more off-target effects because it will be applied as the less volatile DGA formulation. Labels for both DGA formulations, Bayer's future Engenia™ formulation (a poly amine salt 40% less volatile than Clarity (Lingenfelter and Curran, 2014)) and M1691-derived products, will be the only dicamba formulations that are expected to have approval for use on Xtend crops at the present time (Monsanto, 2013a). The DGA formulations with glyphosate may also potentially replace some current uses of the DMA formulations when combined separately with glyphosate by growers, because of the advantages of the lower volatility. EPA-approved DGA dicamba will likely be available to growers of all crops while adoption of Xtend crops is occurring. Since dicamba will also be used for some of these other non-Xtend crops, growers may choose to purchase only one dicamba formulation (i.e., the XtendiMax formulation or the glyphosate plus dicamba formulation (Roundup Ready Xtend)). Consequently, APHIS deems it likely that overall use of more volatile formulations of dicamba may decline if the Xtend crops are determined as nonregulated.

Though off-target dicamba effects may be lower for the Preferred Alternative than for the No Action Alternative, the use of dicamba may occur over a longer season under the Preferred Alternative. This could increase exposure of dicamba-sensitive plants at growth stages later in the season than under the No Action Alternative. These offsetting impacts (less volatile formulations but potentially greater exposure) make it difficult to predict which Alternative is likely to result in more drift and possible plant injury.

Measures to limit off-site transport of 2,4-D choline salt in spray drift have been included as part of the label requirements specified by EPA for the proposed registration of Enlist Duo™ herbicide (a premix of 2,4-D and glyphosate). To mitigate against potential risks to non-target organisms or crops, the herbicide label will require specific techniques, such as a 30-foot on-field buffer zone and use of a specific nozzle/formulation combination (US-EPA, 2014b). It is probable that EPA will impose the same types of requirements for the proposed new uses of dicamba on Xtend crops.

5.7.3 Changes in Agronomic Practices in Cotton and Soybean Production

Changes in Tillage Practice

Summary: Conventional tillage is increasing in some soybean and cotton growing areas, most likely because of increased problems with glyphosate-resistant weeds. This conclusion applies especially to Mid-South states, which includes declines in both conventional and reduced tillage practices. Production of MON 88701 cotton and MON 87708 soybean and other newer *herbicide-resistant crops may be able to reverse some of those trends, especially in the near term, because new HR crops will be available for commodity growers experiencing problem weeds. Under the Preferred Alternative, adoption of MON 88701 cotton and MON 87708 soybean may help reverse these recent trends, allowing some growers to return to using conservation tillage.*

No-till farming practices are centered on effective herbicide-based weed control. Under the No Action Alternative increased or more extensive tillage is occurring in certain areas where HR weeds are no longer effectively controlled by currently-registered herbicides. More aggressive tillage is one effective weed control option. APHIS suggests that adoption of MON 88701 cotton and MON 87708 soybean may reverse this trend of increasing tillage that is occurring under the No Action Alternative. Reports of increased tillage as a result of GR weeds have already been made for cotton and soybean (Shaw et al., 2012; Riar et al., 2013). In some Tennessee counties (included in the region "Mid-South"), the area devoted to conservation tillage decreased by as much as 25% in soybean fields infested with GR horseweed (Shaw et al., 2012). As noted earlier, survey of regional tillage patterns and expert assessments suggest that problem weeds were at least partially responsible for increases in conventional tillage and declines in conservation tillage; these conclusions were especially applicable in the Mid-South states (*see* Current Management Practices, Section 5.4). To some extent these were similar to other regions that showed declines in no-till practices, although these were accompanied with increases in reduced till practices.

Under the Preferred Alternative, adoption of MON 88701 cotton and MON 87708 soybean and EPA registration for Xtend is expected to improve the control of GR weeds, decreasing tillage intensity when compared to the No Action Alternative. This potential reduction in tillage is most likely to occur with the use of MON 88701 cotton because the increase in the use of tillage for weed management has occurred particularly in the management of Palmer amaranth in cotton where "researchers recognize that integrated weed management (IWM) strategies that include tillage may be necessary" (Shaw et al., 2012). Soybean-planted acres that are in direct rotation with corn acres that also have the same weed complex will also benefit from the adoption of MON 87708 soybean and facilitation of reduced tillage. Midwestern states are beginning to identify GR Palmer amaranth just as in locations in the Southern States (Brooks, 2013) and indications are that tillage practices have begun to change similar to those observed in the Mid-South states. Under the Preferred Alternative, APHIS concludes that control of these GR weeds could improve in both regions, since a dicamba-based herbicide strategy using Xtend crops should provide herbicide diversity and effective use of dicamba. If dicamba resistant weeds develop, growers might consider increased tillage as a remedy. APHIS anticipates that growers who practice good stewardship of this technology will attain extended usefulness of Xtend crops. However, alternatives will eventually be needed, and thus additional effective herbicide strategies may require development, and new cultural or mechanical practices may require adoption.

Changes in Crop Rotation

Under the Preferred Alternative, adoption of MON 88701 cotton and MON 87708 soybean and EPA registration for Xtend is not expected to change cotton and soybean crop rotational practices. However, if dicamba-resistant weeds reduce the cost effectiveness of growing certain crops, rotation practices may need to change. For example (see Table 19 and Table 20), wheat and small grain crops are sometimes rotated with soybeans (wheat, 22%, barley, 1.9%, oats, 4.9%) and with cotton (wheat 9.3%, Table 20 barley, 0.4%). Usage of dicamba on wheat crops was either 0.5% (following cotton rotation) or 5% (following soybean rotation; *see* Table 19 and Table 20). Some growers of small grain cereals rely on dicamba for inexpensive weed control. If dicamba was to become ineffective and the cost of alternative herbicides was too expensive, these growers may choose not to grow small grains. Input costs are just one factor that determines whether a given rotation crop is grown. However, other considerations include benefits to the soil, disease management considerations, and economic returns from growing the rotation crop. Under the Preferred Alternative, APHIS concludes that minor changes to crop rotations are possible, but not likely to be substantial.

Table 19. Rotational Practices Following Soybean Production in the United States.

A	B	C	D	E	F	G	H	I	J	K
State	Total Soybean Acres[1]	Major Crops Following Soybean in Rotation	Total Acreage of Rotational Crop in the U.S.[1]	Rotational Crop Acres Following Soybean[2]	% Rotational Crop Following Soybean[3]	% Rotational Crop of Total Soybean[4]	Acreage of Dicamba in Rotational Crop Option[5]	% Dicamba Usage in Rotational Crop Option[6]	% Soybean Acres Preceding Major Rotations[7]	Estimated % Dicamba Usage in Major Rotations[8]
United States	**75,037**	Corn	80,130	51,500	64.3	68.6	5,053	9.8%		
		Soybean	75,037	10,866	14.5	14.5	4,350	40.0%		
		Sorghum	4,020	841	20.9	1.1				
		Cotton	3,767	1,570	41.7	2.1	153	9.7%		
		Wheat	37,414	8,396	22.4	11.2	448	5.3%		
		Barley	2,159	41	1.9	0.05				
		Oats	1,995	98	4.9	0.1				
		Rice	2,301	1,042	45.3	1.4				
		Alfalfa	1,864	162	8.7	0.2				
		Sugar Beets	830	144	17.3	0.19				
		Potatoes	334	32	9.6	0.04				
		Dry Beans	1,183	35	3.0	0.05				
		Dry Peas	520	38	7.3	0.05				
		Millet	250	41	16.4	0.05				
		Flax	345	76	22.0	0.10				
		Other[9]	452	155	31.3	0.20				
		Total	212,601	75,037			10,004		35.3	4.7

This U.S. summary was developed by compiling the data from all three regional summaries. All acreage is expressed as 1000s of acres.

[1]Acreage planted of the specific crops is based on 2008 planting data (USDA-ERS, 2012b) "other" crop and newly seeded alfalfa acreages are based on 2008 planting data from the Individual States data which was obtained from Quick Stat searches on http://www.nass.usda.gov/Data_and_Statistics/Quick_Stats/index.asp.

Originally provided in Petition for the Determination of Nonregulated Status for Dicamba-Tolerant Soybean MON 87708 (Monsanto, 2012a) Table VIII-24

[2]Column E is obtained by compiling the data from all three regional summaries.

[3]Column F is obtained by dividing Column E by Column D.

[4]Column G is obtained by dividing Column E by Column B.

[5]Column H is obtained by compiling the data from all three regional summaries.

[6]Column I is obtained by dividing Column H by Column E.

[7]Column J is obtained by dividing Column B by Column D Total.

[8]Column K is obtained by dividing Column H Total by Column D Total.

[9]Various vegetables.

Table 20. Rotational Practices Following Cotton Production in the United States.

A	B	C	D	E	F	G	H	I	J	K	L	M
Total Acres Cotton Acres[1]	**Rotational Crops Following Cotton**	**Rotational Crop Acres[2]**	**% Rotational Crop of Total Cotton[3]**	**Dicamba Usage in Rotational Crop[4]**		**Glufosinate Usage in Rotation Crop[5]**		**Glyphosate Usage in Rotation Crop[6]**		**% Usage in Total Rotational Crop Acres[7]**		
				%	**Acres**	**%**	**Acres**	**%**	**Acres**	**Dicamba**	**Glufosinate**	**Glyphosate**
United States 10,974	Cotton	5,858	53.4	50	2,930	21.	1,264	90.2	5,284	26.7	11.5	48.2
	Corn	1,736	15.8	8.1	141	6	37	88.0	1,527	1.3	0.3	13.9
	Soybean	861	7.8	50	431	2.1	8	95.9	826	3.9	0.1	7.5
	Sorghum	836	7.6	8.3	69	1.0		34.7	290	0.6		2.6
	Wheat	1,025	9.3	5.6	57	NL		14.1	145	0.5		1.3
	Barley	40	0.4	5.0		NL		27.5	11	0.02		0.1
	Peanut	432	3.9	NL		NL		21.1	91			0.8
	Sunflower	22	0.2	NL		NL		72.7	16			0.1
	Alfalfa[8]	47	0.4	NL		NL		50	24			0.2
	Vegetables[9]	50	0.5	NL		NL		2	1			0.01
	Dry Beans	0.5	0.005	NL		NL		40.0	0.2			0.002
	Peppers	8	0.1	NL		NL		37.5	3			0.03
	Tomatoes	24	0.2	NL		NL		45.8	11			0.1
	Onions	6	0.06	NL		NL		33.3	2			0.02
	Tobacco		0.3	NL		NL		NL				
		Total: 10,974			**Total: 3,630**		**Total: 1,309**		**Total: 8,231**	**33.1**	**11.9**	**75.0**

This table was developed by compiling the data from all four regional summaries (Tables VIII-21 through VIII-24 of Monsanto Petition for Dicamba Cotton). All acreages are expressed as 1000s of acres.
NL indicates not labeled for use.
1 Cotton acreage based on 2010 planting data (USDA-ERS, 2012b; USDA-NASS, 2014c).
2 Column C is obtained by compiling the data from the four regional summaries.
3 Column D is obtained by dividing Column C by Column A.
4 Column E is obtained by dividing Column F by Column C; Column F is obtained by compiling the data from all four regional summaries.
5 Column G is obtained by dividing Column H by Column C; Column H is obtained by compiling the data from all four regional summaries.
6 Column I is obtained by dividing Column J by Column C; Column J is obtained by compiling the data from all four regional summaries
7 Column K is obtained by dividing Column F Total by Column C Total; Column L is obtained by dividing Column H Total by Column C Total; Column M is obtained by dividing Column J Total by Column C Total.
8 Newly seeded alfalfa.
9 Vegetables: Cauliflower (37k acres), lettuce (271 k acres), and broccoli (124k acres) (USDA-ERS, 2012b).
10 Totals may not be exact due to rounding

Changes in Additional Agronomic Inputs

Adoption of MON 88701 cotton and MON 87708 soybean is not expected to change the general agronomic inputs associated with cotton and soybean production except to increase dicamba usage. Fertilizer, insecticide, fungicide, and water use are expected to remain unchanged from the No Action Alternative.

5.7.4 Socioeconomics

Potential Impacts of Dicamba-Resistant Weeds on Production Practices for Other Crops and Grower Economics

To analyze the potential impacts from increased selection for dicamba-resistant weeds under the Preferred Alternative, APHIS assumed that the greatest potential for impacts would be in regions where appreciable acres of cotton or soybean were grown in proximity to appreciable acres of crops that already use dicamba for weed management.

This impact is likely to be highest in crops grown in rotation with Xtend cotton and soybean. Corn is the largest crop grown after soybean, followed in frequency by soybean again, then wheat, cotton and rice (Table 19). When moisture is adequate, growers in southern Indiana, Illinois, Missouri and Arkansas may double-crop winter wheat and soybeans in the same year. This leads to rotation of much of the winter wheat in this area with soybeans. However, there are no accurate ways of determining exactly what land is rotated from corn or soybean to other crops reliant on dicamba for weed control. The rotation varies by region, such that for the eight state Southeast region, where soybean most frequently follows soybean, then corn, cotton, wheat and rice (ER Table VIII-26, (Monsanto, 2012a)). Cotton again is the largest crop grown following cotton (i.e., continuous cotton), followed by corn, wheat, soybean and then sorghum (Table 20).

Selection of dicamba-resistant weeds in cotton or soybean may cause some types of cumulative impacts on other regional crops. APHIS conservatively assumed that proximity of other dicamba-treated crops to dicamba-treated Xtend cotton and soybean could facilitate the potential impacts. The APHIS analysis is based on percentage of cropland devoted to cotton and soybean and the percent of cropland devoted to crops to which dicamba is applied in each region. Table 17 identifies the major crops onto which dicamba is applied. Crops include: small grains (e.g., barley, oats), corn, cotton, sorghum, soybeans, sugarcane, and wheat. APHIS also obtained the percent of regional cropland devoted to other major rotational crops of each region. These data are summarized in Table 21.

Regions D, E, F, and J are areas where cotton and soybean production are predominant (at least >45% of crop acres) and could potentially be at greater risk for development of dicamba resistant weeds. Crops which receive applications of dicamba are components of this landscape (*see* Table 17. In Regions L and M, cotton (no soybean) is of modest acreage and not expected to contribute to the cumulative impacts because there are few crops grown in these regions on which dicamba are applied. Region K has sorghum associated with a modest cotton crop, and selection of dicamba-resistant weeds may have possible impact on sorghum production. In contrast, Regions D, F, and I, represent areas where cotton and soybean, and other crops onto which dicamba is applied are grown frequently in rotation and in proximity of one another (shaded in gray in Table 21).

Region J has frequent co-planting of cotton and wheat, which may be supportive for generating dicamba-resistant weeds and be difficult to suppress if dicamba were used frequently in wheat. However, use of dicamba on wheat amounts to only 8% [winter wheat] on these crops (see Table 17) and so alternatives to dicamba are being used and loss of dicamba usage because of dicamba resistant weeds would not be an insurmountable problem to control of weeds in wheat. Region D includes the coastal Southeast and the Northeast to Pennsylvania. Principal crops to which dicamba is applied in this region are corn and wheat which together make up 43% of the crops grown. Soybean and cotton account for 53% of the crop acreage. With a large percentage of the acreage potentially planted to Xtend soybean and cotton, and another two crops to which dicamba would be applied (non-Xtend cotton as a pre-plant and wheat as a post-emergent), this region may have an increased potential to generate dicamba-resistant weeds. If dicamba-resistant weeds become widely prevalent in these regions, growers of dicamba appropriate rotation crops would be affected, although those who are affected could change their management practices.

Region F includes southern states bordering the Mississippi River (Louisiana, Mississippi, Arkansas, Tennessee, and Missouri). Soybean is a principal crop for 51% of acres, and other crops that have dicamba applied in this region are wheat, cotton, and sugarcane (although sugarcane has limited rotation potential). This region has a high incidence of GR weeds, so the potential for selecting weeds with multiple resistance to glyphosate and dicamba is high relative to other regions. The likelihood will depend on the extent to which growers rely exclusively on Xtend versus employing a range of other management techniques. Because of losses recently experienced with GR weeds, growers may be more motivated to employ best management practices.

Region H includes parts of western North and South Dakota. The major crop in this region is wheat on which dicamba may be applied. Acreage for wheat in this region (34% of acres) is somewhat lower than that for corn and soybean together (46% of acres). A large percentage of the crops could have dicamba applied, and these may enhance the potential for development of weed resistance.

Region I consists of central Kansas, Nebraska, and part of Oklahoma. Major crops in the region that may receive dicamba treatment are wheat, cotton, sorghum, and small grains. Soybean is about one fifth of the crop acreage and potentially could be replaced with Xtend soybean, while 43% of the other crops would use a modest amount of dicamba. This region could potentially see an increased development of weed resistance to dicamba.

Region J consists of a part of north-central Texas. This region most frequently grows cotton. Crops that receive applications of dicamba include small grains, cotton, and sorghum. In both Regions I and J, other crops receiving applications of dicamba exceed the amount of cotton and soybean that is grown. Determinations of nonregulated status for MON 87708 and 88701 could increase the potential for development of weed resistance to dicamba in several crops. Cumulative impacts are not expected in Region J under Alternative 4 (nonregulated status of MON 87708 soybean, only) or in the case that Xtend cotton is not widely adopted in this region.

Table 21. Percent of Regional Cropland Devoted to Crops on which Dicamba is Used in Each EcoRegion.

Percent of Regional Cropland											
Ecoregion	**Crops on which dicamba is used (table also includes other important crops)**									**Total**	**Total**
	Corn	**Soy**	**Wheat**	**Oat, Barley, Millet**	**Cotton**	**Rice[2]**	**Sorghum**	**Alfalfa[1]**	**Nut and Fruit Trees[1]**	**% of Cropland in Cotton + Soy**	**% of Cropland in Other Crops Using Dicamba**
A	48	18	6	2				18		18	56
B	53	26	3					15		26	56
C	53	40	3					3		40	56
D	28	32	15		21				<1	53	43
E	52	46	7		1			<1		47	59
F	51	20	10		12	11		1		32	72
G	45	40	8							40	53
H	26	20	34					3		20	60
I	34	23	33	1	12		9			35	76
J	2	0	39		54		6			54	47
K	13	0			26	6	48		6	26	67
L	12	0	12	6	25			40		25	30
M	9	0	14		10			13	28	10	23

Multiple crops may be grown the same year: double cropping of wheat for example, is common. Regions shaded in gray indicate areas where cotton and soybean are major crops (>40%) and other dicamba using crops are also widely prevalent (>40%).
1. No dicamba use
2. Little or no dicamba use

<u>Weed Control, Herbicide Alternatives and Dicamba Use in Non-GE Crops: Possible Economic Impacts of Xtend Cotton and Soybean to Rotation Crops on Which Growers Use Dicamba</u>

Summary: Production of minor crops in ecoregions where soybean, cotton and corn are major parts of the landscape (i.e., those crops that represent a small proportion of total crop acreage), are not likely to be impacted by the potential development of new dicamba-resistant weeds. APHIS considered whether the possibility of dicamba-resistant weed developing in cotton or soybean would lead to difficulties in typical rotation crops. APHIS concludes that in the use of dicamba for fallow and burndown, there are several other herbicides that may be used in the same price range, in the event that dicamba resistant weeds were to develop. Although use of any herbicide requires consideration of cost, efficaciousness, plant-back considerations and problem weeds, the possibility of new dicamba resistant weeds appearing, then increases in costs for weed control in some crops may be acceptable. In the case of sorghum, it appears that dicamba resistant weeds would be controllable by availability of at least some of the alternative herbicides. An APHIS determination of nonregulated status would not cause large impacts to pasture and rangeland by diminished effectiveness of dicamba because use of dicamba is relatively small, mechanical and cultural techniques are relatively important and numerous *other herbicide choices are available. For small grains, cost comparative alternatives exist, including those effective on broadleaf weeds, and other tillage and cultivation possibilities that are practical present themselves in the event of developing dicamba resistant weeds. Should dicamba resistant weeds develop in conventional corn (that is, not dicamba resistant) no appreciable impacts on corn are expected, since only 12% of the corn producers are using dicamba, and there are a number of alternative choices available for burndown use, both for PRE and POST applications. APHIS concludes that additional choices for control of multiply resistant weeds in soybean (such choices are increased with dicamba resistant varieties) may also be helpful for corn production, which is a frequent rotation crop, and this benefit may outweigh possible impacts of the loss of dicamba usefulness in corn production.*

To evaluate how crops on which dicamba is currently used for weed control might be impacted if dicamba-resistant weeds become more prevalent, APHIS examined the management options and costs for weed control in these crops. Weed control programs vary by crop, weed problem, geography, and cropping system (e.g., no-till, conventional-till, etc.). In those crops where it is labeled for use, dicamba is usually just one part of a much broader weed management strategy. Many growers use a combination of weed control techniques including cultural, mechanical, and chemical. APHIS is aware that the weeds of importance in one crop (e.g., soybean) are not necessarily the same ones that are problem weeds in a rotation crop (e.g., wheat). Thus, the potential impacts from a dicamba resistant weed species arising in soybean may not have a similar impact on wheat crops.

From a 2012 BASF market estimate of agricultural uses of dicamba (Monsanto, 2014a), APHIS identified eight crops (or fallow cropland) where as much as 8% of the crop is treated with dicamba (Table 17). Many of these, (e.g., small grains) are managed similarly and are considered together. For each crop, or group of similar crops, APHIS considered the types and cost of herbicides that are used for broadleaf weed control. APHIS focused on post-emergent, broadleaf weed control, as this is the primary use of dicamba in these crops.

Pasture

One important agricultural use of dicamba is for broadleaf weed control on pastures, as noted in Table 17.

<u>*Alternative Herbicides and Management Options*</u>

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

Other methods that have a definite place in range management are: chemical, roto-beating, plowing, disking, railing, chaining, burning, reseeding, and changes in grazing schedules. There are specific sites and reasons for use of the controls listed. Each is effective if used properly (Prather, 2014).

Table 22 shows a range of herbicide products that are currently registered for pastures and rangeland and their estimated costs. Herbicide alternatives to dicamba that provide reasonable low-cost herbicide control are shaded in gray. Most pasture is not treated with herbicide. Mowing is a non-chemical control method that is often used and is estimated to cost $13.95/acre in Nebraska (University of Nebraska, 2012).

Table 22. Post-emergence Broadleaf Herbicides Commonly Used in Pastures and Rangeland.

Herbicide (common name)	MOA[1]	Rate (lb ae or ai/A)	Cost $/Acre
2,4-D	4	1-2	5.00-10.00
Aminopyralid	4	0.06-0.11	16.12-32.11
Metsulfuron	2	0.06-0.6	1.35-13.53
Carfentrazone	14	0.015-0.031	1.70-3.40
Chlorsulfuron	2	0.19-1.0	5.00-25.08
Clopyralid	4	0.14-0.375	13.33-35.70
Dicamba	4	0.5-1.5	9.99-29.97
Fluroxypyr	4	0.6-0.72	20.63-24.76
Picloram	4	0.25	7.50
Triclopyr	4	0.25	3.75
Hexazinone	5	0.67-1.12	25.54-42.69
Paraquat	22	0.25-0.5	3.98-7.96
Tebuthiuron	7	0.4	16.00

Source: (Texas Cooperative Extension)

[1]Weed Science Society of America mode of action category
Note: Alternative low cost herbicide options to dicamba are shaded.
lb ae/A = pounds acid equivalent per acre
lb ai/A = pounds active ingredient per acre

Potential Impacts to Pasture and Rangeland from Increased Weed Resistance

Although, according to BASF market estimates, pasture and rangeland represents the fourth largest agricultural use of dicamba, most pasture and rangeland is not treated with herbicides. Non-chemical options are most often used, and there are similarly priced chemical alternatives to dicamba (Table 22). Healthy stands of forage pastures tend to exclude weeds, and good management includes mechanical, cultural, biological as well as chemical controls, so a variety of weed control methods are typically used, that may or may not use herbicides (Green *et al.*, 2006). The cumulative impacts on pasture and rangeland would be diminished utility of dicamba because of selection for dicamba-resistant weeds in the rotated Xtend crops. APHIS concludes that even if dicamba-resistant weeds became more prevalent, the cumulative impacts to pasture and rangeland weed management are expected to be small under all the Alternatives.

Small Grains (Wheat, Barley, Oats)

Spring wheat applications of dicamba have declined from 12% to 5% of acres from 2006 to 2012, respectively (USDA-NASS, 2014c), in NASS's seven program states[11] (USDA-NASS, 2005a). Applications to winter wheat[12] increased from 8% to 15% in that same period in USDA-NASS' 15 program states. Conditions are usually very favorable to winter wheat growth in the fall, and the crop out-competes many weeds. About 96% of spring wheat was treated with herbicide, while about 57% of winter wheat was treated. Wheat may be rotated with corn or soybeans. In some areas such as Indiana, Illinois, Kentucky, Missouri, and Arkansas, winter wheat is often planted with the intent to double crop with soybeans the same season. Winter wheat is harvested (usually in June) and soybeans are planted in no-till wheat stubble when there are favorable moisture conditions (North Dakota State University; Moechnig and Wrage, 2012).

In 2003 and 2011, 5% of barley acres received applications of dicamba (USDA-NASS, 2014c) and 88% of barley acres were treated with herbicides in NASS's program states.[13] Market reports indicate that the use of dicamba in barley has been declining since 2008 (Table 23) (Monsanto, 2014a).

Table 23. Changes in Dicamba Application to Crops 2006-2012.

Year	2006	2008	2010	2012
Crop	**Dicamba-Treated Acres**			
Corn	8,080,614	8,113,801	6,459,632	11,919,844
Fallow	2,144,260	3,017,717	4,274,678	6,665,140
Wheat, Winter	2,348,897	3,742,572	2,577,953	3,622,102
Pastureland	1,454,649	1,218,179	2,604,944	3,221,382
Wheat, Spring	1,569,079	1,351,665	1,512,894	1,804,742
Sorghum (Milo)	550,795	1,114,162	955,997	1,683,584
Cotton	590,953	589,919	854,649	1,455,309
Soybeans	279,275	529,638	648,509	1,055,926
Sugarcane	198,042	177,089	225,295	190,317
Barley	108,393	211,067	101,158	47,144

BASF market data. In Monsanto NOI supplement (Monsanto, 2014a)

Alternative Herbicides and Management Options

A wide range of herbicide products are currently registered for small grains that could replace dicamba. Use of pre-plant or pre-emergence herbicides occurs on a small portion of grain acreage usually with 1-2 post-emergence applications. Post-emergence graminicides are often used to control grass weeds such as wild oats and foxtail. Many different herbicides are available for post-emergence broadleaf weed control. Dominant modes of action in small grains are auxins (WSSA Group 4) and ALS inhibitors (WSSA Group 2). While one auxinic class herbicide, 2,4-D is a widely used herbicide for these crops, it does not provide acceptable control of some key broadleaf weeds such as kochia and wild buckwheat (Zollinger et al., 2006). Glyphosate and 2,4-

[11] AR, MN, MT, ND, OR, SD, WA

[12] Program States 2012: CO, ID, IL, KS, MI, MO, MT, NE, OH, OK, OR, SD, TX and WA USDA-NASS (2013a)

[13] Program States 2011: AZ, CA, CO, ID, MN, MT, ND, OR, PA, VA, WA, WI, and WY USDA-NASS (2012).

D treatments are often combined with one of the herbicides listed in Table 24 (Zollinger et al., 2006).

A number of alternative herbicides and estimated costs are listed in Table 24. Chlorsulfuron, an ALS inhibitor for example, can provide control similar to dicamba at low cost (Zollinger et al., 2006; Zollinger, 2014). However, resistance to ALS inhibitors is widespread. The cost of some other products is similar, such as pyrosulfotole and bromoxynil or premixes of both, which provide high levels of control of some key broadleaf weeds, such as kochia and also wild buckwheat (Zollinger et al., 2006).

Some non-chemical control methods can also substitute for dicamba or enhance other control measures. Weeds such as common lambsquarters and common ragweed often germinate early in the spring. Tillage just before spring planting can eliminate the major flush of these early emerging weeds. A 2009 USDA report on custom tillage rates estimated the cost of harrowing at $7.30-8.40 per acre in Kansas (USDA-NASS, 2009f). Crop rotation is a recommended weed management practice, providing a tangible, recognized level of control where practiced, and this cultural means of control is often an important part of an integrated weed control plan.

Table 24. Post-emergence Broadleaf Herbicides Currently Approved for Use in Wheat, Barley, Oats, and Rye.

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

Herbicide (common name)	MOA[1]	Crops[2]	Rate (lb. acid equivalent or active ingredient/A)	Cost $/Acre	Comments
				31.85	
Tribenuron	2	WW, SW, B	0.008-0.16	4.70-9.35	
Metsulfuron	2	WW, SW, B	0.004	1.50	
Prosulfuron	2	WW, SW, B, O	0.009-0.018	3.65-7.25	
Pyraflufen	14	WW, SW, B, O, R	0.0008-0.0016	1.65-3.30	Primarily pre-plant but can be applied POST
Triasulfuron	2	WW, SW	0.013-0.026	3.00-6.05	
Imazamox	2	WW, SW	0.031-0.047	16.25-24.40	Clearfield varieties only

Alternative low cost herbicide options to dicamba are shaded.
1. WSSA Mode of Action
2. Crops labelled for use
Abbreviations:
B=barley; O=oats; SW=spring wheat; R=rye; WW=winter wheat
Source: (DAS, 2013b)

Potential Impacts of Dicamba-Resistance on Small Grains

Winter wheat, spring wheat, barley, and oat growers often do not use herbicides. When needed, dicamba provides an inexpensive and effective weed management tool especially for some weeds not controlled by some other herbicides, such as wild buckwheat. As noted in the discussion that follows, there are several areas where these crops are rotated with either cotton or soybean or grown in proximity. If dicamba-resistant weeds were to develop in cotton and soybean fields, it is likely that they could eventually be found in wheat and small grain crops on rotated Xtend acreage or on neighboring farms. MCPA and 2,4-D are low priced, common alternatives, but if applied to emerged wheat can cause damage, and as noted, may not control key weeds (Johnson and Nice, 2009). Other low cost herbicides, such as the ALS inhibitor chlorsulfuron, may not be as effective because of widespread resistance to ALS inhibitors. Pyraflufen is a low-cost PPO inhibitor that is usually used pre-plant. It cannot be used post-emergent (unlike dicamba) on small grains except wheat, and it has more restrictions than dicamba when used on wheat. Most likely, alternative chemical control options would be more expensive. Thus, some chemical alternatives are less flexible and some may be more costly. This indicates that there may potentially be cumulative impacts to wheat and small grain growers if dicamba-resistant weeds become more prevalent.

Fallow and Burndown Uses

For many crops, including soybean, dicamba has been used in mixes with other herbicides such as glyphosate, 2,4-D, glufosinate, or paraquat in the spring or fall as a “burndown” herbicide prior to planting, especially in connection with a glyphosate- or glufosinate-resistant crop

(PennState-Extension, 2013). This timing may extend anywhere from 0-30 days prior to planting, depending on the crop, geography, and product used. It is used to improve control of winter annuals, perennials, and early-emerging, summer annual weeds. Examples of weeds controlled include shepard's purse, marestail, dandelion, common lambsquarters, and giant ragweed. When used as a burndown, its control of broad leaf weeds is excellent, but control of Palmer amaranth may not be as effective as that achieved by flumioxazin (Edwards et al., 2012). More recent recommendations include mixtures of flumioxazin (residual) with diuron or with paraquat (foliar active herbicides) (University of Georgia CAES Extension, 2014).

Often burndown herbicides are a critical part of an overall weed control program since these remove weeds that will be competing with the crop as it emerges. Burndown herbicide applications are almost obligatory for no-till crop production systems where tillage is not desired. Use of no-till crop culture is common in corn, soybeans, cotton, and wheat. Both soybeans and cotton are largely planted as GR varieties and glyphosate is an important herbicide used in post-emergent weed control. For wheat managed with herbicides, burndown applications are popular but there are post-emergent options including bromoxynil and pyrasulfotole, provided these are applied in early stages of wheat growth (Johnson and Nice, 2009; Zollinger, 2014).

Fallowing (land left plowed or disced lightly but not sown to crops) is used in arid areas of the plains and the West as a means to store soil moisture for a following crop. Fallow may encompass the summer season but is usually applied to a longer period of time (often 4-12 months). Weed control on fallowed acres is critical for reducing moisture loss. While tillage is an alternative to herbicidal control, it is usually less desirable because it increases erosion, costs of fuel and labor, and soil moisture loss (Simmons and Nafziger, 2012; Fernandez-Cornejo et al., 2013).

Alternatives to Dicamba

Herbicides effective for burndown and foliar activity on broadleaf weeds are listed in Table 25. Depending on the crop to be planted and the target weed species, these products can offer an alternative to dicamba, with some at greater cost. In several cases, these herbicides offer some advantages over dicamba such as longer residual control.

Some non-chemical control methods can also substitute for dicamba or enhance other control measures. Tillage can substitute for herbicide applications to remove weeds before planting except where no-till conditions are desired (Croissant et al., 2008). Using a price for diesel of $3.50 per gallon, the fuel cost for tillage ranges from $19-25/acre using the USDA energy estimator for tillage in Iowa, North Carolina, and Arkansas (USDA-NRCS, 2013a).

Table 25. Herbicides Available for Use on Fallow and for Burndown.

Herbicide (common name)	MOA[1]	Crops[2]	Rate (lb acid equivalent or active ingredient/A)	Cost $/Acre	Comments
2,4-D amine	4	C, SB, CT, SG	0.25-0.5	1.15-2.30	

Herbicide (common name)	MOA[1]	Crops[2]	Rate (lb acid equivalent or active ingredient/A)	Cost $/Acre	Comments
Atrazine	5	C	1.0	3.20	
Isoxaflutole	6	C	0.05-0.09	14.90-29.80	
Chlorimuron	14	SB	0.033	8.10	Usually in combination with metribuzin ($18/Acre)
Metribuzin	5	C, SB	0.5-0.75	5.60-8.50	Often at lower rates in combination w/ other herbicides
Dicamba	4	C, SB, CT,SG	0.25	5.25	
Mesotrione	28	C	0.18-0.24	32.00-41.00	
Glyphosate	9	C, SB, CT, SG	1.0-1.5	4.00-6.00	
Flumioxazin	14	CT, SB	0.05-0.1	9.00-18.00	
Sulfentrazone	14	SB	0.14-0.375	23.60-63.00	Obtained at lower cost in premixes
Saflufenacil	14	C, SB, SG	0.02	5.45	
Paraquat	22	C, SB, CT, SG	0.5-1.0	9.00-18.00	
Glufosinate	10	C, CT, SB	0.53-0.66	13.60-16.85	
Iodosulfuron	2	C, SB	0.0019	7.20	Fall only for soybeans, up to 30 days before corn

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

Potential Impacts of Dicamba Resistance on Fallow and Burndown Applications

Under the Preferred Alternative, development of weed resistance to dicamba would have limited impact on fallow and burndown applications because numerous herbicides are available, and mixes of glyphosate with 2,4-D or atrazine complements glyphosate effectiveness (University of Nebraska Extension, 2014). Important or resistant weeds may be controlled by various herbicides or combinations, and as the University of Nebraska Extension presents for corn, 31 combinations or single herbicides are recommended as broadleaf burndowns for corn alone; soil-active residuals (such as flumioxazin) also may be mixed into the burndown application (University of

Nebraska Extension, 2014). Soybean burndown in Nebraska has about 20 choices, of which five are glyphosate or a tank mixture with glyphosate. Certain weeds (e.g., lambsquarters) have always been tolerant of glyphosate and are more effectively controlled by other herbicides. Several herbicides priced similar to dicamba are available for general weed management. For specific weed applications, many recommended herbicides are more costly. However, when weed pressure of certain species has become high, growers will necessarily choose these to provide efficacious control. Each grower selection takes into account crop selectivity (plant back limits), problem weeds, application requirements and cost. APHIS concludes that toss of dicamba as an effective herbicide may increase management costs in some cases. Crops that may be adversely impacted include cotton, soybean, corn, and possibly wheat.

Corn

Dicamba is used on about 12% of U.S. corn and unavailability of dicamba treatment options because of dicamba resistant weeds in corn could require that growers choose other herbicides, if available. Since soybean is followed by corn 64% of the time, the possibility of dicamba-resistant weeds arising in corn may be a relevant issue. A large number of herbicide alternatives are available for weed control in corn. Iowa State (2014) for a herbicide effectiveness rating chart lists 10 PRE herbicides and 23 POST choices. For burndown options in no-till corn, Penn State Extension (2014) lists14 herbicides used alone or in combinations with other herbicides. Various *Amaranthus* species can be problem weeds because of multiple herbicide resistance, and in Iowa, PPO-, HPPD-, ALS- and glyphosate-resistant weeds are known in Iowa. (Iowa State Extension, 2014) For preplant use, if these resistant weeds are not present, seven of ten of the Iowa-listed herbicides give good to excellent control. For POST use, 17 of 23 of the herbicides have good to excellent effectiveness.

Potential Impacts of Dicamba-resistant Weeds on Corn

While the potential for dicamba-resistant weeds arising in soybean and then found in corn following typical rotations is a possible consequence of Xtend soybean production, sufficiently broad numbers of choices of alternative corn herbicides are available. Some of the *Ameranthus* with resistance to various herbicide classes may be more likely controllable with a new option for POST dicamba treatment in soybean. That dicamba may not be usable in field corn, in which at present it is only modestly deployed, may be outweighed by the benefits of having new control measures for resistant weeds in soybean.

Sorghum

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

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

Common combinations include 2,4-D with atrazine, dicamba with atrazine, and bromoxynil with atrazine (Kansas State University Cooperative Extension, 2014). In-season row cultivation has been used in the past to control weeds, but it is less commonly used today because it requires costly fuel and labor expenses (Kansas State University Cooperative Extension, 1998).

Alternative Herbicides and Management Options

Several possible alternative herbicides for weed control in sorghum and their estimated costs are summarized in Table 26. Atrazine, pendimethalin, saflufenacil and 2,4-D/atrazine mixtures are effective on a variety of broadleaf weeds and are similar in cost (Moechnig et al., 2010).

Some non-chemical control methods can also substitute for dicamba or enhance other control measures. Weeds such as common lambsquarters and common ragweed often germinate early in the spring. Tillage just before planting can eliminate these early emerging weeds. A 2009 USDA report on custom tillage rates estimated the cost of harrowing at $7.30-8.40 per acre in Kansas (USDA-NASS, 2009f). In season row cultivation provides another, non-chemical alternative and costs between $7.00 and $8.00 per acre (University of Nebraska, 2012).

Table 26. Post-emergence Broadleaf Herbicides Currently Available for Use on Sorghum.

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

*Alternative low cost herbicides to dicamba are shaded.
[§]WSSA mode of action category.
Source: (DAS, 2013b)

Potential Impacts of Dicamba-Resistant Weeds on Sorghum

If dicamba-resistant weeds were to become a problem, sorghum growers would likely have additional choices of herbicides. 2,4-D may be applied with other herbicides such as carfentrazone (a PPO inhibitor) for more rapid activity to improve control. Weeds effectively controlled with 2,4-D, include ragweed, pigweed, and lambsquarters, but atrazine- and ALS-resistant biotypes may exist for these weeds. Therefore, if dicamba-resistant weeds become a problem, weed management costs for sorghum would not likely increase, since alternatives exist, but alternatives may be somewhat limited.

Rice

Rotating rice with corn or soybean is limited to the Mississippi River Valley and Texas (Louisiana State University Research and Extension, 2013; University of Arkansas, 2013). In 2008, rice followed soybean in 1.4% of overall planted soybean acreage (Table 19). As indicated in Table 21, for Region F, rice production rises to 11% of acres of the region. Although rice is not a registered usage of dicamba, another auxinic herbicide, 2,4-D, was used on 13% of planted fields (USDA-NASS, 2014c). However, there is no information about cross-resistance of weeds to dicamba in rice; therefore, this is not further discuss this within Cumulative Impacts.

Non-Extend Cotton

Cotton is rotated with other crops less than one-half the time (Table 20). In Texas and the High Plains, for example, few other crops are productive in the conditions of low rainfall and high heat favorable for cotton cultivation. In drought years, dryland cotton may be abandoned on a large percentage of these acres (Smith, 2013). Mostly in the mid-South, rotations are more common. There, cotton may be rotated with soybeans or corn (University of Georgia CAES Extension, 2014). Most dicamba applications are made prior to planting, with some made in the late fall (Monsanto, 2014a). If growers were to plant non-Xtend cotton and use dicamba as an herbicide after producing an Xtend cotton crop in the previous season, they would not be making an appropriate choice, since rotation of herbicides is an important principle of weed management.

Weed Management Programs and Options

Cotton is an annual crop that is usually planted in wide rows (38-40 inches apart). Use of no-till is common in cotton and herbicides are an important means of weed control. Currently, most cotton varieties in the U.S. are glyphosate-resistant, so glyphosate is the primary herbicide used. A common cotton production practice is application of a pre-plant or pre-emergence, soil-residual herbicide followed by 1-2 post-emergence treatments usually with glyphosate. The soil-residual herbicides include a range of modes of action. Although a large portion of cotton acreage was once treated only with post-emergence applications of glyphosate or with a glyphosate burndown (Givens et al., 2009), this practice is declining because GR weeds are now widely prevalent in cotton fields. Glufosinate-resistant cotton varieties are increasingly being used (e.g., in a five state region of the mid-South, these crops accounted for 33% of all professionally surveyed cotton acres), so post-emergent glufosinate applications are replacing glyphosate for some growers (Riar et al., 2013).

Recent recommendations for cotton production in those areas experiencing GR weeds in glyphosate-resistant crops would include a burndown with multiple herbicides, a pre-emergent treatment with residual herbicides, post-emergent herbicide treatments of glyphosate and a residual broadleaf herbicide or graminicide, and perhaps layby application to keep weeds controlled until canopy closure (Clemson-University-Extension, 2012; Bond et al., 2014).

Because cotton is naturally sensitive to dicamba, 2,4-D and other auxinic herbicides, the current use of dicamba for this crop is limited to pre-plant burndown or fall application. 2,4-D is sometimes added to burndown applications to improve control of winter annuals, perennials, and early emerging summer annual weeds and was used on about 7% of cotton acres in a 2010 survey (USDA-NASS, 2014c) and dicamba at 8% during that same season. Estimates for 2011 suggest that on cotton, 2,4-D was used on 17% of acres and dicamba on 10% (Monsanto, 2013a). Burndown occurs 0-30 days prior to planting depending on crop, geography, and product used. Burndown herbicide applications are almost obligatory for no-till crop production systems (Hartzler, 2013). Dicamba and 2,4-D are typically used in combination with other broad-spectrum herbicides, such as glyphosate, glufosinate or paraquat. Herbicides with utility in burndown and significant foliar activity on broadleaf weeds are listed in Table 25. These herbicides are alternatives to dicamba.

Some non-chemical control methods can also substitute for dicamba or enhance other control measures. Tillage can be a substitute for herbicide applications to remove weeds before planting except where no-till conditions are desired. USDA reports on custom tillage rates estimated the cost of most pre-plant tillage at $13-15 per acre (University of Nebraska, 2012).

Potential Impacts to Cotton Growers from Dicamba-Resistant Weeds

According to Bayer Crop Sciences proprietary grower surveys, dicamba use in cotton is limited to pre-plant burndown since cotton is sensitive to the herbicide. However, because of the widespread adoption of no-till in cotton production combined with the prevalence of GR weeds in cotton fields, dicamba is one of several herbicides for burndown applications in cotton and these could include 2,4-D, paraquat, and flumioxazin. Consequently, if dicamba-resistant weeds become more prevalent in non-Xtend cotton, PRE weed management costs will likely be similar or possibly slightly increased for some cotton producers. As noted earlier, a variety of post-emergent or lay-by herbicides can be used for cotton weed control, and dicamba is not used for such post emergent uses. Under the Preferred Alternative, the nonregulated status of Xtend cotton and soybean would have inconsequential effects on non-Xtend cotton production if dicamba resistant weeds were to increase.

Sugarcane

While a large proportion of sugarcane is treated annually with dicamba, the crop may be harvested in three seasons including the one following planting, and then receive a fallow year, so in the four year cycle, rotated crops are not an issue in typical sugarcane production (LSU-Extension, 2014).

Weed Management Choices and Development of Resistant Weeds

Xtend cotton and soybean are expected to be attractive to those cotton and soybean growers who have or will have difficulty with weed control caused by GR weeds. In the event that Xtend cotton and soybean become widely used, and dicamba-resistant weeds become more widespread, there are three types of growers that are most likely to be impacted.

1. The first type is the soybean and cotton growers who almost exclusively have adopted GR crops and are already confronted with weed control problems related to GR weeds.

Until now, these growers have relied more on glyphosate than dicamba, but can be assumed will adopt Xtend crops and develop a reliance on dicamba as a solution to the GR weed problem. The ease and effectiveness of dicamba use is expected to delay the need to adopt a more diversified weed management program for these growers. Once dicamba-resistant weeds became prevalent, these growers would have to become less reliant on dicamba and diversify their management programs in ways that would be similar to that described in the No Action Alternative.

2. The second type of growers is those that have responded to the advice of state extension experts (e.g., following seminars given to growers: e.g., B. Young, Purdue University, 2014 Commodity Classic (Young, 2014), of state agronomy publications (Iowa State Extension, 2014)), national grower associations such as American Soybean Association (ASA, 2011), and representatives of the seed technology companies. These specialists continue to alert growers to the needs for a new paradigm of weed control that will require integrated weed resistance management and understanding of the target weeds' sensitivity to herbicide sites of action).

   Overreliance on a single herbicide, whether glyphosate or dicamba, for weed control, is no longer a realistic option. These sources of advice often provide dramatic evidence that failure to consider and vigorously respond to the existence of resistant weed populations will result in a loss of yield and sometimes loss of an entire crop. Consequently, these growers will use several Best Practices to both avoid weed resistance and control resistant weeds already present or that are believed to be present. The potential for enhanced weed control offered by this and other new crop resistances to herbicides will be fully embraced, and these growers will be actively delaying the onset of weed resistance within their own fields. Because these growers will be following Best Practices recommendations, the response to weed control will be more integrated, with greater precautions taken to avert new weed resistance. These growers will be likely to deter new weed development using these Xtend crops, and use other HR crops such as 2,4-D-resistant crops or MGI-resistant (mesotrione, glufosinate, isoxaflutole) soybean. Because new herbicide Best Management practices along with true integrated weed management will exemplify these growers' programs, these growers will likely find that availability of Xtend soybean and cotton will provide weed management benefits for multiple years.

3. The third type of growers is those who already rely on dicamba for weed control in non-GR crops; growers of sorghum, corn or certain small grains are examples. These growers are more reliant on dicamba than glyphosate for weed control and may not currently be faced with the same degree of weed control problems as the first group. The development of dicamba-resistant weeds resulting from reliance on either dicamba alone or Xtend herbicides by Xtend crop adopters may render dicamba less effective to those who were already using it on these other crops. This could necessitate adopting more costly and less environmentally beneficial weed management practices than are currently in use.

4. No cumulative impacts are expected on organic growers because these growers do not use herbicides, such as dicamba, for weed control, and the practices they employ (including tillage, cultivation, hand-weeding, cover crops) would be as effective on resistant as non-resistant weeds. The potential for undesired volatilization or drift of

applied dicamba onto organic crops is as of high possibility, but no less than those onto conventional soybean or cotton. APHIS concludes that because EPA will mandate use of the low-volatility formulations of dicamba, and that organic crops likewise are not at any higher risk than conventional crops, impacts on organic crops may occur, but at reduced incidence because the formulation of dicamba being delivered onto the Xtend crop is less volatile than dicamba being used on other crops; the low volatility formulation may also be more frequently used in place of higher volatility and older dicamba formulations.

5.7.5 Health and Safety Aspects for Livestock and Humans

No cumulative impacts were identified on human health or livestock for any of the Alternatives. EPA considers the direct and indirect impacts from herbicide use on human health and non-target organisms as part of their regulatory decision. hose impacts are outside the scope of this DEIS.

5.8 Biological Resources

5.8.1 Animal Communities

As described in the No Action Alternative, agricultural practices can affect wildlife in and around agricultural fields. Wildlife commonly found in each region is described in the Affected Environment, Chapter 3. As discussed in Chapter 4, MON 88701 cotton and MON 87708 soybean are not expected to directly or indirectly impact wildlife differently from the cotton and soybean varieties that are currently available under the No Action Alternative. While direct impacts from the changes in herbicide use associated with Xtend could potentially affect certain wildlife, those impacts are outside the scope of this DEIS.

The EPA considers impacts on wildlife as part of its evaluation of the new label. Dicamba has an extensive history of safe use. It has been thoroughly reviewed and reregistered by all major regulatory agencies in the world within the last ten years. The EPA affirmed that dicamba posed no unreasonable adverse effects on the environment when used as directed. Therefore, cumulative impacts on animal resources are not expected to differ from the No Action and Action Alternatives. Impacts of herbicides on nontarget organisms are assessed by the EPA.

5.8.2 Plant Communities

Summary: In some areas of the Midwest states, multiply-resistant waterhemp, is susceptible to only some PPO inhibitors, to PSII inhibitors and to dicamba. Similarly, in some Southern states, pigweeds in soybean are only susceptible to PPO inhibitors and to dicamba. When dicamba can be coordinately applied with one of the few herbicides to which these weeds are susceptible, it reduces the chance that resistance to these herbicides will develop, since the use of overlapping sites of action is an important strategy advanced by weed scientists for suppressing weed resistance. AHPIS concurs that dicamba use in Xtend crops can potentially extend the longevity of unique herbicides that are needed for the control of specific highly resistant weeds.

A significant issue for the potential of weeds to develop resistance is whether growers will select appropriate strategies for management options that avert future weed resistance. Best management practices will include employing a diversity of herbicides, rotation of herbicide *choices, crop rotation, and others that will be mandated by new EPA labelling to deter weed resistance development. State extension agents, seed providers, herbicide suppliers and other professionals, will also provide advice to growers, who are becoming more likely to perceive the needs for sustainable weed management and execute needed practices. APHIS concludes that overall success in averting weed resistance will depend on these management choices that are appropriately made by individual growers.*

Clearly the grower's responses to recommended practices prescribed by extension personnel and weed scientists will determine the potential impacts and benefits for Xtend adoption. Reduced usefulness of Xtend herbicides compared to potential benefits may also be a consequence. Because growers have become more receptive to understanding causes of developing herbicide resistance herbicide they have also become more responsive to these issues. Under the Preferred Alternative, as under the No Action Alternative, APHIS concludes that more growers are likely to take actions that reduce the chances for weed resistance, especially as more recent studies have shown that there is only modest additional short-term cost for applying these actions, with no change in profitability. Large long-term costs for not applying these actions are also a likely consequence, which weed experts will continue to emphasize to growers.

Monsanto estimates of herbicide use under the likeliest scenario are listed in Table 4-9 of Appendix 4 for soybean at 40% and 100% adoption, and 4-12 for cotton at 50% adoption. An increase in herbicide use is expected under all four Alternatives. Dicamba use on crops may increase from 3.8 million pounds in 2011 under the No Action Alternative to 29.5 million pounds at full adoption (Table 8-1 in Appendix 8 and Appendix 4) (Monsanto, 2013a). Under Alternative 2, the increase may reach 25.7 million pounds at the height of adoption, assumed to be 50% of cotton acres and 35% of soybean acres, but these rates are difficult to predict.

With EPA approval of the new uses of dicamba, the increased use of dicamba under both the No Action (see Appendix A in the Monsanto ER (Monsanto, 2013a)) and Action Alternatives may be expected to result in increased selection pressure for dicamba-resistant weeds. However, selection pressure is influenced by factors other than the volume of herbicide applied. The selection pressure is strongly related to the repeated use of one or a limited number of herbicides (Durgan and Gunsolus, 2003; Duke, 2005). It is also a function of the diversity of management practices employed. The greater the diversity of management practices, the smaller the selection pressure for resistant weeds.

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

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

Overall APHIS Responsibility and Weed Management

When assessing issues of weed resistance to herbicides, especially those of existing resistances but also that which may develop to dicamba from commercialization of Xtend products, there are at least two perspectives that these assessments must take into account. The first is that growers are presently in need of short-term solutions for GR weeds, which are certainly extensive and probably increasing. The second is that growers need to embrace the complexity of weed control with not just herbicides and HR crops, but with all the possible cultural, mechanical, chemical and preventative methods. The first perspective is intimately tied to short-term approaches to resistant weed control and weed control in general, but the second is one that is longer term, requiring more experimental effort, and experience with control of problem weeds. This EIS deals necessarily with the first perspective, since that can be addressed with herbicide technology provided by seed companies and pesticide providers, including making Xtend crops commercially available. Unquestionably, there is a grower- and professionally-expressed need for additional herbicide technologies for responding to widespread issues of herbicide resistance.

From the second perspective, weed control should optimally be done using integrated weed management practices, without over-reliance on herbicides. Many growers are already using multiple technologies, but as more challenging problem weeds arise (with resistance to both herbicides and other techniques) there is need to further develop these practices. Parts of USDA deal with developing production methods, such as the NRCS does with improving tillage practices, and with planting cover crops that may outcompete weeds. Other parts of USDA, such as ARS, take into account the physiology of crops, weeds, and interactions between them and are providing basic research useful to knowing the biology and ecology of agricultural weeds in farm ecosystems.

USDA-APHIS has responsibility for assuring that new GE crops are not plant pests, which is a limited category of agricultural concern. Necessarily, APHIS must focus primarily on that issue, while perhaps making brief assessments of possible impacts on the agroecosystem of first, the plant, and then secondarily of herbicides used on the crop. However, by the Coordinated Framework agreement and by U.S. statutes, this area of herbicide use, environmental impacts and stewardship belongs clearly to EPA.

The EPA has noted the increasing problems and also the economic issues growers are facing from the emergence of herbicide resistant weeds. Because of the concern about the possibility that using Enlist Duo (a premix of 2,4-D and glyphosate) could result in the spread of weeds resistant to 2,4-D, EPA is proposing to impose requirements on the manufacturer to ensure that DAS successfully manages weed resistance problems. These proposed requirements include robust monitoring and reporting to the EPA, grower education and remediation, and would allow the EPA to take swift action to impose additional restrictions on the manufacturer and the use of the pesticide if resistance develops (US-EPA, 2014b). It would allow the EPA to modify the registration quickly and easily to impose additional measures to manage resistance if needed.

The label would also contain information on resistance management consistent with the Weed Science Society of America's BMPs for comprehensive resistance management approaches (US-EPA, 2014b). The details of the EPA's new proposed requirements related to weed resistance management for registration of Enlist Duo are provided in Appendix 10 of the DEIS. It is probably that the EPA will include similar requirements when considering the approval of dicamba for use on Xtend cotton and soybean.

A large complex of state extension agents, herbicide producer representatives, seed company staff, are all involved in bringing science and technology to farms, showing growers how to efficiently deal with weeds, and weed resistance issues, and these certainly include appeals to consider all the possible non-chemical means of improving weed control. The advice of state extension experts, as well as input from USDA studies, will continue to provide growers with expert support as they design ever more complex management systems to preserve profitability and sustainability of their production systems. Financial reward for growers will ultimately be the mechanism by which increased integrated weed management is practically advanced in U.S. farming.

Herbicide-Resistant Weeds

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

As of April 12, 2014, worldwide, there were 429 instances of HR weeds in 234 species (Heap, 2014c). The first HR biotypes were described in the 1950s. The number of weeds resistant to herbicides increased dramatically in the 1980s and 1990s. Today, resistance to 22 of the 25 known herbicide sites of action has been identified (Heap, 2014d). Of the 25 known herbicide sites of action, 11 are commonly used on cotton and soybean (Appendix 4). Furthermore, while there are hundreds of cases of HR weeds, most of these weeds are not actively managed or directly targeted in cotton and soybean. The analysis below focuses on weeds that are actively managed in cotton and soybean fields and addresses which of these have developed herbicide resistance to the major herbicides used in cotton and soybean.

There are 69 broadleaf and 11 grass weed species that require control measures in the major growing regions of soybean and cotton (Appendix 5). There are 25 broadleaf and six grass weeds, respectively, that are a problem in both cotton and soybean, 23 broadleaf and three grass weeds that are mostly problematic in cotton (Table 5-1 in Appendix 5), and 21 broadleaf and two grass weeds that are mostly problematic in soybean (Table 5-1 in Appendix 5).

The most common types of weed resistance in the U.S. are to ALS and PSII herbicides. There are 15 problem weed biotypes resistant to each mode of action. The problem weed resistant to the most sites of action is waterhemp (Table 27). Multiple resistance involving biotypes with 13 combinations of sites of action have been reported, including one biotype that is resistant to five sites of action (Owen, 2012). Common ragweed, and pigweed, waterhemp, and kochia are each reported to have biotypes resistant to four or more sites of action including biotypes that are multiply resistant to two herbicides (Table 27, Table 28). Multiple HR biotypes have also been selected in redroot pigweed and giant ragweed. None of the problem grasses have multiple resistances.

To respond to this trend and to avoid decreased crop yields resulting from weed competition, growers must continually adapt previous weed management strategies. Appropriate weed management requires much more than the application of herbicides. Rotation of herbicides with alternative sites of action is one method (Norsworthy et al., 2012). Alternative sites of action refer to using herbicides that have different physiological modes of action. Some common sites of herbicide action include auxin growth regulators, amino acid inhibitors, chlorophyll pigment inhibitors, and lipid biosynthesis inhibitors (Ross and Childs, 2011) (Appendix 3).

Dicamba Resistance Trait Sustaining Other Effective Herbicides

Use of overlapping sites of action, in which problem weeds are targeted with more than one effective herbicide is a key weed management strategy (Herbicide-Resistance-Action-Committee, 2014). The practice of using herbicides with overlapping and alternative sites of action could potentially diminish the populations of GR weeds and reduce the likelihood of the development of new HR weed populations (Dill et al., 2008; Duke and Powles, 2008; Owen, 2008; Duke and Powles, 2009; DAS, 2010; Norsworthy et al., 2012).

In the Midwest, waterhemp has susceptibility at present only to N-phenylthalamides of the PPO group (saflufenacil, flumioxin, sulfentrazone used on soybean) (Legleiter and Johnson, 2013) and to PS II groups (metribuzin) along with dicamba (Table 28). In southern states, the pigweed species (see Table 27) have resistance to all herbicide groups commonly used on soybean except for PPOs and dicamba. Because weed scientists are recommending that such problem and resistant weeds need to be treated with overlapping effective herbicides (Herbicide-Resistance-Action-Committee, 2014), the enabling technology of dicamba resistant soybean (and cotton) with use of PPO herbicides applied concurrently would often be the only effective herbicide strategy that would be successful. Further, prevention of resistance to both would more likely be achieved if both were simultaneously applied, rather than singly in alternate seasons. Thus, the availability of Xtend crops used with suitable choices of herbicides could promote sustainable use of herbicides, such as PPOs in the case of these two major resistant weeds.

Table 27. Known Weed Resistance in the Southern United States.[1]

Most Common Broadleaf Weeds (# states where listed as a top weed)	Resistance Group [2]	ALS (Group 2)			PPO (Group 14)		PS II (Group 5)	Glycine (Group 9)		Phenoxy (Group 4)
	Chemistry Class [2]	Sulfonylurea	Imidazolinones	Triazoles	Diphenyl ether	N-phenyl thalimide	Triazinones	-	Phenoxy	Benzoic acid
	Example	chlorimuron	imazethapyr	chloransulam	lactofen fomesafen	flumioxazin	metribuzin	glyphosate	2,4 D	dicamba
Pigweed spp. [3] (12)		X	X	X	X		X			
Velvetleaf (11)										
Lambsquarters (10)		X	X				X			
Cocklebur (9)		X	X	X						
Common ragweed (7)		X	X	X	X	X		X		
Smartweed spp. (6)										
Morning glory (5)										
Waterhemp (5)		X	X	X	X			X	X	
Horseweed (marestail) (3)		X		X				X		
Giant ragweed (3)		X	X	X				X		
Kochia (2)		X	X					X		X

[1] Source: (Heap, 2014c)

[2] Cross resistance is possible within a resistance group and/or chemistry class

[3] Includes redroot pigweed and smooth pigweed

Table 28. Known Weed Resistance in the Midwestern United States.

Most Common Broadleaf Weeds (# states where listed as a top weed)	Resistance Group [1]	ALS (Group 2)			PPO (Group 14)		PS II (Group 5)	Glycine (Group 9)		Phenoxy (Group 4)
	Chemistry Class [1]	Sulfonurea	Imidazolinones	Triazoles	Diphenyl ether	N-phenyl thalimid	Triazinones	-	Phenoxy	Benzoic acid
	Example	chlorimuron	imazethapyr	chloransulam	lactofen fomesafen	flumioxazin	metribuzin	glyphosate	2,4 D	dicamba
Pigweed spp. [2] (12)		X	X	X	X		X			
Velvetleaf (11)										
Lambsquarters (10)		X	X				X			
Cocklebur (9)		X	X	X						
Common ragweed (7)		X	X	X	X	X		X		
Smartweed spp. (6)										
Morning glory (5)										
Waterhemp (5)		X	X	X	X			X	X	
Horesweed (marestail) (3)		X		X				X		
Giant ragweed (3)		X	X	X				X		
Kochia (2)		X	X					X		X

Source: www.weedscience.org

1 Cross resistance is possible within a resistance group and/or chemistry class

2 Includes redroot pigweed and smooth pigweed

Managing Glyphosate-Resistant Weeds

APHIS, recognizing that the increasing development of glyphosate-resistant weeds has been the reason why the MON 88701 cotton and MON 87708 soybean have been developed, has considered whether the current impacts of the management practices for resistant weeds may also potentially contribute to the cumulative impacts of Xtend crops. In 2012, the area of U.S. cropland infested with GR weeds expanded to 61 million acres, according to a survey conducted by Stratus Agri-Marketing (Farm Industry News, 2013). Table 27 and Table 28 lists horse weed species that have been identified as HR in at least some part of their range in the U.S. The use of glyphosate on cotton and soybean is not expected to increase under any of the Alternatives because most cotton and soybean in the U.S. already has the GR trait and so glyphosate use is saturated on these crops. Between 2011 and 2013, HR soybean was planted on 93-94% of total soybean acres and HR cotton planted on 73%-82% of total cotton acres (USDA-NASS, 2012c; 2013c). The increase of GR weeds only makes glyphosate use less attractive, although as noted, glyphosate still controls large numbers of weeds (Monsanto, 2013a). From 2008 to 2011, acres to which glyphosate was applied were either stable or declined, but other herbicides (residuals applied to soil that persist for extended periods) applied increased by 177% (Monsanto, 2013a). To manage glyphosate resistance, growers are not using more glyphosate, but are using more sites of action in addition to glyphosate.

Mid-South and possibly the Southeastern state soybean growers who previously adopted no-till production are now replacing that with increasingly aggressive tillage in their management programs (see Cumulative Impacts: Cotton and Soybean Agronomic Practices and Costs of Production. Changes in Tillage). In parts of the Heartland, GR waterhemp and marestail are widespread (Bowman, 2013). No-till practices are being maintained in many areas, but the presence of HR weeds and rapidly increasing presence of GR weeds in particular, sometimes necessitate the inclusion of tillage in weed control strategies (Arbuckle and Lasley, 2013). An Iowa poll disclosed that farmers there used mechanical weed control (i.e., cultivation) 25% of the time, and 55% found it to be effective or very effective for weed control (Arbuckle and Lasley, 2013). Farmers apparently value soil cultivation for weed control, but practice it only to a limited extent (25%) at present.

Under the No Action Alternative, GR weeds are likely to be an increasingly serious concern in the Mid-South, and Southeast (Prince et al., 2012a) and Great Plains regions (Spaunhorst et al., 2014). Multiply-resistant weeds have also begun to be discovered, and in Iowa, 88% of 2011 waterhemp populations may be multiply resistant; imidazolinone herbicide weed resistance was the highest, with up to 92% of waterhemp in soybean having cross resistance, even though pressure on weeds with this herbicide was not maintained in recent years (Owen, 2014b). The availability of Xtend crops under the Preferred Alternative (along with the EPA decision to register Xtend herbicides) would increase the herbicide weed control chemicals available for post emergent weed control, allowing more selective control of weeds whose resistances were known.

Under the No Action Alternative, growers would likely use increased conventional tillage or additional herbicides to control weeds. The further adoption of conservation tillage practices could be impeded as growers who have already adopted conservation tillage are forced to return to more aggressive tillage systems to maintain soybean yields (Conley, 2013). This practice is likely in a limited number of locations where alternative herbicides are not effective.

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

<u>Potential for Weed Resistance to M1691 or Other Dicamba Herbicides</u>

Summary: Weed resistance is not a consequence of the use of herbicide resistant crops. APHIS under the Preferred Alternative concludes that the extent and types of resistant weeds depend on how growers either employ the techniques of weed management or ignore them. Some growers may choose to rely exclusively on Xtend crops and dicamba, and not diversify their weed control practices, leading to unsustainable dicamba use. Others are expected to rotate this chemistry by using other herbicides and rotation crops, and deter development of new herbicide resistant weeds.

If the modes of action of two herbicides are overlapping for targeting one weed species, weed scientists expect that weed resistance will be importantly delayed. Dicamba used post-emergent will add to the overlapping weed target potential of other herbicides. However, for areas where glyphosate resistance is already prevalent, the use of Xtend crops, with the potential for using only glyphosate and dicamba, is not expected to be effective in delaying herbicide resistance. If growers do not accept that the use of Xtend crops in areas with such glyphosate resistant weeds is inadvisable, APHIS concludes that weed resistance to dicamba, if it develops, may be hastened.

Under the Preferred Alternative, APHIS notes that EPA will have new regulatory mechanisms in place to oversee HR crops and to deter resistant weed development. The EPA will likely require Monsanto to provide information for averting weed resistance on dicamba labels for use on Xtend dicamba-resistant crops, as it has recently done for Dow Agrosciences' Enlist Duo (glyphosate and 2,4-D premix) to be used on 2,4-D-resistant soybean and corn. The EPA is also expected to require crop oversight by manufacturers for reporting and responding to new incidences of weed resistance. Monsanto will be required to take action to deal with such weed resistance in Xtend crops, following the pattern being established by the EPA for Dow Agrosciences for the continuing oversight of 2,4-D and Enlist crops.

The relative risk that a resistant weed biotype will be selected following herbicide exposure is highly correlated to the herbicide mechanism of action (Sammons et al., 2007). Herbicide families have been classified according to their risk of resistant weed development. Beckie (2006) lists ALS- and ACCase-inhibiting herbicides as high risk for selection of resistant biotypes, while glyphosate and auxin type herbicides are considered low risk. Weeds resistant to auxin herbicides have been slowly accumulating over the past seventy years, but none have become particularly problematic. As of 2013, there are 31 species listed that include biotypes that are resistant to auxin herbicides, eight of which are located in the United States (Table 28, prepared from data in (Heap, 2014b)). Of the 31 species found world-wide, seven are resistant to dicamba. Of these, two are found within the United States (Table 28, highlighted in gray) and five are found outside the United States (yellow starthistle, lambsquarters, common hempnettle, wild mustard, indian hedge mustard, kochia, and prickly lettuce). Of these, GR biotypes are found only for kochia and lambsquarters. Thus, the combination of glyphosate and dicamba currently controls a wide range of problem weeds.

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

Though auxin HR weeds (e.g., 2,4-D and dicamba) have been relatively slow to develop and are not particularly widespread, some will note that the same was true for GR weeds prior to the widespread use of glyphosate on GR crops. The selection of GR weeds purportedly came about through the almost exclusive use of glyphosate for weed control in some crops such as cotton, corn and soybean. Thus, depending on how glyphosate and dicamba are used on Xtend cotton and soybean crops, selection of dicamba resistant weeds may be preventable. If growers rely exclusively on dicamba and glyphosate for weed control, resistance might be selected quickly.

The likelihood of selection of dicamba-resistant weeds is greater as the selection pressure for resistance increases. When considering cumulative impacts under the Preferred Alternative, selection pressure is expected to be greater than under the No Action Alternative because dicamba use is expected to be considerably higher (Appendix 4, Table 4-9 and 4-12) if the EPA registers the new use of dicamba Xtend (M1691) on MON 88701 cotton and MON 87708 soybean. To mitigate the increased selection pressure associated with the increased use of dicamba, Monsanto recommends[14] the following practices for weed management and for herbicide selection:

- Actively growing weeds in fields compete with the crop, so should be eliminated prior to planting.
- Maintain good weed control until crop canopy can be an indicator of good weed control throughout the remainder of the season.
- Include two or more crops in a crop rotation and ideally rotate to a different crop each year.

[14] Website, April 15, 2014: http://www.monsanto.com/weedmanagement/pages/field-management-guidelines.aspx

- Use a broad spectrum soil active residual herbicide in the corn season of a crop rotation and in soybeans when hard-to-control weeds are present.
- The addition of a non-glyphosate herbicide reduces the sole use of glyphosate which can decrease the risk of developing of weed resistance.
- Use the full, labeled rate of glyphosate based on the most difficult-to-control weed in the field.
- Control weeds before they reach four inches tall (in soybeans before eight inches tall).
- Reduce weed populations from year to year, allowing for more efficient use of herbicides and other cultural practices to control weeds.
- Tillage should be considered as an alternate weed control practice where appropriate.

The selection and distribution of dicamba-resistant weeds is impossible to predict because the extent to which growers will use best practices with these HR crops is uncertain. A 2010 grower survey (Prince et al., 2012b) observed that many growers were using practices targeted specifically at preventing or managing GR weeds, but that these practices were not new introductions to their weed management plans. Growers recognized that rotating herbicides, using tank mixes, and increasing tillage would be effective strategies to manage GR weeds but did not seem to recognize that HR weeds were the result of repeated use of a herbicide or herbicides with the same site of action (Prince et al., 2012b). Education efforts to increase grower awareness are ongoing and there appears to be an increase in grower perception of the effectiveness of practices recommended by the weed science community (Prince et al., 2012b).

Modeling studies suggest that exclusive use of an herbicide can select for HR weeds in as little as five years (Neve et al., 2011). Because growers who adopt Xtend crops are expected to be those who have had the most difficulty with GR weeds, the selection of biotypes exhibiting multiple resistance to both glyphosate and dicamba is expected to be related to the probability of selecting resistance to just dicamba and not the product of selecting resistance to both sites of action. Thus, multiple resistance could be expected to appear in as little as five years if glyphosate and dicamba are used exclusively. The southernmost part of the Southeast (Region D) is expected to be a problem region because GR weeds are already reported to be present in greater than 90% of cropland (Farm Industry News, 2013). In this region, Palmer amaranth can no longer be controlled with glyphosate and would be a particular risk for the selection of multiple resistant biotypes. In the Heartland (Regions C and G) and prairie states (Region I), HR waterhemp has been selected to several herbicides and a biotype resistant to four herbicides has been detected (Bell et al., 2013). Furthermore, biotypes with resistance to either dicamba or glyphosate have already appeared in Nebraska (Table 29). A multiply-resistant biotype could form by hybridization and dissemination. APHIS concludes that if Xtend products are exclusively used by growers for weed management, without appropriate use and coordination with use of other herbicide sites of action, independently arising weed biotypes that are multiply resistant to dicamba and other herbicides are likely to be selected.

Table 29. Auxin-Resistant Weeds.

	Species	**Year/Location**	**Auxin**	**Situation**	**GR/GT**
1	***Amaranthus tuberculatus Ameranthsyn. rudis)***	2009 - USA (Nebraska)	2,4-D	Pasture	+

	Species	Year/Location	Auxin	Situation	GR/GT
	Common Waterhemp				
2	***Carduus nutans***	1981 - New Zealand	2,4-D	Pasture	
	Musk Thistle				
3	***Carduus pycnocephalus***	1997 - New Zealand	2,4-D, MCPA, MCPB	Pasture	
	Italian Thistle				
4	***Centaurea cyanus***	2012 – Poland	Dicamba	Winter wheat	
5	***Centaurea solstitialis***	1988 - USA (Washington)	Picloram	Roadsides	
	Yellow Starthistle				
5	***Chenopodium album***	2005 - New Zealand	Dicamba	Corn	
	Lambsquarters				
6	***Cirsium arvense***	1979 - Sweden	MCPA	Cropland	
	Canada thistle	1985 - Hungary	2,4-D and MCPA	Pasture	
8	***Commelina diffusa***	1957 - USA (Hawaii)	2,4-D	Sugarcane	
	Spreading Dayflower				
9	***Daucus carota***	1957 - Canada (Ontario)	2,4-D	Roadsides	
	Wild Carrot	1993 - USA (Michigan)	2,4-D	roadsides and cropland	
		1994 - USA (Ohio)	2,4-D	soybean	
10	***Descurainia sophia***	2011 - China	MCPA	winter wheat	
	Flixweed				
11	***Digitaria ischaemum***	2002 - USA (California)	quinclorac	rice	
	Smooth Crabgrass				
12	***Echinochloa colona***	2000 - Colombia	quinclorac	rice	+
	Junglerice				
13	***Echinochloa crus-galli var crus-galli***	1998 - USA (Louisiana)	quinclorac	rice	
	Barnyardgrass	1999 - Brazil	quinclorac	rice	
		1999 - USA (Arkansas) *Multiple - 2 MOA's	propanil and quinclorac	rice	
		2000 - China	quinclorac	rice	
		2009 - Brazil *Multiple - 2 MOA's	bispyribac-sodium, imazethapyr, penoxsulam, and quinclorac	rice	
		2013 - Uruguay	quinclorac	rice	
14	***Echinochloa crus-galli var. zelayensis***	2013 - China	quinclorac	rice	
15	***Echinochloa crus-pavonis***	1999 - Brazil	quinclorac	rice	
	Gulf Cockspur				
16	***Fimbristylis miliacea***	1989 - Malaysia	2,4-D	rice	
	Globe Fringerush				
17	***Galeopsis tetrahit***	1998 - Canada (Alberta)	dicamba, fluroxypyr, and MCPA	barley, cereals,	

	Species	Year/Location	Auxin	Situation	GR/GT
				cropland, wheat	
	Common Hempnettle				
18	***Galium spurium***	1996 - Canada (Alberta) *Multiple - 2 MOA's	imazethapyr, metsulfuron-methyl, quinclorac, sulfometuron-methyl, thifensulfuron-methyl, triasulfuron, and tribenuron-methyl	cereals and wheat	
	False Cleavers				
19	***Kochia scoparia***	1995 - USA (Montana)	dicamba and fluroxypyr	cropland and wheat	+
	Kochia	1995 - USA (ND)	dicamba	wheat	
		1997 - USA (Idaho)	dicamba	roadsides	
		1999- USA (Colorado)	dicamba	corn	
		2010 - USA (Nebraska)	dicamba	corn	
20	***Lactuca serriola***	2007 - USA (Washington)	2,4-D, dicamba, MCPA	cereals	
	Prickly Lettuce				
21	***Limnocharis flava***	1995 - Indonesia	2,4-D	rice	
	Yellow bur-head	1998 - Malaysia *Multiple - 2 MOA's	2,4-D and bensulfuron-methyl	rice	
22	***Limnophila erecta***	2002 - Malaysia *Multiple - 2 MOA's	2,4-D, cinosulfuron, mesosulfuron-methyl, and pyrazosulfuron-ethyl	rice	
	Marshweed				
23	***Papaver rhoeas***	1993 - Spain *Multiple - 2 MOA's	2,4-D and tribenuron-methyl	cereals and wheat	
	Corn Poppy	1998 - Italy *Multiple - 2 MOA's	2,4-D, iodosulfuron-methyl-sodium, and tribenuron-methyl	wheat	
		1998 - Italy	2,4-D	wheat	
24	***Ranunculus acris***	1988 - New Zealand	MCPA	Pastures	
	Tall Buttercup				
25	***Raphanus raphanistrum***	1999 - Australia (Western Australia)	2,4-D	cereals	+
	Wild Radish	2006 - Australia (South Australia) *Multiple - 3 MOA's	2,4-D, diflufenican, MCPA, and triasulfuron	cereals	
		2009 - Australia (Victoria) *Multiple - 2 MOA's	2,4-D, chlorsulfuron, and metosulam	barley and wheat	
		2010 - Australia (Western Australia)	2,4-D, chlorsulfuron, diflufenican,	Fallow	

	Species	Year/Location	Auxin	Situation	GR/GT
		*Multiple - 4 MOA's	glyphosate, imazethapyr, MCPA, metosulam, and sulfometuron-methyl		
		2011 - Australia (Victoria)	2,4-D	Barley and Wheat	
		2013 - Australia (New South Wales)	2,4-D	Barley, Oats, and Wheat	
26	***Sinapis arvensis***	1990 - Canada (Manitoba)	2,4-D, dicamba, dichlorprop, MCPA, mecoprop, and picloram	barley, cropland, and wheat	
	Wild Mustard	2008 - Turkey *Multiple - 2 MOA's	dicamba, propoxycarbazone-sodium, thifensulfuron-methyl, triasulfuron, and tribenuron-methyl	not specified	
27	***Sisymbrium orientale***	2005 - Australia (South Australia) *Multiple - 2 MOA's	2,4-D, imazethapyr, MCPA, metosulam, and metsulfuron-methyl	cereals	
	Indian Hedge Mustard		dicamba, propoxycarbazone-sodium, thifensulfuron-methyl, triasulfuron, and tribenuron-methyl		
28	***Soliva sessilis***	1999 - New Zealand	clopyralid, picloram, and triclopyr	Golf courses	
	Carpet Burweed				
29	***Sphenoclea zeylanica***	1983 - Philippines	2,4-D	rice	
	Gooseweed	1995 - Malaysia	2,4-D	rice	
		2000 - Thailand	2,4-D	rice	
30	***Stellaria media***	1985 - United Kingdom	mecoprop	cereals and wheat	
	Common Chickweed	2010 - China	fluroxypyr and MCPA	winter wheat	
31	***Tripleurospermum perforatum (=T. inodorum)***	1975 – France	2,4-D	cereals	
	Scentless Chamomile	1975 – United Kingdom	2,4-D	cereals	

Source: (Heap, 2014b)
U.S. dicamba resistance highlighted in gray.

The Monsanto Xtend crops are also resistant to low levels of 2,4-D (Feng and Brinker, 2010). Impacts from drift of 2,4-D would not likely be a large issue for Xtend crops, but would have unknown relevance for weeds that might develop resistance to one or the other herbicide. Because many types of resistance could potentially arise in weed populations, no predictions could be made for cross resistance by unknown new weed biotypes. As indicated in Table 29, weed resistance to both herbicides is rare, with only two known occurrences.

Cumulative Impacts of Other HR Crops on Xtend Crops and on Weed Resistance

Summary: Other crops are currently being evaluated for nonregulated status by USDA-APHIS which, if determined as nonregulated, may have impacts with Xtend crops on the development of herbicide-resistant weeds. These crops include GE soybean, corn and cotton with resistance to the auxinic class herbicide 2,4-D, and two GE soybean varieties with resistance to HPPD inhibitors.

Weed resistance to auxin class herbicides is relatively limited compared to other herbicide classes. Nevertheless, there has been some detection of cross resistance in weed populations to more than one class of auxinic herbicide, including a few with 2,4-D and dicamba resistance. The extent and mode of such cross resistance has not been well-investigated. However, because of the potential for cross-resistance, growers will likely be cautioned not to plant 2,4-D-resistant and dicamba-resistant crops in successive years on the same fields. Under the Preferred Alternative, APHIS concludes that weed cross-resistance should and will be monitored carefully. EPA will likely mandate remediation by the Xtend technology developer, should such resistance develop.

Newly available HR crops will facilitate recommendations from weed scientists that include rotation of herbicide chemistries to help reduce resistance development. HPPD inhibitor-resistant soybeans include one nonregulated soybean (isoxaflutole) cultivar and another in process of attaining non-regulated status (mesotrione and isoxaflutole). APHIS concludes that rotation of Xtend crops with these HR crops with auxinic activity would then add additional flexibility when these crops are also available to cotton and soybean growers. MON-887Ø1-3 cotton also has resistance to glufosinate, which will offer breadth in mode of action chemistry. Other existing herbicide resistant crops include those with glufosinate resistance alone, and these also may enhance flexibility for sustainable weed management decisions.

Other crops with auxin class herbicide activity. In addition to glyphosate- and glufosinate-resistant crops planted by growers, other HR crops may be determined as nonregulated and become available. Along with dicamba-resistant Xtend crops, growers will likely select from those with two new herbicide classes of activity. GE crops with petitions for determinations of nonregulated status before APHIS include 2,4-D-resistant Enlist corn, soybean and cotton. 2,4-D, along with dicamba, are both synthetic auxins (auxinic class). If the petitions for determinations for nonregulated status are made by APHIS for both Xtend and Enlist crops, use of both dicamba and 2,4-D is expected to increase above current usage.

Weed resistance to auxinic class herbicides. Depending on how widely these crops are adopted and what weed control management practices are followed by growers, weed resistance to each herbicide could potentially increase, and weeds arise with resistance to both herbicides. The

Monsanto patent for dicamba-resistant soybean indicates that at low doses of 2,4-D, the dicamba-resistant plants sustain only moderate levels of damage (Feng and Brinker, 2010). The patent asserts that the dicamba-resistant soybean would have resistance to 2,4-D that may have drifted from another application site (Feng and Brinker, 2010). That cross resistance exists to another auxinic herbicide in dicamba-resistant soybean suggests that weeds may also have potential to be cross-resistant to both herbicides.

Although both dicamba and 2,4-D have been used widely in agriculture for about five decades, only a limited number of resistant weeds have arisen compared to the number that have arisen to other herbicide modes of action (Mithila et al., 2011). Detected weed resistance to dicamba occurred in two species, although Kochia resistance arose in five locations (Table 29) (Heap, 2014c). Kochia resistant to dicamba in Montana may also have low-level resistance to 2,4-D. Weed resistance to 2,4-D occurred in four US species, only two of which occur in soybean and cotton production areas (Heap, 2014c). Two 2,4-D resistant weeds, wild mustard, *Sinapis arvensis*, and prickly lettuce, *Lactuca serriola* also have dicamba resistance, the first in Canada, the second in Washington (Heap, 2014c). Thus, only three weed species have arisen with resistance to both dicamba and 2,4-D in the United States and Canada. With 23 herbicides in the auxinic group (Heap, 2014c), the world list of resistant weeds in the group was either only 29 populations (Mithila et al., 2011) or 31 populations (Heap, 2014c).

That relatively few 2,4-D resistant weeds have developed over a long period in U.S. corn, soybean or cotton production suggests that high levels of new weed resistance may not be anticipated following determination of nonregulated status for Xtend soybean and cotton, particularly if the lessons from averting overuse of glyphosate have been thoroughly assimilated. Agricultural usage of dicamba on all U.S. crops was increasing between 1990 and 1994, when it reached 9.4 million pounds applied annually (Petition VIII-11) (Monsanto, 2012b). The frequency of annual use of dicamba was 1.00 for corn (2006) 1.00 for cotton (2008) and 1.02 for corn (2006) (Table VIII-13 (Monsanto, 2012b)). Agricultural usage of 2,4-D averaged 30 million pounds in the period 1992-2000 in an earlier era when fewer herbicide choices were available (US-EPA, 2005)[15], and would have been expected to result in high levels of resistant weed populations because of frequent use. Although usage of 2,4-D has declined considerably, as recently as 2004, according to USDA-NASS, usage was still between 21 to 33% for wheat, corn, cotton, and soybean crops (Mithila et al., 2011).

Additional considerations may influence the low incidence of weed resistance to 2,4-D and dicamba. One of these is a relatively low frequency of repeated exposures both historically and in current usage. Practical crop production issues limit the usefulness of 2,4-D treatments, and may have led to its replacement by other herbicides. For example, 2,4-D in soybean may be used in burndown treatments no less than15 to 30 days in advance of planting depending on rate of application (Nufarm, Undated), and this is a lengthy wait for a preplant herbicide. 2,4-D may be used once, pre-emergence, and then most likely, less frequently on emerged corn that is 8 inches

[15] Current use on cotton, soybean and corn (2010-2012, most recent data USDA-NASS (2014c)) is 9.3 million pounds. Next most recent report of usage for these crops (2005-2007 most recent data, USDA-NASS, (2014c)) is 6 million pounds.

or taller because it requires application by directed nozzles only (Nufarm, Undated). 2,4-D may not be used on cotton at all. Dicamba presently is used infrequently; in 2012, the herbicide was used on only 4% of corn, 5% of cotton and 0.3% of soybean in the United States (see Table 17). Dicamba on soybean may be applied 14 to 28 days before planting (dependent on rate) and then once on mature soybeans at pre-harvest. Cotton may receive a dicamba treatment as a pre-plant application, and later only as a pre-harvest treatment (BASF, 2010). On corn, dicamba may be used as a pre-plant (but not around the time of germination) or after the corn is more than 8 inches tall (but with restrictions if soybean is planted nearby) (BASF, 2010).

Potential for development of weed herbicide resistance to dicamba. Resistance to one of the auxinic herbicides does not necessarily predispose resistance to another auxinic herbicide; for example, yellow star thistle with 3-fold resistance to picloram has 4.4-fold resistance to dicamba, but no resistance to 2,4-D (Fuerst et al., 1996). Another recent report of 2,4-D resistance in waterhemp shows that for visual injury levels, field resistant water hemp had 19.2-fold resistance to 2,4-D, but had only 4.5-fold resistance to dicamba (Bernards et al., 2012). While there are three groups of auxinic herbicides, Beckie and Tardiff (2012) note, "the extent and level of cross resistance among classes varies widely by auxinic-resistant weed species and is currently unpredictable." Some mechanisms may restrict the potential for resistance to these auxinic herbicides, including dicamba. Possibilities that may diminish resistance potential of weeds to 2,4-D include fitness penalties for plants carrying resistance traits, complexities of the mode of action of auxin, or the rare occurrences of resistance alleles in the target weed populations (Mithila et al., 2011). Presumably, mechanisms of potential dicamba resistance are similar to 2,4-D mechanisms and will also engender limited herbicide resistance development in weeds.

Other crops with new herbicide resistance. Other HR crops that exhibit resistance to different herbicide modes of action would provide rotational choices that adhere to best management practices. Enlist 2,4-D-resistant crops (corn, soybean and, later, cotton) may be of limited usefulness to growers that plant Xtend dicamba-resistant soybean and cotton because both have the same mode of action. Those other HR crops include one with nonregulated status and the other is a petition requesting nonregulated status, both of which are resistant to HPPD inhibitors: these are isoxaflutole-resistant and mesotrione-resistant soybean (USDA-APHIS, 2014c). With these alternative HR soybean varieties, the availability of Xtend crops will accommodate rotations of auxinic and HPPD inhibitor herbicide chemistries from one season to another. Thus, sequential multi-season use of the HPPD inhibitors will help growers avoid the continued applications to fields of WSSA Class 4 herbicides (2,4-D and dicamba) which would be a risk factors for development of resistant weeds. It is difficult to decide whether the grower benefits of an additional mode of action in an herbicide resistant rotation crop will outweigh the concerns of having two simultaneous auxinic class herbicides that may additively increase the risk of HR weed development. Aside from glufosinate resistant cotton, no other HR cotton is available. However, since soybean is a rotation crop for cotton in about 8% of cotton acres, the soybean resistant to HPPD inhibitors may be of value in providing a diversity of herbicides that may reduce resistant weed development. APHIS concludes that MON 88701 cotton and MON 87708 soybean will encourage the use of diverse herbicides for improved problem weed control, as long as other auxin class herbicides are not also used in successive crop rotations with these varieties.

5.8.3 Biodiversity

Summary: While generally, herbicides do not promote biodiversity, the potential for biodiversity may be enhanced by availability of an additional herbicide chemistry in a resistant crop because its use may lead to enhanced productivity and hence, increased yield on existing agricultural land. APHIS concludes that the consequences of such yield increase could include a somewhat diminished demand for new conversion of CRP lands or other as yet unconverted nonagricultural lands, and thus to increased potential for maintaining animal and plant biodiversity.

As described in the No Action Alternative, agricultural practices can affect biodiversity in and around agricultural fields. Growers have the opportunity to choose many different practices to manage their operations.

Agricultural practices have the potential to impact diversity at the farm level by affecting farm biota, including birds, wildlife, invertebrates, soil microorganisms, and weed populations. Conservation tillage leaves a higher rate of plant residue and increases soil organic matter (Hussain et al., 1999). This benefits soil biota by providing additional food sources (energy) (USDA-NRCS, 1996) and increasing the diversity of soil microorganisms. It also benefits invertebrate detritivores, their predators, and ultimately, birds and other wildlife higher in the food chain (Towery and Werblow, 2010; Carpenter, 2011). Ground-nesting and seed-eating birds, in particular, have been found to benefit from greater food and cover associated with conservation tillage (SOWAP, 2007).

Herbicide use in agricultural fields can impact biodiversity by decreasing weed quantities or causing a shift in weed species. This can affect insects, birds, and mammals that use these weeds. The quantity and type of herbicide use associated with conventional and GE crops depends on many variables, including cropping systems, type and abundance of weeds, production practices, and individual grower decisions.

Both tillage and herbicide use patterns influence biodiversity. If MON 88701 cotton and MON 87708 soybean are approved, it is likely that use of no-till management will remain the same or increase. Therefore, use of these products is likely to provide stability to biodiversity, especially in fields where tillage is used currently to control GR weeds. In many regions tillage is used for purposes other than weed control, so in these areas only the changes in herbicide use patterns may influence biodiversity. Because many management choices affect farm level biodiversity, the magnitude of this impact on biodiversity is uncertain.

Habitat loss is the greatest direct impact that agriculture has on biodiversity (Ammann, 2005). Therefore, methods that increase crop yields have the potential to reduce impacts to biodiversity by reducing the amount of land converted to agriculture (Carpenter, 2011). Gains in yields have generally not been obtained by HR cultivars unless higher yielding ones are modified to incorporate an HR trait (NRC, 2010). APHIS concludes that nonregulated status for MON 88701 cotton and MON 87708 soybean will have no effect on existent biodiversity. As described in the No Action Alternative, agricultural practices can affect biodiversity in and around agricultural fields. Growers have the opportunity to choose many different practices to manage their operations.

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5.8.4 Physical Environment

Summary: Potential cumulative impacts on the Physical Environment can mostly be ascribed to the use of dicamba on Xtend soybean and cotton. Dicamba may avert growers from returning to conventional tillage that may otherwise become necessary for controlling glyphosate-resistant weeds. Under the No Action Alternative, development of additional glyphosate-resistant and other herbicide-resistant weeds will likely continue; one response that growers may take would be to increase such tillage. The potential impacts on Soil, Water, Air Quality and Climate Change, which are directly affected by the increased use of tillage, would be diminished under the Preferred Alternative. Any direct and indirect impacts of dicamba use are being assessed by the EPA, and are outside the scope of this EIS.

After the EPA approves the proposed uses of dicamba and the Preferred Alternative is chosen by APHIS, there is an expectation that the use of dicamba will increase. This increase in dicamba use has the potential to impact natural resources. APHIS does not regulate the use of dicamba. The direct and indirect impacts which arise from this increased use are the result of the action that EPA is taking with respect to labeling Xtend for use on the cotton and soybean events that are the subject of the two petitions being considered in this DEIS. APHIS has considered the cumulative impacts from changes in production practices that may arise from HR weeds.

Soil Quality

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

If conventional tillage increases to control glyphosate- and other herbicide-resistant weeds, there may be an impact on soil quality. Residue management that employs intensive tillage and leaves low amounts of crop residue on the surface results in greater losses of soil organic matter (SOM) (USDA-NRCS, 1996). The total acreage that may be impacted by such an increase in tillage would be based on the extent of resistant weeds present in a field and the weed management strategy chosen by a grower. Adoption of MON 88701 cotton and MON 87708 soybean can provide growers with an alternative herbicide to glyphosate and glufosinate. Intensive use of glyphosate on GR crops has been associated with increased selection for GR weeds. Many growers have expressed a need for these crop events during the scoping comment period associated with this DEIS because of their weed problems.

Based on individual grower needs, these two events and EPA approval of dicamba use on them could provide growers with an alternative to intensive tillage practices that may be used to address herbicide resistance issues. This could reduce the potential loss of SOM and soil erosion that may result when more aggressive tillage practices are used to combat HR weeds under the No Action Alternative. However, the selection of weeds resistant to glyphosate, dicamba, and glufosinate will limit the use of this product and any benefit to soil that may arise. The magnitude of the benefit or the loss of the benefit is uncertain because growers individually make decisions on soil management practices. Therefore, each action could contribute incrementally to the problem of soil erosion.

Water Quality

Under the No Action Alternative, increased tillage to manage GR weeds may occur and lead to increased soil erosion and decreases in water quality from sedimentation and transport of nutrients and other chemicals to surface water. When considering the cumulative impacts of the Preferred Alternative, Xtend cropping systems for cotton and soybean may help to preserve gains in conservation tillage in the short term. In the long term, selection of dicamba- resistant weeds may result in similar aggressive tillage practices that are expected to occur under the No Action Alternative and negate the benefits mentioned above.

Air Quality

Under the No Action Alternative, increased tillage to manage GR weeds may occur and lead to decreased air quality from increased air particulates and exhaust from farm equipment. When considering the cumulative impacts of the Preferred Alternative, Xtend cropping systems for cotton and soybean may help to preserve gains in conservation tillage and benefit air quality in the short term. In the long term, selection of dicamba resistant weeds may result in similar aggressive tillage practices that are expected to occur under the No Action Alternative and negate the benefits mentioned above.

Climate Change

Under the No Action Alternative, there is a potential impact on climate change from increased herbicide use and more aggressive tillage regimes to control HR weeds, causing increased release of GHG from burning additional fossil fuels and soil disruption that releases sequestered carbon as GHGs. When considering the cumulative impacts of the Preferred Alternative, Xtend cropping systems for cotton and soybean may help to preserve gains in conservation tillage and reduce GHG contributions to climate change in the short term. In the long term, selection of dicamba resistant weeds may result in similar aggressive tillage practices that are expected to occur under the No Action and negate the benefits mentioned above.

5.9 Cumulative Impacts - Alternative 3

5.9.1 Agronomic Practices

Under Alternative 3, only MON 88701 cotton would no longer be subject to regulation by APHIS. MON 87708 soybean would continue to be regulated. Under this Alternative, supplementation of EPA's registration for dicamba use on Xtend cotton, dicamba use is predicted to increase relative to the No Action Alternative (Appendix 4, Table 4-12), but is less than the increase expected under the Preferred Alternative.

The increased use of dicamba may increase the selection of dicamba-resistant weeds, which might increase the costs for weed control in cotton, sorghum, soybean, and fallow applications. The pressure for selecting dicamba-resistant weeds is expected to be lower in Alternative 3 than Alternative 2 because dicamba-resistant soybeans could not be commercially grown. Those regions where there is a higher percentage of cotton acres and less of soybean will show less usage of dicamba and thus less likelihood of dicamba-resistant weeds, especially under Alternative 3 (Regions J,K, L). GR weeds would have one less tool for their control in soybean if Xtend were not available for soybean applications, and under present management conditions, these GR weeds would potentially by more difficult to control.

5.9.2 Health and Safety Aspects for Livestock and Humans

No cumulative impacts from the changes in production practices were identified on human health for any of the Alternatives. EPA considers the direct and indirect impacts from herbicide use on human health as part of their regulatory decision. Therefore, those impacts are outside the scope of this DEIS.

5.9.3 Biological Resources

Depending on the adoption rate of MON 88701 cotton as well as the management practices employed by growers, there may be an increase in the selection of dicamba-resistant weeds under Alternative 3 relative to the No Action Alternative. However, the selection of dicamba-resistant weeds is expected to be less than under the Preferred Alternative. An increased level of resistant weeds would result in need for additional herbicide applications for their control, which could have impacts by drift to vegetation in the vicinity. Impacts on beneficial insects that typically may improve insect control on crops may be incurred because of the additional chemicals inadvertently applied to adjacent natural plants (Egan et al., 2014). EPA considers the direct and indirect impacts from herbicide use on non-target organisms as part of their regulatory decisions. Therefore, those impacts are outside the scope of this DEIS. EPA is analyzing the potential impacts of the proposed new uses of dicamba on the environment, including non-target organisms. It is probable that EPA will include label restrictions and requirements to limit off-site transport of dicamba as has been done with the proposed registration of Enlist Duo™ (US-EPA, 2014b).

5.9.4 Physical Environment

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

5.10 Cumulative Impacts - Alternative 4

5.10.1 Agronomic Practices

Under Alternative 4, MON 87708 soybean would be granted nonregulated status but MON 88701 cotton would continue to be regulated. If APHIS selects this Alternative and EPA approves the new use of dicamba on MON 87708 soybean, Monsanto estimates an increase in dicamba use associated with adoption of Xtend soybean (at peak adoption of 40%) to 20.5 million (Table 4-9) or 5.4 times the dicamba use on all crops under the No Action Alternative (Appendix 4, Table 4-9). The increased use of dicamba may increase the selection of dicamba-resistant weeds which may eventually increase costs for weed control in cotton, sorghum, soybean, and fallow applications. The pressure for selecting dicamba-resistant weeds is expected to be lower in Alternative 4 than the Preferred Alternative. Those regions where soybean acres are high with respect to cotton (Regions E, F, G, I, see Table 21) would show less overall dicamba use (since dicamba would be used at minimal levels in cotton), and less likelihood for development of dicamba-resistant weeds than in areas with high acreage of both cotton and soybean. Control of GR weeds in cotton would include herbicides other than dicamba, so less control over these weeds is a consequence of not having dicamba available for pre and post-emergent treatment of these weeds.

Those regions where there is a higher percentage of cotton acres and less of soybean will show less usage of dicamba and thus less likelihood of dicamba-resistant weeds, especially under

Alternative 4 (Regions J, K, and L). No cumulative impacts were identified on Human Health for any of the Alternatives.

5.10.2 Health and Safety Aspects for Livestock and Humans

No cumulative impacts were identified on human health or livestock for any of the Alternatives. EPA considers the direct and indirect impacts from herbicide use on human health and non-target organisms as part of their regulatory decisions. Therefore, those impacts are outside the scope of this DEIS.

5.10.3 Biological Resources

Depending on the adoption rate of MON 87708 soybean and the management practices used by growers, there may be an increase in the selection of dicamba-resistant weeds under Alternative 4 relative to the No Action Alternative. The selection of dicamba-resistant weeds is expected to be less than under the Preferred Alternative. An increased level of resistant weeds would result in the need for additional herbicide applications for their control, which could impact non-target organisms in the vicinity. Impacts on beneficial insects that typical may improve insect control on crops may be incurred because of the additional chemicals inadvertently applied to adjacent natural plants (Egan et al., 2014). EPA considers the direct and indirect impacts from herbicide use on non-target organisms as part of their regulatory decisions. Therefore, those impacts are outside the scope of this DEIS. EPA is analyzing the potential impacts of the proposed new uses of dicamba on the environment, including non-target organisms. It is probable that EPA will include label restrictions and requirements to limit off-site transport of dicamba as has been done with the proposed registration of Enlist Duo™ (US-EPA, 2014b).

5.10.4 Physical Environment

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

6 OTHER IMPACTS AND MITIGATION MEASURES

This section describes other potential impacts associated with the implementation of the Action Alternatives, including unavoidable impacts; short-term versus long-term productivity of the environment; and irreversible/irretrievable commitment of resources. This section also describes potential impact mitigation measures, as applicable, beyond what is already built into the Alternatives.

6.1 Unavoidable Impacts

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

6.2 Short Term Versus Long Term Effects

In the short term, growers who adopt MON 87708 soybean or MON 88701 cotton are likely to experience more efficient and less costly control of GR weeds. Adopters may be better able to maintain conservation tillage programs on their farms. Growers of non-GE crops and other GE crops may experience a decline in the weed seed bank as overall weed control improves on neighboring farms.

Over the long term, as weeds develop resistance to dicamba or glufosinate, multiple resistance to these compounds and glyphosate, will likely reduce the efficiency of weed control. This will tend to increase weed management costs. Some growers may need to use more aggressive tillage to control resistant weeds. Adoption of conventional tillage would be expected to result in greater soil erosion, loss of organic matter, soil compaction, and reduced moisture holding capacity, as compared to conservation or reduced tillage methods. This would lead to an increase in potential sedimentation and turbidity in nearby surface waters during rain and irrigation events and adverse impacts to biological resources. Non-adopters and growers of non-GE crops will again be impacted by weeds from neighboring farms. Growers of small cereal crops will experience greater weed control costs as alternatives to these herbicides are likely to be more costly.

6.3 Irreversible Resource Commitments

Irreversible resource commitments represent a loss of future options. This applies primarily to the use of nonrenewable resources and to factors that are renewable only over long time spans, or to adverse impacts that cannot be reversed. An irretrievable commitment of resources represents opportunities that are lost for the period of the proposed action. It also includes the use of renewable resources, such as timber or human effort, as well as other utilization opportunities that are foregone in favor of the proposed action.

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

6.4 Mitigation Measures

As defined in the CEQ regulations for implementing NEPA (40 CFR § 1508.20) mitigation includes:

- avoiding the impact altogether by not taking a certain action or parts of an action;
- minimizing impacts by limiting the degree or magnitude of the action and its implementation;
- rectifying the impact by repairing, rehabilitating, or restoring the affected environment;
- reducing or eliminating the impact over time by preservation and maintenance operations during the life of the action; and
- compensating for the impact by replacing or providing substitute resources or environments.

APHIS does not have the authority to regulate types of management practices or use of herbicides. Nevertheless, mitigation can occur by a number of means. First growers may voluntarily adopt best practices recommended by weed experts. Second, any grower who uses either MON 87708 soybean or MON 88701 cotton will be expected to follow a stewardship agreement. APHIS assumes that there would be no binding enforcement mechanism to ensure that farmers follow the stewardship agreement but failure to do so could jeopardize a grower's access to the technology.

Mitigation measures to oversee the proper use of herbicides are determined by EPA and are disseminated to the herbicide users through EPA-approved labels. Adherence to herbicide label requirements, including application rates and techniques and following industry herbicide stewardship programs, will largely minimize improper herbicide usage. The extent of herbicide drift will be mitigated by the requirement to use dicamba and glufosinate by conditions on the label that will require nozzles that limit drift and restrictions on when and how the herbicide can be applied. State and local governments may also impose restrictions on when and how herbicides can be applied (see Appendix 7).

7 THREATENED AND ENDANGERED SPECIES

The Endangered Species Act (ESA) of 1973, as amended, is one of the most far-reaching wildlife conservation laws ever enacted by any nation. Congress passed the ESA to prevent extinctions facing many species of fish, wildlife and plants. The purpose of the ESA is to conserve endangered and threatened species (TES) and the ecosystems on which they depend as key components of America's heritage. To implement the ESA, the U.S. Fish & Wildlife Service (USFWS) works in cooperation with the National Marine Fisheries Service (NMFS), other Federal, State, and local agencies, Tribes, non-governmental organizations, and private citizens. Before a plant or animal species can receive the protection provided by the ESA, it must first be added to the Federal list of threatened and endangered wildlife and plants.

A species is added to the list when it is determined by the USFWS/NMFS to be endangered or threatened because of any of the following factors:

- The present or threatened destruction, modification, or curtailment of its habitat or range;
- Overutilization for commercial, recreational, scientific, or educational purposes;
- Disease or predation;
- The inadequacy of existing regulatory mechanisms; and
- The natural or manmade factors affecting its survival.

Once an animal or plant is added to the list, protective measures apply to the species and its habitat. These measures include protection from adverse effects of federal activities.

7.1 Requirements for Federal Agencies

Federal Section 7 (a)(2) of the ESA requires that federal agencies, in consultation with USFWS and/or the NMFS, ensure that any action they authorize, fund, or carry out is "not likely to jeopardize the continued existence of a listed species or result in the destruction or adverse modification of designated critical habitat." It is the responsibility of the federal agency taking the action to assess the effects of their action and to consult with the USFWS and NMFS if it is determined that the action "may affect" listed species or designated critical habitat. To facilitate their ESA consultation requirements, APHIS met with the USFWS from 1999 to 2003 to discuss factors relevant to APHIS' regulatory authority and effects analysis for petitions for nonregulated status and developed a process for conducting an effects determination consistent with the Plant Protection Act (PPA) of 2000 (Title IV of Public Law 106-224). APHIS uses this process to help fulfill its obligations and responsibilities under Section 7 of the ESA for biotechnology regulatory actions.

APHIS met with USFWS officials on June 15, 2011, to discuss whether APHIS has any obligations under the ESA regarding analyzing the effects of pesticide use associated with all GE crops on TES. As a result of these joint discussions, USFWS and APHIS have agreed that it is not necessary for APHIS to perform an ESA effects analysis on pesticide use associated with GE crops currently planted because EPA has both regulatory authority over the labeling of pesticides and the necessary technical expertise to assess pesticide effects on the environment under FIFRA. APHIS has no statutory authority to authorize or regulate the use of dicamba, glufosinate, or any other herbicide, by cotton and soybean growers. Under APHIS' current Part 340 regulations, APHIS only has the authority to regulate MON 87708 soybean and MON 88701 cotton or any GE organism as long as APHIS believes they may pose a plant pest risk (7 CFR § 340.1). APHIS has no regulatory jurisdiction over any other risks associated with GE organisms including risks resulting from the use of herbicides or other pesticides on those organisms.

After completing a plant pest risk analysis, if APHIS determines that MON 87708 soybean and MON 88701 cotton seeds, plants, or parts thereof do not pose a plant pest risk, then these articles would no longer be subject to the plant pest provisions of the PPA or to the regulatory requirements of 7 CFR Part 340, and therefore, APHIS must reach a determination that these articles are no longer regulated. As part of its analysis, APHIS considered the potential effects of MON 87708 soybean and MON 88701 cotton on the environment including, as required by the ESA, any potential effects to threatened and endangered species and critical habitat. As part of this process, APHIS thoroughly reviews the GE product information and data related to the organism (generally a plant species, but may also be other GE organisms). For each transgene/transgenic plant, APHIS considers the following:

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

7.2 Potential Effects of MON 88701 Cotton and MON 87708 Soybean on TES

In following this review process, APHIS, as described below, has evaluated the potential effects that a determination of nonregulated status of MON 87708 soybean and MON 88701 cotton may have, if any, on federally-listed TES species and species proposed for listing, as well as designated critical habitat and habitat proposed for designation. Based upon the scope of the DEIS and production areas identified in the Affected Environment section of the DEIS, APHIS reviewed the USFWS list of TES species (listed and proposed) for each state where soybean and cotton are commercially produced (USFWS, 2014c; 2014b).

Prior to this review, APHIS considered the potential for MON 87708 soybean and MON 88701 cotton to extend the range of soybean production and also the potential to extend agricultural production into new natural areas. APHIS has determined that agronomic characteristics and cultivation practices required for MON 87708 soybean and MON 88701 cotton are essentially indistinguishable from practices used to grow other cotton and soybean varieties, including other herbicide- resistant varieties (Monsanto, 2012a; 2012b; 2013a; USDA-APHIS, 2014a; 2014b). Although MON 87708 soybean and MON 88701cotton may be expected to replace other varieties of cotton and soybean currently cultivated, APHIS does not expect the cultivation of these to result in new cotton or soybean acres to be planted in areas that are not already devoted to agriculture. Accordingly, the issues discussed herein focus on the potential environmental consequences of the determination of nonregulated status of MON 87708 soybean and MON 88701 cotton on TES species in the areas where cotton and soybean are currently grown.

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

For its analysis of effects on TES animals, APHIS focused on the implications of exposure to the novel proteins expressed in the plants (Table 30) as a result of the transformation, and the ability of the plants to serve as a host for a TES.

Table 30. Novel Proteins Associated with MON 87708 Soybean and MON 88701 Cotton.

Regulated Article	Protein	Phenotypic Effects
MON 87708 soybean	dicamba mono-oxygenase (DMO)	Resistance to the herbicide Dicamba (3,6-dichloro-2-methoxybenzoic acid).
MON 88701 cotton	dicamba mono-oxygenase (DMO)	Resistance to the herbicide Dicamba (3,6-dichloro-2-methoxybenzoic acid).
	phosphinothricin acetyltransferase (PAT)	Resistance to glufosinate

Source:(Monsanto, 2012a; 2012b)

7.2.1 Potential Effects of MON 88701 Cotton on TES Plant Species

Upland cotton (*G. hirsutum*) possesses few of the characteristics common to plants that are successful weeds (Baker, 1965; Keeler, 1989) and is not considered to be a serious or common weed in the U.S. It is not listed as a weed in the major weed references (Crockett, 1977; Holm LG *et al.*, 1979; Muenscher, 1980), nor is it present on Federal or State lists of noxious weed species (USDA-APHIS, 2012; USDA-NRCS, 2012d). Modern Upland cotton is a domesticated perennial grown as an annual crop that is not generally persistent in unmanaged or undisturbed environments without human intervention. Modern cultivars are not frost tolerant and do not survive freezing winter conditions, do not produce abundant or long-lived seeds that can persist or lie dormant in soil, do not exhibit vegetative propagation or rapid vegetative growth, and do not compete effectively with other cultivated plants (OECD, 2008). In areas where winter temperatures are mild and freezing does not occur, cotton plants can occur as volunteers in the following growing season. These volunteers can be easily controlled by herbicides or mechanical means. Excepting dicamba and glufosinate, MON 88701 is expected to be sensitive to the same herbicides as other cotton varieties (USDA-APHIS, 2014b). Cotton can become locally feral or naturalized in suitable areas, such as southern Florida, Hawaii, and Puerto Rico (Fryxell 1984; Coile and Garland, 2003; Wunderlin and Hansen, 2008; USDA-NRCS, 2012b).

The agronomic and morphologic characteristics data provided by Monsanto were used in the APHIS analysis of the weediness potential for MON 88701 cotton, and evaluated for the potential to impact TES and critical habitat. Agronomic studies conducted by Monsanto tested the hypothesis that the weediness potential of MON 88701 cotton is unchanged with respect to conventional cotton (Monsanto, 2012b; 2013a). Monsanto collected agronomic data relevant to weedy traits such as plant vigor and height and seed yield from field experiments conducted in two studies at a total of 15 (Study 1) and 11 (Study 2) locations across the U.S. during the 2010 growing season (Monsanto, 2012b). All locations in Study 2 were also included in Study 1. Data were collected for control Coker 130 cotton and MON 88701 cotton, as well as for MON 88701 cotton treated with the herbicides glufosinate (0.5 lb a.i./acre at the 3 – 5 leaf stage) and dicamba (0.5 lb a.e./acre at the 6-10 leaf stage) to allow for assessment of MON 88701 under the agronomic system that it is expected to be used (Monsanto, 2012b). Data were also collected for 11 (Study 1) and eight (Study 2) commercial reference varieties (four varieties grown per site) to establish statistical tolerance intervals for the various traits assessed (Monsanto, 2012b).

Plant vigor was assessed qualitatively. No differences in vigor were observed between MON 88701 cotton and the Coker 130 control at 14 and 30 days after planting for 73 out of 74 comparisons across all sites and treatments. At one site, MON 88701 cotton plants were slightly less vigorous than Coker 130 at 30 days after planting, but were within the range of vigor ratings of the commercial reference varieties (Monsanto, 2012b). Other agronomic data were assessed quantitatively. In the combined-site analysis, no statistically significant ($p < 0.05$) differences were observed between MON 88701 cotton and the Coker 130 control for stand count at 14 and 30 days after planting, final stand count, seed cotton yield, number of immature seeds per boll, boll weight, or a variety of fiber characteristics (Monsanto, 2012b). In both studies, whether untreated or herbicide treated, MON 88701 cotton plants were shorter than Coker 130 control plants, took slightly longer to mature, produced more but smaller seed, and had a slightly increased fiber strength (Monsanto, 2012b). These differences were all small and in all cases the mean values for these characteristics were within the range observed for the commercial reference varieties (Monsanto, 2012b). Changes in disease or insect pest susceptibility or in response to abiotic stress were not observed in MON 88701 cotton relative to the control (Monsanto, 2012b).

In summary, no differences were detected between MON 88701 cotton and non-transgenic cotton in growth, reproduction, or interactions with pests and diseases, other than the intended effect of resistance to the two herbicides (Monsanto, 2012b; USDA-APHIS, 2014b).

As part of its analysis of effects on species and habitat, APHIS evaluated the potential of MON 88701 cotton to cross with wild relatives. Cultivated *G. barbadense* (Pima or Egyptian cotton), is grown in Arizona, California, New Mexico, and Texas (Pleasants and Wendell, 2005; USDA-

NASS, 2012e). Naturalized populations of *G. barbadense* grow in Puerto Rico, the Virgin Islands and most of the major Hawaiian Islands (Fryxell 1984; Bates, 1990; USDA-NRCS, 2012a). Two wild species of cotton are native to the U.S., *G. thurberi* and *G. tomentosum*, and grow in Arizona and Hawaii respectively (Fryxell 1984; USDA-NRCS, 2012a). *G. hirsutum* is tetraploid and thus effectively incompatible with diploid species such as *G. thurberi*. Plants from these two groups do not normally hybridize spontaneously and produce fertile offspring, and experimental crosses are difficult (OECD, 2008). In contrast, *G. hirsutum* is sexually compatible with the tetraploids *G. barbadense* (cultivated Pima or Egyptian cotton) and *G. tomentosum* and can form viable and fertile progeny with both species (Brubaker CL *et al.*, 1993; Saha *et al.*, 2006; OECD, 2008). Thus, unassisted outcrossing and gene introgression could potentially occur in areas where these species are co-located (USDA-APHIS, 2014b).

For transgene introgression from MON 88701 cotton to occur there would have to be spatial proximity between MON 88701 cotton and the recipient variety or species; overlap in their flowering period; and because cotton is insect pollinated, they must share similar pollinators (Pleasants and Wendell, 2005). Published studies report that there has been relatively little gene introgression from *G. hirsutum* into native or naturalized *G. barbadense* in Mesoamerica and the Caribbean, despite the fact that *G. barbadense* has been grown in the presence of the predominant *G. hirsutum* since prehistoric times (Wendel *et al.*, 1992; Brubaker CL *et al.*, 1993). In contrast, introgression from *G. barbadense* to native or naturalized *G. hirsutum* in these areas has been relatively common (Wendel *et al.*, 1992; Brubaker CL *et al.*, 1993). Various mechanisms have been suggested to account for this difference (Percy and Wendel., 1990; Brubaker CL *et al.*, 1993; Jiang and PW Chee, 2000; OGTR, 2008). While none of these mechanisms leads to complete isolation between the two species, the reported asymmetry in gene flow suggests that gene introgression from cultivated *G. hirsutum* varieties such as MON 88701 to native or naturalized *G. barbadense* should be rare (USDA-APHIS, 2014b).

Natural populations of *G. tomentosum* are found on all Hawaiian Islands except Kauai and Hawaii. Populations are located on the drier, leeward coastal plains of the islands at low elevations, which are also the areas that are primarily used for agriculture (Pleasants and Wendell, 2005). As discussed further in the PPRA, there is overlap in the timing of flowering (both seasonally and time of day), and potential pollinators with *G. hirsutum* (USDA-APHIS, 2014b). However, *G. hirsutum* has not been grown as an agricultural commodity in Hawaii for decades, and, seed companies no longer use the Hawaiian Islands as a winter nursery for cotton (Grace, 2012; USDA-APHIS, 2014b). Even if gene introgression into wild relatives were to occur, expression of the DMO and PAT proteins does not cause any major changes in the phenotype of cotton plants other than to confer resistance to the herbicides dicamba and glufosinate (Monsanto, 2012b; USDA-APHIS, 2014b). In the absence of treatment with these herbicides, the transgenic material in MON 88701 is unlikely to confer a selective advantage on any hybrid progeny that may result from outcrossing (USDA-APHIS, 2014b).

None of the relatives of cotton are Federally listed (or proposed) as endangered or threatened species (USFWS, 2014a). In Florida wild populations of upland cotton, *G. hirsutum* have been listed as endangered by the state (Coile and Garland, 2003). However, wild *G. hirsutum* is not present in the northwestern panhandle where cotton cultivation occurs, and cultivation of cotton is prohibited by the EPA in those areas of southern Florida where it is found (US-EPA, 2001;

Coile and Garland, 2003; Wunderlin and Hansen, 2008). Thus, outcrossing from MON 88701 cotton to naturalized *G. hirsutum* in Florida is highly unlikely. Accordingly, a determination of nonregulated status of MON 88701 cotton is not expected to impact state endangered feral cotton populations.

Based on agronomic field data, literature surveyed on cotton weediness potential, the biology of cotton, and no sexual compatibility of TES with cotton in areas where cotton is commercially grown, APHIS has concluded that MON 88701 cotton will have no effect on threatened or endangered plant species or on critical habitat

7.2.2 Potential Effects of MON 88701 Cotton on TES Animal Species

Threatened and endangered animal species that may be exposed to the gene products in MON 88701 cotton would be those TES that inhabit cotton fields and feed on MON 88701 cotton. To identify potential effects on threatened and endangered animal species, APHIS evaluated the risks to threatened and endangered animals from consuming MON 88701 cotton.

Cotton plants contain the anti-nutrient gossypol that plays a role in defense of cotton against insect pests (Chan *et al.*, 1978; Kong *et al.*, 2010). Gossypol is a yellow polyphenolic pigment found in the cotton plant and in the small pigment glands in the seed (Ely and Guthrie, 2012). Studies indicate that on cotton bollworm (*Helicoverpa armigera*) higher levels of gossypol were fatal although lower levels were found to be beneficial to growth (Paz Celorio-Mancera *et al.*, 2011). Gossypol is harmful to monogastrics such as chickens, swine, and young ruminants (Ely and Guthrie, 2012). This defense seems to have little effect in reducing feeding by adult ruminants. In the North Carolina, 92% of cotton growers surveyed reported damage from white-tailed deer (NCDA&CS, 2010). Whole cottonseed is often used by deer managers as a supplemental feed because it is cheaper than protein pellets and feral hogs and raccoons will not consume it (DeYoung, 2005; Taylor *et al.*, 2013). When doing so, managers generally stop feeding in June to allow time for plasma gossypol levels to reduce prior to entering the breeding season. Although feeding studies of whole cottonseed to whitetails is lacking, there is a general belief that feeding high concentrations, especially during breeding season, may reduce breeding success (Bullock *et al.*, 2010). Studies on European red deer indicate that bucks fed whole cottonseed had negative response in regard to body weight and antler growth (Brown *et al.*, 2002). In studies of fallow deer, feeding whole cottonseed to bucks resulted in decreased body weight, body condition score, antler growth, and plasma testosterone concentration (Mapel, 2004).

Whole cottonseed is commonly used as a supplemental protein feed for cattle (Ely and Guthrie, 2012). However, care must be taken to not overfeed because of the possibility of gossypol toxicity. If fed too much whole cottonseed, even mature dairy cows have been known to become ill and fatalities have occurred when it was the sole diet (Ely and Guthrie, 2012). Other domestic ruminants such as goats have also shown negative effects from consumption of whole cottonseed feed. However, some of the detrimental effects were attributed to the increased dietary intake of ether extract and neutral detergent fiber rather than gossypol (Luginbuhl *et al.*, 2000). One study indicated that whole cottonseed introduced as 15% of the diet to Nubian buck kids had positive results in growth, but at 30%

had increased red blood cell fragility and reduced reproductive performance (Solaiman, 2007).

Perhaps partly because of the toxic effects of gossypol in cotton plants, especially in non-ruminants, information on wildlife depredation of cotton other than whitetail deer is lacking. However, wildlife may use cotton fields as a food source, consuming the insects that live on and among the plants. Quall and some other birds are known to nest in grassy strips on the edge of cotton fields and will enter the fields to obtain food or grit (Palmer and Bromley, NoDate). However, TES generally are found outside of agricultural fields in natural settings. Few if any TES are likely to use cotton fields because they do not provide suitable habitat. Only whooping crane (*Grus americana*), sandhill crane (*Grus canadensis pulla*), piping plover (*Charadrius melodus*), interior least tern (*Sterna antillarum*), and Sprague's pipit (*Anthus spragueii;* a candidate species) occasionally feed in farmed sites (USFWS, 2011). These bird species may visit cotton fields during migratory periods, but would not be present during normal farming operations (Krapu *et al.*, 2004; USFWS, 2011).

Monsanto has presented information comparing the compositional elements of MON 88701 cotton variety with conventional varieties and evaluating the differences between varieties with and without herbicide applications (Monsanto, 2012b). The samples for compositional assessment were collected from eight locations in 2010, chosen to represent typical cotton growing regions of the U.S., and compared to a control variety, Coker 130 (Monsanto, 2012b). Analytes were assessed quantitatively and included 47 nutrients (proximates, fiber, amino acids, fatty acids, minerals, and vitamin E) and five anti-nutrients (fatty acids, gossypol). Statistically significant ($p < 0.05$) differences in the combined-site nutrient levels were observed for 16 nutrients in both herbicide treated and untreated MON 88701 cotton compared to the Coker 130 control: the proximates ash, calories, carbohydrates, moisture, and total fat; acid detergent fiber, neutral detergent fiber, total dietary fiber; the amino acid arginine; the fatty acid 14:0 myristic acid; the minerals calcium, magnesium, manganese, potassium, and zinc; and vitamin E. Three additional nutrients were significantly different in herbicide treated MON 88701 cotton only (the amino acids methionine and proline, and the fatty acid 18:2 linoleic acid), while one additional nutrient was significantly different in untreated MON 88701 cotton only (crude fiber) (Monsanto, 2012b). With the exception of calcium (increased 14% and 15% relative to control in treated and untreated MON 88701 cotton respectively), all differences in nutrient levels were 10% or less. In addition, most of the statistically significant differences in nutrient levels were not consistently observed across locations, with the exception of calcium (statistically significant differences observed in seven of eight locations), ash (statistically significant differences observed at six (treated) and four (untreated) locations), 18:0 stearic acid (statistically significant differences observed at five locations), and manganese (statistically significant differences observed at five locations for untreated MON 88701 cotton only) (Monsanto, 2012b). However, in all of these cases, the mean levels of all nutrients in MON 88701 cotton were within the 99% tolerance interval established from the conventional commercial reference varieties (ILSI, 2010). While the mean level of methionine in herbicide treated (but not untreated) MON 88701 were slightly outside of the 99% tolerance interval, the mean increase in methionine was less than 5%. The increase was not consistently observed across locations (a statistically significant difference was observed at only one of the eight locations), and the mean level of methionine was within the natural variation observed for commercial cotton varieties (ILSI, 2010).

Statistically significant ($p < 0.05$) increases in combined-site anti-nutrient levels were observed for two anti-nutrients in both herbicide treated and untreated MON 88701 cotton: the cyclopropenoid dihydrosterculic acid and total gossypol. In addition, a statistically significant increase in free gossypol was observed in treated MON 88701 cotton. The increase was less than 10% in all cases except dihydrosterculic acid in untreated MON 88701 cotton, which increased 12.6% (Monsanto, 2012b). The increases were not consistently observed across locations and the anti-nutrient levels were all within the 99% tolerance interval established from the conventional commercial reference varieties (ILSI, 2010).

The significant changes observed for the above-mentioned nutrients and anti-nutrients are unlikely to make MON 88701 cotton more susceptible to pests and diseases, or to cause MON 88701 cotton to have a greater impact on non-target organisms, than existing cotton varieties (USDA-APHIS, 2014b). The disease, insect pest, arthropod abundance, and agronomic data presented for MON 88701 cotton did not indicate any significant difference from the control variety (Monsanto, 2012b).

Monsanto used a multistep approach to characterize the novel DMO protein in MON 88701 cotton to determine if DMO is safe for human and animal consumption. It was found that MON 88701 cotton DMO has no relevant amino acid sequence similarities with known allergens, gliadins, glutenins, toxins, and other biologically active proteins that may have adverse effects on mammals (Monsanto, 2013a). The DMO protein was rapidly degraded in simulated gastric and intestinal fluids and a high dose of this protein in a mouse acute oral toxicity evaluation demonstrated it is not acutely toxic, and does not cause any adverse effect (Monsanto, 2013a). The DMO enzyme present in MON 88701 cotton has sequence similarity and many catalytic and domain structural similarities with a wide variety of oxygenases found in numerous species of microorganisms widely distributed and prevalent in the environment (Chakraborty J *et al.*, 2012). It also has similarity with oxygenases such as pheophorbide A oxygenase which are found in plants such as rice, maize, canola and pea (Rodoni S *et al.*, 1997; Yang M *et al.*, 2004) that are consumed in a variety of food and feed sources which have a history of safe human consumption. Plants, animals and humans are extensively exposed to these types of enzymes (Monsanto, 2012b). The PPRA, Petition, and the petitioner's Environmental Report all support the conclusion that exposure to MON 88701 cotton DMO poses no meaningful risk to the environment, or human and animal health (Monsanto, 2012b; 2013a; USDA-APHIS, 2014b).

The PAT enzyme present in MON 88701 cotton is identical to the wild-type protein produced in *S. hygroscopicus* and is analogous to the PAT proteins in commercially available glufosinate-resistant products in several crops including cotton, corn, soybean, and canola (USDA-APHIS, 2014c). OECD recognizes PAT proteins produced from different genes to be equivalent with regard to function and safety (OECD, 1999). PAT proteins are structurally similar only to other acetyltransferases known to not cause adverse effects after consumption (Herouet *et al.*, 2005). In 1997, a tolerance exemption was issued for PAT proteins by the EPA (40 CFR part 180, 1997; CFR Part 180.1151, 2005).

On April 6, 2012, Monsanto submitted a safety and nutritional assessment summary document to the FDA to initiate a consultation on the food and feed safety and compositional assessment of MON 88701 cotton. Monsanto received a completed consultation letter from the FDA on April

24, 2013 (US-FDA, 2013). FDA concluded: "food and feed derived from MON 88701 cotton are not materially different in composition, safety, and other relevant parameters from cottonseed-derived food and feed currently on the market, and that GE MON 88701 cotton does not raise issues that would require premarket review or approval by FDA (US-FDA, 2013)." All indications are that the ingestion of the plant or plant parts is unlikely to affect threatened and endangered species. There is no allergenicity potential with MON 88701 cotton, and the slight increase in levels of gossypol in MON 88701 cotton is insignificant. Therefore, there is no increased risk of direct or indirect toxicity or allergenicity impacts on animal species that feed on cotton or the associated biological food chain of organisms. Based on these analyses, APHIS concludes that, although unlikely, consumption of MON 88701 cotton would have no effect on any listed threatened or endangered animal species or animal species proposed for listing.

APHIS considered the possibility that MON 88701 cotton could serve a host plant for a threatened or endangered species (i.e., a listed insect or other organism that may use the cotton plant to complete its lifecycle). A review of the species list reveals that there are none that would use cotton as a host plant (USFWS, 2014b).

7.2.3 Summary of Potential Effects of MON 88701 Cotton on TES Species

After reviewing the possible effects of allowing the environmental release of MON 88701 cotton, APHIS has not identified any stressor that could affect the reproduction, numbers, or distribution of a listed TES or species proposed for listing. As a result, a detailed exposure analysis for individual species is not necessary. APHIS also considered the potential effect of a determination of nonregulated status of MON 88701 cotton on designated critical habitat or habitat proposed for designation, and could identify no differences from effects that would occur from the production of other cotton varieties. Cotton is not considered a particularly competitive plant species and has been selected for domestication and cultivation under conditions not normally found in natural settings. Cotton is not sexually compatible with, nor does it serve as a host plant for any listed species or species proposed for listing. Consumption of MON 88701 cotton by any listed species or species proposed for listing will not result in an allergic reaction or increase the risk of a toxic reaction. Based on these factors, APHIS has concluded that a determination of nonregulated status of MON 88701 cotton, and the corresponding environmental release of this cotton variety will have no effect on listed species or species proposed for listing, and would not affect designated habitat or habitat proposed for designation. Because of this no-effect determination, consultation under Section 7(a)(2) of the Act or the concurrence of the USFWS or NMFS is not required.

7.2.4 Potential Effects of MON 87708 Soybean on TES Plant Species

Soybean has been cultivated around the globe without any report that it is a serious weed or that it forms persistent feral populations (OECD, 2000). Soybean does not possess any of the attributes commonly associated with weeds (Baker, 1965), such as long persistence of seed in the soil; the ability to disperse, invade, and become a dominant species in new or diverse landscapes; or the ability to compete well with native vegetation. Furthermore, mature soybean seeds have no innate dormancy; germinating seedlings and plants are sensitive to cold, are not expected to survive in freezing winter conditions and do not vegetatively reproduce (Raper Jr. and Kramer, 1987; OECD, 2000). Soybeans that volunteer from the previous year's crop are rarely a management issue, as crop losses attributable to interference from soybean volunteers are minimal (Owen and Zelaya, 2005). However, volunteers can be a problem particularly in the South where winters are milder, and particularly if weather events lead to soybean seed loss prior to harvest (York *et al.*, 2005).

The agronomic and morphologic characteristics data provided by Monsanto were used in the APHIS analysis of the weediness potential for MON 87708 soybean. Agronomic studies conducted by Monsanto tested the hypothesis that the weediness potential of MON 87708 soybean is unchanged with respect to conventional soybean (Monsanto, 2013a). No differences were detected between MON 87708 soybean and nontransgenic soybean in growth, reproduction, or interactions with pests and diseases, other than the intended effect of herbicide resistance to dicamba (Monsanto, 2013a). MON 87708 also has slightly increased resistance/reduced sensitivity to three other phenoxy synthetic herbicides compared to the conventional control soybean A3525 (USDA-APHIS, 2014a). This increased resistance is not expected to significantly affect control of MON 87708 soybean volunteers. Excellent ratings are obtained for post-emergence control of volunteer soybeans in the rotational crops corn, sorghum, wheat, barley, oats, cotton and rice for one or more labeled herbicides with different modes of action than the synthetic auxins to which MON 87708 has acquired complete or partial resistance (Monsanto, 2012a).

Based on analysis of the information provided by Monsanto, along with knowledge of soybean biology, APHIS has concluded that the expression of the DMO protein providing the herbicide resistance traits in MON 87708 soybean is unlikely to appreciably improve seedling establishment or increase weediness potential (Monsanto, 2012a; 2013a). APHIS has concluded that the approval of a petition of nonregulated status for MON 87708 soybean does not present a risk of weediness when compared to other currently cultivated soybean varieties (USDA-APHIS, 2014a).

APHIS evaluated the potential of MON 87708 soybean to cross with listed species. APHIS has determined that there is no risk to unrelated plant species from the cultivation of MON 87708 soybean. Soybean is highly self-pollinating and can only cross with other members of *Glycine* subgenus *Soja* (OECD, 2000). Wild soybean species are endemic in China, Korea, Japan, Taiwan and the former Union of Soviet Socialist Republics; in the U.S. there are no *Glycine* species found outside of cultivation and there is no potential for outcrossing (OECD, 2000). After reviewing the list of threatened and endangered plant species in the U.S. where soybean is grown, APHIS determined that MON 87708 soybean would not be sexually compatible with any listed threatened or endangered plant species proposed for listing, as none of these listed plants are in the same genus nor are known to cross pollinate with species of the genus *Glycine* (USFWS, 2014c).

Based on agronomic field data, literature surveyed on soybean weediness potential, lack of ability to disperse outside of agricultural fields, and no sexually compatibility with wild relatives or listed plants with soybean, APHIS has concluded that MON 87708 soybean will have no effect on threatened or endangered plant species or critical habitat.

7.2.5 Potential Effects of MON 87708 Soybean on TES Animal Species

Threatened and endangered animal species that may be exposed to the gene products in MON 87708 soybean would be those TES that inhabit soybean fields and feed on MON 87708 soybean. To identify potential effects on threatened and endangered animal species, APHIS evaluated the risks from consuming MON 87708 soybean.

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

The Delmarva fox squirrel (*Sciurus niger cinereus*), which inhabits mature forests of mixed hardwoods and pines, may be found adjacent to agricultural areas of the Delmarva Peninsula (USFWS, 2008). The squirrel forages for food in woodlots and openings, such as farm fields, with a diet that mainly includes acorns, nuts/seeds of hickory, beech, walnut, and loblolly pine. They also feed on tree buds and flowers, fungi, insects, fruit, and seeds in the spring and mature, green pine cones in the summer and early fall (USFWS, 2008). The Louisiana black bear (Ursus americanus luteolus), occurring in Louisiana, Mississippi, and Texas, may occasionally forage on soybean; however, other crops such as corn, sugarcane, and winter wheat are preferred by the species (MSU, No Date).

APHIS has examined data on the food and feed safety of MON 87708 soybean, evaluating the agronomic and morphological characteristics, including compositional and nutritional characteristics, safety evaluations and toxicity tests, as compared to a conventional hybrid soybean variety grown at multiple sites (Monsanto, 2012a; 2013a). Nutrients assessed in this analysis included proximates (ash, carbohydrates by calculation, moisture, protein, and fat), fiber, amino acids (18 components), fatty acids (FA, C8-C22), and vitamin E (α-tochopherol) in seed, and proximates (ash, carbohydrates by calculation, moisture, protein, and fat) and fiber in forage. The anti-nutrients assessed in seed included raffinose, stachyose, lectin, phytic acid, trypsin inhibitors, and isoflavones (daidzein, genistein, and glycitein) (Monsanto, 2013a). The results confirmed that the differences observed in the analysis were not meaningful to food and feed safety or the nutritional quality of MON 87708 soybean (Monsanto, 2013a). In addition, the levels of assessed components in MON 87708 soybean were compositionally equivalent to the conventional control and within the range of variability of the commercial reference varieties that were grown concurrently in the same field trial (Monsanto, 2013a). This indicates that the only significant compositional difference between MON 87708 soybean and conventional hybrid soybean is the expression of the DMO proteins.

Monsanto used a multistep approach to characterize the novel DMO proteins in MON 87708 soybean to determine if DMO is safe for human and animal consumption. It was found that MON 87708 soybean DMO has no relevant amino acid sequence similarities with known allergens, gliadins, glutenins, toxins, and other biologically active proteins that may have adverse effects on mammals (Monsanto, 2013a). MON 87708 soybean DMO was rapidly degraded in simulated gastric and intestinal fluids and a high dose of this protein in a mouse acute oral toxicity evaluation demonstrated that it is not acutely toxic, and does not cause any adverse effect (Monsanto, 2013a). The safety assessment supports the conclusion that exposure to MON 87708 soybean DMO poses no meaningful risk to the environment, or human and animal health.

On November 9, 2010 Monsanto submitted a safety and nutritional assessment summary document to the FDA to initiate a consultation on the food and feed safety and compositional assessment of MON 87708 soybean (Monsanto, 2012a). Monsanto received a completed consultation letter from the FDA on October 11, 2011 (US-FDA, 2011b). FDA concluded: “food and feed derived from MON 87708 soybean are not materially different in composition, safety, and other relevant parameters from soybean-derived food and feed currently on the market, and that the GE MON 87708 soybean do not raise issues that would require premarket review or approval by FDA” (US-FDA, 2011b). Therefore, the ingestion of the plant or plant parts is unlikely to affect threatened and endangered species. Because there is no toxicity or allergenicity potential with MON 87708 soybean, there would be no direct or indirect toxicity or allergenicity impacts on animal species that feed on soybean or the associated biological food chain of organisms. Therefore, based on these analyses, APHIS concludes that, although unlikely, consumption of MON 87708 soybean would have no effect on any listed threatened or endangered animal species or animal species proposed for listing.

APHIS considered the possibility that MON 87708 soybean could serve as a host plant for a threatened or endangered species (i.e., a listed insect or other organism that may use the soybean plant to complete its lifecycle). A review of the species list reveals that there are no members of the genus *Glycine* that serve as a host plant for any threatened or endangered species (USFWS, 2014c).

Combining the above information, cultivation of MON 87708 soybean and their progeny are expected to have no effect on threatened or endangered animals or those proposed for listing.

7.2.6 Summary of Potential Effects of MON 87708 Soybean on TES

After reviewing the possible effects of allowing the environmental release of MON 87708 soybean, APHIS has not identified any stressor that could affect the reproduction, numbers, or distribution of a listed TES or species proposed for listing. APHIS also considered the potential effect of a determination of nonregulated status of MON 87708 soybean on designated critical habitat or habitat proposed for designation, and could identify no differences from effects that would occur from the production of other soybean varieties. Soybean is not considered a particularly competitive plant species and has been selected for domestication and cultivation under conditions not normally found in natural settings. Soybean is not sexually compatible with, or serves as a host species for, any listed species or species proposed for listing. Consumption of MON 87708 soybean by any listed species or species proposed for listing will not result in a toxic or allergic reaction. Based on these factors, APHIS has concluded that a determination of nonregulated status of MON 87708 soybean, and the corresponding environmental release of this soybean variety will have no effect on listed species or species proposed for listing, and would not affect designated habitat or habitat proposed for designation. Because of this no-effect determination, consultation under Section 7(a)(2) of the Act or the concurrences of the USFWS or NMFS is not required

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

8.1 Executive Orders with Domestic Implications

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

- ***Executive Order (EO) 12898 (US-NARA, 2013), "Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations,"*** requires Federal agencies to conduct their programs, policies, and activities that substantially affect human health or the environment in a manner so as not to exclude persons and populations from participation in or benefiting from such programs. It also enforces existing statutes to prevent minority and low-income communities from being subjected to disproportionately high and adverse human health or environmental effects.

- ***EO 13045 (US-NARA, 2013), "Protection of Children from Environmental Health Risks and Safety Risks,"*** acknowledges that children may suffer disproportionately from environmental health and safety risks because of their developmental stage, greater metabolic activity levels, and behavior patterns, as compared to adults. The EO (to the extent permitted by law and consistent with the Agency's mission) requires each Federal agency to identify, assess, and address environmental health risks and safety risks that may disproportionately affect children.

The No Action and Preferred Alternatives were analyzed with respect to EO 12898 and EO 13045. None of the Alternatives are expected to have a disproportionate adverse effect on minorities, low-income populations, or children.

FDA completed new protein and biotechnology consultations with Monsanto on MON 87708 soybean and MON 88701 cotton (US-FDA, 2011b; 2013). As part of the evaluations for these events, FDA reviewed the safety and nutritional assessments submitted by Monsanto concluding that food and feed derived from MON 87708 soybean and MON 88701 cotton are not materially different in composition, safety, and other relevant parameters from soybean- and cotton-derived food and feed currently on the market.

Monsanto conducted compositional analyses to establish the nutritional adequacy of forage- and grain-derived products from MON 87708 soybean and MON 88701 cotton in comparison to conventional counterparts. The studies compared data on key nutrients, secondary metabolites, and anti-nutrients for MON 87708 soybean and MON 88701 cotton forage and grain samples and the conventional variety controls. According to Monsanto, the measured parameters were within the combined literature range for soybean and cotton and the comparisons indicated no biologically meaningful differences for food and feed safety and nutrition (US-FDA, 2011b; 2013).

The DMO protein in MON 87708 soybean and MON 88701 cotton was investigated for its potential to be a toxin or allergen. Bioinformatics studies confirmed the absence of any biologically significant amino acid sequence similarity to known protein toxins or allergens. Digestibility studies demonstrated that this protein would be rapidly degraded following ingestion, similar to other dietary proteins. Enzymatic activity of the DMO protein was shown to be eliminated under all heating conditions (US-FDA, 2011b; 2013).

Acute oral mouse toxicity studies were performed for the DMO protein, as ingestion represents the most likely route of human exposure to these proteins. No clinical signs of toxicity were observed in any of the test animals.

Monsanto indicated in their submission to FDA that the PAT protein in MON 88701 cotton was shown to be equivalent to that produced in other transgenic crops and previous assessments have shown it is non-toxic to mammals and does not exhibit any potential to be allergenic to humans. A biotechnology consultation on cotton lines containing the PAT protein was completed on June 5, 2003 (US-FDA, 2003) and also was evaluated as part of the consultation on MON 88701 cotton completed in 2013 (US-FDA, 2013). As with the DMO protein, Monsanto evaluated the allergenicity of the PAT protein inserted in MON 88701 cotton through bioinformatics analyses. No meaningful homologies to known or reputed allergens or toxins were identified.

Taken together, the evidence indicates that the DMO and PAT proteins are not toxic or not likely to be allergenic to humans.

Additionally, both Food Standards Australia New Zealand (FSANZ) and Health Canada have evaluated the food safety of MON 87708 soybean (FSANZ, 2012; Health Canada, 2014) and FSANZ has evaluated the food safety of MON 88701 cotton (FSANZ, 2013). FSANZ did not identify any potential public health and safety concerns and concluded that food derived from MON 87708 soybean and MON 88701 cotton "is considered to be as safe for human consumption as food derived from conventional soybean or cotton cultivars" (FSANZ, 2012; 2013). Health Canada has granted food safety approval for MON 87708 soybean in 2012 (Health Canada, 2014).

Based on the information submitted by the applicant and reviewed by APHIS, MON 87708 soybean and MON 88701 cotton are agronomically, phenotypically, and biochemically comparable to conventional soybean and cotton grown, marketed, and consumed except for the inserted proteins DMO and PAT proteins. The results of available mammalian toxicity studies associated with the DMO and PAT proteins establish the safety of MON 87708 soybean and MON 88701 cotton and associated products to humans, including minorities, low-income populations, and children who might be exposed to them through agricultural production and/or processing. No additional safety precautions would need to be taken with nonregulated MON 87708 soybean and MON 88701 cotton. Based on these factors, a determination of nonregulated status to MON 87708 soybean and MON 88701 cotton is not expected to have a disproportionate adverse effect on minorities, low-income populations, or children.

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

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

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

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

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

> ***EO 13112 (US-NARA, 2013), "Invasive Species,"*** states that Federal agencies take action to prevent the introduction of invasive species, to provide for their control, and to minimize the economic, ecological, and human health impacts that invasive species cause.

Neither soybean nor cotton is listed in the U.S. as a noxious weed species by the Federal government (USDA-NRCS, 2013b), nor are these crops listed as invasive species by major invasive plant data bases (University of Georgia and USDOI-NPS, 2012; GRN, 2014).

While pollen-mediated gene transfer can occur, there are no differences in the potential for gene flow and weediness from conventional or other GE varieties. Outcrossing and weediness are addressed in the PPRAs (USDA-APHIS, 2014a; 2014b) and MON 87708 soybean and MON 88701 cotton are similar to other HR-soybean or HR-cotton varieties. The risk of gene flow and weediness of MON 87708 soybean and MON 88701 cotton is no greater than that of other nonregulated, HR soybean or cotton varieties.

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

> ***EO 13186 (US-NARA, 2013), "Responsibilities of Federal Agencies to Protect Migratory Birds,"*** states that federal agencies taking actions that have, or are likely to have, a measurable negative effect on migratory bird populations are directed to develop and implement, within two years, a Memorandum of Understanding (MOU) with the Fish and Wildlife Service that shall promote the conservation of migratory bird populations.

Data submitted by the applicant has shown no substantial difference in compositional and nutritional quality of MON 87708 soybean compared with other GE soybean or non-GE soybean, apart from the presence of the DMO protein. Similarly, except for the presence of the inserted proteins, MON 88701 cotton has been found to be compositionally and nutritionally comparable to other GE cotton or non-GE cotton varieties. Additionally, the PAT protein has been cultivated in commercial cotton strains since 2003. The migratory birds that forage in soybean and cotton fields are unlikely to be affected adversely by ingesting MON 87708 soybean or MON 88701 cotton and their associated products.

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

8.2 International Implications

> ***EO 12114 (US-NARA, 2013), "Environmental Effects Abroad of Major Federal Actions"*** requires federal officials to take into consideration any potential environmental effects outside the U.S., its territories, and possessions that result from actions being taken.

APHIS has given this EO careful consideration and does not expect a significant environmental impact outside the U.S. in the event of a determination of nonregulated status of MON 87708 soybean and MON 88701 cotton. All existing national and international regulatory authorities and phytosanitary regimes that currently apply to introductions of new soybean and cotton cultivars internationally apply equally to those covered by an APHIS determination of nonregulated status under 7 CFR part 340.

Any international trade of MON 87708 soybean and MON 88701 cotton subsequent to a determination of nonregulated status of the product would be fully subject to national phytosanitary requirements and be in accordance with phytosanitary standards developed under the International Plant Protection Convention (IPPC) (IPPC, 2011). 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, 2011). The protection it affords extends to natural flora and plant products and includes both direct and indirect damage by pests, including weeds.

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

The *Cartagena Protocol on Biosafety* is a treaty under the United Nations Convention on Biological Diversity (CBD) that established a framework for the safe transboundary movement, with respect to the environment and biodiversity, of LMOs, which include those modified through biotechnology. The Protocol came into force on September 11, 2003, and 160 countries are Parties to it as of December 2010 (CBD, 2012). Although the U.S. is not a party to the CBD, and thus not a party to the Cartagena Protocol on Biosafety, U.S. exporters will still need to comply with those regulations that importing countries which are Parties to the Protocol have promulgated to comply with their obligations. The first intentional transboundary movement of LMOs intended for environmental release (field trials or commercial planting) will require consent from the importing country under an advanced informed agreement (AIA) provision, which includes a requirement for a risk assessment consistent with Annex III of the Protocol and the required documentation.

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

APHIS continues to work toward harmonization of biosafety and biotechnology consensus documents, guidelines, and regulations, including within the North American Plant Protection Organization (NAPPO), which includes Mexico, Canada, and the U.S., and within the Organisation for Economic Cooperation and Development (OECD). NAPPO has completed three modules of the Regional Standards for Phytosanitary Measures (RSPM) No. 14, *Importation and Release into the Environment of Transgenic Plants in NAPPO Member Countries* (NAPPO, 2003).

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

8.3 Compliance with Clean Water Act and Clean Air Act

This DEIS evaluated the potential changes in soybean and cotton production associated with approving the petition for a determination of nonregulated status to MON 87708 soybean and MON 88701 cotton (see , 4.2.1) and determined that the cultivation of MON 87708 soybean and MON 88701 cotton would not lead to the increase in or expand the area of soybean and cotton production that could impact water resources or air quality any differently than currently cultivated soybean and cotton varieties. The herbicide resistance conferred by the genetic modification of MON 87708 soybean and MON 88701 cotton is not expected to result in any changes in water usage for cultivation compared to current soybean and cotton production. Based on these analyses, APHIS concludes that an extension of a determination of nonregulated status to MON 87708 soybean and MON 88701 cotton would comply with the CWA and the CAA.

8.4 Impacts on Unique Characteristics of Geographic Areas

Approving the petition for a determination of nonregulated status to MON 87708 soybean and MON 88701 cotton is not expected to impact unique characteristics of geographic areas such as parklands, prime farmlands, wetlands, wild and scenic areas, or ecologically critical areas.

Monsanto has presented results of agronomic field trials for MON 87708 soybean and MON 88701 cotton that demonstrate there are no differences in agronomic practices, between MON 87708 soybean and currently available HR-soybean varieties or between MON 88701 cotton and currently available HR-cotton varieties. The common agricultural practices that would be carried out in the cultivation of MON 87708 soybean and MON 88701 cotton are not expected to deviate from current practices. The product is expected to be cultivated by growers on agricultural land currently suitable for production of soybean or cotton, and is not anticipated to expand the cultivation of soybean or cotton to new, natural areas.

The Preferred Alternative for MON 87708 soybean and MON 88701 cotton does not propose major ground disturbances or new physical destruction or damage to property, or any alterations of property, wildlife habitat, or landscapes. Likewise, no prescribed sale, lease, or transfer of ownership of any property is expected as a direct result of a determination of nonregulated status for MON 87708 soybean and MON 88701 cotton. 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 MON 87708 soybean and MON 88701 cotton, including the use of EPA-registered pesticides.

Based on these findings, including the assumption that pesticide label use restrictions are in place to protect unique geographic areas and that those label use restrictions are adhered to, approving the petition for a determination of nonregulated status to MON 87708 soybean and MON 88701 cotton is not expected to impact unique characteristics of geographic areas such as park lands, prime farm lands, wetlands, wild and scenic areas, or ecologically critical areas any differently than soybean and cotton varieties already in commercial agriculture.

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

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

The APHIS proposed action, a determination of nonregulated status of MON 87708 soybean and MON 88701 cotton is not expected to adversely impact cultural resources on tribal properties. Any farming activity that may be taken by farmers on tribal lands would only be conducted at the tribe's request. Thus, the tribes would have control over any potential conflict with cultural resources on tribal properties.

The APHIS Preferred Alternative would neither impact districts, sites, highways, structures, or objects listed in or eligible for listing in the National Register of Historic Places, nor would it likely cause any loss or destruction of significant scientific, cultural, or historical resources. This action is limited to a determination of nonregulated status of MON 87708 soybean and MON 88701 cotton.

The APHIS proposed action is not an undertaking that may directly or indirectly cause alteration in the character or use of historic properties protected under the NHPA. In general, common agricultural activities conducted under this action do not have the potential to introduce visual, atmospheric, or noise elements to areas in which they are used that could result in effects on the character or use of historic properties. For example, there is potential for increased noise on the use and enjoyment of a historic property during the operation of tractors and other mechanical equipment close to such sites. A built-in mitigating factor for this issue is that virtually all of the methods involved would only have temporary effects on the audible nature of a site and can be ended at any time to restore the audible qualities of such sites to their original condition with no further adverse effects. These cultivation practices are already being conducted throughout the soybean and cotton production regions. The cultivation of MON 87708 soybean and MON 88701 cotton is not expected to change any of these agronomic practices that would result in an adverse impact under the NHPA.

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In addition to this distribution list APHIS notified all of its stakeholders of the availability of the DEIS for review and comment.

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12 INDEX