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

Monsanto Petition (19-316-01p) for Determination of Nonregulated Status for Dicamba, Glufosinate, Quizalofop, and 2,4-D Tolerant MON 87429 Maize with Tissue-Specific Glyphosate Tolerance Facilitating the Production of Hybrid Maize Seed [OECD Unique Identifier: MON-87429-9]

Draft Environmental Impact Statement

August 2023

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Abstract: Monsanto Company submitted a petition (19-316-01p) to the U.S. Department of Agriculture (USDA), Animal and Plant Health Inspection Service (APHIS), requesting that MON 87429 corn, a plant developed using genetic engineering that is currently regulated by APHIS, and any progeny derived from it, no longer be regulated under Title 7 of the Code of Federal Regulations part 340 (7 CFR part 340). As part of the evaluation of the petition APHIS developed this draft Environmental Impact Statement to consider the potential effects of a determination of nonregulated status for MON 87429 corn on the human environment pursuant to the National Environmental Policy Act (NEPA, 42 U.S.C. § 4321 et seq.) and implementing regulations at 40 CFR 1500–1508. Areas of potential impact evaluated include U.S. agricultural production, physical environment and biological resources, public health, socioeconomic impacts, and threatened and endangered species. MON 87429 corn hybrids, comprised of 4 transgenes and MOAs controlling 5 herbicide resistant traits, could potentially facilitate effective weed management within Integrated Weed Management (IWM) programs and contribute to helping allay/prevent the development of herbicide resistant weeds. MON 87429 corn hybrids, to the extent grown, would influence the mix and amount of herbicide active ingredients used on U.S. crops. The off-target movement of dicamba sprayed over the top of dicamba-resistant soybean and cotton crops has resulted in economic impacts on non-dicamba resistant crops since 2017. There have also been documented, non-monetized impacts reported on plants in natural areas proximate to dicamba resistant soybean and cotton crops, and on wild and cultivated plants on residential and commercial properties. There are potential ecological impacts on fauna that depend on plants affected by herbicide spray/vapor drift. Effective management of weeds and development of herbicide resistant weeds in stacked-trait MON 87429 corn cropping systems, and precluding of off-target effects on other crops and non-crop plants, would depend on implementation of EPA guidance and compliance with herbicide label use requirements, compliance with any state herbicide use requirements, and implementation of IWM strategies recommended by weed scientists.

*All comments on this draft EIS must be submitted by the date specified in the Federal Register Notice of Availability for review of this draft EIS.

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ACRONYMS AND ABBREVIATIONS

a.e.	acid equivalent
a.i.	active ingredient
AOSCA	Association of Official Seed Certifying Agencies
CAA	Clean Air Act
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations (United States)
CO	carbon monoxide
CO_2	carbon dioxide
CS3-pat	gene encoding for expression of the phosphinothricin N–acetyltransferase. (PAT) protein
CS-cp4 epsps	gene encoding for the 5-enolpyruvylshikimate-3-phosphate synthase (EPSPS) protein
CS-dmo	gene encoding for the dicamba monooxygenase (DMO) protein
CS-ft_t	Gene encoding for expression of a modified version of R-2,4-Dichlorophenoxypropionate dioxygenase gene (FT_T)
CWA	Clean Water Act
DMO	dicamba monooxygenase (DMO)
DNA	deoxyribonucleic acid
EA	Environmental Assessment
EFSA	European Food Safety Agency
EIS	Environmental Impact Statement
EO	Executive Order
EPA	U.S. Environmental Protection Agency
EPSPS	5-enolpyruvylshikimate-3-phosphate synthase
ESA	Endangered Species Act of 1973
FDA	U.S. Food and Drug Administration
FFDCA	Federal Food, Drug, and Cosmetic Act
FIFRA	Federal Insecticide, Fungicide, and Rodenticide Act
FQPA	Food Quality Protection Act
FT_T	Modified version of R-2,4-dichlorophenoxypropionate dioxygenase
FWS	U.S. Fish and Wildlife Service
Ha	Hectare
HR	herbicide resistant
IPCC	Intergovernmental Panel on Climate Change

ACRONYMS AND ABBREVIATIONS

IR	insect resistant
IWM	integrated weed management
Lb	pound
N_2O	nitrous oxide
NAAQS	National Ambient Air Quality Standards
NEPA	National Environmental Policy Act of 1969 and subsequent amendments
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NOP	National Organic Program
NPS	non-point source (pollution)
NRC	National Research Council
NWQI	National Water Quality Initiative
OECD	Organization for Economic Cooperation and Development
PAT	phosphinothricin N-acetyltransferase
PIP	plant-incorporated protectant
PPRA	Plant Pest Risk Assessment
PPA	Plant Protection Act
TES	threatened and endangered species
TSCA	Toxic Substances Control Act
U.S.	United States
USDA	U.S. Department of Agriculture
USDA-AMS	U.S. Department of Agriculture–Agricultural Marketing Service
USDA-APHIS or APHIS	U.S. Department of Agriculture–Animal and Plant Health Inspection Service
USDA-ARMS	U.S. Department of Agriculture–Agricultural Resource Management Survey
USDA-ERS	U.S. Department of Agriculture–Economic Research Service
USDA-NASS	U.S. Department of Agriculture–National Agricultural Statistics Service
USC	U.S. Code
USFWS	U.S. Fish & Wildlife Service
WPS	Worker Protection Standard (40 CFR part 170)

EXECUTIVE SUMMARY

ES 1 PURPOSE AND NEED FOR AGENCY ACTION

In July 2019, Monsanto Company (Bayer)[1] submitted a petition (19-316-01p) to the U.S. Department of Agriculture (USDA), Animal and Plant Health Inspection Service (APHIS), requesting that MON 87429 maize (corn),[2] which was developed using genetic engineering, no longer be considered regulated under Title 7 of the Code of Federal Regulations part 340 (7 CFR part 340).

As part of evaluating the petition APHIS developed this draft Environmental Impact Statement (EIS) to consider the potential effects[3] of a determination of nonregulated status for MON 87429 corn on the human environment.[4] The primary purpose of an EIS is to ensure agencies consider the environmental impacts of their actions in decision making. This EIS is to provide a full and fair discussion of the potential environmental impacts, beneficial and adverse, so as to inform decision makers and the public of the potential outcomes of deregulation of MON 87429 corn, and ways to avoid or minimize any potential adverse impacts.

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

ES 2 SCOPING AND PUBLIC INVOLVEMENT

On April 28, 2021, APHIS published a Notification of Intent (NOI) to prepare an environmental impact statement (EIS) for the petition for nonregulated status for MON 87429 corn. APHIS requested public comment to help identify alternatives, and relevant information, studies, and/or analyses APHIS should consider in the EIS.[5] APHIS accepted public comments until midnight, July 30, 2021. At the end of the comment period, APHIS had received 3,069 comments. There were 23 unique comments submitted in response to the NOI for the EIS, the remainder of submitted comments were nearly identical in content

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[1] Monsanto Company was acquired by Bayer AG after U.S. regulatory approval in 2018. The company name "Monsanto" was eventually discontinued, and is now referred to solely as Bayer AG.

[2] Maize is the botanical term used globally for the cereal plant *Zea mays*. In the United States maize is commonly referred to as corn. Both terms are used interchangeably in this document. For consistency with the common plant name and petition APHIS uses the term maize, but also refers to corn in certain instances, such as in reference to food products.

[3] Effects include ecological (such as the effects on natural resources and on the components, structures, and functioning of affected ecosystems), aesthetic, historic, cultural, economic (such as the effects on employment), social, or health effects. Effects may also include those resulting from actions that may have both beneficial and detrimental effects, even if on balance the agency believes that the effect will be beneficial (40 CFR 1500 - 1508).

[4] The term "human environment" means comprehensively the natural and physical environment and the relationship of present and future generations of Americans with that environment (40 CFR § 1508.1(m)).

[5] Federal Register, Vol. 86, No. 80, Wednesday, April 28, 2021, p. 22384 - Bayer; Notice of Intent to Prepare an Environmental Impact Statement for Determination of Nonregulated Status for Maize Developed Using Genetic Engineering for Dicamba, Glufosinate, Quizalofop, and 2,4-Dichlorophenoxyacetic Acid Resistance, With Tissue-Specific Glyphosate Resistance Facilitating the Production of Hybrid Maize Seed. [Agency/Docket Number: APHIS–2020–0021]. Available at https://www.federalregister.gov/documents/2021/04/28/2021-08879/bayer-notice-of-intent-to-prepare-an-environmental-impact-statement-for-determination-of

based on the same form letter submitted by different individuals. Among the 23 unique comments, Friends of the Earth, a non-governmental environmental organization headquartered in Washington, D.C., provided a submission with over 23,500 signatures using the same form letter. APHIS also received comments from two tribal nations, the Oneida Nation of Wisconsin, and the Upper Sioux Community of Minnesota. APHIS received one comment from industry, Bayer Crop Science.

APHIS evaluated all comments received on the NOI for the EIS; a summary of the comments received, and APHIS response to comments, are provide in Appendix 1 of this draft EIS. A full record of all comments submitted online is available at www.regulations.gov.[6]

ES 3 ALTERNATIVES CONSIDERED

NEPA implementing regulations (40 CFR 1500–1508) require agencies to evaluate alternatives to the proposed action—APHIS' regulatory status decision in response to the petition—that would avoid or minimize adverse impacts, or enhance the quality of the human environment, while meeting the purpose and need for the Agency's action (in this case, a regulatory status decision). Two alternatives are evaluated in this EIS: (1) No Action, denial of the petition, which would result in the continued regulation of MON 87429 corn, and (2) Preferred Alternative, approval of the petition, which would result in a determination of nonregulated status for MON 87429 corn. APHIS considers these two alternatives consistent with the scope of its statutory authority under the PPA, implementing regulations at 7 CFR part 340, and NEPA implementing regulations at 40 CFR 1500–1508.

ES 4 SCOPE OF ANALYSIS

APHIS developed a list of topics for consideration in this draft EIS based on issues identified in public comments on the petition, public comments submitted on the NOI for this EIS, public comments submitted for other EAs and EISs evaluating petitions for nonregulated status, prior EAs and EISs for biotechnology-derived corn varieties, the scientific literature on agricultural biotechnology, and issues identified by APHIS specific to wild and cultivated *Zea* and *Tripsacum* species. The following topics were identified as relevant to the scope of analysis (40 CFR § 1501.9 – Scoping):

- Agricultural Production: Acreage and areas of corn production, agronomic practices and inputs
- Physical Environment: Soils, water resources, air quality
- Biological Resources: Soil biota, animal communities, plant communities, potential gene flow and weediness, biodiversity
- Public health and worker safety
- Food animal health and welfare
- Domestic economy and international trade
- Potential impacts on threatened and endangered species

[6] See https://www.regulations.gov/document/APHIS-2020-0021-4127 [Docket No. APHIS-2020-0021-4127 at www.regulations.gov]

- Compliance of the Agency's regulatory status decision with Executive Orders, and environmental laws and regulations to which the action is subject.

Because the introduced trait genes are involved in weed management, the primary focus of this EIS is on: (1) weed and herbicide resistant weed management, (2) potential effects of exposure to the introduced trait genes and gene products on human health and wildlife, and (3) gene flow and potential weediness of MON 87429 corn. Because spray and vapor drift of dicamba and to some extent 2,4-D has resulted in documented cases of injury to crop and non-crop plants, and both herbicides could be used with MON 87429, socioeconomic impacts are also considered.

ES 5 U.S. CORN PRODUCTION

Acreage and Areas of U.S. Corn Production

Approval of the petition would have little to no effect on lands used for U.S. corn production; corn acreage is determined by national and international market demand for corn-based food, feed, fuel, and industrial commodities, independent of APHIS' regulatory status decision. Acreage could also be determined by the inherent yield potential of a given corn cultivar, pest and weed pressures, the potential contribution of herbicide resistant (HR) traits to effectively controlling weeds, and agronomic production factors. MON 87429 was compared to a conventional control line in a combined-site analyses for phenotypic and agronomic characteristics. No statistically significant differences in yield were detected between MON 87429 corn and the conventional control line (Monsanto 2019).

Agronomic Practices and Inputs

Weed and Herbicide Resistant Weed Management

A primary issue for current and future crop protection and production is identifying effective herbicide mode of action (MOA) mixes and rotations to control weed populations, development of herbicide resistance in weeds, and effective utilization of such mixes and rotations in integrated weed management (IWM) programs. This applies to both conventionally bred non-HR crops as well as stacked-trait HR crops (Evans et al. 2016; Hicks et al. 2018). The widespread and continued emergence of HR weed populations, and the diversity of herbicide MOAs to which weeds are evolving resistance, has become a significant concern in terms of sustaining efficient crop production and food security (Godfray et al. 2010; MacLaren et al. 2020). Herbicide resistant weeds are one of the principal challenges to achieving maximal crop yields; yield loss from weed interference, in the absence of weed-control measures, can range from 15% to 57% (Bridges 1992; Soltani et al. 2017; WSSA 2020a). Overall, average percent yield loss with no weed control is around 52%, and can be as high 15% with weed control (Bridges 1992; WSSA 2020a). On an annual basis, potential loss in value for corn from weed interference is $27 billion and for soybean is $16 billion based on data from 2007 to 2013In general, weeds cause average yield losses of around 35%, worldwide (Oerke 2006); this figure could be much higher without effective herbicide use.

There is no single tactic that can be effectively used to control weeds; effective weed management utilizes a diverse set of tools and practices in IWM programs that include crop rotation, tillage, cover crops, weed seed harvest control, and rotation/combination of herbicide active ingredient (a.i.) MOAs. Chemical management of weed control will remain a primary weed management tool for the foreseeable future, and the potential for weeds to evolve resistance to herbicide active ingredients will remain a concern. Stacked-trait HR varieties employing differing herbicide MOAs are recognized as a potentially useful tool for reducing or preventing the further development of HR weed populations. Stacked-trait HR crops can facilitate use of combinations of differing herbicide MOAs, flexibility in the choice of herbicide MOAs, and herbicide MOA rotations.

In summary, the use of stacked-trait HR crop varieties is a potential strategy for crop producers in managing weeds that impair crop development/yield, and development of herbicide resistant weeds. The need for effective weed management strategies for current HR weeds, and to prevent the further development of HR weed populations is primary concern in the agricultural community; tank mixing of differing herbicide MOAs that continue to show control of HR weeds is considered an effective strategy in this respect (Evans et al. 2016). The efficacy provided by stacked-trait HR crops in the management of HR weed development is, however, dependent on multiple factors (Gressel et al. 2017; Hicks et al. 2018; Comont et al. 2020). Where stacked-trait crop varieties are not integrated into weed management programs employing diverse non-chemical strategies, such as use of cover crops, crop rotation, harvest weed seed control (Owen 2016; Gressel et al. 2017; Creech 2018; ISU-Ext 2018; Gage et al. 2019), and/or robotic weeding (Gaines 2018; Beckie et al. 2019), they could potentially exacerbate issues with the development and management of HR weed populations (Gould et al. 2018; Beckie et al. 2019; Gage et al. 2019).

In broad terms, current management is founded on the theory that increasing the diversity of herbicide MOAs used can reduce the rate of evolution of resistance in weeds (Hicks et al. 2018). However, it is not inevitable that using a combination of MOAs will reduce the rate of evolution of resistance. The concept of combination treatment is based on the assumption that resistance to each MOA is driven by mutations at specific loci, termed "target site resistance" (TSR) (Powles and Yu 2010; Hicks et al. 2018). However, much of the evolved resistance in weeds is driven by more general, nonspecific mechanisms, termed "non-target site resistance" (NTSR), which can confer resistance to multiple herbicide MOAs within a given weed species and cross-resistance to different herbicide MOAs. Examples include increased herbicide a.i. sequestration, or increased herbicide a.i. metabolism that inactivates an herbicide a.i., the latter referred to as metabolic resistance (MBR) (Hicks et al. 2018; Comont et al. 2020).

Recent studies have found that NTSR (e.g., herbicide a.i. sequestration or increased herbicide a.i. metabolism) is playing an increasingly larger role, as opposed to evolution of TSR. For example, Kansas State University weed scientists confirmed a six-way resistant Palmer amaranth population, with MBR responsible for resistance to five of the herbicide MOAs (Shyam et al. 2021).

Notably, there has been widespread occurrence of resistance to multiple herbicide MOAs developing over the last two decades (Heap 2022). As of 2020, there were 60 species (within the same population) resistant to 2 MOAs, 21 species resistant to 3 MOAs, 13 species resistant to 4 MOAs, 8 species resistant to 5 MOAs, and 1 species resistant to 7 MOAs (Heap 2022). While mixing and rotating herbicides with differing MOAs can slow or even preclude the evolution of resistance, cross-resistance to differing herbicide MOAs associated with MBR, and other NTSR type mechanisms, could significantly impede the effectiveness of these strategies. In an aggregate sense, looking at the total number of reported cases of multiple resistance in weed species, globally (not necessarily within the same population), 106 species have been reported to develop resistance to 2 different herbicide MOAs, 55 species to 3 different MOAs, 15 species with development of resistance to 5 MOAs, 6 species with developed resistance to 8 MOAs, and 1 species developed resistance to 11 different MOAs.

Iowa State University extension suggests that weeds that have developed resistance to either 2,4-D or dicamba, both synthetic auxin herbicides, similar MOAs, had cross-resistance to the other about 50% of the time. When cross-resistance was present, in most weeds the level of resistance was lower to the herbicide not responsible for selection of resistance, than for the herbicide that selected the resistance (i.e., a resistant weed population selected by repeated 2,4-D use had a lower level of resistance to dicamba) (ISU-Ext 2021). While cross-resistance between 2,4-D and dicamba is not a given, it occurs frequently enough to reinforce the need for IWM practices to sustain the value of these herbicides.

Another consideration is that absent prevention of further development of HR weeds—which stacked-trait HR crops can potentially facilitate—herbicide use could increase to control those HR weed populations that may emerge in the coming years. HR weeds have increased steadily in the United States since the mid-1980s, although the trend in increase has appeared to taper off since 2015 (Heap 2022). As of the end of 2020, there were 165 unique cases of HR weeds in the United States (weed species by herbicide MOA) (Heap 2022). As HR weed populations develop, and increase in prevalence and diversity, farmers must use additional herbicides with different MOAs for their control. Hence, the potential benefits of a stacked-trait HR crop allying/preventing HR weed development can outweigh single HR trait or conventional crops when used in conjunction with IWM programs (e.g., rotation and mix of herbicide MOAs).

Bayer states that they are committed to Product Stewardship (Bayer 2022b), ensuring that products, services, and technologies are safe and sustainable, that their use is environmentally responsible, while meeting customer expectations and needs. Bayer endorses the Food and Agriculture Organization of the United Nations (FAO) Code of Conduct on Pesticide Management (FAO 2022), CropLife International Plant Biotechnology Code of Conduct (CropLife 2022), Excellence Through Stewardship (ETS) and Responsible Care programs (ETS 2022), and provides guidance to reduce the development of HR weed populations, to include implementation of IWM strategies (Bayer 2022a).

Successful management of development of HR weeds in stacked-trait MON 87429 corn cropping systems would depend on grower implementation of EPA herbicide use label requirements, EPA guidance (US-EPA 2017a, 2022b, a), and IWM strategies recommended by weed scientists (e.g., (Gressel et al. 2017; Heap and Duke 2018; Beckie et al. 2019; Gage et al. 2019)) and the Weed Science Society of America (WSSA 2020b). In 2017 the EPA issued PR Notice 2017-2, *Guidance for Herbicide-Resistance Management, Labeling, Education, Training and Stewardship* (US-EPA 2017a), which provides registrants and growers information on slowing the development and spread of HR weeds with the use of registered herbicides. In addition, the EPA has issued specific requirements for glufosinate resistance management (US-EPA 2016b).

Herbicide Drift and Volatilization

As noted above, the EPA regulates the use of herbicides under FIFRA. Under FIFRA, the EPA assesses whether use of an herbicide on particular crops in accordance with its label would cause unreasonable adverse effects on human health and the environment, to include via herbicide spray or vapor drift. The

EPA has reviewed and issued registrations for each of the herbicides that would be used with MON 87429 corn.

The potential for herbicides to move off-site from where they were applied to other areas can be a concern for impacts on non-target plants, to include wild plants and other crops. This is often referred to as off-target movement, which can occur via run-off, or spray or vapor drift. Herbicides applied to crops can move off-site when environmental conditions are favorable for spray or vapor drift. Off-site movement can result in injury to adjacent crops as well as to nearby non-crop plants, both wild and cultivated on residential and commercial properties. In general, herbicide spray drift out of the target area will be greater with low relative humidity, high temperatures, wind, and temperature inversions (US-EPA 2020m, n). Vapor drift potential is a function of the inherent volatility—vaporization potential—of an herbicide active ingredient, as well as the herbicide formulation (Ouse et al. 2018; Ferreira et al. 2020). The synthetic auxin herbicides dicamba and 2,4-D can be more of a concern in terms of spray and vapor drift, relative to other herbicides, due to their functions as plant hormones, which can affect a wide variety of broad-leaf crop and non-crop plants at low dosages (Gage et al. 2019) and the tendency of some formulations to volatilize after application (US-EPA 2020o).

Among the herbicides that would be used with MON 87429 corn, use of dicamba, and to some extent 2,4-D, with the introduction of dicamba resistant and 2,4-D resistant cotton and soybean crops in 2016 presented drift issues, offsite movement, with late season (summer) over-the-top (OTT) application on these crops (US-EPA 2020q, x, 2021d). Spray drift and volatilization with both herbicides during late season application had impacts on crops not resistant to dicamba and 2,4-D. Current HR soybean and HR cotton crops on which dicamba and 2,4-D are used, marketed under the Xtend® and Enlist™ traits, are provided in Table ES-1.

Table ES-1. Recently Commercialized Stacked-Trait HR Seed Products

Crop	Product name	Manufacturer	Resistant to:	Deregulated	Commercialized
Corn	Enlist	Dow	2,4-D choline, glyphosate, and select ACCase inhibitors	2014	2018
Cotton	Enlist	Dow	2,4-D choline, glyphosate, and glufosinate	2015	2016
	Xtend	Bayer	Dicamba, glyphosate, and glufosinate	2015	2016
Soybeans	Enlist	Dow/Corteva	2,4-D choline, glyphosate, and glufosinate	2014	2019
	Xtend	Bayer	Dicamba and glyphosate	2015	2016

Source: (Wechsler et al. 2019)

* Note that Monsanto 87419 corn, which is dicamba and glufosinate resistant, was deregulated by APHIS on 3/23/2016. However, as of March 2022, MON 87419 corn has not yet been commercialized.

During the 2015 and 2016 growing seasons there were no dicamba products registered for OTT applications to dicamba resistant cotton and soybean crops. After the registration of OTT dicamba products for use on dicamba resistant cotton and soybean crops in late 2016, there was an increase in dicamba use in the United States. Prior to the registration of dicamba for Xtend® and Enlist™ soybeans and cotton, about 35 million acres of agricultural land were treated annually with 6 million pounds of dicamba (5-yr average; 2012–2016) (US-EPA 2020m). Field corn and winter and spring wheat were the crops with the largest number of acres treated with dicamba, at an average of 19.8 million acres treated per year (2012–2016). Other sites with substantial use from 2012–2016 include cotton, fallow land, pasture land, sorghum, and soybeans (pre-plant only) (US-EPA 2020m). The share of soybean acreage planted with dicamba-resistant seeds increased to 33% by 2018, at which time approximately 29.9 million acres were dicamba-resistant (Table ES-2). However, in some states such as Mississippi, dicamba-resistant soybean accounted for almost 80% of planted acres (US-EPA 2020n). Total cotton acres treated with dicamba increased to around 7 million acres by 2018, comprising 56% of cotton acres (Table ES-3).

Table ES-2. Annual Average Soybean Acres Planted by Seed Trait, 2013–2014 and 2017–2018

Variety	Acres	% Acres	Acres	% Acres
	2014–2015		*2017–2018*	
Conventional	3,690,000	4%	3,530,000	4%
Glyphosate Resistant (a)	76,100,000	90%	40,700,000	46%
Other Herbicide Resistant (b)	4,680,000b	6%	15,200,000	17%
Dicamba Resistant (c)	0	-	29,900,000	33%
U.S. Total Soybean Acres	84,400,000		89,400,000	

a. Includes varieties with combined resistance to glyphosate and sulfonylurea herbicides.

b. Includes varieties with combined resistance to glufosinate and/or sulfonylurea herbicides.

c. Includes varieties with combined resistance to dicamba, glyphosate, and sulfonylurea herbicides.

*Note: Dicamba resistant seed was available in 2016, but postemergence dicamba was not registered until after the 2016 growing season. 2016 was considered a transition year for dicamba resistant soybean.

Source: (US-EPA 2020z)

Table ES-3. Annual Average Cotton Acres Planted by Seed Trait, 2013–2014 and 2017–2018

Variety	Acres	% Acres	Acres	% Acres
	2013–2014		*2017–2018*	
Conventional	730,000	7%	780,000	6%
Glyphosate Resistant	8,630,000	82%	2,210,000	16%
Glufosinate Resistant	150,000	1%	0	-
Glufosinate & Glyphosate Resistant	1,030,000	10%	1,810,000	16%
Dicamba, Glufosinate and Glyphosate Resistant	0	-	7,070,000	56%
2,4-D, Glufosinate, and Glyphosate Resistant	0	-	670,000	5%
U.S. Total Cotton Acres	10,550,000		12,540,000	

Source: (US-EPA 2020aa)

In 2017 and 2018, growers used dicamba on 8% and 17% of all U.S. soybean and cotton acres (dicamba-resistant and non- dicamba-resistant) prior to crop emergence, respectively, and on 17% and 34% of all U.S. soybean and cotton acres after crop emergence (dicamba-resistant crops), respectively (US-EPA 2020n). This comprised around 15.1 million to 15.2 million acres of soybean (post-emergent use), and 4.2

million to 4.5 million acres of cotton (post-emergent use). Postemergence dicamba has primarily been used to target herbicide-resistant Palmer amaranth and redroot pigweed, although it is effective at controlling a range of broadleaf weed species (US-EPA 2020q). As of 2019, dicamba-resistant soybeans were planted on around 60% of all soybean acres in the United States, approximately 60 million acres (Hettinger 2019b). As of 2020, around 70% of cotton acres—approximately 8.5 million acres—were planted to dicamba-resistant varieties (US-EPA 2020aa).

From 2007 to 2016, before use of OTT dicamba was allowed on dicamba resistant soybeans and cotton, an average of 172,000 to 590,000 pounds of dicamba a.i. was applied to soybeans, and 130,000 to 164,000 pounds dicamba a.i. was applied each year to cotton (Figure ES-1, Table ES-4). For 2017, around 10.64 million pounds of dicamba were applied to soybeans, and 3.06 million pounds were applied to cotton. In 2019, 5.58 million pounds of dicamba a.i. were applied to cotton. In 2018, 9.75 million pounds dicamba a.i. were applied to soybean (latest data). –

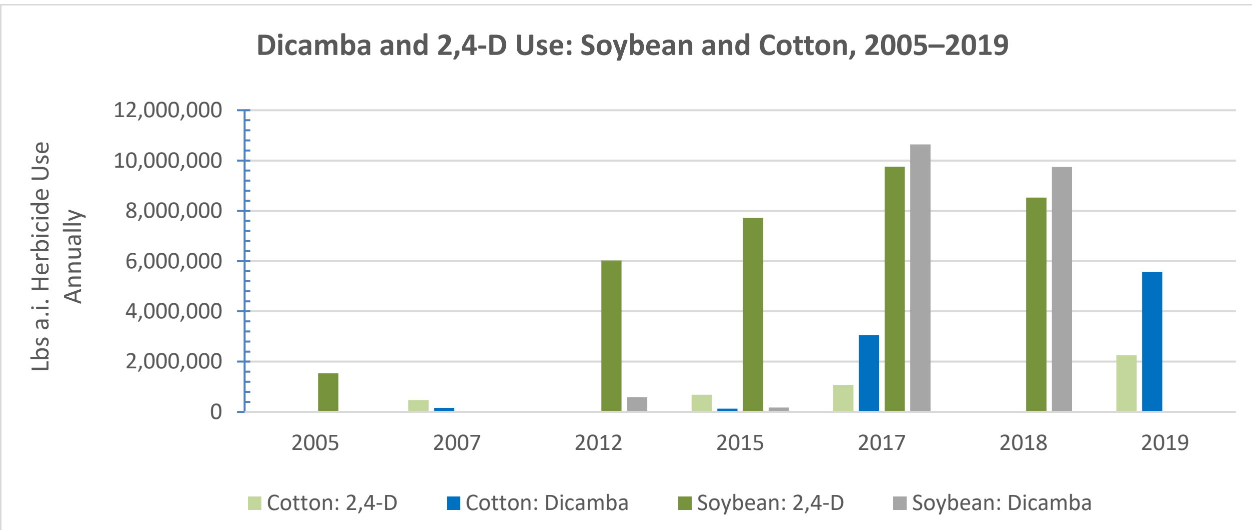

Figure ES-1. Dicamba and 2,4-D Use, 2005–2019

*Note that soybean dicamba use was not available in 2019, and cotton dicamba use was not available in 2018.
Source: Source: (USDA-NASS 2023)

Table ES-4. Dicamba and 2,4-D Use: U.S. Cotton and Soybean

	Pounds a.i. of Herbicide Use Annually						
	2005	2007	2012	2015	2017	2018	2019
Cotton: 2,4-D	-	475,000	-	683,000	1,072,000	-	2,255,000
Cotton: Dicamba	-	164,000	-	130,000	3,061,000	-	5,575,000
Soybean: 2,4-D	1,539,000	-	6,021,000	7,715,000	9,756,000	8,529,000	-
Soybean: Dicamba	-	-	590,000	172,000	10,643,000	9,742,000	-

Beginning in 2016, the EPA registered three dicamba products with significantly lower volatility for OTT application to DT cotton and soybean – Xtendimax™ with VaporGrip™ Technology (diglycolamine salt; Bayer; EPA Reg. No. 524-617), FeXapan™ with VaporGrip™ Technology (diglycolamine salt; Corteva; 352-913) and Engenia™ (bis aminopropyl methylamine or BAPMA salt; BASF; 7969-345) (USEPA 2016a, 2016b, 2017). In April 2019 Tavium™ with VaporGrip™ (diglycolamine salt co-formulated with s-metolachlor; Syngenta; 100-1623) was registered. Source: (US-EPA 2020n; USDA-NASS 2023)

In 2016, the EPA received reports of crop injury alleged to be caused by off-target movement from the use of dicamba. The EPA concluded the 2016 incidents were related to misuse of previously registered, more volatile dicamba pesticide products on dicamba resistant cotton and dicamba resistant soybeans (US-EPA 2018). In 2017, there were approximately 2,708 reported cases of off-target movement of dicamba to other crops, with an estimated impact on around 3.6 million acres of non-dicamba resistant soybeans, approximately 4% of the total 90.2 million acres planted in 2017. In 2018, the Association of American Pesticide Control Officials (AAPCO) reported that approximately 1,400 official complaints of alleged dicamba injury [damage due to off-site movement of dicamba] were reported to state regulatory authorities" (US-EPA 2018). Only 16 of 34 registered states report regularly to AAPCO and EPA, so it is likely that this number underestimated dicamba-related crop damage (US-EPA 2018).

In response, in 2017 and again in 2018, the EPA amended the registrations of all OTT dicamba products following reports that growers had experienced crop damage and economic losses resulting from the off-site movement of dicamba. The U.S. Court of Appeals for the Ninth Circuit vacated the 2018 dicamba registrations in June 2020. In October 2020, the EPA issued new registrations for two dicamba products and extended the registration of an additional dicamba product. All three registrations included cutoff dates for applications in late summer and expanded buffers for counties with listed species that EPA expected would prevent off-target movement and damage to non-target crops and other plants.

These factors considered, some farmers simply did not abide by EPA or state requirements for use of dicamba. For example, in Arkansas, settlement offers on fines for farmers believed by the Plant Board to have violated the state's ban on spraying dicamba in 2018 and 2019 amounted to more than $1.1 million. The Arkansas Plant Board sent out $592,000 in settlement offers (fines) to 18 farmers between April 17 and May 15, 2020 for dicamba use violations (Steed 2020). One farmer in Arkansas reached a fines settlement with the state ($476,900) for 14 cases of violations involving dicamba drift, one count for spraying dicamba on days banned by the state, and 84 instances of dicamba use at higher volumes than allowed under state and federal regulations, among other violations (Steed 2021). Six other farmers also reached fine settlements with the state for illegal uses of dicamba. The violation most often cited in settlement offers has been for spraying dicamba after the state's cutoff dates in 2018 and 2019. Arkansas regulators received more than 1,500 complaints of dicamba damage as of 2016 (Steed 2021). This is an example of one state alone.

In December 2021, the EPA released a summary of dicamba-related incident reports for the 2021 growing season, obtained from pesticide registrants, states, the general public, and non-governmental organizations (US-EPA 2021e). Despite the control measures implemented in the EPA's October 2020 dicamba registration decision (US-EPA 2020m, n), the EPA 2021 incident reports showed little change in the number, severity, and/or geographic extent of dicamba-related drift incidents when compared to the reports the EPA received before the 2020 control measures were required (US-EPA 2020k). In March 2022, the EPA approved additional labeling to further restrict use of dicamba OTT in Minnesota and Iowa (US-EPA 2022d), and in February 2023, the EPA approved additional labeling for Iowa, Illinois, Indiana, and South Dakota (US-EPA 2023b). The dicamba use restrictions are intended to reduce the likelihood of volatility and offsite movement of dicamba OTT by avoiding application on days with high temperatures. For Iowa, the February 2023 amendment supersedes the March 2022 amendment.

Additionally, in August 2022, as part of EPA's obligation to re-evaluate pesticides every 15 years, the EPA published for public review and comment an updated draft human health risk assessment (US-EPA 2022b) and a draft ecological risk assessment for dicamba (US-EPA 2022a). After reviewing comments received during the public comment period, the EPA may issue a revised risk assessment, explain any changes to the draft risk assessment, and respond to comments and may request public input on risk mitigation before completing a proposed registration review decision for dicamba. Through this program, the EPA is ensuring that each pesticide's registration is based on current scientific and other knowledge, including its effects on human health and the environment.

In summary, reported instances of dicamba drift off-site increased with the introduction of dicamba-resistant crops into the U.S. market in 2016 (Figure ES-2). Prior to the 2016 registrations for dicamba, dicamba use on soybeans and cotton was limited to preplant and preharvest soybeans and on preplant and postharvest cotton (US-EPA 2020m). Historically, most dicamba applications occurred in late winter or early spring for pre-plant or fallow removal of broadleaf vegetation prior to planting crops (US-EPA 2022a). The new uses registered in 2016 under FIFRA section 3(c)(7)(B) expanded the timing of dicamba applications to post-emergence OTT applications to dicamba-resistant soybean and cotton crops (US-EPA 2020m). Due to an increased number of applications of dicamba across increased acreage of dicamba-resistant soybean and cotton, and later (warmer) season OTT use, the potential for offsite movement and injury to surrounding sensitive plants through drift and/or volatility increased. Additionally, spraying dicamba on green plant tissues, as in post emergent applications, can increase dicamba emissions more than 300% over those observed when dicamba herbicides were sprayed onto other surfaces such as bare soil (Mueller and Steckel 2021).

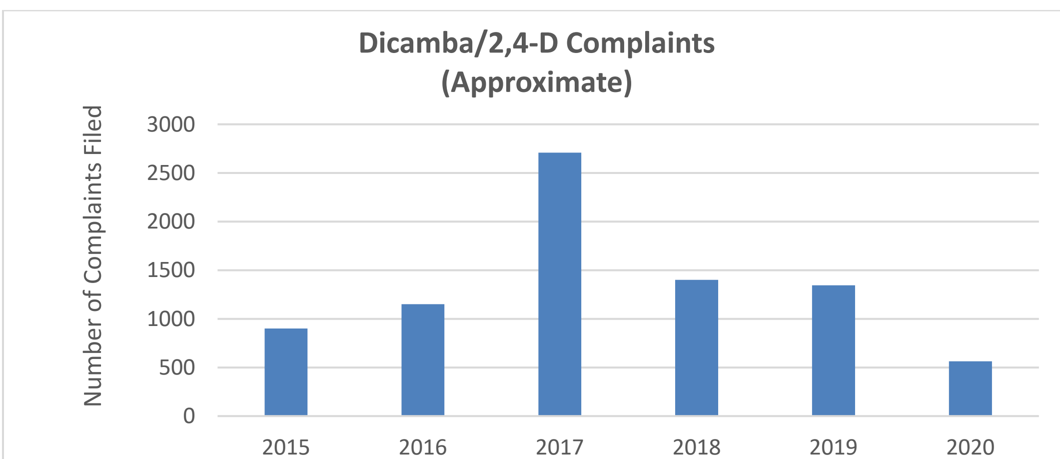

Figure ES-2. Approximate Number of Reported Dicamba and 2,4-D Drift Complaints for 16 States

Many states reported agricultural herbicide drift complaints. States included in this figure are: AL, AR, AZ, IA, IL, IN, ND, MO, OK, GA, SC, MS, NC, NE, TN, and SD. Incidents occurred in other states for these years although data were incomplete for every year and not included. Dicamba is registered for OTT use in 34 states.
Source: (Unglesbee 2019a; Hartzler and Jha 2020; Unglesbee 2020b; US-EPA 2020m; AAPCO 2021)

Farmers' responses to the USDA's Soybean Production Practices and Costs Report for 2018 suggest that approximately 4% percent of soybean fields were damaged by off-target dicamba movement. The largest share of fields damaged were in Nebraska and Illinois, where damage from dicamba was reported on approximately 1 in every 13 fields (Wechsler et al. 2019). Some of the states with the least damage to soybeans were also the states where the most dicamba was sprayed. For instance, while over half of soybean fields in Mississippi were treated with dicamba, only 3% of soybean fields were damaged by off-target dicamba movement in 2018. This was largely attributed to the fact that 73% of the soybeans planted in Mississippi were dicamba-resistant. However, federal- and state-level restrictions on dicamba use may also have played a role in reducing damages (Wechsler et al. 2019). Pesticide applicator consideration of climate conditions that influence the likelihood for off-target movement, such as wind speeds the day of and following application and potential temperature inversions, could also be factors (Bish et al. 2019a; Oseland et al. 2020).

Examples of drift complaints include the following: In 2020, the Arkansas State Plant Board received 336 complaints, 106 of which alleged dicamba injury, six that alleged dicamba and/or 2,4-D, and eight that alleged 2,4-D injury alone (Unglesbee 2019a). Agronomists in Iowa evaluated 329 pesticide misuse complaints involving dicamba drift. The reported dicamba injury cases across the Iowa landscape was the most extensive the state had seen since the introduction of dicamba in the 1960s (Hartzler and Jha 2020). Agronomists in several areas of the state reported nearly all non-dicamba resistant soybean exhibited symptoms characteristic of dicamba injury, and in many fields the injury was found fence row to fence row (Hartzler and Jha 2020). The extensive nature of the injury was due to several factors. There was a record early season pace for planting of both corn and soybean across most of the state. This resulted in soybean reaching susceptible stages when early applications of dicamba were being made to corn. In many areas there was an overlap between dicamba being sprayed on corn and soybean—these two factors do not commonly coincide (Hartzler and Jha 2020). Weather conditions offered few days ideal for applying herbicides. In some areas wind speeds during the day averaged greater than 12 MPH for 10 of the 14 days, resulting in a total of 40 hours during that time period when daytime wind speeds were between 3 and 10 MPH. Temperatures exceeded 85° F on five of those days. Weather conditions limited opportunities to apply dicamba, resulting in large quantities of dicamba being applied in a small time period. Limited rainfall left dicamba on soil and foliar surfaces for extended periods of time where it was prone to volatilization during hot periods (Hartzler and Jha 2020).

Some weed scientists have used the term "atmospheric loading" to describe problems with dicamba drift and volatilization. Atmospheric loading refers to an effective amount of dicamba moving into/through the atmosphere in a given area, where it can be difficult to identify the specific site(s) of application that resulted drift and injury to a particular crop field (Hartzler and Jha 2020). This is what appears to have occurred across much of Iowa in 2020. Weed scientists at Iowa State University concluded that there is no simple solution to this issue—other than reevaluating dicamba use in corn and soybean (Hartzler and Jha 2020). Other herbicides do not usually lead to atmospheric loading. This feature of dicamba can result in harm to crops not resistant to dicamba, and wild and cultivated plants, as a result off target movement even when applicators follow EPA registration label, and makes it nearly impossible to identify who is responsible for the atmospheric loading.

In Indiana, state regulators received 152 drift complaints as of June, 2020, with 51 specifically alleging dicamba injury (Unglesbee 2020b). Missouri logged 68 pesticide drift complaints in 2020, 23 were alleged dicamba drift and five are alleged 2-4, D drift. The Illinois Department of Agriculture had received 104 pesticide misuse complaints as of July 3, 2020, with 25 specifically alleging dicamba misuse (Unglesbee 2020b). As of February 2020, the Missouri Department of Agriculture had a backlog of over 600 complaints from farmers related to dicamba drift from another farm harming their crops.

A 2016–2020 Weed Science Society of America (WSSA)/EPA survey of midwestern state farmers growing specialty crops (states of ND, SD, MN, WI, MI, OH, IN, IL, MO, IA, NE, KS) found almost half of respondents reporting crop injury from dicamba and 2,4-D drift (Table ES-5). Moderate to severe damage to specialty crops was reported for all years (Table ES-6).

Table ES-5. Summary of Midwestern State Herbicide Drift Survey on Specialty Crops

Inquiry	Percent of Growers
Did dicamba cause plant damage on your farm?	47%
Did 2,4-D cause plant damage on your farm?	44%
Did glyphosate cause plant damage on your farm?	20%
Did an UNKNOWN herbicide cause plant damage on your farm?	27%
Did OTHER cause plant damage on your farm?	10%

* Specialty crops in the survey: Green, snap, or lima beans; Green peas; Edamame / Food-grade soybean; Dry edible beans; Dry edible peas; Tomatoes; Potatoes; Peppers; Cucumber/Melon; Pumpkins/Squash; Lettuce/Greens; Grapes; Peaches; Apples; Blueberries; Brambles; Strawberries; Flowering annuals; Ornamental perennials; Landscape trees and shrubs; Christmas trees.
Source: (WSSA/EPA 2020)

Table ES-6. Level of Herbicide Damage to Specialty Crops, 2016–2020

Year	2020	2019	2018	2017	2016
Number of Farmers Surveyed	238	231	232	231	231
No drift damage	55%	47%	46%	52%	58%
Minor drift damage	17%	22%	20%	21%	16%
Moderate drift damage	18%	17%	17%	13%	13%
Severe drift damage	10%	13%	14%	11%	8%
NA - no specialty crops grown	0%	1%	3%	4%	5%

Specialty crops in the survey: Green, snap, or lima beans; Green peas; Edamame / Food-grade soybean; Dry edible beans; Dry edible peas; Tomatoes; Potatoes; Peppers; Cucumber/Melon; Pumpkins/Squash; Lettuce/Greens; Grapes; Peaches; Apples; Blueberries; Brambles; Strawberries; Flowering annuals; Ornamental perennials; Landscape trees and shrubs; Christmas trees
Source: (WSSA/EPA 2020)

It should be noted that not all farmers file a complaint when herbicide drift injury has occurred, for various reasons; hence, actual incidences of drift and crop injury are likely underreported in currently available data. In a 2019–2020 WSSA/EPA survey, 40% of Midwestern state farmers reported they could see no benefit in filing a complaint, and 51% were concerned with creating bad relationships with neighboring farms; further reasons are summarized in Table ES-7.

Table ES-7. Summary of Herbicide Drift Survey on Specialty Crops, 2019–2020

Reasons for Not Filing a Complaint (N=99)	Percentage
I filed a complaint any time I had damage	6%
Drift was caused by activities on our own operation	3%
Process involved too much time and paperwork	10%
Could see no benefit in filing a complaint	40%
Consequences to offender are not meaningful	32%
Damage was minor	23%
Unable to identify the source of the drift	26%
Concerned with creating bad relationships with neighboring farms	51%
Concerned with ability to market crops	4%
Resolved the problem without the state's assistance	9%
Another party filed the complaint on my behalf	1%
None of the provided reasons	4%
Other	15%

*Number of respondents = 99. Specialty crops included in the survey: Green, snap, or lima beans; Green peas; Edamame / Food-grade soybean; Dry edible beans; Dry edible peas; Tomatoes; Potatoes; Peppers; Cucumber/Melon; Pumpkins/Squash; Lettuce/Greens; Grapes; Peaches; Apples; Blueberries; Brambles; Strawberries; Flowering annuals; Ornamental perennials; Landscape trees and shrubs; Christmas trees. Source: (WSSA/EPA 2020)

Synthetic Auxin Herbicides and Crop Injury

Synthetic auxin herbicides, which function as plant hormones, can injure a wide variety of broadleaf plants at very low levels of drift, including twisting or epinasty of stems and cupping of leaves (Sciumbato et al. 2004; Gage et al. 2019). Injury to soybean, for example, has been documented at the low rate of 0.03 g/hectare (ha) (0.012 g/acre) of dicamba (Solomon and Bradley 2014). Robinson et al. (2013) observed visible injury (<5% of the crop) at a 0.06 g/ha (0.02 g/acre) dose of dicamba. Three other studies applied dicamba at rates of less than 1 g/ha (0.40 g/A) and observed plant injury; Johnson et al. (2012) observed >25% injury at 0.6 g/ha (0.02 g/acre), Solomon and Bradley (2014) observed at least 10% injury at 0.028 g/ha (0.011 g/acre), and Weidenhamer et al. (1989) reported injury, foliar aberrations, at 0.06 g/ha (0.02 g/acre)—percent of crop injury was not reported.

Besides susceptible cotton and soybean crops, vegetable and fruit crops, orchards, vineyards, and residential and commercial properties can be damaged by off-target movement of synthetic auxins (Dittmar et al. 2016; Streibig and Green 2017). For example, tomato (*Lycopersicon esculentum* Mill. 'Marglobe") and lettuce (*Latuca sativa* L.) crops may be injured with as little as 0.001% of the labeled use rate for 2,4-D butyl ester (Van Rensburg and Breeze 1990). Depending on the susceptibility of plants, off-target injury can occur at a considerable distance from the point of application; once herbicides become suspended in the atmosphere they can be re-deposited by gravity, or rainfall (Bish et al. 2021; Oseland et al. 2022). Thus, as synthetic auxin herbicide resistance traits become more widely utilized in crops, the potential for off-target movement and injury to non-resistant crops can also increase.

As an example: Crops resistant to dicamba and 2,4-D could be a cause of concern for sweet potato (*Ipomoea batatas*) producers owing to the potential effects of spray or vapor drift. A field study was conducted in 2016 and 2017 to assess the impacts of reduced rates of combinations of glyphosate with 2,4-D or dicamba on sweet potato growth and production (Miller et al. 2020). Reduced rates of 1/10x, 1/33x, 1/66x, and 1/100x the rate of glyphosate at 1 lb/acre plus 2,4-D choline at 0.94 lb/acre and glyphosate at 1 lb/acre, plus diglycolamine salt of dicamba at 0.5 lb/acre, were applied to Beauregard sweet potato at 10 and 30 days after transplanting. With respect to visual injury, glyphosate plus dicamba proved to be more injurious than glyphosate plus 2,4-D, particularly within the lower rate range. Typical auxin injury symptomology was evident 35 days after application. In most cases, injury to sweet potato plants was greater at later application timing, presumably due to larger plants having greater leaf surface area for herbicide interception (Miller et al. 2020).

ES 6 PHYSICAL ENVIRONMENT

Soils

The agronomic practices and inputs used for MON 87429 corn production that can impact soil quality (e.g., tillage, pesticide use, irrigation, cover cropping) would not be substantially different from those currently used in crop production, thus, potential impacts on soils resulting from MON 87429 corn/progeny cultivation would be the same or similar as for other corn crop varieties. There could be shifts in the types and quantities of herbicide active ingredients used on corn, as previously discussed, although this would not be expected to present a significant risk to soils—no more so than the agronomic practices currently used in corn production. The HR trait genes/gene products, which were derived from naturally occurring soil bacteria (e.g., *Sphingobium, Streptomyces, Stenotrophomonas, Agrobacterium*), are not expected to have any adverse effects on soil quality/fertility.

Where growers are concerned about weeds resistant to multiple herbicides, they are more likely to use tillage on a greater proportion of their fields—potentially as an emergency stop-gap measure (Dentzman and Burke 2021). Hence, where HR weeds are particularly problematic and other strategies are not effective, growers may forego conservation tillage and use more aggressive tillage practices to control HR weeds, which can increase soil erosional capacity. Stacked-trait HR varieties, such as MON 87429 corn hybrids, could potentially help prevent, or curtail, the further development of HR weed populations, thereby limiting the need for tillage in control of resistant weed populations, as well as use of additional herbicides for control of HR weeds.

Water Resources

The sources of potential impacts on water resources, namely non-point source (NPS) pollutants in agricultural run-off, would not substantially differ with MON 87429 corn (e.g., sediments, fertilizers, insecticides, herbicides, fungicides). Cultivation of MON 87429 corn hybrids, where adopted, would however contribute to shifts in the types and patterns of herbicides used, facilitating the use of glyphosate, glufosinate, dicamba, 2,4-D, and quizalofop-p-ethyl in lieu of other herbicides. As use of stacked-trait HR varieties increases, how they may, or may not, contribute in a collective manner to increased annual herbicide use on U.S. corn acres is uncertain. Herbicide use would be influenced by the extent and type of weeds and HR weeds present on individual farms. Any increase in herbicide use with MON 87429 corn hybrid production could—in combination with current stacked-trait HR crops and those stacked-trait HR crops adopted in the future—potentially contribute to increased risks to surface water and groundwater quality in areas where stacked-trait HR crops are grown. Relative to run-off, there could also be risks to downstream estuaries and nearshore environments.

In general, herbicides may cause biological impairments of water bodies if they occur in water or sediment at sufficient concentrations to have an effect. Most commonly, they enter surface water in runoff, or groundwater in leachate. Herbicides can also be deposited to surface waters via atmospheric deposition, by dry deposition of particulates or rainfall (Bish et al. 2021; Oseland et al. 2022). Because most herbicides have relatively low toxicity to fish and invertebrates (US-EPA 2021a), acute toxicity is likely only when herbicides are deliberately or accidentally applied directly to water bodies (US-EPA 2021b). The only herbicides used with MON 87429 corn that present a potential risk of toxicity to fish and invertebrates are 2,4-D esters and quizalofop-p-ethyl, albeit at relatively high concentrations (US-EPA 2021a). All herbicide use with MON 87429 corn would be subject to EPA and state use requirements/limits/restrictions, which are intended to be protective of water quality and aquatic biota (US-EPA 2019h).

As discussed above for soils, stacked-trait HR varieties, such as MON 87429 corn hybrids, could potentially help prevent, or curtail, the further development of HR weed populations, thereby limiting the need for tillage for control of HR weed populations, as well as use of additional herbicides for control of HR weeds. In this respect, stacked-trait HR varieties could be considered of potential benefit to water quality in the long-term; provided they are incorporated into effective IWM programs.

There is no association between MON 87429 corn and increased water demand (e.g., irrigation), relative to its phenotype (Monsanto 2019). Thus, potential impacts on surface or groundwater use would be no different than that with most other dent corn varieties.

Air Quality

To protect environmental and public health the EPA, pursuant to the Clean Air Act (CAA), establishes National Ambient Air Quality Standards (NAAQS) that aim to limit atmospheric emissions (US-EPA 2019e). NAAQS are established for six criteria pollutants: ozone (O_3), nitrogen dioxide (NO_2), carbon monoxide (CO), sulfur dioxide (SO_2), lead (Pb), and particulate matter (PM). In addition to criteria pollutants, the EPA regulates 187 hazardous air pollutants under the CAA, such as ammonia and hydrogen sulfide, as well as greenhouse gas emissions.

MON 87429 corn hybrids, if adopted by growers, would be expected to replace HR corn varieties currently cultivated, as opposed to augmenting current corn crops. Because there would be little to no increase in acreage resulting from MON 87429 corn seed or hybrid production, nor changes to emission sources (i.e., tillage, fossil fuel burning equipment, the application of fertilizers and pesticides), no significant changes in the volume of emissions from U.S. corn production would be expected. Whether there may be increased frequency of herbicide applications with MON 87429 corn hybrids over a growing season is somewhat uncertain (Lingenfelter and Curran 2022), although not expected to occur. In general, the contribution of MON 87429 corn hybrid production to the aggregate emissions of air pollutants from U.S. cropping systems is expected to be similar to what currently occurs with other corn crops.

Cultivation of MON 87429 corn hybrids, where adopted, would contribute to shifts in the types and patterns of herbicides used, facilitating the use of glyphosate, glufosinate, dicamba, 2,4-D, and quizalofop-p-ethyl in lieu of other herbicides. As use of stacked-trait HR varieties increases, how they may, or may not, contribute in a collective manner to increased annual herbicide use on U.S. corn acres, via tank mixing of differing herbicide MOAs, is uncertain. Increased volume of herbicide use could pose risks to air quality through herbicide drift and volatilization. While an increase in herbicide use could occur through tank mixing of different herbicide MOAs, increasing the volume of total herbicides applied in one application, all herbicides used with MON 87429 corn have annual use limits—maximal EPA permitted amounts for use during a crop season (e.g., (US-EPA 2014a, 2016c, 2018, 2019f; Lingenfelter and Curran 2022)).

Relative to the efficacy of MON 87429 corn hybrids in the management of weeds and HR weed development, as previously discussed, effective weed management within an IWM program can reduce/eliminate the need for tillage in weed control. On average, farmers who switch from continuous conventional till to continuous no-till save more than four gallons of diesel fuel per acre each year (Creech 2018). To the extent MON 87429 corn hybrids facilitate effective IWM programs, and preclude the need for tillage, benefits to air quality would be expected.

ES 7 BIOLOGICAL RESOURCES

Soil Biota

The introduced herbicide resistance transgenes and gene products in MON 87429 corn, which are derived from common soil-borne biota and plants, are not expected to have any effects on soil biota or community structures in corn fields—no different than conventionally bred corn plants. The majority of species of soil microbiota, such as bacilli, non-coryneform rods, streptomycetes, and fungi produce nucleases that degrade free RNA and DNA (Antheunisse 1972). Both free DNA and RNA have been found to be fully degraded in soils, mineralized to nitrogen, within about 30 days (Greaves and Wilson 1970; Keown et al. 2004; Levy-Booth et al. 2008).

Some pesticides used on corn crops can, relative to the application rates, potential toxicity, and frequency of exposure of soil biota to a pesticide, have effects on soil communities (Stevenson et al. 2002; Locke and Zablotowicz 2004). A recent global assessment of the impact of plant protection products on soil functions and soil ecosystems concluded that most agricultural inputs can cause transient changes in the amount, activity, diversity, and community structures of soil organisms (FAO 2017). Changes in community structure are in fact the most common type of effects observed with pesticides (FAO 2017). In general, the herbicides intended for use with MON 87429 corn may have temporary effects on soil organisms/communities, such as increases/decreases in biomass, enzymatic activity, soil respiration, and variations in species composition (Tu 1992; Lupwayi et al. 2004; Singh and Singh 2016; Tarla et al. 2020). There is limited evidence that the observed effects of these herbicides on soil organisms have led to significant and long-lasting decreases in soil functions (FAO 2017).

Most herbicides, used at typical application rates, are generally considered to have no major long-term effect on soil biota populations or biogeochemical processes (Tu 1992; Subhani et al. 2000; Lupwayi et al. 2004; Wolmarans and Swart 2014; FAO 2017). There is currently limited evidence that the observed effects of herbicides on soil organisms, which are primarily changes in community structure/species composition, have led to long-lasting impairment of soil functions (FAO 2017). While the application of herbicides may in some instances lead to the local suppression of a taxonomic unit of soil organisms, the resiliency of soil organisms, or ability to adapt, and functional redundancy across various taxa, serve to limit the effects of herbicides on soil ecosystem processes (FAO 2017). Many herbicide active ingredients, including glyphosate and 2,4-D, serve as carbon and energy sources for soil microbiota (Sviridov et al. 2015; Singh and Singh 2016). Dicamba likewise appears to serve as a carbon and energy source for some soil taxa (Voos and Groffman 1997).

For the herbicides that will be used with MON 87429 corn, soil microbial degradation is a primary process by which they are degraded in the environment (Fogarty and Tuovinen 1995; Hsiao et al. 2007; Cycoń et al. 2011; Singh and Singh 2016; la Cecilia and Maggi 2018; Zhou et al. 2018). The field dissipation half-life for glufosinate ranges from around 3 to 20 days (avg. 13 days) (TOXNET 2019). Biodegradation half-life of glyphosate in soil is around 2 to 7 days under aerobic conditions. Dicamba has a typical field half-life ranging from 30 to 60 days (TOXNET 2019). For 2,4-D, an average half-life of 4 days has been observed (NPIC 2020b). Reported half-lives for quizalofop-p-ethyl range from around half a day to 4 days, although under certain conditions a half-life of 60 days was observed (Mantzos et al. 2017; TOXNET 2019).

The herbicides to be used with MON 87429 corn have a long history of use in U.S. agriculture; impacts on soil biota have not been raised as a significant concern with any of the herbicide active ingredients. Rather, it is the particular agronomic practices employed, such the types of crop rotations, fallowing, tillage, and cover cropping practices, that are the primary determinants of soil microbial activity, soil health (Nielsen and Calderón 2011; FAO 2017). Fundamentally, the vast majority of soil organisms have yet to be identified, and a comprehensive understanding of the effects of herbicides on soil biota is not possible at this time (FAO 2017).

Plant Communities

MON 87429 hybrid production would be expected to have similar impacts on vegetation surrounding MON 87429 corn/hybrid fields as other crops, relative to the particular herbicides that would be used with this variety. When crops are sprayed with herbicides, sublethal doses may reach non-target plants in adjacent habitats through spray drift, runoff, and/or volatilization. Sublethal effects could include negative effects on leaves (photosynthesis), seed production, delays in flowering times, and reductions in flower production. Typically, less than 1% of herbicide applied to crops is lost to groundwater leaching, approximately 1%–4% is carried away in surface runoff, with losses via spray drift and volatilization ranging between 5%–25% (Boutin et al. 2014; Prueger et al. 2017).

Any of the herbicides used with MON 87429 corn—glyphosate, glufosinate, quizalofop-p-ethyl, 2,4-D, and dicamba—could potentially move offsite via run-off or/and spray drift and affect non-crop plants. Among these, as discussed, some formulations of dicamba and 2,4-D, owing to their inherent chemistries—vapor pressures—have been more prone to offsite movement via spray drift and vaporization. As auxin mimic herbicides (plant hormone), dicamba and 2,4-D can affect plants at low doses. Dicamba spray or vapor drift and has presented issues for both crop producers (e.g., vineyards, cotton, soybean, tomato) and property owners outside the agricultural sector (Unglesbee 2018b, 2019a). 2,4-D can, to a lesser extent, present problems with spray and vapor drift, although most 2,4-D formulations are considered low-volatile (e.g., BEE and 2-EHE esters). Given these factors, focus is given here to these herbicides and potential impacts on wild plants, and wild and cultivated plants on residential and commercial properties.

In general, the level of incidence and injury to non-crop plants increased since the adoption of dicamba and 2,4-D resistant soybean and cotton crops that facilitate OTT use of these herbicides later into the growing season when temperatures are higher (Unglesbee 2018b, 2019a; US-EPA 2021d). Xtend soybeans and cotton, which are resistant to dicamba and glyphosate, were commercialized in 2016. Enlist cotton, resistant to 2,4-D, glyphosate, and glufosinate was commercialized in 2016, and Enlist soybean, resistant to glyphosate, glufosinate, and 2,4-D in 2019. Enlist Duo corn, resistant to glyphosate and 2,4-D was commercially available in 2014, and SmartStax Enlist corn resistant to glyphosate, glufosinate, 2,4-D, and ACCase-FOP herbicides commercialized in 2018 (Table ES-8). Note that while these crops and the respective herbicides that could be used with them became commercially available for sale and use, it does not mean they were necessarily utilized, grown for commercial purposes.

Table ES-8. Stacked-Trait 2,4-D, Glyphosate, Dicamba, and Glufosinate Resistant Crops

Crop	Stacked-Trait Herbicide Resistant traits	Trade name	Year Commercialized in the United States
Corn	Glyphosate and glufosinate	SmartStax	2010
Corn	Glyphosate and 2,4-D	Enlist Duo	2014
Corn	Glyphosate, glufosinate, 2,4-D and ACCase-FOP	SmartStax Enlist	2018
Soybean	Glyphosate and glufosinate	Liberty-Link	2009
Soybean	Glyphosate and dicamba	Roundup Ready Xtend	2016
Soybean	Glyphosate, glufosinate and 2,4-D	Enlist E3	2019
Soybean	Glufosinate	LibertyLink	2009
Cotton	Glyphosate and dicamba	Roundup Ready Xtend	2016
Cotton	Glyphosate, glufosinate and 2,4-D	Enlist	2016
Cotton	Glyphosate and glufosinate	GlyTol Liberty Link	2014

Source: (ISAAA 2022)

As previously reviewed, drift of sprays or vapors of dicamba, and some formulations of 2,4-D, owing to their efficacy as auxin mimic herbicides, and effects on a wide variety of broadleaf plants at low doses, could potentially result in off-target effects on plants in natural areas, or on residential or commercial properties, as a result of the use of these herbicides. Both dicamba and 2,4-D are synthetic auxins that mimic plant hormones, which disrupt growth and metabolic processes in a wide variety of broadleaf plants at relatively low doses. Numerous species of trees, vines, shrubs, and herbaceous broadleaf plants have shown sensitivity to dicamba and 2,4-D (Dintelmann et al. 2019).

Herbicide Use with HR Soybean, HR Cotton, and HR Corn

As dicamba and 2,4-D resistant crops were adopted subsequent to commercial availability, use of these herbicides increased in most of these cropping systems (Table ES-9). For example: In 2015, approximately 172,000 lbs of dicamba a.i. was applied to soybean, and 130,000 lbs dicamba a.i. applied to cotton. In 2018, 6,716,000 lbs a.i. dicamba was applied to soybean, and in 2019, 5,575,000 dicamba a.i. applied to cotton. In 2015, approximately 683,000 lbs of 2,4-D a.i. was applied to cotton, and in 2019, 2,255,000 lbs a.i. applied. In general, dicamba use in soybean increased around 7,619% from 2012 to 2018, and dicamba use in cotton increased about 3,299% from 2007 to 2019. Glufosinate use in soybeans—subsequent to introduction of glufosinate resistant Liberty-Link and Xtend soybeans—also increased, from 2,313,000 lbs a.i. in 2015 (5% of total herbicide use), to 9,759,000 lbs a.i. in 2018 (18% of total herbicide use).

Table ES-9. Herbicide Use in Corn, Soybean, and Cotton

	Corn			
	2010	**2014**	**2016**	**2018**
	lbs a.i./Yr			
Glyphosate	**64,359,000**	**61,364,000**	**82,264,000**	**66,586,000**
Treated Acres, % of Area Planted	77%	77%	81%	76%
Portion of Total Herbicide Use	35.33%	34.81%	36.39%	31.01%
Glufosinate	**515,000**	**234,000**	**298,000**	**488,000**
Treated Acres, % of Area Planted	1%	1%	1%	1%
Portion of Total Herbicide Use	0.28%	0.13%	0.13%	0.23%
Dicamba	**998,000**	**1,304,000**	**2,363,000**	**2,929,000**
Treated Acres, % of Area Planted	10%	10%	15%	17%
Portion of Total Herbicide Use	0.55%	0.74%	1.05%	1.36%
2,4-D	**2,936,000**	**4,231,000**	**6,162,000**	**5,308,000**
Treated Acres, % of Area Planted	8%	8%	12%	12%
Portion of Total Herbicide Use	1.61%	2.40%	2.73%	2.47%
Total Herbicides Applied	**182,150,000**	**176,291,000**	**226,042,000**	**214,721,000**
Total Acres Planted	**88,192,000**	**90,597,000**	**94,004,000**	**88,871,000**
	Soybean			
	2012	**2015**	**2017**	**2018**
	lbs a.i./Yr			
Glyphosate	**109,336,000**	**106,935,000**	**93,509,000**	**95,719,000**
Treated Acres, % of Area Planted	*98%*	89%	86%	87%
Portion of Total Herbicide Use	82.22%	71.17%	58.03%	52.00%
Glufosinate	**1,253,000**	**2,313,000**	**6,424,000**	**9,759,000**
Treated Acres, % of Area Planted	*3%*	5%	13%	18%
Portion of Total Herbicide Use	0.94%	1.54%	3.99%	5.30%
Dicamba	**87,000**	**172,000**	**6,810,000**	**6,716,000**
Treated Acres, % of Area Planted	*NR*	NR	15%	14%
Portion of Total Herbicide Use	0.07%	0.11%	4.23%	3.65%
2,4-D	**6,524,000**	**7,715,000**	**9,756,000**	**8,529,000**
Treated Acres, % of Area Planted	*15%*	17%	19%	17%
Portion of Total Herbicide Use	4.91%	5.13%	6.05%	4.63%
Total Herbicides Applied	**132,979,000**	**150,246,000**	**161,144,000**	**184,060,000**
Total Acres Planted	**77,198,000**	**82,660,000**	**90,162,000**	**89,167,000**
	Cotton			
	2007	**2015**	**2017**	**2019**
	lbs a.i./Yr			
Glyphosate	**17,311,000**	**14,386,000**	**14,388,000**	**22,451,000**
Treated Acres, % of Area Planted	91%	88%	80%	93%
Portion of Total Herbicide Use	66.04%	54.63%	48.72%	51.64%
Glufosinate	**77,000**	847,000	1,150,000	746,000

Treated Acres, % of Area Planted	2%	13%	17%	8%
Portion of Total Herbicide Use	0.29%	3.22%	3.89%	1.72%
Dicamba	**164,000**	**130,000**	**1,999,000**	**5,575,000**
Treated Acres, % of Area Planted	7%	6%	33%	40%
Portion of Total Herbicide Use	0.63%	0.49%	6.77%	12.82%
2,4-D	**475,000**	**683,000**	**1,072,000**	**2,255,000**
Treated Acres, % of Area Planted	9%	10%	12%	**20%**
Portion of Total Herbicide Use	1.81%	2.59%	3.63%	5.19%
Total Herbicides Applied	**26,214,000**	**26,334,000**	**29,529,000**	**43,477,000**
Total Acres Planted	**10,827,200**	**8,580,500**	**12,717,500**	**13,735,700**

Source: (USDA-NASS 2023)

Acreage/Areas Potentially Affected by Herbicide Use with MON 87429 HR Corn

Soybean and corn, which are commonly rotated together, are primarily grown in the central United States and east coast mid-Atlantic states (Figure ES-3, Figure ES-4). Cotton is grown in southeastern and southern states (Figure ES-5). These are the areas in which dicamba and 2,4-D resistant soybean and, cotton have been grown, and MON 87429 corn crops would be grown, and associated herbicides predominantly used. There are no dicamba resistant corn varieties yet grown in the United States. In terms of total acreage, in 2020, 194 million acres of corn, soybeans, and cotton combined were planted.

Glyphosate and dicamba-resistant Roundup Ready 2 Xtend soybeans accounted for 60% of the soybeans planted in the United States in 2019, roughly 54 million acres (Unglesbee 2019d). In 2019, Corteva Agriscience estimated Enlist E3 soybeans, resistant to 2,4-D choline, glyphosate, and glufosinate comprised around 10% of U.S. soybean acreage, roughly 9 million acres. The company had over 100 licensees for 2019 and 2020, and since the technology was launched, saw a 15% increase in the number of seed companies that have chosen to obtain a trait license (Unglesbee 2019d). XtendFlex soybeans, resistant to over-the-top use of glyphosate, dicamba, and glufosinate, became commercially available in 2021. The states with the most dicamba-resistant seed use in 2018, were Mississippi, Tennessee, and Kansas—where approximately 79%, 71%, and 69% of soybean acreage was planted with these varieties, respectively (Wechsler et al. 2019).

Enlist cotton acres were estimated to be 1.5 million acres in 2018, up from 500,000 in 2017 (Unglesbee 2018a). Cotton with XtendFlex technology, resistant to glyphosate, dicamba, and glufosinate, was planted on 73% of U.S. cotton acres—9.85 million acres—in 2018 (Fava and Hallahan 2019). XtendFlex cotton and Roundup Ready 2 Xtend soybeans (resistant to glyphosate and dicamba) were planted on an estimated 60 million acres of U.S. farm fields in 2019, which is equal to the land area of Illinois and Indiana combined (Fava and Hallahan 2019).

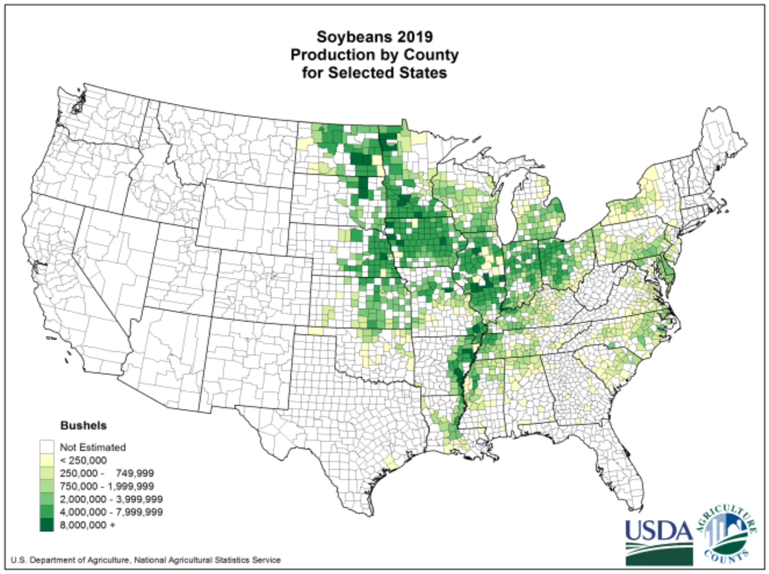

Figure ES-3. Areas of Soybean Production in the United States

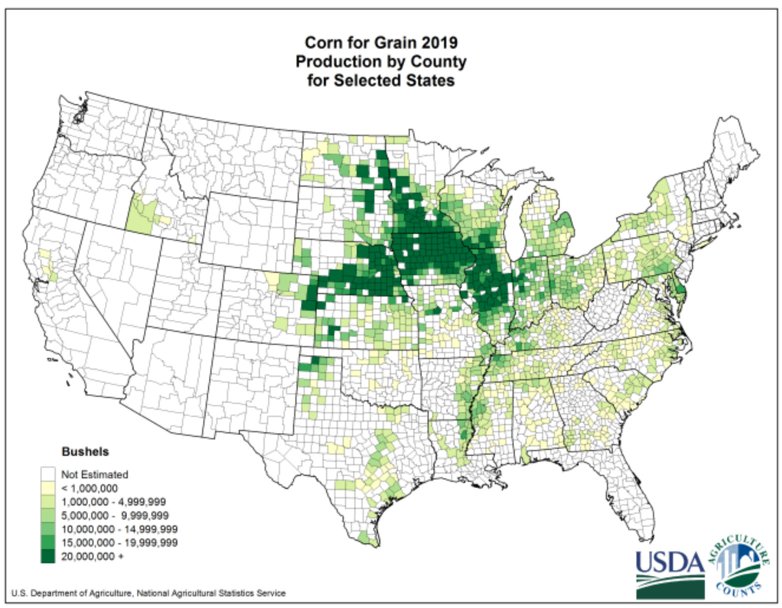

Figure ES-4. Areas of Corn Production in the United States

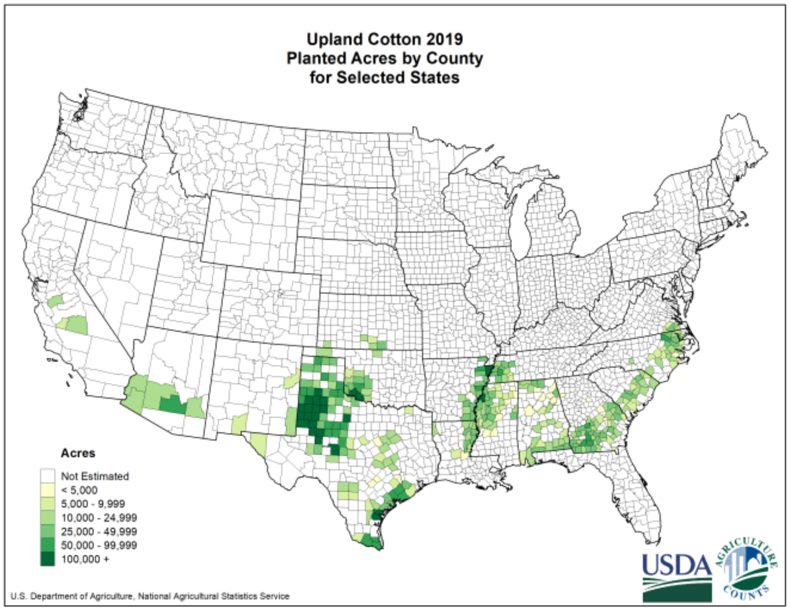

Figure ES-5. Areas of Cotton Production in the United States

Drift Damage Identification, Reporting, and Management

Injuries to non-crop plants can be reported to the Ecological Pesticide Incident Reporting Portal at http://npic. orst.edu/eco/. For drift, misuse, or concerning uses, potential violations are reported to the state pesticide regulatory agency.

It is probable that only a small percentage of actual damages to non-crop plants and private lands are reported to the Ecological Pesticide Incident Reporting Portal or state agencies. Even with crops, not all cases of injury are reported. One survey of Missouri farmers, pesticide applicators, and crop advisors estimated that over 73% of dicamba injury in 2019 went unreported (Bradley 2019). Another study that surveyed growers for dicamba injury to non-dicamba resistant soybeans found that of the survey respondents reporting injury (51%), only 7% actually filed a complaint (Werle et al. 2018). Apart from the underreported incidences of observed dicamba injury, the injuries to non-crop species, such as trees on private residences, forested lands, and other natural areas are likely not often recognized, and thus unreported.

EPA Herbicide Label Requirements and State Use Restrictions

As discussed above, the potential for off-target injury to crop and non-crop plants that has been associated with late season dicamba use is well recognized by the agricultural community and EPA (Unglesbee 2019b; Hartzler and Jha 2020; Unglesbee 2020b; US-EPA 2020x, o, 2021d). Over the last several years, the EPA has revised labels for dicamba products registered for use in soybean and cotton that include restrictions intended to minimize off-target movement (e.g., (US-EPA 2020t, 2022d, 2023b)). For example, the EPA established federal cutoff dates for use of three dicamba herbicides: June 30 for soybeans and July 30 for cotton (US-EPA 2020t, s, r). The new labels include expanded buffers designed to limit off-target movement. The requirement for downwind buffers at field edges is considered one of the most important strategies for protecting monarch butterfly habitat and other natural areas (Hartzler 2018). A downwind buffer of 240 feet between the last treated row of a field and the nearest downwind field edge is now required. The second buffer requirement is a 57-foot omnidirectional buffer, combined with a 310 foot downwind buffer to protect endangered species. This buffer is only required in counties that have been listed on EPA's Bulletins Live! Two website, because they house federally recognized endangered species. No dicamba applications are permitted if the wind is blowing, at any speed, toward a sensitive crop or plant. While dicamba volatility remains a concern, the quantity that leaves fields due to vapor loss is typically much less than associated with particle drift.

As previously mentioned, in March 2022, the EPA approved additional labeling to further restrict use of dicamba in Minnesota and Iowa (US-EPA 2022d), and in February 2023, the EPA approved additional labeling for Iowa, Illinois, Indiana, and South Dakota (US-EPA 2023b). The restrictions are intended to reduce the likelihood of volatility and offsite movement of dicamba by avoiding application on days with high temperatures. For Iowa, the February 2023 amendment supersedes the March 2022 amendment.

If states wish to impose further restrictions on dicamba products, or any other federally registered pesticides, they can do so under section 24(a) of FIFRA (US-EPA 2020p). Section 24(a) establishes that states have the right to regulate federal pesticides through state legislatures or rulemaking procedures.

Bayer states the use of dicamba on MON 87429 corn will follow current EPA registration label use requirements for corn. The maximum annual use rate would be a total of 0.75 lbs. a.e. per treated acre per crop year. Maximum application rate would be 0.5 lb. a.e. per acre, with no more than 2 applications per growing season (Bayer-CropSci 2022). Use restrictions would include (US-EPA 2010):

- Application prohibited if corn is more than 36 inches tall or within 15 days before tassel emergence, whichever comes first.

- Application prohibited when soybeans are growing nearby if any of these conditions exist: corn is more than 24" tall; soybeans are more than 10" tall; soybeans have begun to bloom.

Use of dicamba and 2,4-D based herbicides with MON 87429 corn hybrids would be expected to present the same risks for spray and vapor drift, injury to wild plants, and ornamental plants on residential and commercial properties, as with other crops on which registered dicamba and 2,4-D products are used. Much of the potential risks of off-target effects with these herbicides (as well as other herbicides) will depend on the particular formulations used, EPA and state use requirements/restrictions, and strict adherence of applicators to EPA and state use requirements and restrictions.

Aquatic Plants

Herbicides used on crops and non-crop sites can affect aquatic plants as well via run-off. The U.S. Geological Survey (USGS) conducted a study comprising 100 streams during May–August 2013. A total of 183 pesticide compounds (94 parent pesticides and 89 degradates) were detected in one or more samples, consisting of 98 of the 124 herbicides evaluated, 71 of the 88 insecticides evaluated, and 14 of the 16 fungicides. Corn and soybean herbicides, namely atrazine, metolachlor, acetochlor, and their degradates tended to have the highest detection frequencies and concentrations, consistent with past studies in the Midwest (see review by (Nowell et al. 2018). Other herbicides frequently detected at agricultural sites were dimethenamid and its degradates, sulfentrazone, propazine, 2,4-D, prometon, and glyphosate. Notably, the herbicides 2,4-D, glyphosate, and prometon were detected at higher concentrations and more often at urban sites, as opposed to agricultural sites. For agricultural sites, glyphosate occurrence was found in 41% of samples, atrazine in 57% of samples, metolachlor 32%, and acetochlor 16% of samples.

Herbicide degradates observed in this study, and in past studies of Midwestern streams, include the sulfonic and oxanilic acid degradates of acetanilide herbicides and atrazine degradates CAAT, CIAT, OIET, and CEAT (Nowell et al. 2018). The atrazine degradates OIAT, OEAT, OIET, and 21 acetanilide or amide herbicide degradates are new analytes in the NAWQA project as of 2013. Many of these herbicide degradates, the fungicide/degradate carbendazim, and several degradates of fipronil were among the most frequently detected pesticide compounds at some MSQA site types

The USGS study found that spatially intensive, short-term temporal use of certain pesticides—the herbicides metolachlor, acetochlor, and atrazine; the insecticides imidacloprid, fipronil, and organophosphates; and the fungicide/degradate carbendazim can have acute but likely reversible effects on aquatic plant biomass (Nowell et al. 2018). For aquatic plants, acute but likely reversible effects on biomass were predicted in 75% of streams, with potential longer-term effects on plant communities in 9% of streams. Relatively few pesticides in water—atrazine, acetochlor, metolachlor, imidacloprid, fipronil, organophosphate insecticides, and carbendazim—were predicted to be major contributors to potential toxicity (Nowell et al. 2018). Specifically, the compounds responsible for acute-plant benchmark exceedances were triazine (at 73% of sites), acetanilide (19% of sites), 2,4-D (5%), and sulfonylurea (3%) herbicides.

Agricultural streams had the highest potential for effects on aquatic plants, especially in May–June, corresponding to high spring-flush herbicide concentrations. Maximum herbicide concentrations in streams were significantly related to their agricultural use intensity (e.g., in lbs a.i./acre), and to the percentage of cropland treated in a given basin studied (Nowell et al. 2018). Thus, not surprisingly, there is a direct correlation between the amount of herbicide used, the total area treated the herbicide, and the concentration of herbicides in surface waters (Nowell et al. 2018).

The USGS study concluded that during spring/summer there could be potential for acute, but short-term effects on aquatic plant growth. In the streams evaluated, the potential reversibility, recovery of aquatic plants, can limit the adverse effects of herbicides, on the aquatic environment. In general, herbicides can temporarily suppress the growth of algae and aquatic plants (macrophytes), but populations tend to recover once exposure is reduced (Fairchild 2011).

Ecological Risk Assessments for the Herbicides Used with Mon 87429 Corn

All of the herbicide active ingredients that would be used with MON 87429 corn are currently labeled for use on a variety of crops as well as in non-agricultural settings (e.g., residential and commercial properties). The risks of pesticide use on plants, to include risks from aggregate uses, are assessed by the EPA as part of the pesticide registration process and are regularly reevaluated by EPA for each pesticide to maintain its registered status under FIFRA. The EPA has conducted ecological risk assessments (ERAs) for glufosinate (US-EPA 2016c), dicamba (US-EPA 2022a), 2,4-D (US-EPA 2017b), quizalofop-p-ethyl (US-EPA 2014a), and glyphosate (US-EPA 2019f), and these risks assessments incorporated here by reference as part of hazard assessment for plants. The reader is referred to these ERAs for a more detailed discussion of the potential effects of these herbicides on plants. The EPA uses these risk assessments in establishing herbicide label use requirements that are intended to limit the adverse effects on non-target plants.

In August 2022, as part of EPA's obligation to re-evaluate pesticides every 15 years, the EPA published for public review and comment an updated draft ecological risk assessment for dicamba (US-EPA 2022a). After reviewing comments received during the public comment period, the EPA may issue a revised risk assessment, explain any changes to the draft risk assessment, and respond to comments and may request public input on risk mitigation before completing a proposed registration review decision for dicamba. Through this program, EPA is ensuring that each pesticide's registration is based on current scientific and other knowledge, including its effects on human health and the environment.

Gene Flow and Potential Weediness of Corn

MON 87429 corn, if grown for commercial purposes, would present the same potential risk for gene flow, specifically the propensity for and frequency of gene flow, as current corn varieties. Accordingly, a determination of nonregulated status for MON 87429 corn and subsequent commercial production would not be expected to present more or less risk for gene flow to wild relative species, or other corn crops, as do current corn varieties.

Based on the agronomic field data (Monsanto 2019), MON 87429 corn is unlikely to persist as a problematic volunteer plant with adverse impacts on crop production. There are no differences between MON 87429 and conventional corn in terms growth rate, lodging, seed loss, final stand count, and other agronomic characteristics (Monsanto 2019). Extensive post-harvest monitoring of field trial plots planted with MON 87429 corn under USDA-APHIS authorizations did not reveal any differences in survivability or persistence of MON 87429 corn relative to other varieties of corn currently being grown. MON 87429 corn volunteers can be managed using a variety of currently available cultural methods, as well as herbicides (e.g., Gramoxone® (paraquat), Tricor® (metribuzin), Raptor® (Imazamox), Poast® (sethoxydim), and cyclohexanediones such as clethodim and sethoxydim) (Monsanto 2019), albeit with relatively fewer herbicide options compared to conventional corn.

Animal Communities

MON 87429 corn is compositionally (apart from the HR traits) and nutritionally similar to other dent corn varieties (Monsanto 2019). Consumption of MON 87429 corn grain or other plant parts by wildlife, whether vertebrates or invertebrates, would provide the same general nutritional benefits as other dent corn varieties.

MON 87429 corn differs, however, from other varieties in the four herbicide resistant trait genes, and gene products it produces. MON 87429 corn hybrids would influence the types of herbicides used in U.S. crops, and thereby the potential exposure of wildlife to these herbicides. Thus, conceptually, the potential risks to wildlife, as a matter of hazard assessment, would be from (1) exposure to the HR trait genes and gene products via consumption of the kernel or other plant parts, this type of feeding largely limited to granivorous insects, foraging birds, rodents, and larger mammals, and (2) exposure to the herbicides MON 87429 corn facilitates use of. Exposure to herbicides could result from consumption of plant material immediately after spraying, or exposure to spray drift or vapors during and post-application. As discussed in the section on U.S. Corn Production, there could be increased herbicide use with MON 87429 corn hybrids. Hence, conceptually, there could be increased risk presented to wildlife if herbicide use increases with this crop variety.

APHIS has previously evaluated the *pat*, *dmo*, and *cp4 epsps* trait genes and gene products in previous EAs and EISs (USDA-APHIS 2020d), and provides a summary of the safety of these trait gene/gene products later in this EIS in Section 4.3.4; no risks to vertebrate or invertebrate wildlife communities have been identified. The *ft_t*/FT_T trait could be considered somewhat novel in that it is a modified version of the R-2,4-dichlorophenoxypropionate dioxygenase gene (*Rdpa*) from the soil bacteria *Sphingobium herbicidovorans*. Rdpa is a type of bacterial enzyme classified as aryloxyalkanoate dioxygenases (AADs); similar enzymes (e.g., AAD-1, AAD-12) have been used in prior soybean, corn, and cotton crops to confer 2,4-D resistance (Wright et al. 2010; USDA-APHIS 2020d). APHIS has previously reviewed the genes and gene products *aad-1*/AAD-1 and *aad-12*/AAD-12; APHIS found no risks to wildlife associated with these transgenes and gene products (e.g., petitions 09-233-01p, 13-262-01p, 11-234-01p (USDA-APHIS 2020d)). None of the trait proteins possess any allergenic characteristics (Monsanto 2019). These transgenic trait proteins would be digested—broken down by gastric fluids and proteases into smaller chains of amino acids, in vertebrate and invertebrate digestive systems, and considered physiologically benign (Berg et al. 2002; Klowden 2013; Holtof et al. 2019). Based on the similarity of the *ft_t*/FT_T trait to other AAD enzymes, as reviewed in Sections 4.3.4, it is unlikely that the introduced *ft_t*/FT_T trait would present any risk to wildlife.

Herbicides: Beneficial Insects, Birds, Herbivorous Mammals

Relative to the particular herbicides used with MON 87429 corn, discussed in this EIS, there could be some indirect effects on animal communities via impacts on non-target vegetation that provides food and habitat for wildlife—this would include trophic level impacts, such impacts on insects that feed on vegetation, and subsequent potential effects on birds that feed on insects—the majority of birds rely on insects for at least part of their diets.

As previously discussed, herbicide spray and vapor drift can adversely impact neighboring crops, as well as non-crop plants in natural areas, and on residential/commercial properties. Herbivorous animals that depend on plants for sustenance (e.g., deer, rabbit, squirrel) could be affected by poor quality plant material, resulting from herbicide spray or vapor drift, and the need for animals to spend more time foraging to acquire sufficient food.

The potential effects of herbicide drift offsite on nearby plants and associated populations of beneficial insects (e.g. pollinators, predators and parasitoids) and birds can be of concern (Bohnenblust et al. 2016; NAS 2020). As an example, in 2019 and 2020, the Audubon Society led a community science project to monitor and document dicamba herbicide damage to vegetation on public lands in Arkansas (NAS 2020). Audubon staff and trained volunteers made 363 observations of apparent dicamba injury on a variety of plants across 20 eastern Arkansas counties. Plant species impacted, which included sycamore, oak, pawpaw, redbud, and trumpetvine, were growing on public lands such as university research farms, wildlife management areas, city parks, cemeteries, and along county and state roads. Observations of injury included three state natural areas that harbor the endangered species Red-cockaded Woodpecker and Pondberry (NAS 2020).

Herbicide drift into areas downwind of crop fields and injury to flowering of plants can result in decreased visitation by pollinators and other beneficial insects. For example, one study found that when field margin plants were exposed to dicamba doses from simulated drift, the floral and pollinator resource provisioning capacity of the landscape was reduced by 20%, depending on landscape and crop composition (WSSA 2018). This type of drift-induced damage could decrease agriculturally/commercially beneficial populations of pollinator and natural enemy communities in areas where dicamba is used (Bohnenblust et al. 2016). Insects pollinate around 87.5% of all plants (90% of flowering plants) (Ollerton et al. 2011), and pollinators provide pollination services to dozens of crop varieties, such as canola, cucumber, pear, and squash (Mirocha et al. 1996; Klein et al. 2007).

Although little research has been done on the specific impacts of dicamba on bird habitat and food sources, herbicides prone to drift, and particularly synthetic auxins such as dicamba and 2,4-D, can harm plants that birds, and the prey of birds such as insects, depend on (Knuffman et al. 2020; NAS 2020). The effects of herbicide drift on plants important to birds can include reduced flowering and seed production, reduced number of flowers/seeds, lower fecundity, and modifications in plant morphology and development (Ruhl 2008; Bohnenblust et al. 2016; Wells et al. 2019).

Bohnenblust et al. (2016) examined the effects of dicamba drift on the crop species alfalfa (*Medicago sativa*), which requires insect pollination to produce seeds, and the native plant species common boneset (*Eupatorium perfoliatum*), which is attractive to a wide range of pollinator species. The researchers found that exposure to drift-level doses of dicamba reduced flowering in both plant species. Herbicide-damaged common boneset experienced significantly reduced visitation by insect species, including honeybees (pollinators) and syrphid flies (natural enemies). This study found that both plant species were susceptible to very low doses of dicamba – that just 0.1% to 1% of the expected field application rate can negatively influence flowering. By extension, Bohnenblust et al. (2016) concluded that other broadleaf plant species are likely similarly susceptible to this sort of damage from drift-level doses of dicamba.

It is estimated that around 96% of terrestrial birds rear their young on insects (Tangley 2015), caterpillars being one of the main sources of protein for young birds. During the breeding season, chicks require an ample supply of insects; most birds do not reproduce on berries and seeds (Tangley 2015). In the 16 to 18 days between hatching and fledgling, a clutch of Carolina Chickadee chicks can consume from 6,000 to 9,000 caterpillars (Elliot 2019). This equates to a total of 350 to 570 caterpillars per day, depending on how many chicks are hatched. In the case of chickadees, they all forage within a 150-foot radius of the nest (Tallamy 2021).

Plants and trees can support an impressively diverse number of lepidopteran species, providing food sources and reproductive habitat (Table ES-11). Reduced caterpillar biomass or survival on herbicide-affected plants could impact food resources for birds; insectivorous birds might need to travel farther to collect sufficient caterpillars or other insects to feed their young (Knuffman et al. 2020). In North America, more than 100 species of birds depend on caterpillars as part of their diet, and insect larvae provide a majority of the diets for birds like the Tennessee Warbler, Red-eyed Vireo, and Rose-breasted Grosbeak. The yellow-billed and black-billed cuckoos have the ability to ingest up to 100 very-hairy tent caterpillars per day (Renault 2020).

Table ES-11. Ecologically Valuable Plant Genera Supporting *Lepidoptera* Species in the Mid-Atlantic United States

Rank	Plant genus	Common name	Lepidoptera richness
1	*Quercus*	Oak	534
2	*Prunus*	Cherry; Plum	456
3	*Salix*	Willow	455
4	*Betula*	Birch	411
5	*Populus*	Poplar; Cottonwood	367
6	*Malus*	Crabapple	308
7	*Vaccinium*	Blueberry; Cranberry	294
8	*Acer*	Maple	297
9	*Alnus*	Alder	255
10	*Carya*	Hickory	235
11	*Ulmus*	Elm	215
12	*Pinus*	Pine	201
13	*Crataegus*	Hawthorn	168
14	*Rubus*	Blackberry; Raspberry	163
15	*Picea*	Spruce	150
16	*Fraxinus*	Ash	149
17	*Tilia*	Basswood	149
18	*Pyrus*	Pear	138
19	*Rosa*	Rose	135
20	*Corylus*	Filbert	131

Source: (Tallamy and Shropshire 2009)

On average, native plants support significantly more caterpillar species than non-native plants (Burghardt et al. 2008; Tallamy 2021). Native woody plants used as ornamentals support 14-fold more Lepidoptera than introduced ornamental species (Tallamy and Shropshire 2009). Fifteenfold more native Lepidoptera occurred on native ornamentals than on introduced ornamentals (Tallamy and Shropshire 2009). In general, woody plants support many more Lepidoptera species than do herbaceous species. This may be due to the fact that woody plants in general are both longer lived and larger than most herbaceous plants and thus may be easier targets for insect herbivores to exploit (Tallamy and Shropshire 2009). It is also possible that herbaceous plants are underreported as lepidopteran hosts because they are more difficult to identify and less conveniently searched by collectors.

Research and empirical evidence indicates that the majority of phytophagous insect species are restricted to eating vegetation from plant lineages with which they share an evolutionary history, or, more precisely, plants that produce specific secondary metabolic compounds (e.g., see review by (Tallamy and Shropshire 2009)). In other words, caterpillars and other insect larvae, an important food source for birds, are particular about what they feed upon (Tangley 2015). Up to 90% of all phytophagous insect species are specialists that have evolved in concert with only one or a few plant lineages (Bernays and Graham 1988; Janzen 1988; Novotny et al. 2006). Many species of putative generalists, with a large list of hosts over the entire range of the species, actually specialize on only one or a few host lineages locally (Fox and Morrow 1981; Tallamy and Shropshire 2009). Thus, most lepidopteran populations may be functionally constrained to exploiting a limited group of plants. Such restricted interactions typically require evolutionary time spans to develop (Kennedy and Southwood 1984), and have provided the ability of specialists to track their hosts in time and space, to circumvent physical and chemical defenses through behavioral and physiological adaptations, and to convert their host's tissues to insect biomass quickly and efficiently (Strong et al. 1984; Lewinsohn et al. 2005). The evolution of specialized abilities to eat the tissues of one particular plant lineage usually, in turn, decreases an insect's ability to eat other plants that differ in phenology, chemistry, or physical structure (Ehrlich and Raven 1964; Tallamy and Shropshire 2009).

To survive, birds need insects and both require sufficient healthy plants for food and habitat (Tallamy and Shropshire 2009; Baisden et al. 2018). Aerial insectivores (birds that forage on aerial insects) have experienced significant population declines in North America. Various hypotheses have been proposed for these declines, but current evidence suggests multiple factors could be operating in combination during their annual migratory cycles between breeding and nonbreeding areas. Potential drivers include decreased prey abundance, direct or indirect impacts of environmental contaminants, habitat loss, phenological changes due to warming climate, and conditions on migratory stopover or wintering grounds (Spiller and Dettmers 2019). While no single threat appears to be the cause of aerial insectivore declines, existing evidence suggests that several of these factors could be contributing to the declines at different times in the annual lifecycle. Based on current evidence, Spiller and Dettmers (2019) proposes that changes in the availability of high-quality prey, with variability across breeding and nonbreeding grounds, reduce various combinations of fledging success, post-fledging survival, and nonbreeding season body condition of aerial insectivores, resulting in species and geographic differences in population trends.

Declines in abundance of non-aerial insectivorous birds—grassland or farmland birds—have been correlated with agricultural intensification in the United States (Murphy 2003), the United Kingdom (Chamberlain et al. 2000; Donald et al. 2001; Benton et al. 2002), and across Europe (Reif 2013), supporting the idea that agricultural changes can affect birds through decreases in food quality or quantity. Some aerial insectivores, such as swallows, often use agricultural landscapes for foraging habitat as well (see review by (Spiller and Dettmers 2019)).

Herbivorous animals that depend on plants for sustenance (e.g., deer, rabbit, squirrel) could also be affected by poor quality plant material (resulting from herbicide spray or vapor drift), and the need to spend more time foraging to acquire sufficient food.

Monarch Butterfly

In 2018, the Center for Biological Diversity (CBD) released a report describing a potential threat to monarch butterflies (*Danaus plexippus plexippus*) posed by an increased use of dicamba (Donley 2018). Monarchs rely on nectar from flowering plants throughout their migration—any significant reduction in the flowering of plants along the migration route could impact adults' ability to make the migration, survive the winter, and breed again in the spring (Donley 2018). Milkweed (*Asclepias* spp.) is the sole host plant for the monarch butterfly; it is the only plant adults lay eggs on, and on which monarch caterpillars feed (USDA-FS 2020). Thus, the plant is intrinsically tied to monarch reproductive success. Dicamba's ability to damage or kill milkweed is well established: milkweed is listed as a weed effectively controlled by dicamba on the label of dicamba products (US-EPA 2020t).

Prior to the introduction of glyphosate resistant crops in the late 1990s, about 50% of Iowa's crop fields were infested with low densities of milkweed (Hartzler 2018). A decade later both the number of fields infested and the amount of milkweed in fields declined by more than 80% (Hartzler 2010). Hoey et al. (2016) evaluated the response of common milkweed to low doses of dicamba, and the influence dicamba injury had on oviposition by monarchs. Doses simulating drift equivalent to 0.1% and 1.0% of the labeled rate (0.5 lb/acre) caused distortion of leaves that emerged following application, but the emergence rate of leaves was not affected. The investigators did not determine milkweed biomass; although it is suspected some reduction would occur, much less than 50% (Hartzler 2018). The study by Hoey et al. (2016) found that egg laying by monarchs was not affected by dicamba injury to milkweed.

The decline in the monarch population is complex with many contributing factors; such as habitat fragmentation, loss of habitat in both the overwintering and summer reproduction areas, the availability of late season nectar plants, climate change, neonicotinoids, and disease and predators (Agrawal 2019). Most studies on monarch butterfly migratory dynamics have not shown that suppression of milkweed, alone, by glyphosate or other herbicides to be the cause of monarch decline (NAS 2016; Agrawal 2019). One recent found that monarch numbers began falling decades before glyphosate-based herbicides were used in agriculture (Boyle et al. 2019). Factors such as climate change, deaths during migration and loss of overwintering habitat in Mexico have also been implicated. Dr. Anurag Agrawal, Professor of Ecology and Evolutionary Sciences and Faculty Fellow at the Atkinson School of a Sustainable Future at Cornell University, concluded that the planting of milkweed would be beneficial, although this in and of itself would not increase populations or save monarch populations from decline (Maeckle 2016). However, herbicides as contributing factor remains a debate. These factors considered, the availability of nectar producing plants, populations of which could be damaged or reduced by the drift of herbicide spray or vapors, could be of concern relative to potential effects on migrating monarch populations. Bob Hartzler, a weed scientist with Iowa State University, is of the opinion that herbicide use, including dicamba, and monarchs can co-exist, but it requires appropriate herbicide product selection and responsible application to protect resources adjacent to crop fields (Hartzler 2018).

Due to the population decline in monarch butterfly, the Natural Resources Conservation Service (NRCS) and others—including the USFWS—have developed a collaborative landscape level partnership to benefit the monarch butterfly (USDA-NRCS 2020b). The primary focus of the partnership is the design and application of selected NRCS conservation practices to benefit the monarch butterfly. Much of this work focuses on planting and enhancing stands of milkweed and high-value nectar producing plants. Other actions implemented by the NRCS include the application of conservation practices in the use of pesticides that are of benefit to the monarch butterfly.

MON 87429 Corn Seed Production: Pollinators and Pollen Dependent Insects

MON 87429 corn will be used for hybrid seed production. Specifically-timed glyphosate application results in non-viable pollen in MON 87429 corn tassels (male sterility). This modification in MON 87429 corn precludes the need for manual detasseling to prevent self-fertilization, thereby facilitating cross pollination of MON 87429 corn with other corn plants for the purpose of hybrid seed production. While the female parent plants would have non-viable pollen, this would not be expected to have any effect on pollen feeders in the areas in which MON 87429 corn hybrids are produced. Honeybees and bumble bees, as well as other insects that feed on pollen, show no apparent preference for viable as opposed to nonviable pollen (Zhang et al. 2019). Ample viable pollen would be provided by male corn plants, and other plants in proximity to MON 87429 corn fields.

Aquatic Biota

As previously discussed for Plant Communities, herbicides used on crops and non-crop sites can potentially affect aquatic ecosystems via run-off. Herbicide use patterns change as new biotech crops and uses are approved, and uses are discontinued or restricted by the EPA. Among aquatic stressors, pesticides rank 16th, with pathogens, sediment, nutrients, oxygen depletion, temperature, metals, and polychlorinated biphenyls (PCBs) being the top seven stressors for rivers and streams—in that order (US-EPA 2019i). Among pesticides, atrazine, DDT (banned), dieldrin (banned), chlordane (banned), chlorpyrifos (banned on food crops), diazinon (banned), toxaphene (banned), and unspecified pesticides have been the most common cited contaminants in impaired rivers and streams. For bays and estuaries, pesticides have ranked as the 8th most common cause of impairment, following PCBs (banned), nutrients, mercury (regulated), turbidity, dioxins (no longer produced in the United States), toxic organics, and metals (US-EPA 2019i). Dieldrin, DDT, chlordane, diazinon, and chlorpyrifos have also been cited as the most common contaminants in bays and estuaries (US-EPA 2019i).

Herbicides are developed to control plants and thereby target physiological processes that are specific to plants (e.g., plant hormone disruption, amino acid/protein synthesis pathways, photosynthesis inhibitors). As a result, most herbicides do not present a hazard to aquatic animals (Solomon et al. 2013). Exceptions to this general rule are uncouplers of oxidative phosphorylation and some herbicides that interfere with cell division—processes common among plants and animals (Solomon et al. 2013).

Most herbicides that occur in surface waters are found at very low concentrations in the ng/L range (parts per trillion; ppt), which for the majority of herbicides are levels well below that which would elicit a physiological response in fish, crustaceans, or amphibians (Solomon et al. 2013; USGS 2016). For example, in the USGS study, 2,4-D was detected in the range of 60 ng/L (ppt), dicamba 500 to 2,400 ng/L (ppt), and glyphosate around 200 ng/L (ppt) (Nowell et al. 2018). Other studies have found 2,4-D surface water concentrations around 0.16 µg/L, and dicamba 0.11 µg/L (Belden et al. 2007). Glufosinate has been detected in the range of 0.26 µg/L (ppb) (Scribner et al. 2007). While concentrations detected are generally very low, concentrations can spike into the µg/L (parts per billion; ppb) range following rain events that flush herbicides into nearby surface waters, with potentially transient adverse effects on some aquatic species.

In general, herbicides, to include chemical forms of 2,4-D, glyphosate, glufosinate, dicamba, and quizalofop-p-ethyl, primarily present a potential hazard to aquatic biota by impacting aquatic plants and algae, which can in turn affect food webs or aquatic habitats. While indirect effects might occur when aquatic plants are intentionally controlled by direct treatment of surface waters with an herbicide (e.g., 2,4-D and glyphosate are registered for use to control dense growths of algae or aquatic weeds via direct application to surface waters), indirect effects via run-off from fields (containing any residual herbicide) into surface waters appears to be unlikely, as runoff and subsequent concentrations in surface waters are, for the most part, much less than those that could directly affect plants (Solomon et al. 2013; Nowell et al. 2018).

Aquatic Biota: Exposure Through Atmospheric Deposition

Herbicides that are more volatile, such as dicamba, are removed from the atmosphere through wet (rainfall, snow) and dry (gravity) deposition. Herbicide spray and vapor drift can theoretically result in potential injury to aquatic biota if the level of atmospheric deposition into surface waters exceeds a threshold for causing harm (Riter et al. 2021).

In terms of dry deposition, a recent study by Bish et al. (2019b) used high-volume air samplers to determine concentrations of dicamba in air after treatment to soybean. The highest levels of 22.6 to 25.8 ng/m^3 were detected in the first 8 h after treatment (HAT). When applied simultaneously, the DGA plus VaporGrip and BAPMA salt of dicamba were detected at similar levels over the time course. The highest concentrations for each formulation occurred 0.5 to 8 HAT. Concentration of the DGA plus VaporGrip was 22.6 ng/m^3 whereas that of the BAPMA salt was 25.8 ng/m^3. Both formulations showed similarly rapid dissipation in air, with dicamba concentrations decreasing from >20 ng m^3 at 0.5 to 8 HAT to <7 ng/m^3 at 8 to 16 HAT. By 24 to 48 HAT, dicamba concentrations were approximately 2 ng m^3 and remained at that concentration through 72 HAT (Bish et al. 2019b).

In terms of herbicide exposure via rainfall, studies conducted by the University of Missouri and USDA-ARS quantified atmospheric concentrations and mass fluxes of dicamba in 12 soybean production regions of Missouri. Dicamba was routinely detected in weekly deposition samples collected during agriculturally-intensive spray periods. Observed concentrations were indicative of both local (<1 km) and long-distance transport (>1 to 1000 km) of air-borne dicamba. High deposition events (>100 $\mu g/m^2$)[7] occurred annually in southeast Missouri, and peak dicamba concentrations at these sites (12.5-84.0 µg/L) were sufficient to injure non-dicamba resistant soybean (Oseland et al. 2022).

The highest concentration detected in 2019 was 84 µg/L (Oseland et al. 2022). The highest concentration detected in 2020 was 37 µg/L (Oseland et al. 2022). For both years of the study (2019 and 2020), highest mass fluxes on a weekly and annual basis occurred at the three sites in southeast Missouri. All these sites had peak weekly fluxes >140 $\mu g/m^2$, with the highest weekly mass flux in 2019 observed to be 1,098 $\mu g/m^2$ and the highest in 2020 to be 354 $\mu g/m^2$. These studies found that dicamba was commonly detected in rainwater from April to September, that observed concentrations and fluxes were strongly related to the interaction of dicamba usage near the sites and the timing and magnitude of rainfall events, and that dicamba detected in rainwater samples was sufficient to cause injury to non-dicamba resistant soybean (Oseland et al. 2022).

For dicamba, the most sensitive species on which data are available is the freshwater algae, *Anabaene flos-aquae*, with an LC10 of 4.9 µg /L and an LC50 of 61 µg /L. Other species of freshwater algae are much more tolerant with No Observed Effect Concentration (NOEC) values ranging from 3 mg/L to 10 mg/L. Aquatic macrophytes appear to have an intermediate sensitivity and NOEC of 0.25 mg/L is used to characterize risks to aquatic macrophytes (USDA-FS 2004). At the maximum application rate, peak concentrations in water could be associated with transient effects in sensitive species of algae as well as macrophytes (USDA-FS 2004). These concentrations, however, would rapidly diminish to levels substantially below a level of concern.

Other studies have found the chronic EC50 for 14 freshwater algae, based on growth inhibition, ranged from 100 to > 10,000 µg/L dicamba (Caux et al. 1993), and a 96hr NOEC of 25,000 µg/L and 72hr EC50

[7] Concentrations in rainfall are reported as (X) µg/L and atmospheric deposition as result of rainfall as (X) µg m^2.

of >87,000 µg/L (Lewis et al. 2016). These studies suggest dicamba to be of low toxicity to algae, in general.

At the dicamba deposition rates observed (weekly fluxes >140 µg/m^2, with the highest weekly mass flux in 2019 observed to be 1,098 µg/m^2), and maximal rainfall concentration of 84 µg/L, the upper ranges of the EC values for most algae and macrophytes (e.g., > 10,000 µg/L) exceeds the level of concern for most species. While transient effects from rainfall could be anticipated in sensitive species of algae (e.g., *Anabaene flos-aquae*) and perhaps macrophytes, concentrations of dicamba in surface waters would rapidly diminish—be diluted—to levels substantially below a level of concern. Considering the observed deposition concentrations discussed, there is little basis to assume that adverse effects on aquatic plants and animals are plausible as a result of atmospheric deposition of dicamba.

Glyphosate and Potential Effects on Amphibians

The potential toxicity of glyphosate to amphibians, due to widespread use of the herbicide, has been a topic of research interest. Amphibians may have increased sensitivity compared with other vertebrates due to their developmental characteristics, and reliance on both the aquatic and terrestrial environments.

Various laboratory studies have been conducted on commercial formulations of glyphosate herbicides containing either the surfactant POEA (polyethoxylated tallow amine (also polyoxyethyleneamine)) or an undisclosed surfactant (e.g., Roundup Original, Roundup Original MAX, Roundup Weathermax, Vision, Cosmo-Flux). These lab studies found LC50[8] values ranging from 0.4 to 11.6 mg a.e./L (ppm)(see review by Relyea (2012)). Based on the standard toxicity classifications used by the EPA, these commercial formulations range from slightly toxic (10 mg/L < LC50 < 100 mg/L; ppm) to highly toxic (0.1 mg/L < LC50 < 1 mg/L; ppm), for amphibians.

In a USGS survey of Midwestern surface waters, the glyphosate detection frequency was 87%, with 41% of samples in the 200 ng/L range (ppt) (Nowell et al. 2018). Other studies have found median concentration in rivers, streams, lakes, and ponds around 30 ng/L (ppt), although maximum detections have been in the range of 300 ug/L (ppb) for lakes and ponds (Battaglin et al. 2014; Nowell et al. 2018).

Much of the toxicity of commercial glyphosate formulations has been attributed to the surfactant portion, particularly POEA—rather than glyphosate itself—which has a range of LC50 values (96-hr) between 0.65 and 7.4 mg a.e./L (ppm) (Annett et al. 2014).

Current literature suggests that the sensitivity of amphibians to glyphosate-based herbicides is formulation-, species-, and life stage–specific (Relyea 2012; Annett et al. 2014). Glyphosate-based herbicides with POEA or other tallowamine surfactants are moderately toxic or even highly toxic to amphibian larvae. Overall, glyphosate-based herbicides can be classified as moderately toxic and glyphosate itself as slightly toxic to practically nontoxic to amphibian larvae (Wagner et al. 2013; US-EPA 2015b, 2019f).

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[8] Lethal concentration 50 (LC50) is the amount of a substance suspended in air or water required to kills 50% of a population over a predetermined observation period.

If and how glyphosate-based herbicides and other pesticides may contribute to amphibian population declines is not entirely clear due to lack of sufficient data on how amphibian populations can be affected by active ingredients, surfactants, degradation products, and other factors. Amphibian declines are a global phenomenon, and has continued unabated in the United States since at least the 1960's. Declines are occurring even in protected national parks and refuges. The average decline in amphibian populations has been observed to be around 3.8% per year, although the decline rate is more severe in certain regions of the United States, such as the West Coast and the Rocky Mountains (USGS 2020).

Current data suggests that amphibian populations are declining worldwide, and that there is no single contributing factor—thus no simple solution—to halting or reversing these declines (USGS 2020). While every region in the United States has seen amphibian declines, threats differ among regions, and include:

- Human influence from the Mississippi River east, including the metropolitan areas of the Northeast and the agricultural-dominated landscapes of the Midwest
- Disease, particularly a chytrid fungus in the Upper Midwest and New England
- Pesticide applications east of the Colorado River
- Climate changes across the United States

U.S. EPA Ecological Risk Assessments

All the herbicide active ingredients that would be used with MON 87429 corn are currently labeled for use on a variety of crops, as well as in non-agricultural settings (e.g., residential and commercial properties). The risks of pesticide use on wildlife, to include risks from aggregate uses, are assessed by the EPA as part of the pesticide registration process and are regularly reevaluated by EPA for each pesticide to maintain its registered status under FIFRA. The EPA has conducted ecological risk assessments (ERAs) for glufosinate (US-EPA 2016c), dicamba (US-EPA 2022a), 2,4-D (US-EPA 2017b), quizalofop-p-ethyl (US-EPA 2014a), and glyphosate (US-EPA 2019f), and these risks assessments incorporated by reference as part of hazard assessment for wildlife. The reader is referred to these ERAs for a more detailed discussion of the potential effects of these herbicides on wildlife. The EPA uses these risk assessments in establishing herbicide label use requirements that are intended to limit the risks of wildlife exposure, and adverse effects. Based on current data and EPA label use requirements, the use of glufosinate, dicamba, 2,4-D, quizalofop-p-ethyl, and glyphosate in production of MON 87429 corn/hybrids would present minimal risks to wildlife when used according to EPA label requirements, and EPA guidance (e.g., (US-EPA 2017a)).

Biodiversity

The herbicide resistant trait proteins in MON 87429 corn are unlikely to present any risks to plant, animal, fungal, or bacterial communities. The same or functionally similar proteins and genetic elements are derived from naturally occurring soil bacteria and plants.

As to the herbicides that may be used with MON 87429 corn, the potential impacts on local biodiversity, areas proximate to MON 87429 corn fields, would be relative to the effects of the herbicides primarily on plants—as previously discussed. It should be noted that the herbicide active ingredients that could be used with MON 87429 corn are currently used on a wide variety of crops, as well as in non-agricultural settings (residential and commercial properties, forestry). For example, glufosinate is registered for use on a variety of crops, including apples, berries, citrus, currants, grapes, grass grown for seed, potatoes, rice, sugar beets, and tree nuts. 2,4-D, used since the 1940s, has various registered uses, including for turf/lawns, aquatic sites, forestry sites, and field, fruit, and vegetable crops. Dicamba was first approved for use in the United States in 1962 and has been registered for use on corn, wheat, cotton, soybeans, a wide range of grass crops, as well as for non-crop areas. In general, any potential effects on local biodiversity that may differ from other uses of these herbicides would be relative to the degree of off-target movement of herbicides associated with MON 87429 corn use, and geographic scale of MON 87429 corn production.

Plants are key components of ecosystems, providing the raw material (primary production)[9] upon which food chains are founded. Different plant parts provide a range of resources for various fauna; leaves and stems may be browsed, pollen and nectar provide resources for pollinating insects, and the fruits and seeds are important food for a large number of organisms (Marshall 2001). Plants have other functions in addition to providing food for herbivores. They provide cover, reproduction sites, and structure within habitats. Plants also form a substrate for bacteria, fungi, and algae, both above ground and in the soil (Marshall 2001).

As discussed above for potential effects on plant communities, dicamba and 2,4-D drift can damage non-crop plants, to include trees, and thereby potentially impact communities of wildlife dependent on such plants (e.g., insects, herbivorous mammals, reptiles, birds). Use of dicamba and 2,4-D, owing to the potential for drift and their functions as synthetic auxins, have greater potential for reducing biodiversity in field edges and nearby non-crop habitat through damage to plants, relative to the other herbicides. Dicamba drift issues, in part, have resulted from the ability to use OTT applications later in the growing season on dicamba resistant crops—this is when temperatures are warmer and thereby volatility higher. Hence, effects of spray and vapor drift on plants and associated biota at later stages of life cycles and interactions can occur. Due to lack of data, and uncertainty as to which herbicides will preferentially be used with MON 87429 corn hybrids, it is unclear to what extent, and for how long, injury to field edges and nearby non-crop plants could potentially impact biodiversity in areas where herbicide drift/volatilization occurs.

The above considered, as discussed for animal communities, while herbicides that would be used with MON 87429 corn present minimal direct hazard to wildlife in the event of inadvertent exposure, movement of herbicides off-site can present risks to plants in natural areas, and on residential and commercial properties, that animal communities depend on. Any increase in herbicide use across the agricultural landscape, could likewise increase potential impacts on plant communities, and indirect effects on animal communities that rely on the plant communities as a resource.

Threatened and Endangered Species

Within the Coordinated Framework for the Regulation of Biotechnology, APHIS regulates plant pest risks under the authority of the PPA and implementing regulations at 7 CFR part 340; for biotechnology derived plants, this means the plant itself. The EPA regulates pesticide use with the plant, to include

[9] Primary productivity, in ecology, is the rate at which energy is converted to organic substances by photosynthetic producers (photoautotrophs), which obtain energy and nutrients by harnessing sunlight, and chemosynthetic producers (chemoautotrophs), which obtain chemical energy through oxidation. Nearly all of Earth's primary productivity is generated by photoautotrophs.

PIPs. APHIS met with USFWS officials on June 15, 2011, to discuss and clarify whether APHIS has any obligations under the ESA regarding analyzing the effects on TES that may occur from use of pesticides associated with biotechnology derived crops. As a result of these joint discussions, USFWS and APHIS have agreed that it is not necessary for APHIS to perform an ESA effects analysis on pesticide use associated with biotechnology derived crops because the EPA has both regulatory authority over the labeling of pesticides under FIFRA, and the technical expertise to assess pesticide effects on the environment. APHIS has no statutory authority to authorize or regulate the use of pesticides by corn growers. Under APHIS' current Part 340 regulations, APHIS only has the authority to regulate MON 87429 corn and other biotechnology derived organism as long as APHIS believes they may pose a plant pest risk. APHIS has no regulatory jurisdiction over any other risks associated with biotechnology derived organisms including risks resulting from the use of pesticides on those organisms.

APHIS thoroughly evaluated the possible effects of a determination of nonregulated status for MON 87429 corn (Section 4.3.3.6 –Threatened and Endangered Species), and subsequent commercial production of this variety. APHIS identified no adverse effects on listed TES or species proposed for listing associated with MON 87429 corn. APHIS also considered the potential effect of MON 87429 corn on designated critical habitat and habitat proposed for designation and could identify no differences from effects that would occur from the production of other corn varieties. Corn is not sexually compatible with, nor serves as a host species for, any listed species or species proposed for listing. Consumption of MON 87429 corn by any listed species or species proposed for listing would pose no health risks.

Based on these factors, APHIS concluded that a determination of nonregulated status of MON 87429 corn, and subsequent commercial production of this corn variety, will have no effect on listed species or species proposed for listing, and would not affect designated habitat or habitat proposed for designation. Because of this no-effect determination, consultation under Section 7(a)(2) of the Act or the concurrences of the USFWS or NMFS are not required.

In terms of herbicide use with MON 87429 corn, the EPA's Endangered Species Protection Program (ESPP) carries out EPA's responsibilities under FIFRA in compliance with the ESA. The EPA is responsible for reviewing information and data to determine whether a pesticide product can be registered for a particular use. As part of that determination, the EPA determines if listed species or their designated critical habitat may be affected by use of the product. All pesticide products that the EPA determines "may affect" a listed species or its designated critical habitat may be subject to the ESPP.

Based on the 2020 EPA Ecological Assessment for dicamba use on dicamba resistant cotton and soybean (US-EPA 2020o), the "EPA made no effects determinations for 22 of the 23 listed species and 1 critical habitat that overlap with the action. There was one listed species within the action area, the Eskimo curlew where EPA made a May Effect but Not Likely to Adversely (NLAA) Effect determination. EPA initiated informal consultation with the United States Fish and Wildlife Service (USFWS). USFWS has concurred on the NLAA determination." The EPA initiated informal consultation with the USFWS, and USFWS has concurred on the NLAA determination (US-EPA 2020o).

ES 8 HUMAN HEALTH AND WORKER SAFETY

There are no food safety issues associated with the consumption of MON 87429 corn. Bayer completed a Biotechnology Consultation on Food from GE Plant Varieties with the FDA, evaluating the safety of MON 87429 corn, in July 2022. Based on the information Bayer presented to FDA, the FDA had no further questions concerning the safety of human or animal food derived from MON 87429 corn (BNF No. 000173; (US-FDA 2022)).

The National Bioengineered Food Disclosure Law (NBFDL), passed by Congress in July of 2016, directed the USDA to establish a national mandatory standard for disclosing foods that are or may be bioengineered. The implementation date of the Standard was January 1, 2020, except for small food manufacturers, whose implementation date is January 1, 2021. The mandatory compliance date is January 1, 2022. The Standard requires food manufacturers, importers, and certain retailers to ensure bioengineered foods are appropriately disclosed. It is expected that food products derived from MON 87429 corn would require labeling, subject to the requirements of the NBFDL, and consumers would choose to consume such foods based on preference.

Any risks of spray drift and volatilization, and potential human exposures to the herbicides used with MON 87429 corn, would be the same as those with the use of these herbicides on other crops. MON 87429 corn hybrids, resistant to glyphosate, glufosinate, dicamba, 2,4-D, and quizalofop-p-ethyl, would however, to the extent MON 87429 corn is adopted, facilitate use of these herbicide active ingredients in lieu of other herbicide active ingredients. Hence, risks to human health unique to MON 87429 corn production would be relative to the potential toxicities of these particular herbicide active ingredients—the types and severity of physiological effects these herbicide active ingredients may have—and their use patterns. While drift can be an issue for all herbicides, dicamba, and those herbicides with higher volatility, tend be more problematic. Human health risk assessments for the herbicide active ingredients that may be used with MON 87429 corn hybrids have been conducted by the EPA: Glyphosate (US-EPA 2019f); Dicamba (US-EPA 2006); Glufosinate (US-EPA 2016c); 2,4-D (US-EPA 2017b); and Quizalofop-p-ethyl (US-EPA 2014a). The EPA evaluated the toxicology, product and residue chemistry, and occupational and residential exposure studies for each of these herbicides, from which label use restrictions and requirements were determined. When used in a manner compliant with all label use requirements and restrictions, these herbicides are expected to present minimal risk to human health.

Surface Waters, Groundwater, and Herbicides

Discussed in more detail in Section 4.3.1.2.3 – Pesticides, there are approximately 48 herbicides used on U.S corn crops. Currently, glyphosate comprises around 31% of total herbicide use on U.S. corn crops, 2,4-D 2.5%, dicamba 1.3%, and glufosinate 0.2%. Quizalofop-p-ethyl is an herbicide selective for grasses, that has not been used on corn because corn is in the grass family. Thus, there is no data for quizalofop-p-ethyl use with corn. Use of these herbicides with MON 87429 corn is subject to the Federal Safe Drinking Water Act (SDWA), EPA requirements, and state restrictions. The SDWA gives individual states the opportunity to set and enforce their own drinking water standards if the standards are at a minimum as stringent as EPA's national standards.

Worker Health

The Occupational Safety and Health standards (OSHA; 29 CFR 1928), National Institute of Occupational Safety and Health (NIOSH) agricultural safety and health program, and EPA WPS regulations are expected to provide protections to agricultural workers, pesticide handlers, and other persons via training, pesticide safety and hazard communication requirements, personal protective equipment requirements, and provision of supplies for routine washing and emergency decontamination. Agricultural workers, owners/managers of agricultural establishments, commercial (for-hire) pesticide handling establishments, and crop production consultants are provided guidance for compliance with WPS regulations (US-EPA 2016a). The WPS offers occupational protections to over 2 million agricultural workers and pesticide handlers who work at over 600,000 agricultural establishments.

ES 9 LIVESTOCK HEALTH AND WELFARE

If used for animal feed, MON 87429 corn progeny would be expected to be beneficial to animal health and welfare, as are most other dent corn varieties. Compositional assessments were conducted for major nutrients in MON 87429 grain (protein, amino acids, total fat, linoleic acid, carbohydrates, acid detergent fiber, neutral detergent fiber and ash), forage (protein, total fat, carbohydrates, acid detergent fiber, neutral detergent fiber and ash), and for anti-nutrients in grain (phytic acid and raffinose). Compositional assessments comparing MON 87429 corn and conventionally bred corn were performed using principles and guidelines outlined in the OECD consensus document for corn composition (OECD 2020). These principles are accepted globally and have been employed in previous assessments of modified corn products. The results of the compositional assessments found that there were no nutritional differences between MON 87429 corn and non-modified corn comparators (Monsanto 2019).

The FDA's Center for Veterinary Medicine (CVM) is responsible for the regulation of animal feed products under the FFDCA and FSMA—as discussed for human health. Bayer completed a Biotechnology Consultation on Food from GE Plant Varieties with the FDA, evaluating the safety of MON 87429 corn, in July 2022 (US-FDA 2022)).

ES 10 SOCIOECONOMIC IMPACTS

Domestic Markets and International Trade

MON 87429 corn hybrids could be used to produce food, feed, fuel ethanol, and/or industrial commodities. To the extent progeny of this HR varietal facilitates effective management of weeds and HR weed development, and obtaining high yields, it would be expected to support growers achieving optimal net-returns on crop production. These factors considered, the impacts of MON 87429 corn on the corn industry and consumer markets would be largely beneficial. There are however potential costs—unintended costs—associated with dicamba (and to some extent 2,4-D) spray and vapor drift—relative to other cropping systems on which these herbicides are not used over-the-top later in the growing season. There is also some uncertainty as to the long term efficacy of stacked-trait HR crops in weed and HR management, which could reduce, increase, or have no effect on weed control costs, these topics discussed further below.

Globally, the adoption of HR corn has mainly resulted in lower costs of production, although yield gains from improved weed control have arisen in Argentina, Brazil, the Philippines, and Vietnam (Brookes and Barfoot 2018; Brookes and Barfoot 2020b). For HR corn, farmers in the United States have realized higher incomes due to their use of HR varieties, totaling, in aggregate, approximately $10.8 billion from 1996–2018 (Brookes and Barfoot 2020b). The average gross farm income benefit with HR crops (after deduction of cost of the technology), is around $12.1/acre ($30.1/hectare) (Brookes and Barfoot 2020b). Overall, there continues to be a considerable body of evidence that quantifies the positive economic benefits of HR crops (Klümper and Qaim 2014; Brookes and Barfoot 2018; Brookes and Barfoot 2020b). Currently, approximately 89% of U.S. corn, 95% of cotton, and 94% of soybean acres are planted with HR seeds (USDA-ERS 2022). Biotechnology-derived varieties incorporating two or more traits, such as stacked-trait HR/IR varieties, are now common, and are expected to remain preferred crop varieties in the coming years.

By facilitating achieving maximum yield and thereby domestic production, the potential impacts of MON 87429 corn on the pricing and U.S. trade of corn commodities could be potentially beneficial. MON 87429 corn/hybrids would be subject to the same international regulatory requirements, discussed below, as currently traded corn varieties.

Herbicide Resistant Weed Costs

Over 80% of U.S. acreage used for production of major crops such as corn, cotton, soybean, peanuts, potatoes, and wheat is treated with herbicides. These crops, collectively, comprise around 200 million acres (USDA-NASS 2022). Herbicides are used to a somewhat lesser extent (e.g., 20% - 70%) on a wide variety of other vegetable and fruit crops (e.g., onion, cucumber, bell pepper) (USDA-NASS 2022). A primary concern facing U.S. crop producers—and the agricultural industry in general—is the development of HR weed populations resulting from the repeated, widespread use of a single herbicide MOA. This is not unique to biotechnology-derived crop varieties; development of herbicide resistant weed populations has routinely occurred with non-biotech crops and associated herbicide use since the introduction of herbicides in the 1950s, and can continue to occur with any crop on which any herbicide is repeatedly used. Considering that a substantial portion of major crops are currently planted to HR varieties (i.e., corn, soybean, cotton), such cropping systems and the agronomic practices employed can potentially affect the development of resistant weed biotypes: Either contribute to the effective management of weeds and allaying/prevention of development of weed resistance, or, in the absence of IWM programs, exacerbate the development of herbicide resistance in weed populations.

In a 2016–17 National Cover Crop Survey, 59% of U.S. farmers reported having HR weeds on some of their fields, and that percentage is expected to continue to rise (SARE 2020). Most corn growing states have from around 3 to 8 different species of weeds that are herbicide resistant (Heap 2022). The resistance exhibited by these plants includes resistance to herbicides with various MOAs, such as ALS inhibitors, synthetic auxins, photosynthesis inhibitors, amino acid synthesis inhibitors (Heap 2022). Problematic is the fact that many HR weed populations have developed resistance, and continue to, to more than one herbicide MOA. For example, in U.S. corn crops—as of 2020—there have been 16 instances with a weed population developing resistance to 2 herbicide MOAs, 5 confirmed weed populations with resistance to 3 MOAs, 3 with confirmed resistance to 4 MOAs, and 1 species (tall waterhemp) with confirmed resistance to 5 MOAs.

The presence of HR weeds in crop fields increases the cost of production and can reduce net returns (Fernandez-Cornejo and Osteen 2015). HR weeds cost farmers money due to yield loss (the result of competition from HR weeds), and expenditures on additional herbicides and labor to control HR weed populations. The extent to which HR weed control affects net returns is highly variable and depends on the type and abundance of a problem weed or weeds present; costs associated with herbicides to control HR weeds, tillage, and other weed management practices; and the cost of seed. The economic consequences of HR weeds and their management can be considerable.

A USDA-ERS study estimated the impacts of glyphosate-resistance on corn and soybean production in 2010 and 2012. The results suggest that corn growers who had reported a glyphosate-resistant weed infestation in 2010 realized significantly lower total returns (-$67.29/acre) than similar corn growers who had not reported such an infestation (Livingston et al. 2015). The results suggest that lower yields and higher chemical and fuel costs might have contributed to the shortfall in net returns (Livingston et al. 2015). In general, the occurrence of herbicide resistant weeds normally drives up overall herbicide costs, as more expensive residual herbicides are used to control HR weeds. Oftentimes an extra post-emergence herbicide treatment is employed (a second or third post-emergence application) (SARE 2020).

Currently, HR weeds may be costing U.S. crop producers as much as $2 billion a year in decreased yields, increased input costs, and decreased land values (Van Deynze et al. 2020). Herbicide resistance increases growers' chemical costs by 30% to 40% due to the need to control HR weed populations and protect yield (Weaver 2019). Reported costs to farmers for control of HR weeds range from $14 to $150 per acre, dependent on the weed species present (e.g., Palmer amaranth can reach 6 ft in height at maturity, once it reaches 6-8 inches in height there is no herbicide that can effectively control it (GROW 2021)), prevalence of HR weed populations, and number of herbicide MOAs to which an HR weed is resistant (Hurley et al. 2010; Hembree 2011; Livingston et al. 2015; Bayer-CropSci 2018; Heap 2022).

To mitigate or preclude weed resistance and associated costs, producers of both HR and non-HR crops must employ various weed control tactics that include the judicious and diversified use of differing herbicide MOAs, herbicide rotations, crop rotations, cover crops, tillage as may be needed, and scouting practices (e.g., (Owen 2016; Heap and Duke 2018; Beckie et al. 2019; Korres et al. 2019), and others). Fundamentally, it is the producers of HR and non-HR crops that will decide which set of IWM practices and herbicides used that will best support the sustainability and profitability of the particular crop(s) they are producing.

Stacked-trait HR varieties, along with crop and herbicide rotations and non-chemical methods, are considered a useful tool to facilitate management of weeds and development of resistant weed populations. USDA-ERS analyses suggest that proactively managing for weed resistance is more cost effective in the long run (Livingston et al. 2015). Similarly, Weirich et al. (2011) investigated the effect of grower adoption of glyphosate weed resistance management programs and found them initially more costly, but by protecting yields and net economic returns, and reducing resistant weed problems, weed management costs were offset over the long term.

Liu et al. (2020) evaluated—using economic models—the cost-benefit of utilizing a single herbicide resistant and stacked-trait HR crop. Scenario H represented a post-emergent herbicide application (POST-only) scenario with a single herbicide MOA. Scenario H+X+Y used a three-way stacked HR trait crop with three POST applications, while scenario EWM(ii) used a residual pre-emergent herbicide application (PRE) followed by one POST application in a two-way stacked HR system (data presented in Table 4-31). Both stacked-trait management approaches (H+X+Y, EWM(ii)) were found to provide sustainable weed management after 20 years, and increased net economic gains. While scenario H (single herbicide MOA) provide net gains of $4,583/acre at year 20, this was comprised of 7 years of effective weed resistance control, and 13 years of ineffective weed control due to resistance development/weed control failure (Liu et al. 2020). Proactive herbicide programs, such as H+X+Y and EWM(ii), which required slightly more investment, proved to be more profitable, returning 1.8 to 2 times higher net gain than scenario H in the long term, $8,312.4/acre to $9,566.9/acre (Liu et al. 2020).

Herbicide Spray and Vapor Drift

As previously discussed, dicamba, as well as 2,4-D, spray and vapor drift, and to a lesser extent other herbicides, can damage nearby crop and non-crop plants. Both herbicides are synthetic auxins, mimic plant hormones, and can affect plant structure and physiology at doses below the direct application rates, which may occur from spray or vapor drift. For example, spray/vapor drift from dicamba damaged an estimated 3.6 to 5 million acres of crops, trees, and vegetable farms in 2016 (UM-IPM 2018; CBD 2019), across 24 states (Unglesbee 2017). In 2017 there were approximately 2,708 dicamba-related injury cases under investigation by various state departments of agriculture in the United States. In 2018, there were approximately 1,400 reported cases of dicamba drift (US-EPA 2018), and in 2019 over 1,000 reported cases. In 2019, 19 states reported approximately 1,400 cases of alleged dicamba injury, most of them coming from a group of 10 states with the highest soybean acreage (Unglesbee 2019b). Current survey data indicates that these numbers are likely lower than the actual cases of injury—not all cases of drift injury are reported (Unglesbee 2019b; WSSA/EPA 2020).

Costs due to dicamba spray/vapor drift and crop loss can range from hundreds to tens-of-thousands of dollars; significantly more—millions of dollars—in some instances. Crop producers whose fields have been affected by dicamba drift can lose between 5% to 30% of yield (Barth 2016). Dicamba drift damages are not federally insurable; federal crop insurance only covers weather-related perils, such as flooding or drought, not chemical-related issues. Liability insurance may cover yield loss, but the challenge is pinpointing the dicamba source when drift occurs (GMRC 2019). To recover costs growers must first file an "incident report" with their state agricultural authority. Once an incident report is filed, states will decide whether to open an investigation to determine if a pesticide was misused or if any state or federal law was violated. Crop producers or other property owners may consider whether to pursue a private action to recover damages. Recovery for damage caused by herbicide drift may be sought under several legal paths; including negligence; liability; and, occasionally, chemical trespass or nuisance.

2016–2020 EPA/WSSA surveys of midwestern state farmers growing specialty crops (ND, SD, MN, WI, MI, OH, IN, IL, MO, IA, NE, KS) found that surveyed growers reported crop injury from herbicide spray and vapor drift; 47% reported plant damage from dicamba drift, and 44% from 2,4-D drift (WSSA/EPA 2020). Approximately 9% to 12% reported damages ranging from $10,000 to $50,000, and 27% to 28% reporting damages in the $1,000 to $10,000 range.

Bayer announced a mass tort agreement to settle dicamba drift litigation involving damage to soybean crops; settlement with farmers whose crops have been damaged by drift from the herbicide dicamba. The company will pay up to a total of $400 million to resolve multi-district litigation for the 2015-2020 crop years (Bayer 2020).

Impacts are not limited to crops such as soybeans and cotton; specialty crops, such as fruits and tree nuts, vegetables, culinary herbs and spices, medicinal plants, as well as nursery, floriculture, and horticulture crops[10] can also be damaged by dicamba drift (USDA-AMS 2022). The value, net sales, of horticultural crops alone in 2019 was $13.78 billion (USDA-NASS 2019e). Arkansas, Mississippi, Missouri, Nebraska, Tennessee, and Virginia have each reported injury to various types of trees, ornamental species, garden plants, flowers, and berries (Bradley 2018). For specialty crops and homeowners, these cases are usually reported by total number of plants injured rather than by acreage; as of June 1st, 2018 approximately 200 tomato plants, 150 ornamental trees, 30 fruit trees, 250 vegetable plants, and 150 berry species were reported with probable dicamba injury in these six states, along with approximately 50 acres of hardwood/shade trees (Bradley 2018).

In 2022, Bader Farms, plaintiff, was awarded a total of $75 million due to dicamba drift and crop loss; $60 million in punitive damages, and $15 million in compensatory damages (Dowell 2022). The owner incurred extensive damage to their peach orchard due to dicamba drift from neighboring dicamba resistant cotton crops (Gillam 2020). The dicamba damage to Bader Farms was substantive—injuring more than 30,000 peach trees, about 40% of the crop, and resulted in $1.5 million in loss of sales (Gray 2016; Randles 2017).

In June 2021, a group of Texas vineyards filed suit against Bayer and BASF, alleging that dicamba, used on the state's cotton fields, damaged thousands of acres of wine grapes (Gray 2021). The case alleges that 95% of productive grape vines sustained damage across dozens of vineyards, with the worst occurring in the last three years. Texas is the largest cotton cropping state in the United States in terms of acreage—around 5.7 million acres. The first dicamba-resistant cotton seeds were planted in 2016.

There is little quantitative data on the total economic costs of herbicide drift on residential, commercial, and other non-crop properties such as natural areas, or academic research sites. The instances of crop and non-crop injury considered above, the reported cases of injury to crop and non-crop plants are likely lower than the actual cases of injury; not all instances of herbicide drift injury are likely reported (Unglesbee 2019b; WSSA/EPA 2020).

Identity Preservation Costs

Entry of MON 87429 hybrids into domestic and foreign markets would contribute to the risks of commingling and low level presence (LLP)[11] no differently than other modified crops, and non-modified specialty corn varieties that have and will enter the market. This type of market effect is not considered adverse in nature, rather, segregation and channeling of specific types of harvested grain (e.g., flint, flour, dent, pop, and waxy corn) to various supply chains is inherent to corn and other commodities markets. Identity preservation certification programs are well developed and an intrinsic aspect of crop production in the United States (Sundstrom et al. 2002).

[10] Horticultural crops are classified as: Nursery Stock; Annual Bedding/Garden Plants; Sod, Sprigs or Plugs; Potted Flowering Plants; Herbaceous Perennial Plants; Propagative Materials; Food Crops Grown Under Protection; Foliage Plants; Cut Flowers; Transplants for Commercial Vegetable Production; Cut Christmas Trees (USDA-NASS 2019a).

[11] LLP refers to the unintended presence, at low levels, of biotech crop material that is authorized for commercial use or sale in one or more countries, but not yet authorized in an importing country.

Organic and Conventional Corn Markets

The organic industry is sensitive to the unintended presence of biotechnology derived crop material as it can compromise contractual requirements with businesses that market and sell their products. During the years 2011–2019, the incidence of affected organic farms ranged from around 0.1% to 0.7%. In 2014, 31 farms, out of a total of 14,093 certified organic farms (~0.2%) reported a total $506,552 in losses, with an average of $16,340 per farm (USDA-NASS 2016). In 2015, 32 farms, out of 12,818 total certified organic farms (~0.1%), reported a total of $520,671 on losses due to the unintended presence of biotechnology derived crop material, with an average reported loss of $16,271 (USDA-NASS 2016). For 2019, 125 out of 16,585 certified organic farms reported instances of unintended presence of biotechnology derived material in their crops, respectively (USDA-NASS 2019c). This equates to approximately 0.7% of organic farms affected in 2019.

In general, as the number of organic farms and adoption of biotechnology derived crops increased over the period 2006–2019, the incidence of organic farms reporting economic losses increased from 0.1% to 0.7% (USDA-NASS 2019c). Based on data from 2006 to 2019, the incidence of reported losses to organic production from the unintended presence of biotechnology derived trait material in organic crops or crop products would be expected to be limited, with affected organic farms comprising less than 1% of total organic farms.

Depending on the commodity, conventional and organic crop products may carry a market price premium (Greene et al. 2016). The economic impact to producers of organic and products marketed as "non-GMO" due to unintended presence would depend on the price premium impacted. For instance, organic commodities receive a price premium in the food and personal care products markets (e.g., from 30% to 500%) relative to the price of commodities derived from conventionally grown crops. Because "organic" and "non-GMO" commodities can always be sold as "conventional" commodities, it is the price premium above the conventional price that represents a measure of the value impacted by the unintended presence of biotechnology derived trait material.

The majority (~ 90%) of corn grown in the United States are biotechnology derived dent corn varieties. MON 87429 corn would be expected to replace other HR corn varieties, as opposed to augmenting current HR varieties grown. Thus, entry of MON 87429 corn into commerce, which would likely replace other HR varieties currently cultivated, would have little to no impact on organic and conventional corn commodities markets from the standpoint of unintended presence. The production systems for agricultural commodities derived from biotechnology-based and conventional/organic corn provide a range of ways to efficiently meet consumer needs, preferences, and market demands, both in the United States and abroad. Preserving agricultural commodity identity in the market through IP or similar certification programs is inherent to corn commodity production, segregation, and product streams (Sundstrom et al. 2002). Current IP, "non-GMO", and seed certification programs provide effective means for maintaining product identity; however, commingling or contamination by pollen flow, to some extent, over the long-term, is unavoidable (expected to be rare). MON 87429 corn production and marketing would present no more or less challenges in maintaining crop commodity identities than other corn varieties.

Native American Indian Corn

In addition to the commercial corn varieties described in this EIS, there are around 12,000 acres of traditional or Indian corn produced in the United States on Indian reservations (USDA-NASS 2023). Native American tribes are recognized by the United States Bureau of Indian Affairs (BIA) for federal government purposes. As of 2021, 573 Indian tribes were legally recognized by the BIA (BIA 2021). Traditional or Indian corn are distinct cultivars of *Zea mays*—heritage varieties—of various sizes, color, and drought tolerance. Traditional/Indian corn has been passed from generation to generation through seed saving by American Indian and Hispanic communities (Hill 2021). Traditional or Indian corn is culturally significant and may found be found produced on all reservations in the states of Alabama, Alaska, Arizona, California, Colorado, Connecticut, Florida, Idaho, Indiana, Iowa, Kansas, Louisiana, Maine, Massachusetts, Michigan, Minnesota, Mississippi, Montana, Nebraska, Nevada, New Mexico, New York, North Carolina, North Dakota, Oklahoma, Oregon, Rhode Island, South Carolina, South Dakota, Texas, Utah, Virginia, Washington, Wisconsin, and Wyoming (USDA-NASS 2019a).

While the potential for gene flow from cross-pollination between biotechnology derived corn and non-biotech varieties exists, utilization of best management practices, coordination and cooperation with neighboring growers of adjacent corn crops can preclude the occurrence of cross-pollination. As summarized above under Plant Communities, when corn fields are physically separated by sufficient distances (e.g., around 1,000 feet) they are less likely to have pollen drift and gene flow. Gene flow can also be reduced by staggering planting times—when adjacent corn fields flower and release pollen at different times in the summer.

The ability of each tribal nation to cultivate their own maize variety, and the recognition that Native traditional foods are important to the health and well-being of Native people, is a USDA program focus.[12] The USDA supports Tribal Nations' agriculture, food sovereignty, and traditional foods through various programs.[13] These include loan programs for beginning farmers and ranchers, farm operating loans, the plant pest and disease management and disaster prevention program, specialty crop block grants, and national organic certification cost share program, among others.

ES 11 CLIMATE CHANGE AND GREENHOUSE GAS EMISSIONS

GHGs associated with agriculture are carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). N_2O emissions derive from fertilizer applications, CH_4 emissions from ruminant livestock production and rice cultivation, CH_4 and N_2O emissions from managed livestock waste, and CO_2 emissions from on-farm energy use. The management of cropped, grazed, and forestland can help offset GHG emissions by promoting the biological uptake of CO_2 through the incorporation of carbon into biomass, wood products, and soils—termed carbon sequestration. Net emissions equate to total GHG emissions minus CO_2 sequestration or removal of CO_2 from the atmosphere, including the net forest sink as well as the net soil sink from grazed lands and croplands.

GHG emissions directly impact the environment in which farmers operate, and agriculture stands to be significantly influenced by the effects of climate change (USDA-ERS 2012). Extremes in precipitation;

[12] USDA Office of Tribal Relations [https://www.usda.gov/tribalrelations]

[13] 2016 USDA Resource Guide for American Indians & Alaska Natives, United States Department of Agriculture Office of Tribal Relations [https://www.usda.gov/sites/default/files/documents/2016-usda-tribal-guide.pdf]

more severe storms; soil moisture; nighttime air temperature; heat waves; humidity; drought spells; crop-growing region migration; weed range and infestation intensity; migration and increased incidence in plant insect pests and pathogens; effects on insect generations per season; and effects on pollinators and pollinator management; are all factors that will be influenced by a changing, warming, climate, and in turn effect crop production (USDA-EPA 2012).

MON 87429 corn, and the agricultural inputs and management practices that would be used in cultivation of this variety would contribute to GHG emissions, and the potential for carbon sequestration, as do other corn cropping systems. Any GHG emissions from cultivation of MON 87429 corn would be the same as/similar to current emissions from corn cultivation (US-EPA 2020w).

To help protect future crop production from, and adapt to, the effects of climate change the USDA conducts analyses of adaptation and mitigation options, cost-benefit analyses, and tools to support agriculture, forests, grazing lands, and rural communities. The Climate Change Program Office (CCPO) operates within the Office of Energy and Environmental Policy (OEEP) to coordinate agricultural, rural, and forestry-related climate change program and policy issues across the USDA. OEEP coordinates USDA's climate change activities, including execution of adaptation and resilience plans, through the USDA Global Change Task Force (GCTF), as well as interagency coordination.

In an effort to mitigate climate-related risks the USDA has established seven regional hubs for climate change risk adaptation and mitigation to (USDA 2020b). The USDA is taking steps to create modern solutions to the challenge of climate change. New uniform, science-based guidance on cover crop management helps producers prevent erosion, improve soil properties, supply nutrients to crops, suppress weeds, improve soil water content, and break pest cycles.

ES 12 COMPLIANCE WITH LAWS AND REGULATIONS, EXECUTIVE ORDERS, POLICIES, AND TREATIES

APHIS evaluated legal requirements (discussed in 4.3.8 – Compliance with Federal and State Laws and Regulations, Executive Orders, Policies, and Treaties); approval of the petition for nonregulated status would be compliant with all federal laws and regulations, state laws, executive orders, federal policies and international treaties, and Tribal Nations jurisdiction.

ES 13 POTENITAL IMPACTS ON THE HUMAN ENVIRONMENT

In considering whether the effects of the proposed action could be significant (40 CFR § 1500.1), APHIS analyzed the affected environment and degree of the potential effects identified (40 CFR § 1501.3). As part of this analysis APHIS considered those requirements outlined in sections 102(2)(C) of NEPA, 40 CFR § 1502.16– Environmental consequences, 40 CFR § 1501.3–Determine the appropriate level of NEPA review, 40 CFR § 1502.24–Environmental review and consultation requirements, and 40 CFR § 1502.15–Affected environment, which are summarized below.

Commercial crop production of any type, whether a conventional, organic, or biotechnology-based cropping system always has some degree of impact on the environment (Robertson and Swinton 2005; NRC-IM 2015; Ritchie 2017). The potential introduction of pesticides and fertilizers (organic or synthetic) to surface water or groundwater, soil erosion, emission of air pollutants, and loss of wildlife habitats are all impacts that can derive from commercial crop production. These are issues that all farmers, not just those growing biotech crops, work with in providing sufficient food, feed, biofuels, fiber, and industrial products to meet societal needs. The degree of environmental impacts can be minor or noticeably adverse, depending on a variety of factors that include the type and quantity of agronomic inputs and practices employed, geography and proximity of surface waters and groundwaters to crops, local biota, weather, prevalence and diversity of insect pests and weeds, and crop type being produced. With around 360,000 corn farms comprising some 90 million acres of the land in the United States (USDA-NASS 2023), the scale of potential impacts, namely in an aggregate sense, requires integration of crop production with sustainability and conservation practices—for both biotech and non-biotech crops. While implementing such practices can often result in significant mitigation of environmental impacts, not all impacts can be fully attenuated, and some degree environmental trade-offs in meeting the market demand for corn-based food, feed, fuel, and industrial products are inevitable (Robertson and Swinton 2005; NRC-IM 2015).

On approval of the petition, and subsequent grower adoption of MON 87429 corn, the agronomic practices and inputs that would be used in the cultivation of MON 87429 corn/hybrids, and any contribution of these practices and inputs to impacts on soils, water quality, or air quality, are expected to be similar to those of other corn crops currently cultivated. Dicamba, glufosinate, quizalofop-p-ethyl, 2,4-D, and glyphosate, are used on wide variety of other crops; these would not be novel uses on MON 8742 corn. It is expected that MON 87429 corn would be produced on lands already converted to cropland—replace other HR corn crops currently cultivated.

Potential increased herbicide use with this stacked-trait HR variety, were it to occur, could increase risks to water and air quality, wild and cultivated non-crop plants via spray and vapor drift, and to aquatic plants via runoff. Herbicide spray and vapor drift, as well as runoff, could also present risks to terrestrial and aquatic wildlife by affecting plants that wildlife depend on.

Based on the data reviewed in this EIS, in the event of dicamba spray and/or vapor drift, and to some extent 2,4-D spray and/or vapor drift, or dicamba misuse (use the product off label requirements), there are potentially significant economic impacts on producers of non-herbicide resistant crops proximate to those lands on which MON 87429 corn hybrids were planted and dicamba and/or 2,4-D used. Growers affected could include vegetable, grain, fruit, and horticultural crops. Residential and commercial properties could also be affected by herbicide spray/vapor drift. Herbicide spray or/and vapor drift into areas proximate to crop fields and injury to trees and flowering of plants can result in decreased visitation by pollinators and other beneficial insects. Herbicide spray/vapor drift on such plants, particularly on a broad geographic scale, can impair bird habitat by interfering with insect plant-based food sources. These types of potential impacts would be relative to the scale of the environments affected. For example, corn production utilizes around 90 million acres of land; there are as yet no corn acres planted to dicamba resistant corn. As of 2019, the number of dicamba-resistant soybean planted in the United States comprised around 60% of soybean acreage, approximately 60 million acres (Hettinger 2019b). As of 2020, around 70% of cotton acreage, approximately 8.5 million acres, were planted to dicamba-resistant varieties (US-EPA 2020aa). Considering the geographic scale on which dicamba may be used with dicamba-resistant crops, the scale and variety of off-target non-crop foliage affected could be substantial, dependent on the level of spray and vapor drift that may occur.

All herbicide use with MON 87429 corn would need to be complaint with EPA label use requirements and restrictions (these are legal requirements), as well as any state restrictions that may be imposed in addition to that of the EPA herbicide label. EPA label use requirements are developed so as to be protective of the environment and public health. The EPA label use restrictions establish the maximum quantity of an herbicide that can be applied on an annual basis, as well as limits on use rates during application, and herbicide mixing.

1 PURPOSE AND NEED FOR AGENCY ACTION

1.1 Background

In July 2019, Monsanto Company (Bayer)[14] submitted a petition (19-316-01p) to the U.S. Department of Agriculture (USDA), Animal and Plant Health Inspection Service (APHIS), requesting that MON 87429 maize (corn),[15] which was developed using genetic engineering, no longer be considered regulated under Title 7 of the Code of Federal Regulations part 340 (7 CFR part 340). As described in more detail below under Section 1.4–Requirement to Issue to Regulatory Status Determination, APHIS regulations at 7 CFR part 340 provide that any person may submit a petition to APHIS requesting that an organism should not be regulated, and APHIS must respond to petitioners with a regulatory status decision.

As part of evaluation of the petition APHIS developed this draft Environmental Impact Statement (EIS) to consider the potential effects[16] of a determination of nonregulated status for MON 87429 corn on the human environment.[17] The primary purpose of an EIS is to ensure agencies consider the environmental impacts of their actions in decision making. This EIS is to provide a full and fair discussion of the potential environmental impacts, beneficial and adverse, so as to inform decision makers and the public of the potential outcomes of deregulation of MON 87429 corn, and ways to avoid or minimize any potential adverse impacts.

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

1.2 Purpose of MON 87429 Corn

MON 87429 corn was developed for resistance to the herbicide active ingredients dicamba, glufosinate-ammonium, quizalofop-p-ethyl, and 2,4-dichlorophenoxyacetic acid (2,4-D).[18] MON 87429 corn has also been modified for glyphosate resistance in vegetative and female tissues of the plant, a trait that will be used for hybrid corn seed production. MON 87429 corn will not be marketed as a stand-alone product,

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[14] Monsanto Company was acquired by Bayer AG after U.S. regulatory approval in 2018. The company name "Monsanto" was eventually discontinued and is now referred to solely as Bayer AG.

[15] Maize is the botanical term used globally for the cereal plant *Zea mays*. In the United States maize is commonly referred to as corn. Both terms are used interchangeably in this document. For consistency with the common plant name and petition APHIS uses the term maize, but also refers to corn in certain instances, such as in reference to food products.

[16] Effects include ecological (such as the effects on natural resources and on the components, structures, and functioning of affected ecosystems), aesthetic, historic, cultural, economic (such as the effects on employment), social, or health effects. Effects may also include those resulting from actions that may have both beneficial and detrimental 10425effects, even if on balance the agency believes that the effect will be beneficial (40 CFR § 1508.1(g)(1)).

[17] The term "human environment" means comprehensively the natural and physical environment and the relationship of present and future generations of Americans with that environment (40 CFR § 1508.1(m)).

[18] Note that "Resistance" to herbicides is defined by the Herbicide Resistance Action Committee (HRAC) as the inherited ability of a plant population to survive and reproduce following repeated exposure to a dose of herbicide normally lethal to the wild type. "Tolerance" is distinguished from resistance and defined by HRAC as the inherent ability of a plant to survive and reproduce following exposure to an herbicide treatment. This implies that there was no selection or genetic manipulation to make the plant tolerant; it is naturally tolerant.

its intended purpose is for production of hybrid corn seed—resistant to dicamba, glufosinate-ammonium, quizalofop-p-ethyl, 2,4-D, and glyphosate (Monsanto 2019). The first-generation of the Roundup® Hybridization System (RHS) was based on MON 87427 corn, which was assessed by APHIS and deregulated in 2013. The second-generation RHS would utilize MON 87429 corn to produce glufosinate, dicamba, 2,4-D, quizalofop-p-ethyl, and glyphosate resistant corn seed.

As a "stacked-trait" herbicide resistant (HR) corn variety, with resistance to multiple herbicide active ingredients (a.i.) that have differing modes of action (MOAs), hybrid progeny of MON 87429 corn is intended to facilitate weed and herbicide resistant weed management.

1.3 Coordinated Framework for the Regulation of Biotechnology

On June 26, 1986, the White House Office of Science and Technology Policy issued the Coordinated Framework for the Regulation of Biotechnology (Coordinated Framework), which outlined Federal regulatory policy for ensuring the safety of biotechnology products. The primary federal agencies responsible for oversight of biotechnology products are the USDA, the U.S. Environmental Protection Agency (EPA), and the U.S. Food and Drug Administration (FDA).

In 2015, the Executive Office of the President (EOP) issued a memorandum directing the USDA, EPA, and FDA to update the Coordinated Framework to clarify current roles and responsibilities in the regulation of biotechnology products; develop a long-term strategy to ensure that the Federal biotechnology regulatory system is prepared for the future products of biotechnology; and commission an independent, expert analysis of the future landscape of biotechnology products. On January 4, 2017, the USDA, EPA, and FDA released an update to the Coordinated Framework (USDA-APHIS 2020b), and accompanying National Strategy for Modernizing the Regulatory System for Biotechnology Products (ETIPCC 2017).

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

The purpose of EPA oversight is to protect human and environmental health. The EPA regulates pesticides, including pesticides that are produced by biotechnology derived organisms, termed plant incorporated protectants, under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) (7 U.S.C. 136 *et seq.*). In addition, the EPA regulates certain biotechnology derived organisms (agricultural uses other than pesticides) under the Toxic Substances Control Act (15 U.S.C. 53 *et seq.).* The EPA also sets tolerances (maximum limits) for pesticide residues that may remain on or in food and animal feed, or establishes an exemption from the requirement for a tolerance, under the Federal Food, Drug, and Cosmetic Act (FFDCA; 21 U.S.C. 301 et seq.). The USDA and EPA monitor tolerances, and FDA enforces tolerances—except for meat, poultry, catfish, and certain egg products that are regulated by the USDA—to ensure the safety of the nation's food supply (US-EPA 2019d; USDA-AMS 2020b). Under the National Residue Program, the USDA's Food Safety and Inspection Service (FSIS) monitors meat, poultry, and processed egg products for pesticide residue and takes enforcement actions if it finds pesticide residues that exceed EPA tolerance levels (USDA 2020c).

The purpose of FDA oversight is to ensure human and animal foods and drugs are safe and sanitary. The FDA regulates a wide variety of products, including human and animal foods, cosmetics, human and veterinary drugs, and human biological products under the authority of the FFDCA and Food Safety Modernization Act (FSMA). The FDA created the Plant Biotechnology Consultation Program in 1992 to cooperatively work with plant developers to help them ensure foods made from their new plant varieties are safe and lawful (US-FDA 1992b, 2006). In this program, the FDA evaluates the safety of food/feed from the new biotechnology derived crop before it enters the market. Although the consultation program is voluntary, plant developers routinely participate in it before bringing a new biotechnology derived plant to market. The FDA completed its first plant biotechnology consultation in 1994. Thus far, the FDA has evaluated more than 150 new plant varieties through this program.

A more detailed description of the roles and responsibilities of the USDA, the EPA, and FDA under the Coordinated Framework can be found on USDA's website (USDA-APHIS 2020b).

1.4 Requirement to Issue a Regulatory Status Determination

Under the authority of the plant pest provisions of the Plant Protection Act (7 U.S.C. 7701 *et seq*.), the regulations in 7 CFR part 340, "Movement of Organisms Modified or Produced Through Genetic Engineering," regulate, among other things, the importation, interstate movement, or release into the environment of organisms modified or produced through genetic engineering that are plant pests or pose a plausible plant pest risk.[19] APHIS recently revised 7 CFR part 340 and issued a final rule, published in the *Federal Register* on May 18, 2020 (85 FR 29790-29838, Docket No. APHIS-2018-0034).[20] APHIS' new Regulatory Status Review (RSR) process, which replaces the petition for determination of nonregulated status process, became effective on April 5, 2021 for corn, soybean, cotton, potato, tomato, and alfalfa. The RSR process was effective for all crops as of October 1, 2021.

However, the final rule was implemented in phases, which provided that "Until RSR is available for a particular crop…APHIS will continue to receive petitions for determination of nonregulated status for the crop in accordance with the [legacy] regulations at 7 CFR 340.6 (85 FR 29815)." Pursuant to the terms set forth in the final rule, the petition for a determination of nonregulated status that is the subject of this EIS is being evaluated in accordance with the legacy regulations at 7 CFR 340.6, the regulations prior to the May 18, 2020 revisions, as the petition was received by APHIS, in July, 2019. 7 CFR 340.6 provides that any person may submit a petition to APHIS seeking a determination that an organism should not be regulated under 7 CFR part 340. APHIS must respond to petitioners with a decision to approve or deny the petition. An organism produced using genetic engineering is no longer subject to the requirements of

[19] Genetic engineering in the context of 7 CFR part 340 refers to biotechnology-based techniques that use recombinant, synthesized, or amplified nucleic acids to modify or create a genome. Various terms are used in the lay and peer review literature in reference to new plant varieties that have been developed using modern molecular biology tools, these include "agricultural biotechnology", "genetically engineered", and "genetically modified". In this EIS, the terms "genetic engineering" and "biotechnology" may be used interchangeably. The term "transgenic" may also be used when discussing or referring to a transgene introduced into the genome of a plant. The USDA does not regulate plants that could have been developed through traditional breeding techniques—to include chemical and radiation-based mutagenesis, as long as they are not plant pests or developed using plant pests.

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

7 CFR part 340 or the plant pest provisions of the PPA if APHIS determines, through conduct of a Plant Pest Risk Assessment (PPRA), that it is unlikely to pose a plant pest risk.

2 Scoping and Public Involvement

APHIS seeks public comment on draft EAs and EISs through notices published in the *Federal Register*. On March 6, 2012, APHIS announced in the *Federal Register* updated procedures for the way it solicits public comment on petitions for determinations of nonregulated status.[21] Details on policy and procedures for public participation in the petition review and NEPA process are available in the *Federal Register* notice (USDA-APHIS 2020a).

2.1 Public Involvement for Petition 19-316-01p

On May 8, 2020 APHIS announced in the *Federal Register* that it was making Bayer's petition available for public review and comment to help identify potential environmental and interrelated economic issues that APHIS should consider in evaluation of the petition.[22] APHIS accepted written comments on the petition for a period of 60 days, until midnight, July 7, 2020. At the end of the petition comment period APHIS had received 4,112 submissions on the petition via www.regulations.gov. Comments submitted were from the academic sector, farmers, non-governmental organizations (NGOs), nonprofit organizations, industry, and unaffiliated individuals. APHIS also received one comment from one tribal nation, the Sault Ste. Marie Tribe of Chippewa Indians, which opposed approval of the petition. Among all submissions received, APHIS identified 192 unique comments. In total, three comments received were in favor of the petition, the remainder of comments were in opposition to approval of the petition.

The majority of opposing comments submitted, approximately 3,918, were based on templates, where the wording of the comments submitted were similar or identical, although submitted by a different individual. Among the 192 unique comments received were petitions and form letters submitted by NGOs/nonprofit organizations that included multiple signatures. For example, the Pesticide Action Network and National Family Farm Coalition submitted a form letter comprised of 13,451 signatures. Beyond Pesticides submitted a petition on behalf of 3,804 signatories. Green America submitted a form letter with 9,408 signatories. Friends of the Earth submitted a form letter signed by 19,845 individuals. All petition's and form letters submitted by NGOs/nonprofit organizations opposed deregulation of MON 87429 corn. Issues raised in the opposing comments were in regard to the toxicity of pesticides, potential dicamba and 2,4-D drift, over-reliance on herbicides for weed control, potential increased use of herbicides with stacked-trait HR crops, development of herbicide resistant weeds, and biotechnology-derived crops in general.

Three comments in favor of approval of the petition were from the National Corn Growers Association, and two weed scientists. The three comments in favor of the petition were of the opinion that stacked-trait HR corn varieties can expand grower options and facilitate effective weed management in corn. APHIS also received comment from the National Grain and Feed Association and North American Export Grain

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

[22] Federal Register, Vol. 85, No. 90, Friday, May 8, 2020, p. 27354 - Bayer/Monsanto; Availability of Petition for Determination of Nonregulated Status of Maize Genetically Engineered for Dicamba, Glufosinate, Quizalofop, and 2,4-Dichlorophenoxyacetic Acid Tolerance With Tissue-Specific Glyphosate Tolerance Facilitating the Production of Hybrid Maize Seed. Available at https://www.govinfo.gov/content/pkg/FR-2020-05-08/pdf/2020-09834.pdf

Association, which addressed the commercialization of biotech crops with unique traits, domestic and export supply chains, product stewardship, and securing international market approvals for biotech crops.

2.2 Summary of Comments Submitted on the Notice of Intent to prepare an Environmental Impact Statement

On April 28, 2021, APHIS published a Notice of Intent (NOI) to prepare an EIS for Bayer's petition for nonregulated status for MON 87429 corn. APHIS requested public comment to help identify alternatives, and relevant information, studies, and/or analyses APHIS should consider in the EIS.[23] APHIS accepted public comments until midnight, July 30, 2021. At the end of the comment period, APHIS had received 3,069 comments. There were 23 unique comments submitted in response to the NOI for the EIS, the remainder of submitted comments were nearly identical in content based on the same form letter yet submitted by different individuals. Among the 23 unique comments, Friends of the Earth, a non-governmental environmental organization headquartered in Washington, D.C., provide a submission with over 23,500 signatures using the same form letter. APHIS also received comments from two tribal nations, the Oneida Nation of Wisconsin, and the Upper Sioux Community of Minnesota. APHIS received one comment from industry, Bayer Crop Science.

APHIS evaluated all comments received on the NOI for the EIS; a summary of the comments received, and APHIS response to comments, are provided in Appendix 1. A full record of comments received online is available at www.regulations.gov.[24]

2.3 Issues Considered in this Draft EIS

APHIS developed a list of topics for consideration in this draft EIS based on issues identified in public comments on the petition, public comments submitted on the NOI for this EIS, public comments submitted for other EAs and EISs evaluating petitions for nonregulated status, prior EAs and EISs for biotechnology-derived corn varieties, the scientific literature on agricultural biotechnology, and issues identified by APHIS specific to wild and cultivated *Zea* and *Tripsacum* species. The following topics were identified as relevant to the scope of analysis (40 CFR § 1501.9 – Scoping):

- Agricultural Production: Acreage and areas of corn production, agronomic practices and inputs
- Physical Environment: Soils, water resources, air quality
- Biological Resources: Soil biota, animal communities, plant communities, potential gene flow and weediness, biodiversity
- Public health and worker safety

[23] Federal Register, Vol. 86, No. 80, Wednesday, April 28, 2021, p. 22384 - Bayer; Notice of Intent to Prepare an Environmental Impact Statement for Determination of Nonregulated Status for Maize Developed Using Genetic Engineering for Dicamba, Glufosinate, Quizalofop, and 2,4-Dichlorophenoxyacetic Acid Resistance, With Tissue-Specific Glyphosate Resistance Facilitating the Production of Hybrid Maize Seed. [Agency/Docket Number: APHIS–2020–0021]. Available at https://www.federalregister.gov/documents/2021/04/28/2021-08879/bayer-notice-of-intent-to-prepare-an-environmental-impact-statement-for-determination-of

[24] See https://www.regulations.gov/document/APHIS-2020-0021-4127 [Docket No. APHIS-2020-0021-4127 at www.regulations.gov]

- Food animal health and welfare
- Domestic economy and international trade
- Potential impacts on threatened and endangered species
- Compliance of the Agency's regulatory status decision with Executive Orders, and environmental laws and regulations to which the action is subject.

Because the introduced trait genes are involved in weed management, the primary focus of this EIS is on: (1) weed and herbicide resistant weed management, (2) potential effects of exposure to the introduced trait genes and gene products on human health and wildlife, and (3) gene flow and potential weediness of MON 87429 corn. Because spray and vapor drift of dicamba and to some extent 2,4-D has resulted in documented cases of injury to crop and non-crop plants, and both herbicides could be used with MON 87429 corn, socioeconomic impacts are also considered.

3 ALTERNATIVES

NEPA implementing regulations (40 C.F.R. 1500–1508) require agencies to evaluate alternatives to the proposed action that would avoid or minimize adverse impacts, or enhance the quality of the human environment, while meeting the purpose and need for the agency's action (in this case, a regulatory status decision). Two alternatives are evaluated in this EIS: (1) No Action, denial of the petition, which would result in the continued regulation of MON 87429 corn, and (2) Preferred Alternative, approval of the petition, which would result in a determination of nonregulated status for MON 87429 corn.

APHIS considers two alternatives, the proposed action and the no action alternative, consistent with the scope of its statutory authority under the PPA, and NEPA implementing regulations at 7 CFR part 340. In terms of practicable and feasible options in issuing a decision on Bayer's petition, these are the two alternatives available to APHIS.

3.1 No Action Alternative: Deny the Petition Request

One of the alternatives that APHIS considers is a "No Action Alternative," consistent with CEQ regulations at 40 CFR § 1502.14. APHIS does not have the option to not respond to a petition, which could be considered "no action", because the regulations at 7 CFR part 340 require APHIS to respond to all petitioners with a regulatory decision (see Section 1.4). Thus, for APHIS, "no action" in this context means no change in regulatory status. Under the No Action Alternative APHIS would deny the petition request for nonregulated status and MON 87429 corn and progeny derived from MON 87429 corn would be regulated under 7 CFR part 340. Permits issued by APHIS would be required for the environmental release or shipment of MON 87429 corn. Because APHIS concluded in its draft PPRA that MON 87429 corn is unlikely to pose plant pest risk (USDA-APHIS 2020c), denial of the petition would not be a scientifically nor legally sound response as it would not meet the purpose and need in providing a science based regulatory status decision to the petitioner, pursuant to 7 CFR part 340.

3.2 Preferred Alternative: Approve the Petition for Nonregulated Status

Under this alternative APHIS would approve the petition request. MON 87429 corn and progeny derived from it would no longer be subject to APHIS regulation under 7 CFR part 340 because it was determined that, based on the scientific evidence before the Agency, MON 87429 corn is unlikely to pose a plant pest risk (USDA-APHIS 2020c). APHIS permits would no longer be required for the environmental release or shipment of MON 87429 corn. This alternative satisfies the purpose and need to respond to the petition for nonregulated status with a science based regulatory status decision, pursuant to the requirements of 7 CFR part 340, and the Agency's statutory authority under the PPA.

3.3 Summary of the No Action and Preferred Alternative Analyses

Table 3-1 presents a summary of the potential environmental impacts associated with the No Action Alternative and Preferred Alternative that are evaluated in this draft EIS. Detailed analysis of the affected environment and potential environmental impacts are discussed in Chapter 4.

Table 3-1. Summary of Potential Impacts for the Alternatives Considered

Analysis	No Action Alternative: Continue to Regulate MON 87429 Corn as a Plant Pest	Preferred Alternative: Approve the Petition for Nonregulated Status for MON 87429 Corn
Meets Purpose and Need and Objectives	No	Yes
Management Practices		
Acreage and Areas of Corn Production	Denial of the petition would have no effect on the areas or acreage utilized for corn production. Fluctuations in production areas and acreage would be relative to weed, insect pest, and disease pressures, and market demand for corn commodities. Regulated field trials would be conducted on lands allocated for this purpose.	Approval of the petition would have little to no effect on U.S. corn acreage. MON 87429 corn hybrids, if adopted by growers, would be expected to replace other herbicide resistant (HR) corn varieties currently cultivated, as opposed to augmenting current corn crops.
Agronomic Practices and Inputs	Agronomic practices and inputs used in corn crop production, to include regulated field trials, would remain unchanged. Denial of the petition would have no effect on weed management in corn.	Studies evaluating the phenotypic and agronomic properties of MON 87429 corn indicate the practices and inputs would be similar to that of other corn varieties. Herbicide use would favor dicamba, glufosinate, quizalofop-p-ethyl, 2,4-D, and glyphosate use in lieu of other herbicides. MON 87429 corn hybrids could potentially be of benefit to the management of weeds, and control of development of HR weeds. How stacked-trait HR varieties may contribute to an increase in annual herbicide use is uncertain; there is insufficient data on the relationship between stacked-trait HR crops and herbicide use. Due to EPA annual use restrictions indicated on the label for each herbicide, and costs and efficiency concerns in crop production, it is expected that overall herbicide use with MON 87429 corn hybrids would be limited to what was needed for effective weed and HR weed control.
Use of GE Corn	Approximately 90% of U.S. corn crops are biotechnology derived HR varieties. Denial of the petition would have no effect on grower choice in the planting of biotech HR corn and conventional non-biotech varieties.	Approval of the petition would provide for cultivation of a stacked-trait HR corn variety resistant to 4 differing herbicide modes-of-action (MOA), and 5 herbicides, which could be of benefit to weed and HR weed management in corn cropping systems.

Analysis	No Action Alternative: Continue to Regulate MON 87429 Corn as a Plant Pest	Preferred Alternative: Approve the Petition for Nonregulated Status for MON 87429 Corn
Physical Environment		
Soil Quality	Agronomic practices and inputs associated with corn production potentially impacting soils, to include regulated field trials, would continue along current trends.	The agronomic practices and inputs used for MON 87429 corn production that can impact soil quality would be no different from those currently used in corn production, thus, any potential impacts on soils resulting from MON 87429 corn/progeny cultivation would be the same or similar as for other corn varieties.
Water Resources	Denial of the petition would have no effect on water resources in the United States. Regulated field trials are limited on a spatiotemporal scale, and present negligible risks to water resources.	The agronomic practices and inputs utilized for MON 87429 seed corn/hybrid production would be similar to that currently used. Consequently, sources of potential impacts on water resources, namely NPS pollutants in agricultural run-off, would not be expected to substantially differ. Whether there may be an increase in herbicide use with MON 87429 corn hybrids, which would entail a potential increase in herbicides in runoff, is uncertain. The EPA provides label use restrictions and guidance for pesticides, to include herbicides, that are intended to be protective of surface and groundwater.
Air Quality	Emission sources, namely tillage and machinery combusting fossil fuels, and the level of emissions associated with corn production, to include regulated field trials, would be unaffected by denial of the petition.	Because the acreage would remain unchanged, and agronomic practices and inputs similar, no changes to emission sources nor any significant changes in the volume of NAAQS emissions from U.S. corn production would be expected. Whether there may be an increase in herbicide use with MON 87429 corn hybrids, which would entail a potential increase in herbicide spray drift and volatilization, is uncertain.
Biological Resources		
Soil Biota	Potential impacts of corn production/regulated field trials on soil biota would continue along current trends.	Commercial production of MON 87429 hybrids is not expected to present any risks to soil biota. All of the introduced trait genes are derived from naturally occurring soil bacterium or plants. Thus, the genetic elements, protein products, and organisms from which they were derived, are prevalent in soils; there are no adverse effects on soil biota that would likely derive from the introduced genes or gene products There are no significant impacts on soil biota that have been reported in association with the herbicides used with MON 87429 corn..

Analysis	No Action Alternative: Continue to Regulate MON 87429 Corn as a Plant Pest	Preferred Alternative: Approve the Petition for Nonregulated Status for MON 87429 Corn
Animal Communities	Regulated field trials of MON 87429 corn would present negligible risk to animal communities.	MON 87429 corn hybrids would not be expected to affect animal communities adjacent to or within MON 87429 corn cropping systems much differently from that of current corn cropping systems. MON 87429 corn is nutritionally comparable to other dent corn varieties. It is unlikely that the *pat*, *dmo*, *ft_t*, and cp4 *epsps* gene products present any risks to wildlife. Drift of dicamba, and some formulations of 2,4-D, owing to their efficacy as auxin mimic herbicides, and effects on a wide variety of broadleaf plants at low doses, could result in off-target effects on wild, residential, and commercial plants, as a result of the use of these herbicides with MON 87420 corn. The potential effects of dicamba or 2,4-D drift on nearby plants and associated populations of beneficial insects (e.g., pollinators, predators and parasitoids) and birds can be of concern. Herbivorous animals that depend on plants for sustenance (e.g., deer, rabbit, squirrel) could also be affected by poor quality plant material (resulting from herbicide spray or vapor drift), and the need to spend more time foraging to acquire sufficient food. Herbicide use with MON 87429 corn would be subject and limited to EPA label use requirements, which are intended to be protective of wildlife.
Plant Communities	Regulated field trials of MON 87429 corn would present negligible risks to plant communities in proximity to MON 87429 corn fields.	Because the agronomic practices and inputs that will be used for MON 87429 corn production are similar to that of other corn varieties, potential impacts on plant communities would be the same. Dicamba use, and to some extent 2,4-D, both auxin based herbicides, has been controversial due to spray drift and volatilization issues, and injury to other crops and non-crop plants. The addition of MON 87429 corn hybrids to the landscape could increase dicamba and 2,4-D use on U.S. corn acres, and thereby increase potential risks to plants in proximity to MON 87429 crops via spray and vapor drift. Use of dicamba and 2,4-D with MON 87429 corn progeny (as well as glyphosate, glufosinate, and quizalofop-p-ethyl) would be expected to present the same risks for drift, and injury to nearby

Analysis	No Action Alternative: Continue to Regulate MON 87429 Corn as a Plant Pest	Preferred Alternative: Approve the Petition for Nonregulated Status for MON 87429 Corn
		crops that are not dicamba or 2,4-D resistant, and residential and commercial properties, as with other dicamba and 2,4-D resistant crops, and non-biotech crops on which dicamba and 2,4-D, are used. Herbicide use will be subject to EPA label requirements, any EPA imposed restrictions, as well state requirements.
Gene Flow and Weediness	*Tripsacum* species are the only sexually compatible plants found in the United States. The potential for corn (*Zea mays*) to hybridize with wild relatives of *Tripsacum* is low; hybridization and successful introgression of *Z. mays* genes into *Tripsacum* is rare (de Wet and Harlan 1972; de Wet et al. 1978; Eubanks 1995). Gene flow to *Tripsacum* species during regulated field trials of MON 87429 corn is highly unlikely.	MON 87429 corn hybrids, if grown for commercial purposes, would be cultivated as are current corn varieties and present the same potential risk for gene flow, specifically the propensity for and frequency of gene flow, as current corn varieties. In the unlikely event pollen flow from MON 87429 corn to *Tripsacum* were to occur, it is unlikely the HR traits extant in MON 87429 corn would present any risk to communities of *Tripsacum* species in terms of plant fitness, or their ecological role in the communities of other plants. Successful introgression of *Zea mays* genes into *Tripsacum* populations, successful gene flow in this direction, has not been observed in the wild (de Wet and Harlan 1972; de Wet et al. 1978; Eubanks 1995).
Biodiversity	Denial of the petition, and any further regulated field trials of MON 87429 corn, would present negligible risks to biodiversity in an around MON 87429 corn crops.	Commercial production of MON 87429 corn hybrids, relative to the particular herbicides used, and combinations of herbicides used, could potentially affect biodiversity in and around MON 87429 corn crops—namely via any off-target foliage injury that resulted from spray or/and vapor drift: This would be relative to the geographic scale of such injury. Insects that feed on plants, herbivores, birds that rely on insects for food, could be affected. Thus, there could be shifts in pollinator and bird habitat toward more nutrient rich areas. The HR trait proteins are unlikely to present any direct risks to plant, animal, fungal, or bacterial communities. The same or functionally similar HR proteins are common among soil bacteria.
Human and Animal Health		
Human Health and Worker Safety	Denial of the petition would have no effect on human health. MON 87429 corn would remain regulated and would not be available for food uses.	There are no risks to public health that would derive from approval of the petition for MON 87429 corn. It is unlikely that MON 87429 corn, a field corn variety (e.g., *Zea*

Analysis	No Action Alternative: Continue to Regulate MON 87429 Corn as a Plant Pest	Preferred Alternative: Approve the Petition for Nonregulated Status for MON 87429 Corn
		mays var. *indentata*), would be directly consumed by humans. MON 87429 corn hybrid progeny, could, however, be used for processed foods such as tortilla chips, corn starch, and other corn-based food products. There are no risks to human health associated with the PAT, DMO, FT_T, and CP4 ESPS proteins. Bayer completed a Biotechnology Consultation on Food from GE Plant Varieties with the FDA, evaluating the safety of MON 87429 corn, in July 2022 (US-FDA 2022)). The EPA's regulation of pesticides, and worker protection standards, would remain unchanged.
Animal Health and Welfare	Denial of the petition would have no effect on animal health and welfare. MON 87429 corn would remain regulated and would not be available for feed uses.	MON 87429 corn could potentially be used for animal feed products. As mentioned, Bayer completed a FDA consultation evaluating the food and feed safety of MON 87429 corn in July 2022 (US-FDA 2022)
Socioeconomic		
Domestic Economic Environment	Denial of the petition would effectively preclude MON 87429 corn being available for production of food, feed, and fuel commodities on a broad scale.	MON 87429 corn could be cultivated to produce corn-based food, feed, fuel, and industrial products. MON 87429 corn hybrids may facilitate the management of weeds, and HR weeds and their development. Consequently, this variety may be competitive in grower selection of HR corn varietals. Benefits would be relative to how well MON 87429 corn is utilized in effective integrated weed management (IWM) programs. The potential impacts of MON 87429 corn hybrids—the food, feed, fuel, and industrial commodities that could be derived from MON 87429 corn hybrids—on the corn industry and domestic markets would be considered potentially beneficial. Dicamba spray and volatility drift, and to some extent 2,4-D, have been an issue in U.S. crop production. Impacts to non-crop foliage have also occurred but not well monetized. Crop loss and costs to growers can be substantive (e.g., hundreds of thousands of dollars). To what extent MON 87429 corn, on which dicamba could be used, may or may not contribute to the controversy and potential tangential costs associated with dicamba use is uncertain. Growers may elect not to use dicamba with

Analysis	No Action Alternative: Continue to Regulate MON 87429 Corn as a Plant Pest	Preferred Alternative: Approve the Petition for Nonregulated Status for MON 87429 Corn
		MON 87429 corn, or use infrequently/judiciously, to avoid risks. Any herbicide use will be relative to EPA label use requirements/restrictions, as wells as state requirements.
Trade Economic Environment	Denial of the petition would have no impacts on the trade of corn commodities.	Approval of the petition is unlikely to have any effect on the trade of U.S. corn commodities. As discussed above, MON 87429 corn hybrids are expected to be used for provision of standard corn-based food, feed, fuel, and industrial products.
Coordinated Framework		
U.S. Regulatory Agencies	Denial of the petition would have no effect on the roles of the FDA and EPA in the oversight of MON 87429 corn. Introductions of MON 87429 corn would be regulated by USDA.	Bayer completed a Biotechnology Consultation on Food derived from MON 87429 corn, in July 2022 (US-FDA 2022). Pesticide use will be subject to EPA registration and all label use requirements.
Environmental Regulatory and Policy Compliance		
ESA, CWA, CAA, SDWA, NHPA, EOs	Fully compliant (*not compliant with the Plant Protection Act (PPA) and 7 CFR part 340)	Fully compliant

4 AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

4.1 Scope of Analysis

Evaluation of the Potential Impacts of Agency Action

An impact/effect would be any change, beneficial or adverse, on existing conditions (baseline) described for the affected environment that could result from approval or denial of the petition, subsequent commercial production of MON 87429 corn, and market utilization of commodities derived from this variety.

Pursuant to CEQ regulations (40 CFR § 1508.1(g)), impacts/effects considered are those that are reasonably foreseeable and have a reasonably close causal relationship to the petition decision. Impacts/effects may occur soon after the Agency decision or occur later in time. Potential impacts/effects include ecological (such as effects on wildlife or/and ecosystems), public health, sociological (e.g., minority and underserved communities), and historic and cultural properties. Potential economic impacts, such as on crop producers and crop commodities markets, are also considered.

In considering whether the effects of the proposed action are significant (40 CFR § 1500.1), agencies are to analyze the potentially affected environment, and degree of the potential effects in relation to the affected environment (40 CFR § 1501.3(b)). Agencies should also consider connected actions consistent with 40 CFR§ 1501.9 (e)(1). The potentially affected environment (summarized below) is defined by the areas potentially impacted by the petition decision (e.g., national, regional, or local), and associated resources (e.g., natural, cultural). In considering the degree of the effects, agencies are to consider the following, as appropriate to the proposed action:

- Short- and long-term effects
- Both beneficial and adverse effects
- Effects on public health and safety
- Effects that could violate federal, state, tribal, or local laws protecting the environment

Potentially Affected Environment

The potential impacts of commercial production of a biotechnology-derived crop on the human environment occur within the context of agriculture's general contribution to environmental change (NRC 2010). Crop production has historically converted biologically diverse natural grasslands, wetlands, and native forests into less bio-diverse agroecosystems to produce food, feed, fiber, and fuel sufficient to meet societal needs (NRC 2010). Potential environmental effects depend on the intensity of scale of cultivation over time, the agronomic inputs applied (e.g., fertilizers, pesticides, irrigation water), and the effective management of inputs, pests, weeds, and tillage. There are around 90 million acres of land area in the United States planted to corn, and 323 to 340 million acres of total U.S. cropland planted, on annual basis. Thus, the scale of potential impacts, namely in an aggregate sense, requires integration of crop production with sustainability and mitigation practices, for both biotechnology based and conventional corn cropping systems. In general, tillage, crop monoculture, and fertilizer and pesticide inputs can potentially have adverse effects on topsoil, water quality, air quality, and local biodiversity. Agriculture is a leading cause of water-quality impairment in the United States as a result of run-off crop protection/production inputs (US-EPA 2019i). No-tillage systems, crop rotations, integrated pest and weed management programs, and other environmentally beneficial management practices can help ameliorate some of these impacts, although a tradeoff between the agricultural production food, feed, fiber, and fuel to meet societal needs, and effects on the environment that will require management, will always remain (Robertson and Swinton 2005).

Gene flow, movement of a transgene in a biotech crop plant to another sexually compatible species of crop or non-crop plant has also been a topic of concern, more so in terms of potential economic (e.g., presence of biotech corn grain in non-biotech corn grain), as opposed to ecological impacts. For corn, gene flow to wild relative species has not been an issue to date because sexually compatible relatives of corn do not exist in the United States. However, gene flow of biotechnology-based traits into non-biotech corn varieties is a concern for farmers and markets that depend on adhering to strict non-biotech trait presence and identity preservation standards for certain food and feed commodities. Such gene flow can result in adverse economic impacts to the biotech trait-sensitive market.

Due to the scale of crop production in the United States (e.g., 300 to 330 million acres on an annual basis), developing and implementing environmentally and economically sound, sustainable agricultural management practices is a primary goal of federal and state programs (e.g., (US-EPA 2020ab; USDA-NIFA 2020; USDA-NRCS 2020d, c), and others).

It is within this context that APHIS evaluates the potential impacts of MON 87429 corn on the human environment if cultivated on a commercial scale for production of food, feed, fuel, and/or industrial commodities.

MON 87429 Corn: Assumptions Used in Analysis

As discussed in 1.2 – Purpose of MON 87429 Corn, Bayer states that MON 87429 corn will not be marketed as a stand-alone product, it is intended for production of stacked-trait hybrid HR corn seed through traditional breeding methods, which will be resistant to glufosinate, dicamba, 2,4-D, quizalofop-p-ethyl, and glyphosate. Stacked-trait hybrid HR seed from MON 87429 corn will be marketed for commercial production. It is assumed that MON 87429 corn hybrid seed will be sold to growers, produced, and utilized for commercial purposes. Stacked-trait HR MON 87429 corn progeny—resistant to glufosinate, dicamba, 2,4-D, quizalofop-p-ethyl, and glyphosate—are intended to facilitate weed and HR weed management with U.S. corn crops (Monsanto 2019).

Adoption rates of stacked-trait corn varieties have increased in recent years, with stacked-trait corn expanding from 1% of planted acres in 2000, to 80% in 2020. Currently, only around 9% of corn acres are planted with a single HR trait, and 3% a single IR trait (USDA-ERS 2022). Many varieties now incorporate two or more HR traits (e.g., (NuTech 2020)). The increase in adoption of stacked-trait biotech varieties is due in part to the fact that stacked-trait varieties have been found to potentially provide more cost effective and easier weed control (Brookes and Barfoot 2020b; Liu et al. 2020), in addition yield gains with biotech HR varieties—via improved weed control—have been reported in Argentina, Brazil, the Philippines, and Vietnam (Brookes and Barfoot 2020b).

It is assumed that MON 87429 corn hybrids would be adopted by growers and used for production of standard food, feed, fuel ethanol, and industrial products. The adoption level of MON 87429 corn progeny would depend on the extent to which growers valued the HR traits relative to other stacked-trait HR corn, or conventional corn varieties, and the pricing and production efficiencies that may be provided by MON 87429 corn progeny.

For the purposes of risk analysis, it is also assumed that the only potential direct impacts that could derive from production and utilization of MON 87429 corn hybrids—as compared to other biotech and non-biotech corn varieties, unique to MON 87429 corn—are relative to the trait genes and gene products (Table 4-1). Indirectly, MON 87429 corn hybrids would influence the types of herbicides used on U.S. corn crops.

Table 4-1. Summary of Genetic Elements in MON 87429 Corn

Genetic Element	Description	Origin Species	Occurrence
pat	Maize-optimized phosphinothricin acetyltransferase gene, glufosinate resistance	*Streptomyces viridochromogenes*	Soil bacterium
dmo	Dicamba monooxygenase gene, dicamba resistance	*Stenotrophomonas maltophilia*	Soil bacterium
cp4 epsps	5-enolpyruvylshikimate-3-phosphate synthase (ShkG) gene, glyphosate resistance	*Agrobacterium sp. strain CP4*	Soil bacterium
ft_t	Modified version of R-2,4-dichlorophenoxypropionate dioxygenase (Rdpa) gene from Sphingobium herbicidovorans, which confers quizalofop and 2,4-D resistance	*Sphingobium herbicidovorans*	Soil bacterium

Bayer states the use of dicamba on MON 87429 corn will follow current EPA registration label use requirements for corn. The maximum annual use rate would be a total of 0.75 lbs. a.e. per treated acre per crop year. Maximum application rate would be 0.5 lb. a.e. per acre, with no more than 2 applications per growing season (Bayer-CropSci 2022). Use restrictions would include (US-EPA 2010):

- Application prohibited if corn is more than 36 inches tall or within 15 days before tassel emergence, whichever comes first.
- Application prohibited when soybeans are growing nearby if any of these conditions exist: corn is more than 24" tall; soybeans are more than 10" tall; soybeans have begun to bloom.

4.2 No Action Alternative: Deny the Petition

Because APHIS concluded in its PPRA that MON 87429 corn is unlikely to pose a plant pest risk (USDA-APHIS 2020c), denial of the petition for nonregulated status would be inconsistent with APHIS statutory authority under the plant pest provisions of the PPA, implementing regulations at 7 CFR part 340, and federal policies embodied in the Coordinated Framework. Because it would be unreasonable to implement an alternative absent any APHIS jurisdiction to do so, this alternative is not a practicable option.

While implementing the No Action alternative is not feasible, provided is a summary evaluation for denial of the petition—where MON 87429 corn would be regulated under 7 CFR part 340 and require APHIS authorization for importation, interstate movement, or release into the environment.

APHIS regulation of MON 87429 corn, which would effectively preclude commercial production of MON 87429 corn hybrids, would have no effect on the acreage used for U.S. corn production, nor the current practices and inputs used for the commercial production of corn. Likewise, denial of the petition would have no effect on the physical environment, biological resources, human or animal health, or domestic or international corn commodities markets. Any field testing or interstate movement of MON 87429 corn would require APHIS authorization, which would be provided via permit. Permit applicants must describe how they will perform field testing, including specific measures to keep the regulated organism confined to the authorized field site and measures to ensure that it does not persist after completion of the field test. The permitting provisions found in 7 CFR part 340 describe the information required for permit applications, the standard permit conditions, and administrative information. APHIS can supplement standard permit conditions listed in the regulation with additional conditions or requirements, as necessary.

Actions taken by APHIS on permit applications are subject to NEPA. APHIS ensures compliance of issued permits with NEPA, and CEQ and USDA NEPA implementing regulations.[25] Issuance of permits are typically authorized under a categorical exclusion from the requirement to conduct an EA or EIS, consistent with APHIS NEPA implementation regulations (7 CFR part 372). APHIS conducts EAs or EISs for permits as applicable to the permit request. This process complies with CEQ and USDA and APHIS regulations for implementing NEPA.

There are no anticipated impacts on the human environment that would derive from denial of the petition. To the extent a permittee complies with APHIS permit requirements, EPA requirements for pesticide use, FDA requirements for compliance with the FFDCA, and ESA requirements, there would be little risk of harm to wildlife or natural resources as a result of APHIS authorized field testing of MON 87429 corn. Regulated interstate movement of MON 87429 corn would present negligible environmental risks.

4.3 Preferred Alternative – Approve the Petition

4.3.1 U.S. Corn Production

4.3.1.1 Acreage and Areas of U.S. Corn Production

There are three primary varieties of corn cultivated in the United States: Dent (or field) corn (*Zea mays* var. *indenata*), sweet corn (*Zea mays* var. *saccharata*), and popcorn (*Zea mays* var. *everta*). To a lesser extent flour (*Zea mays* var. *amylacea*) and waxy corn (*Zea mays* var. *ceratina*) varieties are produced.

[25] CEQ regulations for implementing NEPA at 40 CFR 1500; USDA regulations implementing NEPA at 7 CFR part 1b; and APHIS regulations at 7 CFR part 372.

Corn varieties are differentiated by the starch, protein, oil, water, and other properties of the kernel, and produced for specific end uses; e.g., food, animal feed, industrial products.

MON 87429 corn is a dent corn variety. Dent corn, at maturity, has an obvious depression (or dent) at the crown of the kernels—thus its name. Dent corn is primarily used for animal feed and fuel ethanol stock, and comprises the bulk of U.S. production, around 90% of corn acres annually. Among dent corn commodities, animal feed accounts for, depending on year, approximately 38% – 48% of use, and stock for the production of fuel ethanol for approximately 25% – 35%, on annual basis (PRX 2019; USDA-ERS 2019d; NCGA 2021). The remainder is processed into a variety of food and industrial products such as starch, sweeteners, corn oil and corn syrup, and beverage and industrial alcohol (Figure 4-1).

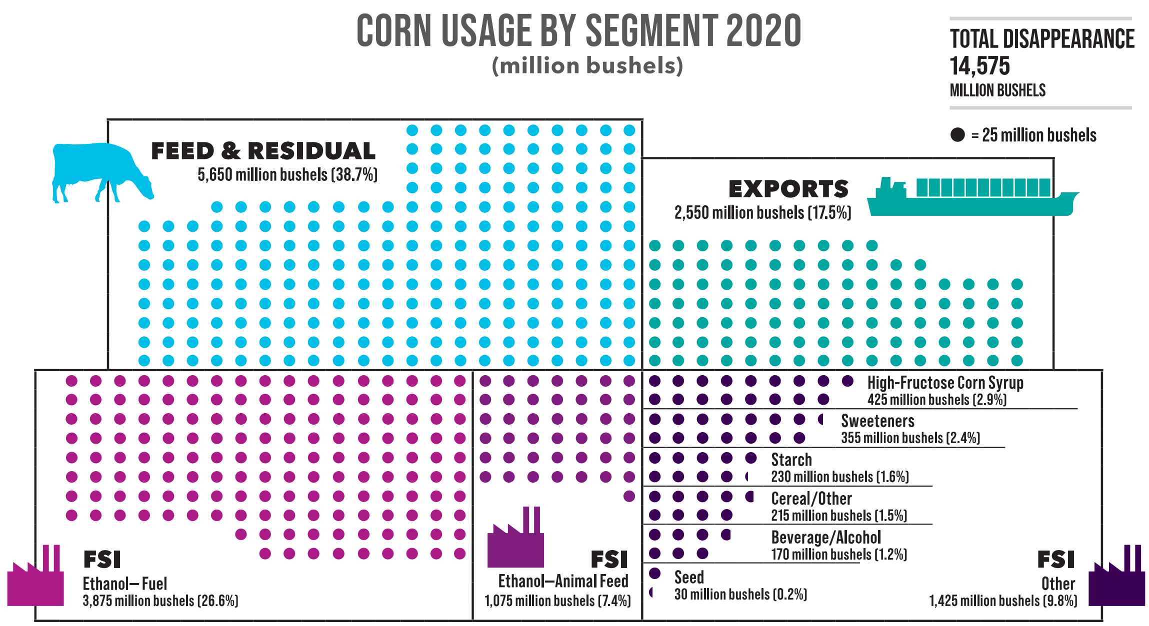

Figure 4-1. Corn Uses in the United States, 2020

Corn has food, seed, and industrial uses (FSI). Note that feed is comprised of grain, and distillers' dried grains with solubles (DDGS). Feed for both dairy and beef has been the primary use of DDGS, but increasingly larger quantities of DDGS are making their way into the feed rations of hogs and poultry. The statistics/percent allocations of corn, provided here for 2020 vary slightly on an annual basis. Source: (NCGA 2021)

Over the last ten years around 85 to 95 million acres of dent corn have been planted on an annual basis (USDA-NASS 2023). This has comprised approximately 25% of total U.S. cropland. Production of popcorn and sweet corn comprise about 0.2 and 0.5 million acres, respectively (< 1% of corn acreage on an annual basis) (USDA-NASS 2019b). While dent corn can be grown in all states to some extent, the majority of commercial production occurs in the Corn Belt, generally defined as Illinois, Iowa, Indiana, southern and western Minnesota, eastern South Dakota and Nebraska, western Kentucky and Ohio, and the northern two-thirds of Missouri. The leading dent corn-producing states of Illinois, Iowa, and Nebraska account for approximately 40 % of the annual U.S. harvest. Substantial production also occurs in Idaho, California’s Central Valley, along the Mississippi River, and up the Eastern Seaboard from Georgia to Upstate New York (Figure 4-2).

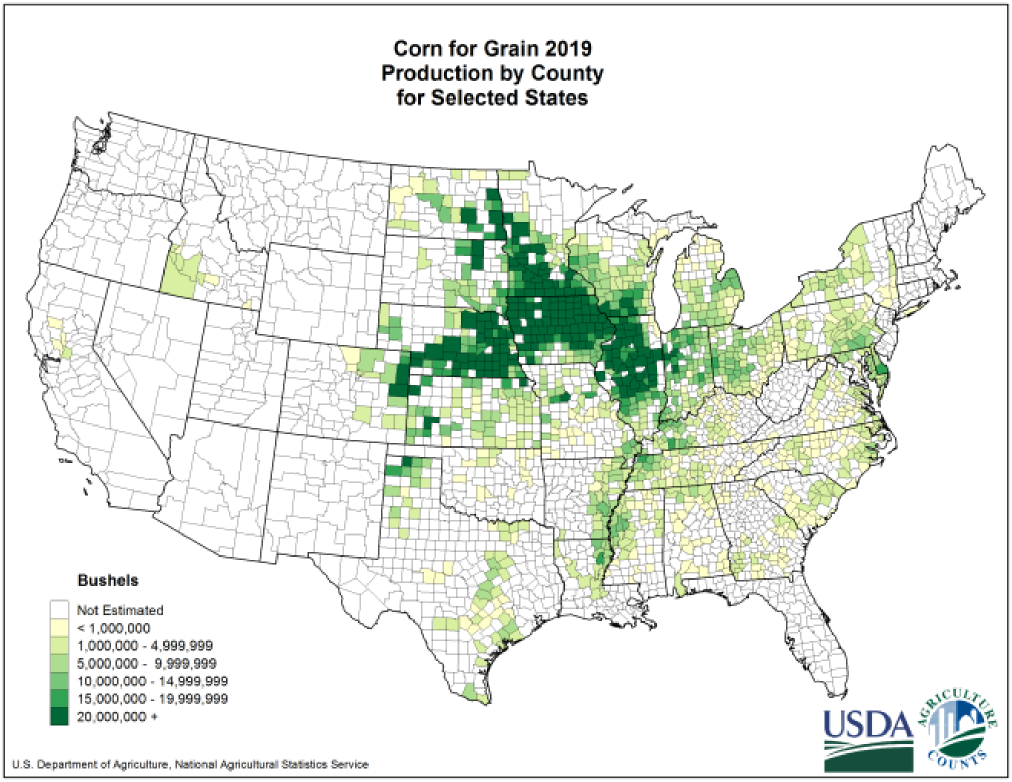

Figure 4-2. Corn Cultivation in the United States by County, 2019

Source: (USDA-NASS 2019d)

Around 90% of the corn produced in the United States is comprised of biotechnology-derived varieties (Figure 4-3), the majority of this is dent/field corn, with limited quantities of biotech sweet corn being grown. Only about 1% of the corn grown in the United States is sweet corn (consumed as canned, frozen, or fresh ears and of that, only about 10% of sweet corn acreage is comprised of biotech varieties (Reiley 2019). Bayer and Syngenta have marketed biotech sweet corn varieties (both are insect resistant), although very little is currently grown/consumed in the United States. There are no biotech popcorn or flour corn varieties. To date, there is one biotech waxy corn that has entered that market (USDA-APHIS 2022). Waxy corn is a specialty corn with the starch composed exclusively of amylopectin; such cornstarch is a valuable commodity due to its superior physicochemical properties and is widely used in the food and paper industry.

Most corn varieties currently produced are stacked-trait herbicide-resistant (HR) and insect-resistant (IR) dent corn varieties. Stacked-trait varieties with both HR and IR traits accounted for 81% of the 2022 corn crop. Only around 9% contained a single HR trait, and 3% a single IR in 2022. Of the ~89.9 million corn acres planted in 2022, around 6.2 million were conventionally bred varieties.

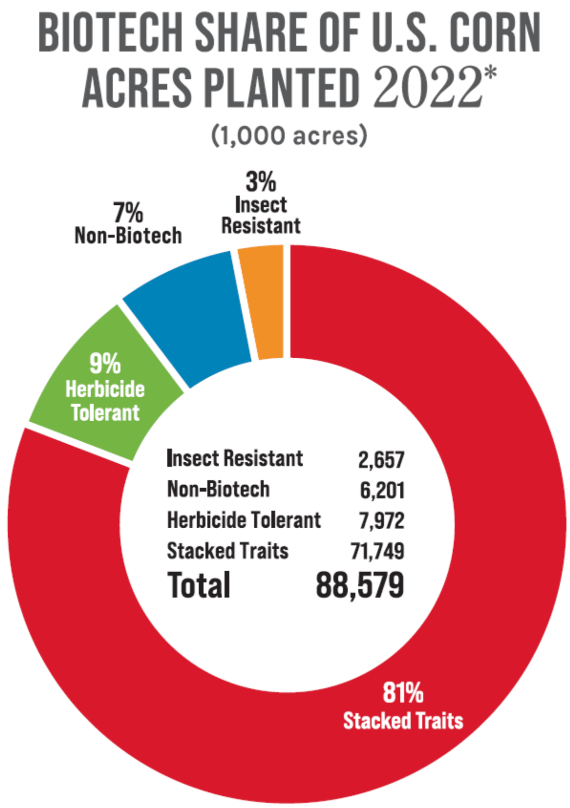

Figure 4-3. Biotechnology Based Corn Traits Planted in the United States

*Projected for crop year Sept. 2022–Aug. 2023

Source: (NCGA 2023)

In addition to the varieties described, there are around 12,000 acres of traditional or Indian corn produced in the United States, primarily on Indian reservations (USDA-NASS 2023). Traditional or Indian corn is an open-pollinated (nonhybrid), non-biotech cultivar of *Zea mays* that was developed by Native Americans and consists of many heritage varieties with specific traits such as size, starch content, color, and drought tolerance. Traditional corn has been passed from generation to generation through seed saving by American Indian and Hispanic communities. Traditional or Indian corn is culturally significant; it is reported to be grown in all states except Alabama, Michigan, Missouri, Montana, Nebraska, South Dakota, Vermont, Virginia, and West Virginia.

4.3.1.2 Agronomic Practices and Inputs

Commercial corn production utilizes a variety of agronomic practices and inputs, the purposes of which are to achieve optimal yield, product quality, and grower net returns. These include the application of manure or synthetic fertilizers; pesticides; tillage; crop rotation; and cover crops. Chemical inputs used for the control of insect pests, nematodes, pathogens, weeds, and the addition of plant nutrients to soils are an essential component of corn production. Some of these practices (e.g., tillage) and inputs (e.g., fertilizers, pesticides) can, when applied in excess or improperly, present environmental challenges in maintaining air, soil, and water quality. Pesticide and fertilizer use can also present risks to wildlife and human health. The relationship between these practices and inputs, and air, soil, and water quality, biological resources, human health, and the socioeconomics of corn production, are discussed in the following sections of this chapter.

Apart from the herbicide-, insect-, or disease-resistant trait(s), there are little differences in the agronomic practices and inputs used for biotechnology-derived and conventionally bred crops. HR crops will influence the types of herbicides used, and the timing of herbicide applications, for weed control. IR crops generally reduce the overall use of insecticides during a crop cycle, and disease resistant crops reduce the use rates of fungicides and other chemicals targeting plant pathogens. The agronomic practices, and current uses of the herbicides expected to be used with MON 87429 corn, are reviewed below.

Growers employ several practices for the management of pests and weeds (Table 4-2). Avoidance (e.g., crop rotation) was the most widely reported monitoring practice in 2021, used on 79% of corn planted acres, and scouting for weeds reported for 60% of corn acres. The most widely used prevention practice was no-till or minimum till (59%). Maintaining ground cover, mulching, or using physical barriers was the most reported suppression practice (43%). Among these, tillage is a practice that can have environmental impacts, and this topic, in relation to HR corn, discussed in more detail.

Table 4-2. Top Practices in Pest Management, 2021 Crop Year

Practice	% of Corn Planted Acres
Avoidance: Rotated crops during last three years	79
Monitoring: Scouted for weeds	60
Prevention: Used no-till or minimum till	59
Suppression: Maintained ground cover, mulched, or used other physical barriers	43

Source: (USDA-NASS 2021)

4.3.1.2.1 Tillage

Tillage is used to control weeds, soil-borne pests, and disease and prepare the seedbed. Tillage types are classified as conventional, reduced, and conservation tillage (to include no-till), which are characterized in part by the amount of plant material left on the field after harvest and the degree of soil disturbance they cause. Conventional tillage involves intensive plowing leaving less than 15% crop residue in the field; reduced tillage leaves 15% to 30% crop residue; conservation tillage involves leaving at least 30% crop residue; and no-till systems leave all crop residue on the field (Claassen et al. 2018; OSU 2019).

Decisions concerning the amount, timing, and type of tillage to employ involve consideration of a wide range of interrelated factors such as the variety and extent of weeds and crop pests present, soil erosional capacity, fuel and other input costs, anticipated weather patterns, and potential air and water quality issues. Over the long-term conventional tillage impairs soil quality, and results in soil erosion and run-off that can adversely affect surface waters (Wallander 2015). Conservation tillage systems are the least intensive and, as the name implies, aim to conserve topsoil and soil quality. Conservation tillage (including no-till) provides a variety of agronomic and economic benefits, such as preservation of soil organic matter, reductions in soil erosion and water pollution, as well as reductions in fuel use and crop production costs (Claassen et al. 2018). However, conservation tillage, especially no till, can also cause production problems such as increased soil compaction, perennial weeds or weed shifts, buildup of plant pathogens or pests in crop residue, and slow early crop growth due to cooler soil temperatures (Roth

2015). A systematic use of crop rotations can improve the success of conservation tillage by eliminating some of these stresses observed in continuous no-till corn (Roth 2015).

The use of conservation tillage in major crops has steadily increased since the 1980s and continues to do so (USDA-ERS 2021). An increase in conservation tillage has been attributed to the availability (since the 1980s) of post-emergent herbicides (Fernandez-Cornejo et al. 2012), which can be applied over crops throughout the growing season—not just before planting. Another factor has been the implementation of soil conservation programs that began in the mid-1980s, which encourage/incentivize conservation tillage practices to help conserve cropland topsoil (USDA-NRCS 2006). Continued increases in conservation tillage since the late 1990s have also been attributed, in part, to the use of HR crops, which can facilitate the herbicidal management of weeds, reducing the need for tillage to control weeds (Givens et al. 2009; USDA-ERS 2012). For example, the share of acreage for major crops—wheat, corn, soybeans, and cotton—using conservation tillage has increased over the past two decades in the United States (USDA-ERS 2021). Further discussed in 4.3.2.1–Soil Quality.

4.3.1.2.2 Fertilizers

Soils in many areas of the United States where corn is produced are naturally deficient in nitrogen, phosphorus, and other nutrients, requiring fertilizer inputs, to include manure, to produce crops efficiently, and the yields necessary, to meet market demand. Given the importance of nutrient availability to corn growth, fertilization with nitrogen, phosphorus, and potassium is practiced widely in the United States. Since 1975, around 94% to 99% of corn acreage has been treated with nitrogen, 79% to 85% of acreage treated with phosphate, 61% to 84% of acreage treated with potash (potassium), and around 15% to 30% treated with sulfur (USDA-ERS 2019c; USDA-NASS 2019f). Inputs for the 2021 crop year totaled approximately 21 billion pounds (Table 4-3). While nitrogen and phosphorus are important agricultural inputs, the introduction of amounts exceeding recommended thresholds can have undesirable impacts on water and air quality.

Table 4-3. Fertilizer Applied to Corn Acres, 2021 Crop Year

Fertilizer	% of Planted Acres	Avg. Rate for Year (lbs/acre)	Total Applied (billion lbs)
Nitrogen (N)	95	150	12.3
Phosphate (P2O5)	75	64	4.1
Potash (K2O)	65	77	4.3
Sulfur (S)	34	19	0.5

Source: (USDA-NASS 2021)

4.3.1.2.3 Pesticides

Pesticides contribute to higher yields, optimal product quality, and grower net returns by controlling insects, nematodes, plant pathogens, and weeds. In 2021, herbicides were applied to 96% of planted corn acres, fungicides to 19%, and insecticides to 14% of planted corn acres (Figure 4-4). Common corn pests requiring control include *Coleoptera* species (beetles), *Lepidoptera* species (moth and butterfly larvae), pathogenic fungi (e.g., corn leaf blight), bacteria (e.g., stalk rot), and viruses (e.g., dwarf mosaic virus) (UMinn 2019). Numerous populations of weed species across the United States require annual management in corn cropping systems (Jhala et al. 2014). Because MON 87429 corn is an herbicide-resistant variety, emphasis here is given to herbicide use in weed and weed resistant management, discussed in the following subsections.

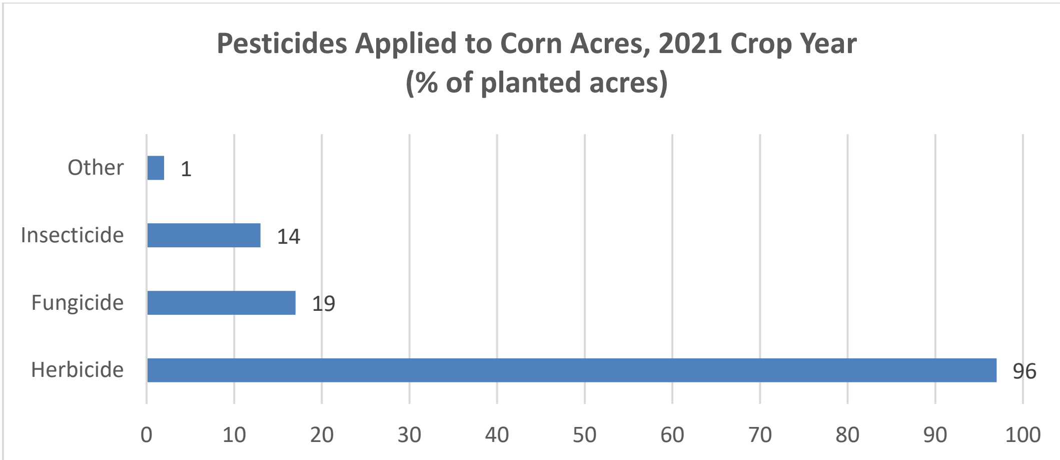

Figure 4-4. Pesticides Applied to Corn, 2021

Source: (USDA-NASS 2021)

4.3.1.2.3.1 Weed Management in U.S. Corn Crops

There are around 50 species of common weeds among U.S. cornfields (Jhala et al. 2014). Among these, there are 23 species that are particularly problematic due to their evolution of herbicide resistance (Heap 2022). Weeds have been and will remain a problem in corn crop production; they are difficult to control, competitive, and use up resources—soil moisture, nutrients, access to sunlight—that would otherwise be available to the corn plant. Their presence can:

- reduce yields by competing for space/acreage;
- increase insect and disease damage in crops by serving as hosts for pests and pathogens;
- reduce seedbed soil moisture and structure as a result of increased tillage needed to kill weeds prior to seeding;
- increase dockage with higher cleaning costs;[26]
- result in reduced grades and quality of harvested grain;
- reduce net economic returns.

As an example: In 2017, Illinois had 22 million acres of corn and soybeans, 75% of which, around 16.5 million acres, were infested with waterhemp (*Amaranthus tuberculatus*), a weedy plant that at maturity reaches up to 8 feet in height. This equates to:

- 825,000 infested acres if 5% of the waterhemp escapes at year's end.
- 25 waterhemp plant escapes per acre on those infested acres.

[26] Foreign material that must be separated from a parcel of grain before a grain grade can be assigned to the grain.

- 500,000 seeds that are potentially produced per escaped plant.
- 50,000 (10%) seeds produced for the next year per escaped plant.
- 5,000 (10%) seeds that actually survive, germinate, and form plants the following year.

This scenario potentially generates 100 billion viable waterhemp plants for Illinois farmers in the following year, 2018 (Gullickson 2020).

In terms of the potential impact of weeds on yield and net returns: Studies have found that U.S. corn yield loss from weed interference, in the absence of weed-control measures, can range from 15% to 57% (Bridges 1992; Soltani et al. 2017; WSSA 2020a). On an annual basis, potential loss in value for corn from weed interference is around $27 billion and for soybean is $16 billion based on data from 2007 to 2013. Overall, average percent yield loss with no weed control is around 52%, and can be as high 15% with weed control (Bridges 1992; WSSA 2020a). Palmer amaranth, a highly competitive species, if uncontrolled can contribute to substantial yield losses of up to 91% in corn, 79% in soybean, 59% in cotton, and 50% in sorghum (Shyam et al. 2021).

Weed Management with Herbicide Resistant Corn

Prior to the development of chemical herbicides, farmers controlled weeds by tillage, mowing, site selection, crop rotation, hoeing or pulling by hand, and ensuring that crop seed was free of weed seeds. U.S. farmers began widescale adoption of chemical herbicides after their commercial introduction in the 1950's because herbicides were inexpensive, effective, easy to apply, reduced labor costs, reduced the need for tillage, and increase crop yields (Gianessi and Nathan 2007; Fernandez-Cornejo et al. 2014c). Because herbicides are effective, they remain the most commonly used among weed management tools. Sixty years ago, herbicides accounted for around 18% of pesticide use by volume on U.S. crops, and insecticides 58% percent. More recently, herbicide and insecticide use accounts for approximately 76% and 6% percent of total pesticide applications, respectively (GROi 2018). In the United States, herbicides are used on around 90% of U.S. corn acres (Fernandez-Cornejo et al. 2014c).

In consideration of herbicide use with a biotechnology based HR corn variety, or any other conventional crop, it is important to clarify that simply looking at the total pounds of herbicide active ingredient (a.i.) used per year, pounds a.i. per acre used, and trends in increase or decrease in lbs a.i. per year—evaluation of these metrics in isolation of other factors—is not particularly useful for assessment of potential environmental or human health risks. Potential risks to the environment and human health, which are evaluated by the EPA for all herbicides (US-EPA 2020c), entails evaluation of the specific herbicide, its mode of action, the potential toxicity of the a.i. to various taxa, the potential toxicity of derivative compounds (degradates), environmental mobility and persistence, as well as the toxicity of herbicide formulations as there may be synergistic effects that derive from such formulations. Bearing these factors in mind, as weight and use rates are some of the most commonly reported metrics, provided below are data on herbicides that are used in corn production (Table 4-4). Those herbicides to which MON 87429 corn is resistant, and would facilitate use of, are in bold.

Table 4-4. Herbicide Use in U.S. Corn Production, 2021

Herbicide a.i.	Application: lbs/Yr	Application: lbs /acre/Yr (Average)	Treated Acres, % of Area Planted	Portion of Total Herbicide Use
ATRAZINE	59,180,000	1.054	65	24.88%
ACETOCHLOR	41,675,000	1.415	34	17.52%
GLYPHOSATE ISO. SALT	32,934,000	0.934	41	13.85%
S-METOLACHLOR	27,002,000	1.154	27	11.35%
GLYPHOSATE POT. SALT	26,812,000	1.237	25	11.27%
GLYPHOSATE	12,691,000	1.303	11	5.34%
METOLACHLOR	7,254,000	2.548	3	3.05%
MESOTRIONE	5,343,000	0.132	47	2.25%
2,4-D, 2-EHE	4,188,000	0.855	6	1.76%
DIMETHENAMID-P	2,891,000	0.575	6	1.22%
DICAMBA, DIGLY. SALT	2,394,000	0.347	8	1.01%
2,4-D, DIMETH. SALT	2,081,000	0.711	3	0.88%
GLYPHOSATE DIM. SALT	2,059,000	1.079	2	0.87%
PENDIMETHALIN	1,163,000	1.007	1	0.49%
DICAMBA, DIMET. SALT	1,096,000	0.28	5	0.46%
CLOPYRALID	1,055,000	0.084	15	0.44%
PARAQUAT	898,000	0.747	1	0.38%
GLUFOSINATE-AMMONIUM	849,000	0.464	2	0.36%
SIMAZINE	642,000	0.912	1	0.27%
TEMBOTRIONE	627,000	0.1	7	0.26%
DICAMBA, SODIUM SALT	446,000	0.104	5	0.19%
CLETHODIM	308,000	0.534	1	0.13%
BICYCLOPYRONE	278,000	0.036	9	0.12%
ISOXAFLUTOLE	251,000	0.073	4	0.11%
CLOPYRALID MONO SALT	214,000	0.076	3	0.09%
METRIBUZIN	208,000	0.215	1	0.09%
FLUMETSULAM	167,000	0.029	7	0.07%
DIFLUFENZOPYR-SODIUM	164,000	0.043	4	0.07%
PYROXASULFONE	120,000	0.091	2	0.05%
SAFLUFENACIL	107,000	0.059	2	0.04%
DICAMBA, POT. SALT	69,000	0.143	1	0.03%
THIENCARBAZONE-METHY	63,000	0.019	4	0.03%
TOPRAMEZONE	62,000	0.012	6	0.03%
DICAMBA	54,000	0.381	(Z)	0.02%
FLUROXYPYR 1-MHE	54,000	0.082	1	0.02%
FLUMIOXAZIN	31,000	0.065	1	0.01%
RIMSULFURON	17,000	0.017	1	0.01%
THIFENSULFURON	10,000	0.012	1	0.004%
HALOSULFURON-METHYL	4,000	0.011	(Z)	0.002%

FLUTHIACET-METHYL	2,000	0.005	1	0.001%
TOTAL	**237,818,000**			

(z) = no data or data unavailable. Herbicides in bold type are those potentially used with MON 87249 corn. The data provided is based on USDA-NASS statistics for corn. Most of the annual NASS survey data generally captures around 80%-90% of acreage for a given crop during a given year. Hence, the data presented likely provides a good approximation of herbicide use in U.S. corn production. Quizalofop-p-ethyl is approved for use on corn (e.g., DuPont™ Assure® II Herbicide), although there is no use data for quizalofop, with corn specifically. Data is not available for certain herbicides, for certain years, consequently, total pounds data may be an underestimate for these herbicides. These include, for corn, 2,4-D, butoxyethyl ester; 2,4-D isopropyl salt; 2,4- dimethyl salt; dicamba isopropanolamine salt.
Source: (USDA-NASS 2023)

Glufosinate and glyphosate resistant corn varieties were first deregulated by USDA–APHIS in 1995 and 1997, respectively. The first 2,4-D and ACCase-inhibitor resistant corn was deregulated in 2014, and dicamba resistant corn in 2016 (Table 4-5).

Table 4-5. HR Corn: Varieties Deregulated by USDA-APHIS

Petition	Applicant	Phenotype/Event	Effective
19-101-01p	Pioneer	High Yield, Resistance to Glufosinate/DP202216	2020
15-218-01p	Syngenta	IR and Glufosinate-Resistant/SYN-ØØØ98-3	2016
15-124-01p	Syngenta	Glufosinate and Glyphosate Resistant/MZHG0JG	2015
15-113-01p	Bayer	Dicamba and Glufosinate Resistant/MON-87419-8	2016
13-290-01p	Bayer	IR/Glyphosate- Resistant/MON-87411-9	2015
11-342-01p	Genective	Glyphosate Resistant/VCO-Ø1981-5	2013
11-244-01p	Pioneer	IR and Glufosinate Resistant/DP-ØØ4114-3	2013
09-233-01p	Dow AgroSciences	2,4-D and ACCase-Inhibitor Resistant/DAS-40278-9	2014
09-063-01p	Stine Seed Farm, Inc.	Glyphosate Resistant/HCEM485	2013
07-152-01p	Pioneer	Glyphosate & Imidazolinone Resistant/98140	2009
03-181-01p	Dow AgroSciences	IR and Phosphinothricin [glufosinate] Resistant/6275	2004
00-136-01p	Dow AgroSciences	IR and Phosphinothricin [glufosinate] Resistant/1507	2001
00-011-01p	Bayer	Glyphosate Resistant/NK603	2000
98-349-01p	AgrEvo	Phosphinothricin [glufosinate] Resistant and Male Sterile/MS6	1999
97-342-01p	Pioneer Hi-Bred	Male Sterile and Phosphinothricin [glufosinate] Resistant/676, 678, 680	1998
97-265-01p	AgrEvo	Phosphinothricin [glufosinate] Resistant and IR/CBH-351	1998
97-099-01p	Bayer	Glyphosate Resistant/GA21	1997
96-317-01p	Bayer	Glyphosate Resistant and IR/MON 802	1997
95-145-01p	DeKalb	Glufosinate Resistant/B16	1995
94-357-01p	AgrEvo	Glufosinate Resistant/T14, T25	1995

HR corn adoption increased from 3% percent of planted acres in 1996 to around 90% by 2020, the majority of this glyphosate resistant. Adoption rates for HR corn appear to have plateaued in recent years, since around 2014, at around 89% to 90% (Figure 4-5). However, adoption rates will vary at the state level on an annual basis due to weed and pest pressures, among other factors.

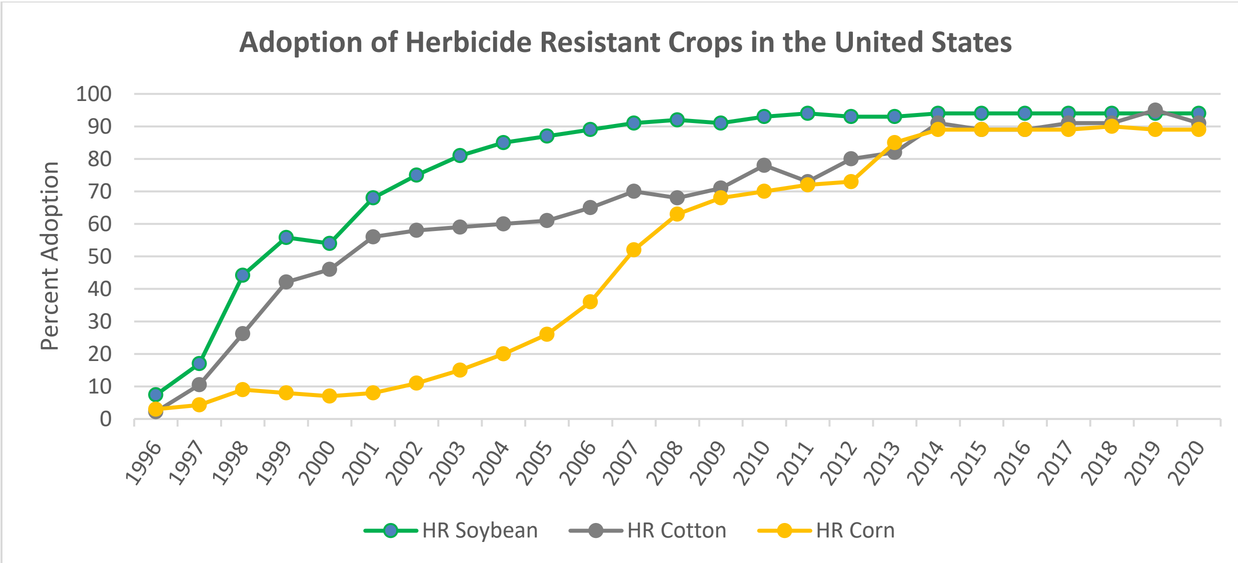

Figure 4-5. Share of Corn, Soybean, and Cotton Acreage Planted with Stacked-Trait Seed, 2020

Source: (USDA-ERS 2022)

Approximate trends in herbicide use with corn are provided following. During the 1996–2021 time frame, herbicide use on corn remained fairly consistent, albeit with a modest increase, in terms of average lbs a.i./acre, since 2014 (Figure 4-6). From 1996 to 2014, total herbicide use with corn, in average lbs a.i./acre, tended to decline, fluctuating around 2.06 lbs a.i./acre (1.9 to 2.3 lbs a.i./acre). Fluctuations in average annual herbicide use can in part be attributed to shifts/rotations in the herbicides used in corn production and their differing application rates (prior Table 4-4). In certain instances, growers may increase use of herbicides to control problematic and HR weeds.

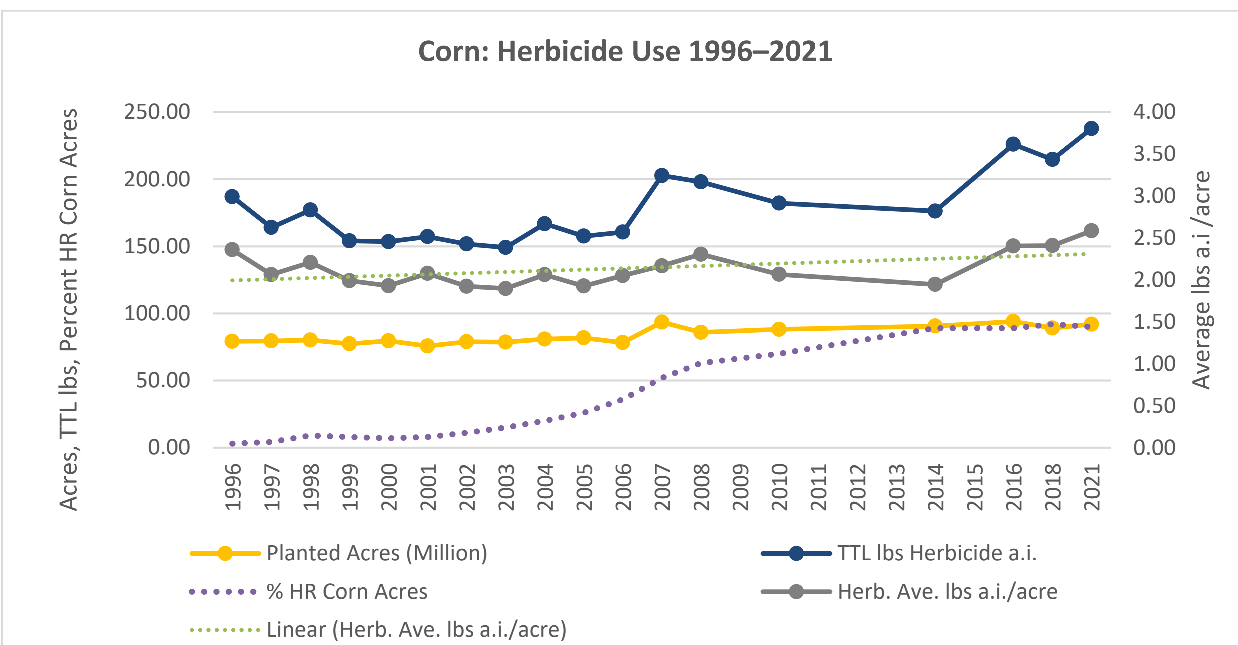

Figure 4-6. Corn: Herbicide Use, 1990–2021

Source: (USDA-NASS 2023)

Glyphosate Resistant Corn

Commensurate with the adoption of glyphosate resistant corn, glyphosate use on corn increased from an average of around 0.03 lbs a.i./acre in 1995, to an average of 0.81 lbs a.i./acre (average use) in 2021 (Figure 4-7). As of 2021, glyphosate was applied on around 79% of corn acres, and comprised around 31% of total herbicide use in corn (prior Table 4-4).

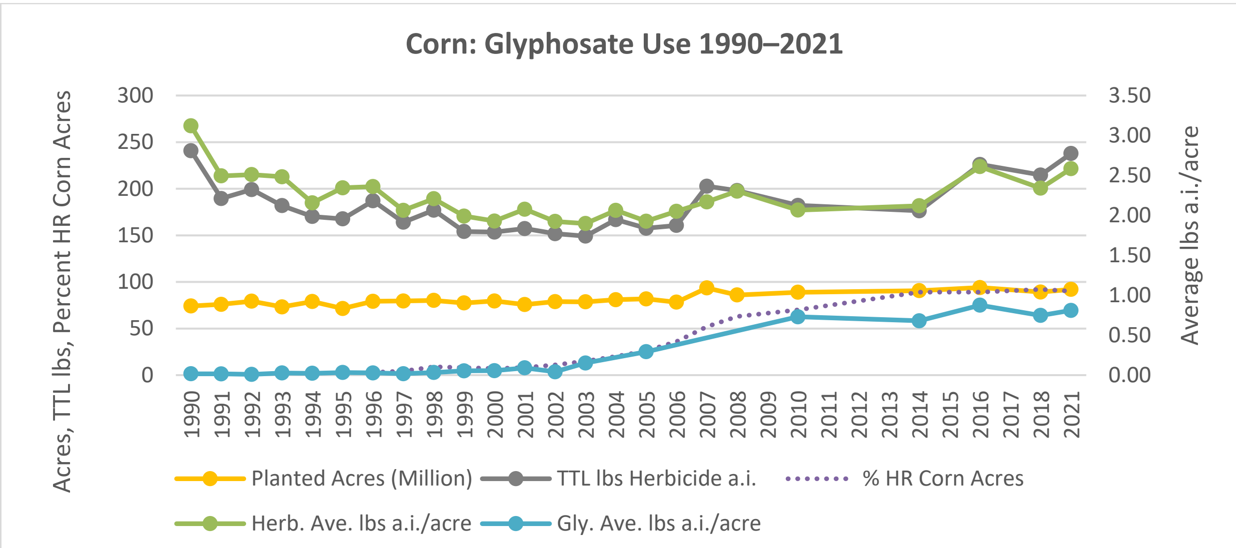

Figure 4-7. Corn: Glyphosate Use, 1990–2021

Source: (USDA-NASS 2023)

While glyphosate use increased, the application of other herbicides used to control broadleaf weeds in corn declined (Figure 4-9). For example, pendimethalin use declined from an average of 0.022 lbs a.i./acre to an average of 0.004 lbs a.i./acre from 1997 to 2018. Metolachlor use declined from an average of around 0.55 lbs/a.i./acre in 1997 to 0.02 lbs a.i./acre in 2018. Alachlor use declined from an average of around 0.22 lbs/a.i./acre in 1997 to 0.004 lbs a.i./acre in 2018.

Glufosinate, Dicamba, and 2,4-D Resistant Corn

Glufosinate resistant corn varieties were first deregulated in the mid- and late-1990s (see previous Table 4-5). 2,4-D and ACCase-inhibitor resistant DAS-40278-9 corn (Enlist™ corn) was deregulated in 2014. Glufosinate and glyphosate resistant MZHG0JG corn was deregulated in 2015. Enlist™ corn, in addition to 2,4-D, is resistant to "FOP" herbicides, such as quizalofop-p-ethyl. Enlist™ corn became commercially available in the United States for the 2018 growing season (Dow AgroSciences 2018). Dicamba and glufosinate resistant MON-87419-8 corn was deregulated in 2016. As of 2023, there are, however, no dicamba resistant corn varieties commercially available.

As glufosinate resistant corn varieties were first deregulated during the years 1995 through 2004 there was a minor increase in glufosinate use during this time. Glufosinate use in corn declined from 2004 to

2014, with an increase in average use of 0.006 lbs a.i./acre from 2014 to 2021 (Figure 4-8). Overall, use of glufosinate on corn, even with glufosinate resistant corn varieties available, has been relatively limited, comprising 0.36% of total herbicide use on corn in 2021 (in terms of average lbs a.i./acre; (Table 4-4)).

There has been an increase in use of 2,4-D in corn production since 2002 (Figure 4-8). This increase began prior to the first commercial availability of 2,4-D resistant corn in 2018. Since 2000, as glyphosate use increased in corn, use of dicamba declined up until around 2010; although in terms of average lbs a.i./total acres of corn, has increased since. While dicamba resistant corn was deregulated in 2016 (MON-87419-8), dicamba resistant corn seeds are not yet commercially available, planted; thus, the increased dicamba use would not be due to the availability of dicamba resistant corn seed.

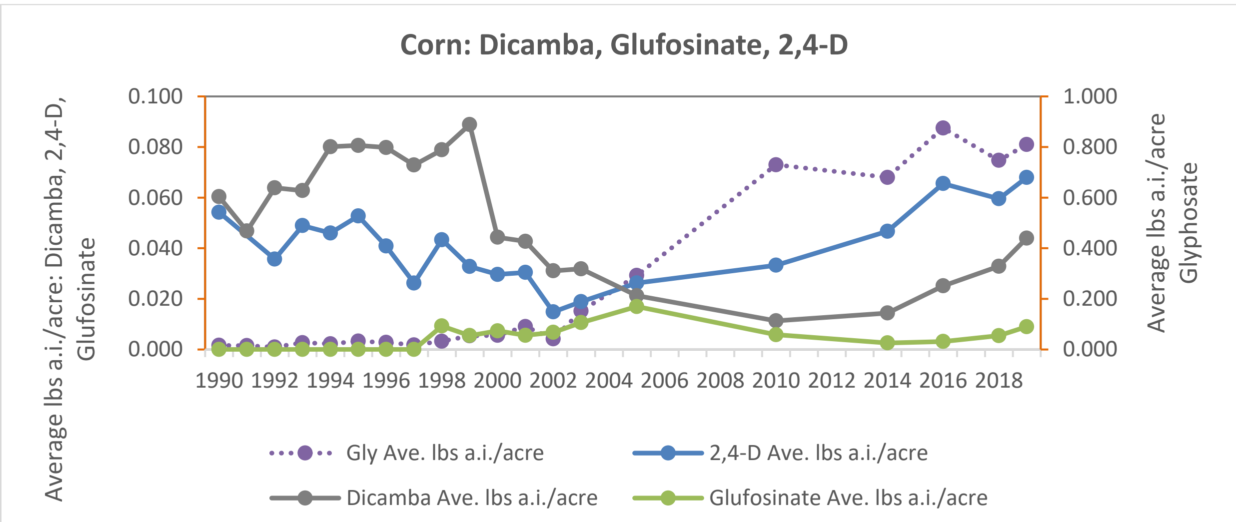

Figure 4-8. Corn: Dicamba, Glufosinate, 2,4-D, 1990–2021

Source: (USDA-NASS 2023)

As of 2021, 2,4-D and dicamba comprised approximately 2.64% and 1.71% of total herbicide use on corn, respectively (Figure 4-9). Glufosinate comprised only 0.36% of total herbicide use (not shown in Figure 4-9). Data on quizalofop–p–ethyl use on corn is unavailable. Historically, quizalofop-p-ethyl has not been commonly applied to corn fields, because, as a grass-family crop, quizalofop-p-ethyl would injure corn.

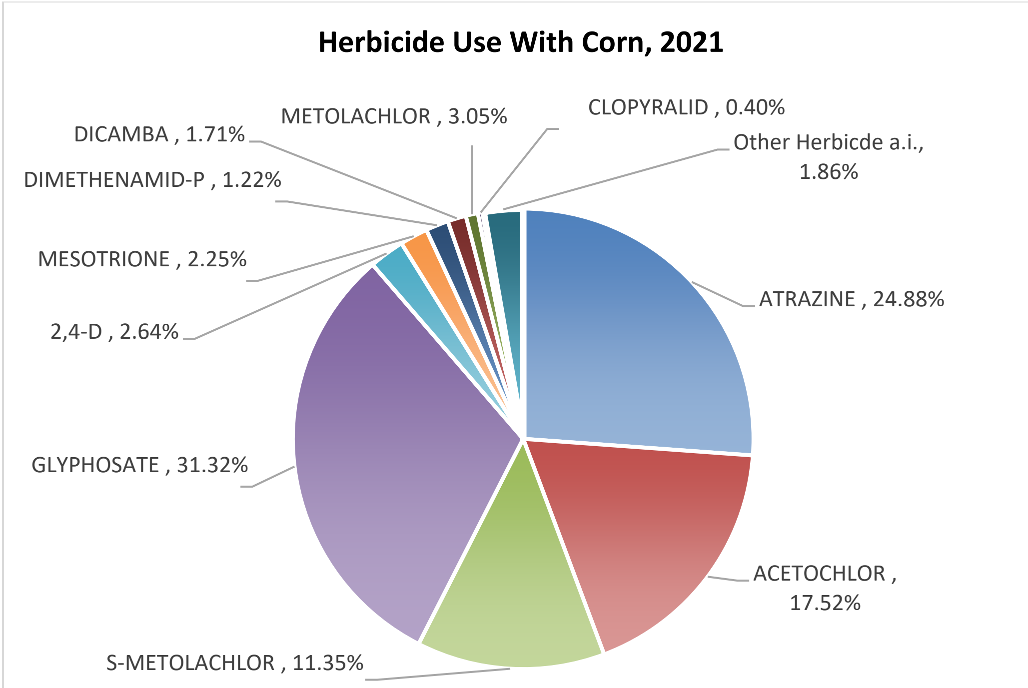

Figure 4-9. Herbicide Use by Total Pounds of Active Ingredient Applied, Portion of Total Herbicide Use on Corn, 2021

Source: (USDA-NASS 2023)

4.3.1.2.3.2 Glyphosate

Glyphosate (2-(phosphonomethylamino)acetic acid) is a non-selective systemic herbicide that has been registered in the United States since 1974. It is widely used in agricultural, residential, and commercial settings to control broadleaf weeds and grasses. Agricultural uses include corn, cotton, canola, soybean, sugar beet, alfalfa, berry crops, leafy vegetables, cereal grains, citrus crops, orchards, and many other crops (US-EPA 2019f). Nonagricultural uses include conservation land, pastures, rangeland, aquatic areas, forests, turf grass, residential areas, non-food tree crops (e.g., pine, poplar, Christmas trees), commercial areas, parks, and wildlife management areas. It is effective at managing invasive and noxious weeds (US-EPA 2019f).

A total of about 237.8 million lbs of herbicides (a.i.) were applied to corn acres in 2021, glyphosate use comprised 74.5 million lbs a.i. of this total (USDA-NASS 2023), around 31% of the herbicides applied to corn (prior Table 4-4). Patterns of glyphosate use in the United States are provide in Figure 4-10.

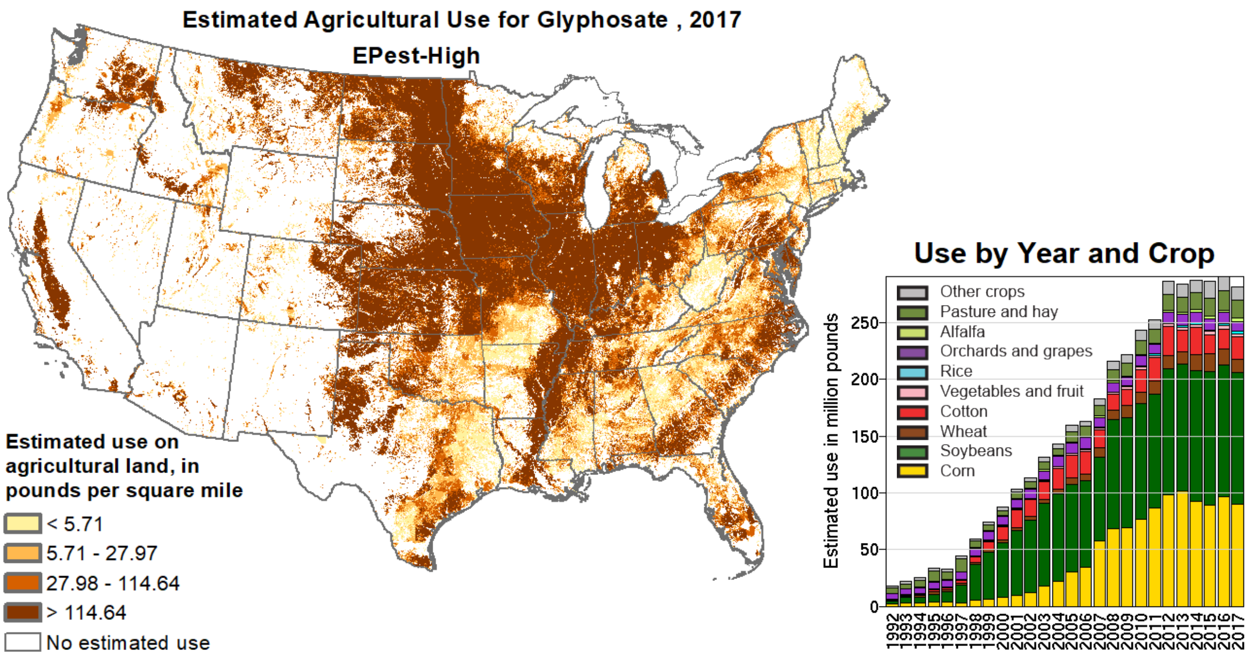

Figure 4-10. Glyphosate Use in the Conterminous United States, 2017

State-based and other restrictions on pesticide use were not incorporated into EPest-high or EPest-low estimates. EPest-low estimates usually reflect these restrictions because they are based primarily on surveyed data. EPest-high estimates include more extensive estimates of pesticide use not reported in surveys, which sometimes include States or areas where use restrictions have been imposed. Source: (USGS 2019)

Glyphosate Mode of Action, Glyphosate Resistance, and EPSPS

5-enolpyruvylshikimate-3-phosphate synthase (EPSPS) is an enzyme produced in algae, higher plants, bacteria, and fungi. EPSPS is involved in the biosynthesis of the essential aromatic amino acids phenylalanine, tyrosine, and tryptophan, as well as other aromatic molecules, that are necessary for plant growth (Alibhai and Stallings 2001). This biosynthesis process is referred to as the shikimate pathway. The multi-step shikimate pathway is ubiquitous among plants and microbes (e.g., bacteria, fungi, parasites), although absent in mammals, fish, bird, reptiles, and insects (Alibhai and Stallings 2001). Glyphosate inhibits the enzymatic activity of EPSPS, thereby preventing the biosynthesis of these essential amino acids, leading to plant cell death.

A version of the EPSPS enzyme that is naturally resistant to glyphosate, yet still efficient enough to support plant growth—function in the shikimate pathway—was identified in an Agrobacterium strain called CP4. It is the CP4 EPSPS, derived from *Agrobacterium tumefaciens*, that was introduced into MON 87429 corn. Thus, resistance to glyphosate is conferred via the presence of the CP4 EPSPS enzyme in MON 87429 corn plant tissues.

4.3.1.2.3.3 Glufosinate

Glufosinate-ammonium (2-amino-4-[hydroxy(methyl)phosphoryl]butanoic acid) is a broad-spectrum, foliar-applied herbicide that is registered for pre-plant and post-emergence control of over 120 grass and broadleaf weeds on crop and non-crop sites. It is marketed in herbicide formulations such as Basta®, Finale®, Rely®, and Liberty®.

Glufosinate is registered for use on a variety of crops, including apples, berries, citrus, currants, grapes, grass grown for seed, potatoes, rice, sugar beets, and tree nuts (US-EPA 2016c). Glufosinate is also registered for use on both biotech and non-biotech canola, corn, cotton, and soybeans. Non-crop use sites include golf course turf, residential lawns, industrial and residential landscape plantings, utility and roadside rights-of-way, and timber site preparation for tree plantings.

The crops that account for the most glufosinate use are soybean, cotton, and corn (together, over 75% of usage) (US-EPA 2016c); these crops have biotech varieties that are resistant to glufosinate. In 2021, 1.09 million lbs of glufosinate were applied to cotton, and in 2020, 7.2 million lbs applied to soybean (USDA-NASS 2023). For corn, 849,000 lbs were applied in 2021 (USDA-NASS 2023). Glufosinate use is significant on several other crops, including canola and pistachios, with more than 40% of these crops treated with glufosinate. Over 20% of almonds, wine grapes, and hazelnut crops are treated with glufosinate (US-EPA 2016c). Patterns of glufosinate use in the United States are provided in Figure 4-11.

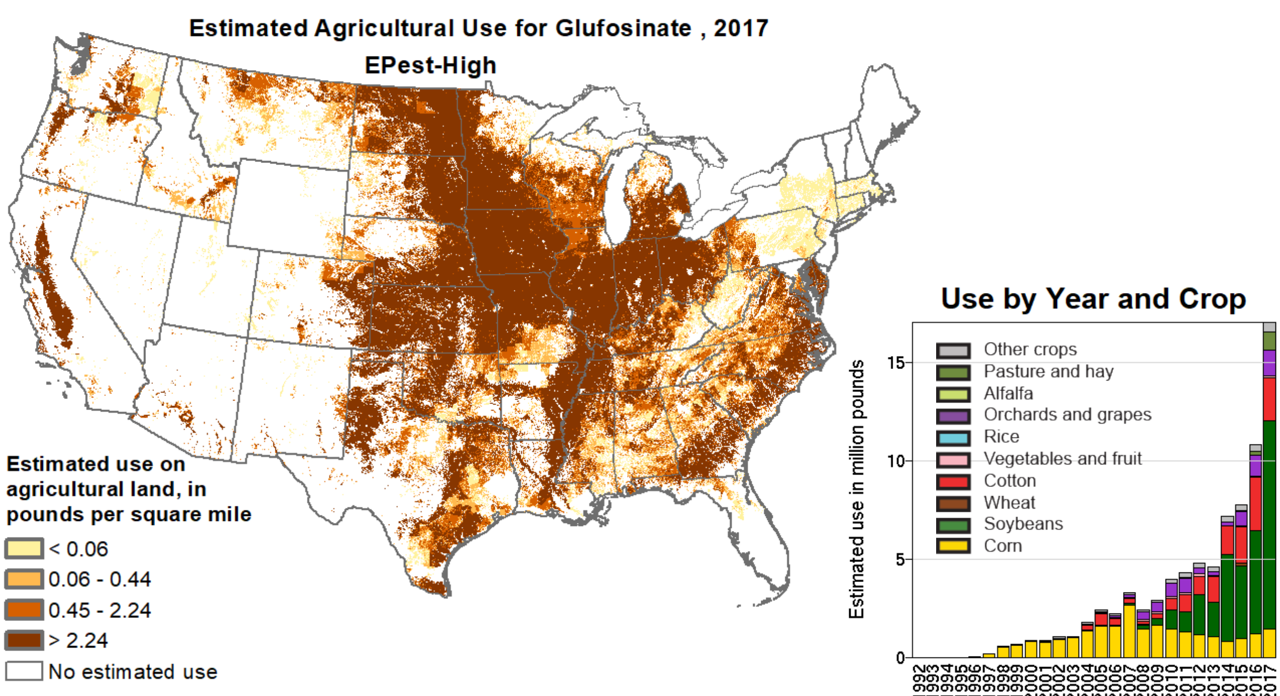

Figure 4-11. Glufosinate Use in the Conterminous United States, 2017

State-based and other restrictions on pesticide use were not incorporated into EPest-high or EPest-low estimates. EPest-low estimates usually reflect these restrictions because they are based primarily on surveyed data. EPest-high estimates include more extensive estimates of pesticide use not reported in surveys, which sometimes include States or areas where use restrictions have been imposed. Source: (USGS 2019)

Overall, use of glufosinate on corn, even with biotech glufosinate resistant corn varieties available, has been relatively limited. As of 2021, glufosinate use comprised 0.36% of total herbicides applied to corn, and was used on only around 2% of corn acres (prior Table 4-4).

Glufosinate Mode of Action, Glufosinate Resistance, and Phosphinothricin Acetyltransferase (PAT)

Bialaphos is an herbicidal compound produced by certain species of soil bacterium among the genus *Streptomyces* (Dayan et al. 2009; Dayan and Duke 2014). Bialaphos is a prototoxin (or protoxin), a non-toxic precursor of the phytotoxin L-phosphinothricin (referred to as phosphinothricin from here out). Bialaphos is converted by plant cells to phosphinothricin, which inhibits glutamine synthetase, an enzyme necessary for the production of glutamine (an essential amino acid) and ammonia detoxification. Reduced levels of glutamine and accumulation of ammonia in plant tissues interferes with photosynthesis and other metabolic processes, resulting in plant death. Glufosinate is a synthetic form of phosphinothricin that has the same herbicidal activity. Glufosinate is the only commercial herbicide that targets glutamine synthetase.

Resistance to glufosinate is conferred by the enzyme phosphinothricin acetyltransferase (PAT), which inhibits the herbicidal activity of glufosinate by acetylation, which generates the non-herbicidal compound N-acetyl L-phosphinothricin. Genes encoding PAT have been isolated from the soil bacteria *Streptomyces hygroscopicus* (*bar*, which is short for bialaphos resistance) (Thompson et al. 1987) and *S. viridochromogenes* (*pat*) (Wohlleben et al. 1988). The *pat* gene, that introduced into MON 87429, is very similar to the *bar* gene with 87 % identity at the nucleotide sequence level; both *bar* and *pat* encode PAT proteins with similar substrate affinity and biochemical activity (Wehrmann et al. 1996).

4.3.1.2.3.4 Dicamba

Dicamba (3,6-dichloro-2-methoxybenzoic acid) is a selective pre- and post-emergent herbicide used to control a wide spectrum of broadleaf weeds and woody plants. Dicamba was first approved for use in the United States in 1962 and has been registered for use on corn, wheat, cotton, soybeans, a wide range of grass crops, as well as for non-crop areas. Prior to the introduction of herbicide-resistant crops, dicamba primarily competed with atrazine and 2,4-D for broadleaf weed control in corn. Atrazine was preferred over dicamba and 2,4-D by most farmers due to its preemergence use, greater margin of crop safety, and lower risk of off-target injury (Hartzler 2017).

Dicamba has been used on less than 20% of U.S. corn acres (see Table 4-4). Dicamba currently comprises about 1.7% of total herbicide use on corn crops. Patterns of dicamba use in the United States are provided in Figure 4-12.

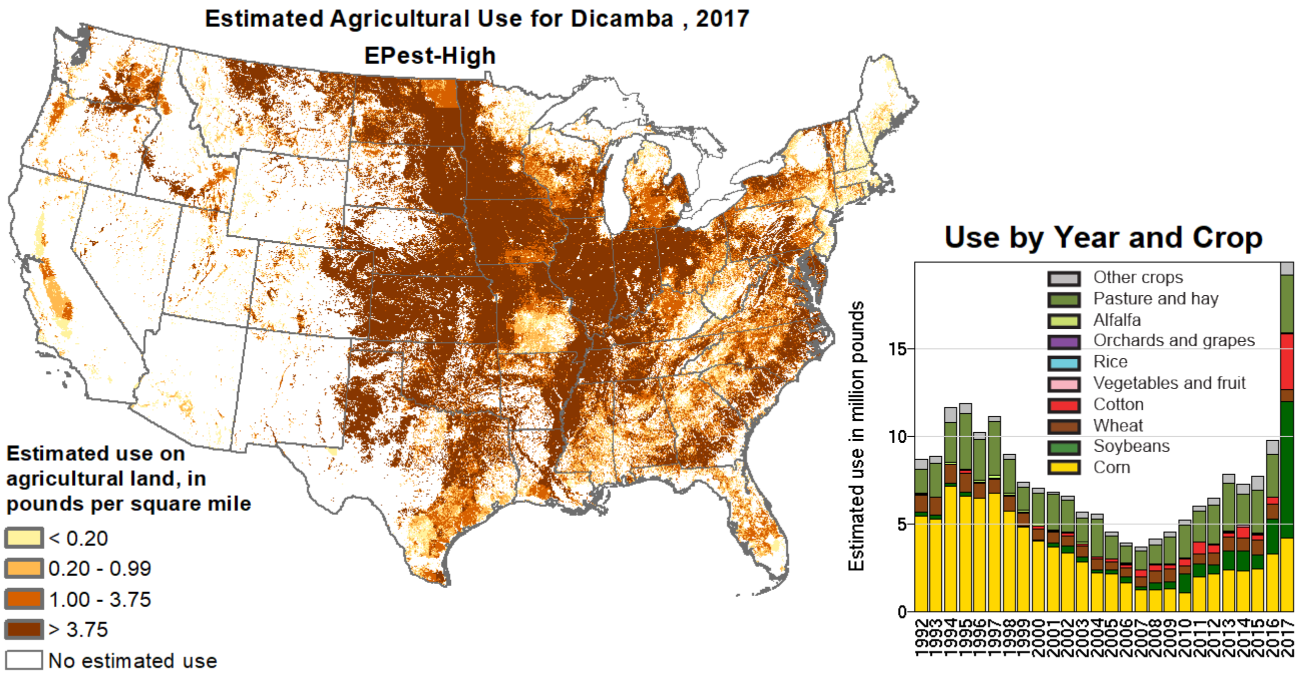

Figure 4-12. Dicamba Use in the Conterminous United States, 2017

State-based and other restrictions on pesticide use were not incorporated into EPest-high or EPest-low estimates. EPest-low estimates usually reflect these restrictions because they are based primarily on surveyed data. EPest-high estimates include more extensive estimates of pesticide use not reported in surveys, which sometimes include States or areas where use restrictions have been imposed. Source: (USGS 2019)

Dicamba Mode of Action and Dicamba Mono-Oxygenase (DMO)

Auxins are a class of plant hormones that regulate plant growth and development. Dicamba is a synthetic auxin. This type of herbicide kills the target weed by mimicking the plant growth hormone indole acetic acid. At low doses, dicamba has similar hormonal effects to natural auxins. High concentrations of dicamba (and other auxin herbicides) can be divided into three consecutive phases in effects on plants: First, stimulation of abnormal growth and gene expression; second, inhibition of growth and physiological responses, such as stomatal closure; and third, senescence and cell death (Grossmann 2010).

Certain soil microbes (e.g, *Stenotrophomonas maltophilia*) produce an enzyme, called dicamba monooxygenase (DMO), that degrades dicamba. Resistance to dicamba can be conferred by introducing a *dmo* gene from *S. maltophilia* into a plant's genome, as is the case with MON 87429 corn. Plants producing DMO enzymes are able to rapidly degrade dicamba in plant tissues upon exposure, rendering the plant resistant to dicamba's herbicidal activity. Currently, there are dicamba resistant varieties of cotton, soybean, and corn that utilize DMO. In these crop plants (not all commercially produced), the DMO enzyme catalyzes the demethylation of dicamba to the non-herbicidal compounds 3,6-dichlorosalicylic acid (DCSA) and formaldehyde.

4.3.1.2.3.5 2,4-D

2,4-D (2,4-Dichlorophenoxyacetic) is a systemic herbicide that selectively kills most broadleaf weeds but leaves most grasses such as cereals, lawn turf, and grasses relatively unaffected. 2,4-D has been widely used since the 1940s. It has various EPA registered uses, including for turf/lawns, aquatic sites, forestry sites, and field, fruit, and vegetable crops. One of the most common uses of 2,4-D has been for turfgrass weed control in the industrial and commercial, and government sectors. 2,4-D is currently used on about 9% of U.S. corn acres and comprises approximately 2.64% of total herbicide use on corn (see Table 4-4). Patterns of 2,4-D use in the United States are provided in Figure 4-13.

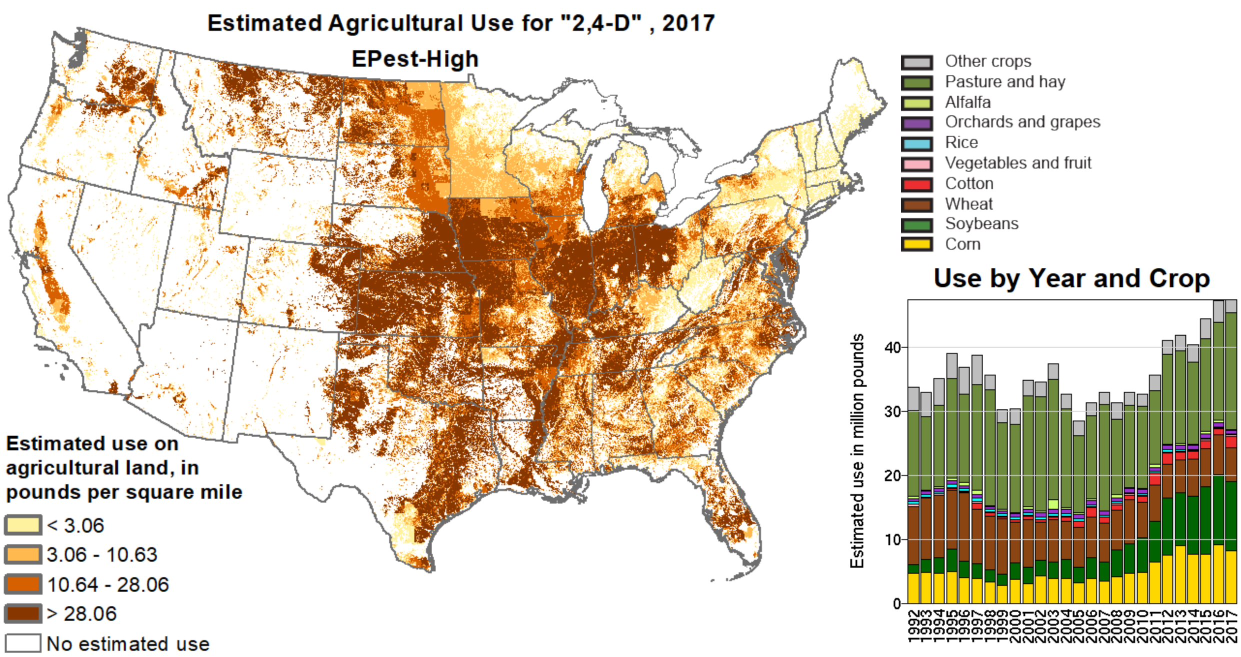

Figure 4-13. 2,4-D Use in the Conterminous United States, 2017

State-based and other restrictions on pesticide use were not incorporated into EPest-high or EPest-low estimates. EPest-low estimates usually reflect these restrictions because they are based primarily on surveyed data. EPest-high estimates include more extensive estimates of pesticide use not reported in surveys, which sometimes include States or areas where use restrictions have been imposed. Users should consult with State and local agencies for specific use restrictions. Source: (USGS 2019)

2,4-D Mode of Action and 2,4-D dioxygenase

Similar to dicamba, 2,4-D is a synthetic auxin, which, mimicking natural auxinic plant hormones induces abnormal growth, senescence, and plant death (Song 2014). Resistance to 2,4-D is conferred by introduction of a modified R-2,4-dichlorophenoxypropionate dioxygenase (*Rdpa*) gene from the soil microbe *Sphingobium herbicidovorans*. The modified gene (*ft_t*) in MON 87429 corn encodes for a dioxygenase (FT_T), which degrades 2,4-D into herbicidally inactive 2,4-dichlorophenol (2,4-DCP) and glyoxylic acid. Succinate and carbon dioxide are also released as byproducts of the degradation process.

4.3.1.2.3.6 Quizalofop-P-Ethyl

Quizalofop-p-ethyl (Ethyl(R)-2-[4-(6-chloroquinoxalin-2-yloxy)phenoxy]propionic acid), is a selective post-emergence herbicide used to control annual and perennial grass weeds in potatoes, soybeans, sugar beets, peanuts, vegetables, cotton, and flax. It is a systemic herbicide absorbed by the leaves with translocation throughout the plant. Historically, quizalofop-p-ethyl hasn't been commonly used with corn, as corn (a grass), is sensitive to quizalofop-p-ethyl. Recent registered uses are to control grassy weeds in HR field corn (e.g., Dow Enlist™ herbicide resistant trait). Note that quizalofop ethyl and quizalofop-p-ethyl are sometimes synonymously used in the scientific literature, and collectively referred to as "quizalofop ethyl." Quizalofop ethyl is a 50/50 racemic mixture of R- and S-enantiomers. Quizalofop-p-ethyl, the purified R-enantiomer, is the herbicidally-active isomer.

Quizalofop-p-ethyl is currently labeled for use in crop and non-crop areas. Patterns of quizalofop use in the United States are provided in Figure 4-14.

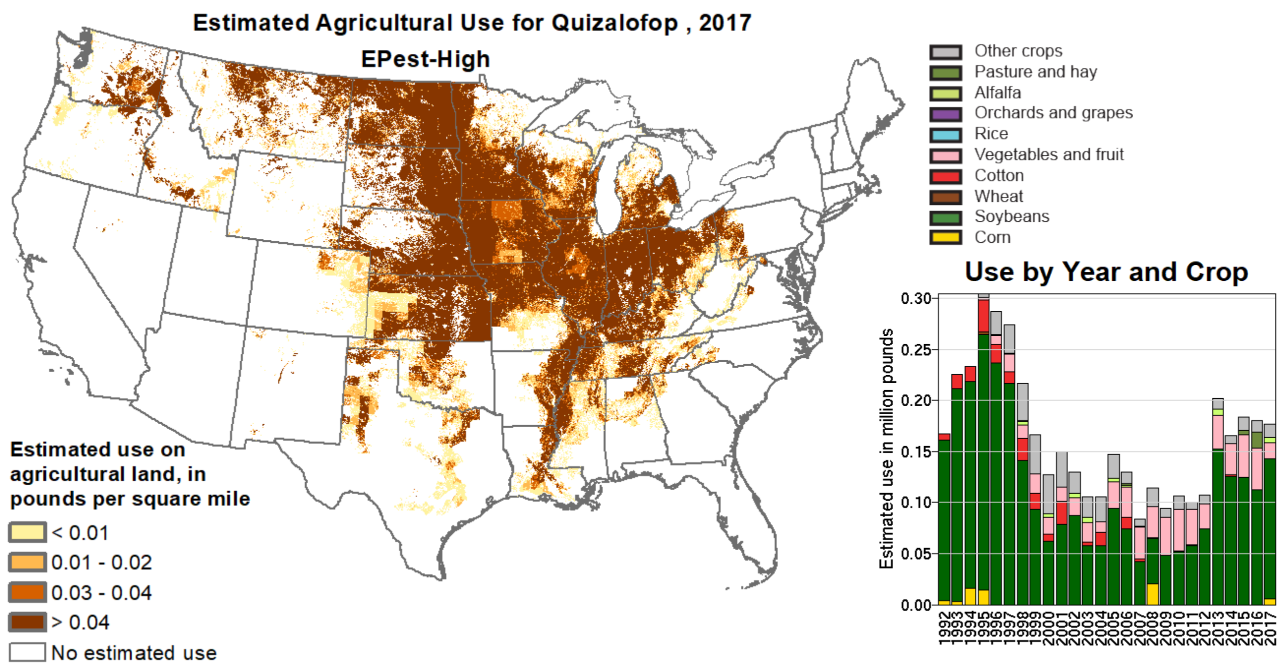

Figure 4-14. Quizalofop Use in the Conterminous United States, 2017

State-based and other restrictions on pesticide use were not incorporated into EPest-high or EPest-low estimates. EPest-low estimates usually reflect these restrictions because they are based primarily on surveyed data. EPest-high estimates include more extensive estimates of pesticide use not reported in surveys, which sometimes include States or areas where use restrictions have been imposed. Users should consult with State and local agencies for specific use restrictions. Source: (USGS 2019)

Quizalofop-P-Ethyl Mode of Action and ACCase Inhibitors

Quizalofop-p-ethyl is an acetyl coenzyme A carboxylase (ACCase) inhibitor. ACCase inhibitors include herbicides belonging to aryloxyphenoxypropionate (FOPs), cyclohexanedione (DIMs), and phenylpyrazolin (DENs) chemistries. Quizalofop-p-ethyl is a member of the FOP family and commonly used for control of annual and perennial weedy grasses. These herbicides inhibit the enzymatic activity of ACCase, which catalyzes the biosynthesis of fatty acids important for cell membrane development and maintenance. In general, most broadleaf plant species are naturally resistant to ACCase inhibitors due to an ACCase enzyme in broadleaf species that is less sensitive to FOP/DIM/DEN inhibition. However, ACCase inhibiting herbicides may cause symptoms on certain broadleaf crops (e.g., soybean, canola).

Resistance to quizalofop-p-ethyl in MON 87429 corn is conferred by the same FT_T enzyme that provides resistance to 2,4-D. This is because the aryloxyalkanoate dioxygenase class of enzymes can degrade both 2,4-D (phenoxy family of herbicides) and FOP classes of herbicides. Thus, similar to 2,4-D degradation, FT_T catalyzes a reaction that degrades quizalofop-p-ethyl into herbicidally-inactive quizalofop phenol and pyruvate. Due to the similar mechanisms by which synthetic auxins and FOPs can be degraded, certain biotech crops such as Enlist™ corn, which was developed primarily for 2,4-D resistance, also provide resistance to FOP herbicides, including quizalofop-p-ethyl.

4.3.1.2.3.7 Herbicide Resistant Weeds in U.S. Corn Crops

Herbicide resistant (HR) weeds are more of an agronomic than ecological concern, however, HR weed populations can potentially contribute to adverse environmental impacts when herbicide use or/and tillage is increased for their control, namely through potential increased soil erosion and run-off of non-point source pollutants (e.g., sediments, herbicides). HR weeds relative to the herbicides that will be used with MON 87429 corn are discussed below.

Over the last 70 years, chemical herbicide use has contributed to gains in crop production and reduced the need for tillage. However, there have also been increases in HR weed species. While herbicides are a highly useful tool in the control of weeds, the repeated singular use of an herbicide active ingredient (a.i.) mode of action (MOA) imparts selection pressure on a population of plants such that individuals inherently resistant to the herbicide survive and eventually predominate.[27] Inherently resistant plants occur naturally within weed populations. They differ slightly in genetic makeup from the rest of the population but remain reproductively compatible. HR plants are initially present in a weed population in extremely small numbers; about 1 in 100,000 to less than 1 in 1,000,000 (Campbell et al. 2015). The repeated use of one herbicide MOA allows the plants resistant to that MOA to survive and reproduce; the herbicide MOA selects for the naturally resistant weeds. The number of resistant plants then increases in the population.

Weed populations can also "evolve" resistance to an herbicide a.i., where the weed adapts to the external chemical stressor. Key to understanding the evolution of herbicide resistance is identifying the mechanism(s) of herbicide resistance, which are broadly classified as target-site resistance (TSR) and non-target-site resistance (NTSR). TSR mechanisms largely involve a mutation(s) in the target protein/enzyme (site of action of an herbicide), resulting in an insensitive or less sensitive target protein/enzyme (Jugulam and Shyam 2019). For example, a mutation in a gene can cause a minor change in a protein's structure, resulting in an herbicide no longer being able to bind and have an inhibitory effect on the protein, rendering the plant "resistant" to the herbicide (e.g., (Yang et al. 2016; Rey-Caballero et al. 2017)). Additionally, TSR can also result from increased expression of the target gene; plants may

[27] The MOA is the unique biological mechanism at the cellular/molecular level by which an herbicide is lethal to a plant.

increase gene expression and by that produce more protein/enzyme. This can reduce the effectiveness of standard herbicide dosages (Jugulam and Shyam 2019).

NTSR to herbicides can be conferred as a result of the alteration of one or more physiological processes, such as herbicide a.i. absorption, translocation, sequestration, and/or metabolism. The mechanisms of NTSR are generally more difficult to identify than TSR. Evolution of NTSR can impart cross-resistance to herbicides with different MOAs, and thus complicate weed resistance management strategies (Jugulam and Shyam 2019).

As of September 2020, the International Herbicide-Resistant Weed Database lists 48 states with the presence of HR weed populations (Heap 2022). As of the end of 2020, there were 165 unique cases of HR weeds in the United States (weed species by herbicide MOA) (Heap 2022). This is not a recent concern, nor is it unique to biotech crops. Herbicide resistant weed populations have been occurring since the advent and wide-spread use of chemical herbicides in the 1950s. As illustrated in Figure 4-15, significant increases in HR weed populations began to occur around the mid-1980s.

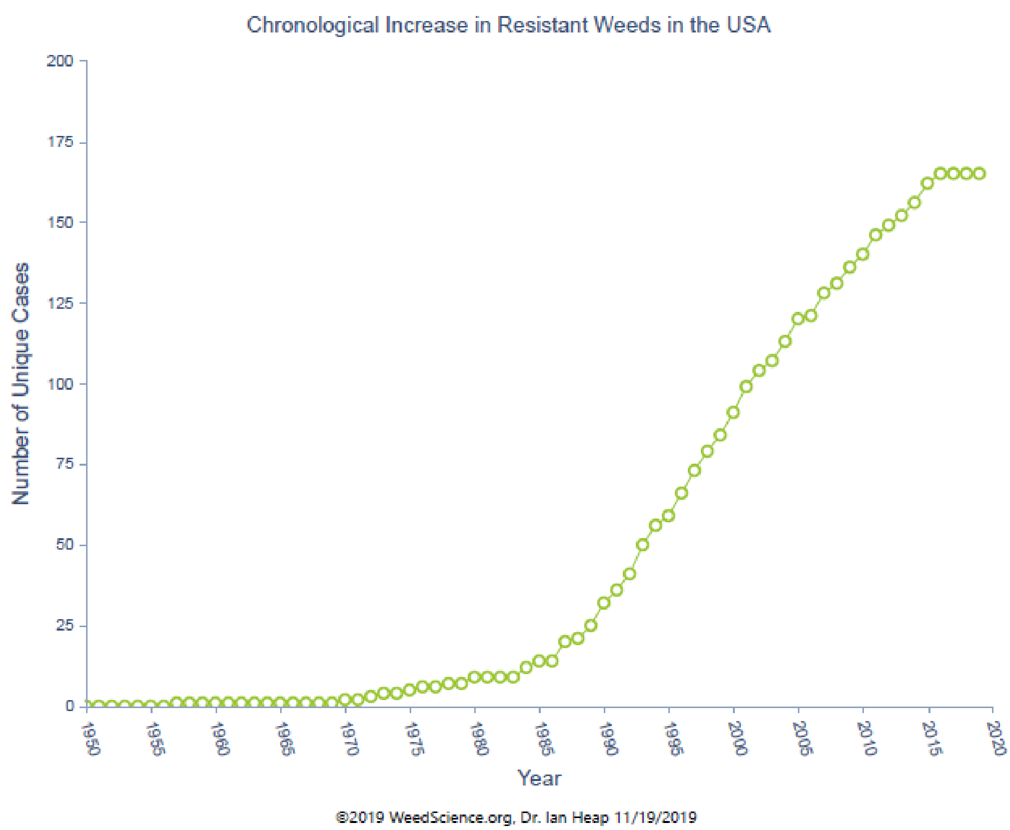

Figure 4-15. HR Weeds in the United States, 1950–2020

Source: (Heap 2022)

Globally, weeds have developed resistance to 21 of the 31 known herbicide MOAs (Figure 4-16), which reduces the variety of chemical weed control options available to growers. Most corn growing states have from around 3 to 8 different species of weeds that are herbicide resistant (Heap 2022). There have been no herbicides with completely novel MOAs developed and commercialized over the last several decades. Consequently, there are no herbicides with novel MOAs with which to control HR weeds.

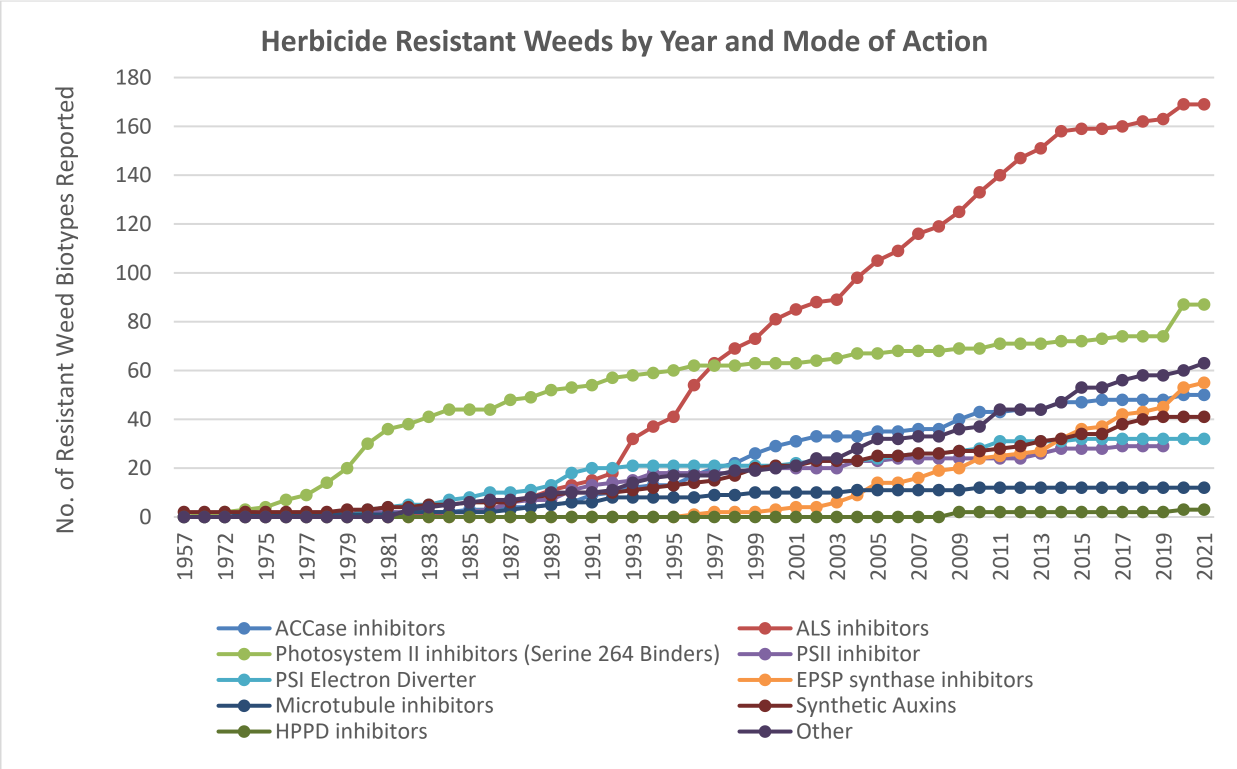

Figure 4-16. Increase in the Development of Herbicide Resistance, Globally—Herbicide Modes of Action

The herbicide groups with the most HR weeds are acetolactate synthase (ALS) inhibitors (i.e., imidazolinone and imazethapyr); ACCase inhibitors (i.e., phenylpyrazoline); triazine based photosynthesis II inhibitors (i.e., atrazine); synthetic auxins (i.e, dicamba, 2,4-D); bipyridilium based photosynthesis I inhibitors such as paraquat; glycines, which include the EPSP synthase inhibitor glyphosate; various ureas and amides that inhibit the photosynthesis II process; and dinitroaniline based microtubule inhibitors such as trifluralin. Source: (Heap 2022)

Problematic is the ongoing trend that many HR weed populations have developed resistance to more than one herbicide MOA. For example, in U.S. corn crops (as of 2020) there were 16 instances with a weed population developing resistance to 2 MOAs, 5 confirmed weed populations with resistance to 3 MOAs, 3 with confirmed resistance to 4 MOAs, and 1 species (tall waterhemp) with confirmed resistance to 5 herbicide MOAs (Table 4-6).

In U.S. corn crops, there are 5 reported instances of weeds resistant to synthetic auxins, across 4 states, and 1 reported instance of weeds resistant to ACCase inhibitors, across 2 states (Heap 2022). As for glyphosate (EPSPS inhibitor), there are 54 reported instances of resistant weeds in U.S. corn crops across 26 states. Two weed species have been reported to be resistant to herbicides that contain glufosinate (glutamine synthetase inhibitor); a population of Italian ryegrasss (*Lolium multiflorum*) in orchards in California and Oregon (Heap 2022), and a population of Palmer amaranth (*Amaranthus palmeri*) in corn in Arkansas' Mississippi County, this being discovered in 2020 (AgWeb 2021).

Table 4-6. Herbicide Resistant Weeds in U.S. Corn: Multiple Modes of Action

Scientific Name	Common Name	State	Yr. Reported	Mode of Action
2 MOAs				
Conyza bonariensis	Hairy Fleabane	California	**2009**	PSI Electron Diverter, EPSPS inhibitors
Kochia scoparia	Kochia	Illinois	**1995**	ALS inhibitors, PS inhibitors
Amaranthus tuberculatus (=*A. rudis*)	Tall Waterhemp	Illinois	**1996**	ALS inhibitors, PS inhibitors
Amaranthus hybridus (syn: quitensis)	Smooth Pigweed	Illinois	**2000**	ALS inhibitors, PS inhibitors
Amaranthus tuberculatus (=*A. rudis*)	Tall Waterhemp	Illinois	**2006**	ALS inhibitors, EPSPS inhibitors
Amaranthus palmeri	Palmer Amaranth	Illinois	**2013**	ALS inhibitors, EPSPS inhibitors
Amaranthus palmeri	Palmer Amaranth	Illinois	**2016**	PPO inhibitors, EPSPS inhibitors
Kochia scoparia	Kochia	Kansas	**2013**	EPSPS inhibitors, Synthetic Auxins
Amaranthus tuberculatus (=*A. rudis*)	Tall Waterhemp	Minnesota	**2016**	PPO inhibitors, EPSPS inhibitors
Amaranthus tuberculatus (=*A. rudis*)	Tall Waterhemp	Missouri	**2009**	ALS inhibitors, EPSPS inhibitors
Ambrosia trifida	Giant Ragweed	Missouri	**2011**	ALS inhibitors, EPSPS inhibitors
Lolium perenne ssp. *multiflorum*	Italian Ryegrass	Missouri	**2013**	ACCase inhibitors, ALS inhibitors
Amaranthus palmeri	Palmer Amaranth	Nebraska	**2014**	PS inhibitors, HPPD inhibitors
Amaranthus retroflexus	Redroot Pigweed	Pennsylvania	**1998**	ALS inhibitors, PS inhibitors
Amaranthus palmeri	Palmer Amaranth	South Carolina	**2010**	ALS inhibitors, EPSPS inhibitors
Amaranthus palmeri	Palmer Amaranth	Wisconsin	**2014**	ALS inhibitors, HPPD inhibitors
3 MOAs				
Amaranthus palmeri	Palmer Amaranth	Georgia	**2010**	ALS inhibitors, PS inhibitors, EPSPS inhibitors
Amaranthus tuberculatus (=*A. rudis*)	Tall Waterhemp	Illinois	**2002**	ALS inhibitors, PS inhibitors, PPO inhibitors
Amaranthus palmeri	Palmer Amaranth	Kansas	**2009**	ALS inhibitors, PS inhibitors, HPPD inhibitors
Amaranthus tuberculatus (=*A. rudis*)	Tall Waterhemp	Missouri	**2005**	ALS inhibitors, PPO inhibitors, EPSPS inhibitors
Ambrosia artemisiifolia	Common Ragweed	North Carolina	**2015**	ALS inhibitors, PPO inhibitors, EPSP synthase inhibitors
4 MOAs				
Amaranthus tuberculatus (=*A. rudis*)	Tall Waterhemp	Illinois	**2009**	ALS inhibitors, PS inhibitors, PPO inhibitors, EPSPS inhibitors
Amaranthus tuberculatus (=*A. rudis*)	Tall Waterhemp	Iowa	**2011**	ALS inhibitors, PS inhibitors, HPPD inhibitors, EPSPS inhibitors
Kochia scoparia	Kochia	Kansas	**2013**	ALS inhibitors, PS inhibitors , EPSPS inhibitors, Synthetic Auxins
5 MOAs				
Amaranthus tuberculatus (=*A. rudis*)	Tall Waterhemp	Illinois	**2016**	ALS inhibitors, PS inhibitors, PPO inhibitors, HPPD inhibitors, Synthetic Auxins

Source: (Heap 2022)

Herbicide Resistant Weed Management

Over-reliance on herbicides for weed control in lieu of other non-chemical methods, and continued issues with the development of HR weed populations, has fueled debate on how to best utilize herbicides so as to sustain their longevity, and prevent the further development of HR weed populations (e.g., (Owen 2016; Heap and Duke 2018; Beckie et al. 2019; Korres et al. 2019), and others). Strategies for managing weeds and avoiding the development of HR weed populations in U.S. agriculture continue to be refined (e.g., (Owen 2016; Heap and Duke 2018; Beckie et al. 2019; Korres et al. 2019), and others). A combination of preventive, cultural, mechanical, biological, and chemical methods are recommended for effective long-term weed and weed resistance management. The coordinated use of these is termed integrated weed management (IWM), a system of strategies developed and recommended by the crop protection and seed industries, the USDA, weed scientists working with university extension services and the Weed Science Society of America (WSSA), the EPA, and state departments of agriculture. In 2017, the EPA issued PR Notice 2017-2, *Guidance for Herbicide-Resistance Management, Labeling, Education, Training and Stewardship* (US-EPA 2017a), which provides registrants and growers detailed information on slowing the development and spread of HR weeds. PR Notice 2017-2 communicates the EPA's current thinking and approach to addressing herbicide-resistant weeds by providing guidance on labeling, education, training, and stewardship for herbicides undergoing registration review or registration.

4.3.1.3 Potential Effects on U.S. Corn Production

4.3.1.3.1 Potential Effects on Land Use

Approval of the petition would have little to no effect on lands used for U.S. corn production. U.S. corn acreage is determined by national and international market demand for corn-based food, feed, fuel, and industrial commodities, independent of APHIS' regulatory status decision. Acreage could also be determined by the inherent yield potential of a given corn cultivar, pest and weed pressures, the potential contribution of HR and IR traits to effectively controlling weeds and insect pests, and agronomic production factors. MON 87429 was compared to a conventional control line in a combined-site analysis for phenotypic and agronomic characteristics. No statistically significant differences in yield were detected between MON 87429 corn and the conventional control line (Monsanto 2019).

4.3.1.3.2 Seed Corn Production in the United States

MON 87429 corn will not be marketed as a stand-alone product (Monsanto 2019), its intended purpose is for production of hybrid corn seed that will sold to growers for commercial production. The first-generation of the Roundup® Hybridization System (RHS) was based on MON 87427 corn, which was assessed by APHIS and deregulated in 2013. The second-generation RHS would utilize MON 87429 corn to produce glufosinate, dicamba, 2,4-D, quizalofop-p-ethyl, and glyphosate resistant corn seed.

MON 87429 corn expresses the enzyme 5-enolpyruvlshikimate-3-phosphate synthase (EPSPS) in vegetative and female reproductive tissues (the ear; consisting of a cob, eggs that develop into kernels after pollination, and silks), which renders these tissues resistant to glyphosate. MON 87429 corn utilizes an endogenous small interfering RNA (siRNA) in corn to reduce expression of the EPSPS enzyme in male tassel tissues and pollen, via inhibition of EPSPS messenger RNA (mRNA). Because MON 87429 corn has limited or no production of the EPSPS enzyme in tassel tissues and pollen these tissues remain sensitive to glyphosate. Specifically-timed glyphosate application results in non-viable pollen in MON 87429 corn (male sterility), which prevents self-fertilization. This modification in MON 87429 corn precludes the need for manual detasseling to prevent self-fertilization, thereby facilitating cross pollination of MON 87429 corn with other corn plants for the purposed of hybrid seed production.

MON 87429 corn hybrid seed production would occur on lands allocated to seed and new variety plant production, lands regularly used for this purpose. As to MON 87429 corn hybrid progeny; if adopted by growers, MON 87429 corn HR hybrids would be expected to replace other HR corn varieties currently cultivated, as opposed to augmenting current corn crops.

There could be a minor increase in acreage used for hybrid corn seed production, or no increase; it is not possible to determine with any certainty. Hybrid corn varieties can last on the market for around three to seven years (Unglesbee 2019e). MON 87429 corn may augment current seed crops for a period of time or replace a seed corn variety currently produced—one that will be phased out. If there is a minor increase in seed corn acreage, any associated impacts on the physical environment and biological resources would be expected to be *de minimis*.

The volume of hybrid corn seed produced in the United States was 31.80 MBu in 2019. At an average yield of 167.8 bushels per acre, this comprised around 189,511 seed corn acres—compared to around 90 million acres of field corn, sweet corn, and popcorn production. Hybrid seed corn production in the United States has declined relative to total corn grain production and corn acreage (Table 4-7). This is attributed to increased yields/acre over the last two decades for many of newer corn cultivars (USDA-NASS 2023). New seed varieties are continually tested, developed, and marketed each year, with new lines introduced, and some discontinued; e.g., 11 new corn varieties were introduced in 2019, and several hundred lines tested (Begemann 2016; Neuenschwander 2016). Acreage allocated to seed corn production remains relatively constant and is not expected to significantly change with the introduction of MON 87429 corn.

Table 4-7. Corn: Hybrid Seed Production

Year	Seed (million Bushels)	Grain (billion Bushels)	Seed: Percent of Corn Production	Bushels per Acre
1996	22.28	9.23	0.24%	127.10
1998	22.32	9.76	0.23%	134.40
2000	22.45	9.92	0.23%	136.90
2002	23.75	8.97	0.26%	129.30
2004	24.22	11.80	0.21%	160.30
2006	28.55	10.53	0.27%	149.10
2008	27.23	12.04	0.23%	153.30
2010	29.58	12.43	0.24%	152.60
2012	30.96	10.75	0.29%	123.10
2014	29.26	14.22	0.21%	171.00
2016	29.30	15.15	0.19%	174.60
2018	29.40	14.42	0.20%	176.41
2019	31.80	13.70	0.23%	167.80

Source: (USDA-ERS 2019b)

4.3.1.3.3 Weed Management and Herbicide Resistant Weeds

Chemical weed control will remain a primary weed management tool for the foreseeable future, and the potential for weeds to evolve resistance to herbicide active ingredients will be ever present. There is no single tactic that can be effectively used when it comes to controlling weeds; effective weed management utilizes a diverse set of tools and practices that include crop rotation, tillage, cover crops, weed seed harvest control, and rotation/combination of herbicide active ingredients (MOAs).

Stacked-trait HR varieties employing differing herbicide MOAs are recognized as potentially useful tool for allaying or preventing the further development of HR weed populations. Stacked-trait HR crops facilitate utilization of combinations of differing herbicide MOAs, flexibility in the choice of herbicide MOAs, and herbicide MOA rotations. Utilization of stacked-trait HR crop varieties is expected to be a preferred method for weed management for many crop producers, particularly in areas where weeds are problematic and HR weeds are present.

The development of HR weeds continues in many areas of the United States and can be difficult to prevent, as well as control. Since 2015, there have been 43 reported cases of newly developed HR weeds in the United States (Heap 2022). There have been 576 reported cases of HR weeds since 1970. Most corn growing states have from around 3 to 8 different species of weeds that are herbicide resistant; e.g., Palmer Amaranth (*Amaranthus palmeri*), Kochia (*Kochia scoparia*), Tall Waterhemp (*Amaranthus tuberculatus* (=*A. rudis*)), Pigweed (*Amaranthus hybridus* (syn: quitensis)), Ragweed (*Ambrosia artemisiifolia*) (Heap 2022).

Certain herbicide MOAs appear to be more susceptible to development of resistance. For example, development of resistance to ALS inhibitors—amino acid synthesis inhibitors—is the most common, there have been around 169 resistant weed species reported worldwide (prior Figure 4-16), a trend that is attributed to the relative ease with which plants can evolve resistance. Several single amino acid substitutions that are sufficient to confer resistance to ALS inhibitors have been identified in plant genes. Resistance to the photosynthesis (PSII) inhibitor herbicide group occurs less frequently as it requires a specific point mutation in the *psbA* gene, which is generally maternally inherited—in contrast to ALS inhibitors; there are 74 cases of PSII resistance reported worldwide (Holt et al. 2013).

Among herbicide active ingredients, glufosinate-ammonium is considered a valuable tool for grower's in the management of weeds, and weed resistance (US-EPA 2016c). This is attributed to its MOA—a glutamine synthetase inhibitor—to which there are only two weed species in the United States that have developed resistance; Italian ryegrass (*Lolium perenne* ssp. *multiflorum*), with populations in orchards in California and Oregon, and Palmer amaranth (*Amaranthus palmeri*), which was recently reported in an Arkansas corn field (Table 4-8). Similarly, dicamba and 2,4-D (synthetic auxins), and quizalofop-p-ethyl (ACCase inhibitor) are likewise considered good herbicides for use in management of weeds, and HR weed development. As of 2021, there were 21 reported cases of weeds resistant to synthetic auxins (9 different weed species across 16 states), and 51 reported cases of weeds resistant to ACCase inhibitors (12 different weeds species across 26 states). It is noted that, however, worldwide, 41 weed species have been reported resistant to synthetic auxins, and 49 species reported resistant to ACCase inhibitors (Heap 2022).

Table 4-8. HR Weeds in the United States: Synthetic Auxins, Glutamine Synthetase Inhibitors, ACCase inhibitors

Scientific Name	Common Name	Yr. Reported	State	Multiple Resistance–Also Resistant to:
Amaranthus palmeri	Palmer Amaranth	2015	Kansas *Multiple - 5 SOA's	Photosystem II inhibitors, ALS inhibitors, EPSP synthase inhibitors, HPPD inhibitors
		2018	Kansas	NR
		2020	Tennessee	EPSP synthase inhibitors
Amaranthus tuberculatus (=A. rudis)	Tall Waterhemp	2009	Nebraska *Multiple - 3 SOA's	Photosystem II inhibitors, ALS inhibitors

		2016	Illinois *Multiple - 5 SOA's	ALS inhibitors, ALS inhibitors, Photosystem II inhibitors, PPO inhibitors, HPPD inhibitors
Centaurea solstitialis	Yellow Starthistle	1988	Washington	NR
Commelina diffusa	Spreading Dayflower	1957	Hawaii	NR
Daucus carota	Wild Carrot	1993	Michigan	NR
		1994	Ohio	NR
Digitaria ischaemum	Smooth Crabgrass	2002	California	NR
Echinochloa crus-galli var. crus-galli	Barnyardgrass	1998	Louisiana	NR
		1999	Arkansas *Multiple - 2 SOA's	PSII inhibitor (Ureas and amides)
Kochia scoparia	Kochia	1994	Montana	NR
		1995	North Dakota	NR
		1997	Idaho	NR
		1999	Colorado	NR
		2009	Nebraska	NR
		2013	Kansas *Multiple - 4 SOA's	ALS inhibitors, Photosystem II inhibitors, EPSP synthase inhibitors
		2013	Kansas *Multiple - 2 SOA's	EPSP synthase inhibitors
Lactuca serriola	Prickly Lettuce	2007	Washington	NR
Plantago lanceolata	Buckhorn Plantain	2016	Indiana	NR
Glutamine Synthetase Inhibitors				
Scientific Name	**Common Name**	**Yr. Reported**	**State**	**Multiple Resistance–Also Resistant to:**
Lolium perenne ssp. *multiflorum*	Italian Ryegrass	2010	Oregon	EPSP synthase inhibitors
Lolium perenne ssp. *multiflorum*	Italian Ryegrass	2015	California	NR
Amaranthus palmeri	Palmer Amaranth	2020	Arkansas	NR
ACCase Inhibitors				
Scientific Name	**Common Name**	**Yr. Reported**	**State**	**Multiple Resistance–Also Resistant to:**
Avena fatua	Wild Oat	1991	Minnesota	NR
		1991	North Dakota	NR
		1991	Washington	NR
		1992	Idaho	NR
		1997	Colorado	NR
		2002	2002 - Montana	NR
		2009	South Dakota	NR
		2012	South Dakota *Multiple - 2 SOA's	ALS inhibitors
Bromus tectorum	Downy Brome (Cheatgrass)	2005	Oregon	NR
Digitaria ischaemum	Smooth Crabgrass	1996	New Jersey	NR
Digitaria sanguinalis	Large Crabgrass	1992	Wisconsin	NR
		2008	Georgia	NR
Echinochloa crus-galli var. crus-galli	Barnyardgrass	2000	California *Multiple - 2 SOA's	Lipid Inhibitors
		2011	Mississippi *Multiple - 4 SOA's	ALS inhibitors, PSII inhibitor (Ureas and amides), Cellulose inhibitors
Echinochloa phyllopogon (=E. oryzicola)	Late Watergrass	1998	California	NR

		2000	California *Multiple - 2 SOA's	Lipid Inhibitors
Leptochloa panicoides	Amazon Sprangletop	2009	Louisiana	NR
Lolium perenne ssp. multiflorum	Italian Ryegrass	1987	Oregon	NR
		1990	North Carolina	NR
		1990	South Carolina	NR
		1991	Idaho	NR
		1993	Virginia	NR
		1995	Arkansas *Multiple - 2 SOA's	ALS inhibitors
		1995	Georgia	NR
		1998	Maryland	NR
		2004	Kentucky	NR
		2005	Arkansas	NR
		2005	Idaho *Multiple - 3 SOA's	ALS inhibitors, Long chain fatty acid inhibitors
		2006	Tennessee	NR
		2007	North Carolina *Multiple - 2 SOA's	ALS inhibitors
		2009	Georgia *Multiple - 2 SOA's	ALS inhibitors
		2010	South Carolina *Multiple - 2 SOA's	ALS inhibitors
		2013	Missouri *Multiple - 2 SOA's	ALS inhibitors
		2015	California *Multiple - 3 SOA's	PSI Electron Diverter, EPSP synthase inhibitors
		2016	California *Multiple - 4 SOA's	ALS inhibitors, PSI Electron Diverter, EPSP synthase inhibitors
		2017	Oklahoma	NR
Lolium persicum	Persian Darnel	1993	Montana	NR
Phalaris minor	Little seed Canary grass	2011	California	NR
Rottboellia cochinchinensis (=R. exaltata)	Itchgrass	1997	Louisiana	NR
Setaria faberi	Giant Foxtail	1991	Wisconsin	NR
		1994	Iowa	NR
		1998	Illinois	NR
Setaria viridis	Green Foxtail	2005	Montana	NR
Setaria viridis var. major (=var. robusta-alba, var. robustapurpurea)	Giant Green Foxtail	1999	Minnesota	NR
		1999	Minnesota	NR
Sorghum halepense	Johnsongrass	1991	Kentucky	NR
		1991	Mississippi	NR
		1995	Tennessee	NR
		1995	Virginia	NR
		1997	Louisiana	NR

*NR: None Reported

Source: (Heap 2022)

Glyphosate resistant weeds, due to their variety and prevalence, can be problematic to manage. As of 2020, there were 169 reported cases of glyphosate resistant weeds in the United States, among 16 species of weeds (Heap 2022). In corn, there have been 143 cases of glyphosate resistant weeds reported, across 9 species. Several species have developed resistance to an additional 2 to 4 MOAs, with HR varieties of Palmer Amaranth being reported resistant to glyphosate and 4 other herbicide MOAs, these cases being in Kansas and Arkansas (Table 4-9).

Table 4-9. HR Weeds - Glyphosate

Years Reported	Scientific Name	Common Name	No. of States	Multiple Resistance –MOAs
2006 - 2020	*Amaranthus palmeri*	Palmer Amaranth*	24	EPSP synthase inhibitors and 1 or more ALS inhibitors, HPPD inhibitors, Photosystem II inhibitors, Synthetic Auxins
2012 - 2015	*Amaranthus spinosus*	Spiny Amaranth	1	EPSP synthase inhibitors
2006 - 2016	*Amaranthus tuberculatus (=A. rudis)*	Tall Waterhemp*	16	EPSP synthase inhibitors and 1 or more ALS inhibitors, EPSP synthase inhibitors, HPPD inhibitors, Photosystem II inhibitors, PPO inhibitors
2004 - 2017	*Ambrosia artemisiifolia*	Annual Ragweed*	14	EPSP synthase inhibitors and 1 or more: ALS inhibitors, EPSP synthase inhibitors, PPO inhibitors
2004 - 2011	*Ambrosia trifida*	Giant Ragweed*	13	EPSP synthase inhibitors and ALS inhibitors
2002 - 2015	*Conyza bonariensis*	Horseweed*	21	EPSP synthase inhibitors and PSI Electron Diverter or ALS inhibitors
2008	*Echinochloa colona*	Barnyard Grass*	1	EPSP synthase inhibitors
2010 - 2011	*Eleusine indica*	Goosegrass	2	EPSP synthase inhibitors
2015	*Helianthus annuus*	Sunflower *	1	EPSP synthase inhibitors
2007 - 2014	*Kochia scoparia*	Summer Cypress*	12	EPSP synthase inhibitors and 1 or more: ALS inhibitors, Photosystem II inhibitors, Synthetic Auxins
2004 - 2016	*Lolium perenne ssp. multiflorum*	Italian Ryegrass*	8	EPSP synthase inhibitors and 1 ore more: ACCase inhibitors, ALS inhibitors, EPSP synthase inhibitors, PSI Electron Diverter, Glutamine synthase inhibitors
1998	*Lolium rigidum*	Annual Ryegrass	1	EPSP synthase inhibitors
2014	*Parthenium hysterophorus*	Santa Maria Feverfew	1	EPSP synthase inhibitors
2010 - 2013	*Poa annua*	Annual Meadow Grass	3	EPSP synthase inhibitors
2015 - 2016	*Salsola tragus*	Prickly Russian Thistle	3	EPSP synthase inhibitors
2007 - 2010	*Sorghum halepense*	Johnson Grass	3	EPSP synthase inhibitors

HR weeds denoted with an asterisk (*) are present in U.S. corn fields.

Source: (Heap 2022)

A primary strategy currently recommended for allaying or preventing the development of herbicide resistant weed populations is to use two or more herbicide active ingredients in a tank mix that have differing MOAs, and rotation of herbicides with differing MOAs (Norsworthy et al. 2012; Owen 2016; Beckie et al. 2019; Gage et al. 2019; Comont et al. 2020). For example, a USDA-ARS and University of Illinois study found that fields with a mean herbicide complexity of 2 herbicide MOAs per application were 83 times less likely to select for glyphosate-resistant waterhemp (*A. tuberculatus*) within four to six years compared with fields with a mean complexity of 1 MOAs per application (Evans et al. 2016). Waterhemp seeds in fields with maximum annual application of mixtures of three MOAs were 51 times less likely to be glyphosate resistant than those from fields with two MOAs per application. The authors however stressed that while measures such as herbicide tank mixing may delay HR weed development, this tactic alone is unlikely to prevent the development of HR weeds. Long-term weed management requires highly diversified use of chemical based and non-chemical management practices that collectively minimize selection for herbicide resistance in weeds (Evans et al. 2016).

MON 87429 corn hybrids, resistant to four differing herbicide MOAs—synthetic auxins, ACCase inhibitors, EPSP synthase inhibitors, and glutamine synthetase inhibitors—could potentially facilitate effective weed management within an IWM program, contribute to helping allay/prevent the development of resistant weed biotypes, and management of current HR weed populations.

4.3.1.3.4 Herbicide Use with MON 87429 Corn

It is important to clarify that APHIS has no legal authority to regulate or otherwise determine herbicide use with HR crops, or any other crop. APHIS regulatory role in the Coordinated Framework is limited to assessing whether an organism produced using genetic engineering could present a "plant pest risk" as defined under the PPA and APHIS implementing regulations at 7 CFR part 340. APHIS has regulatory oversight over the plant itself, not any pesticides that may be used in cultivation of the plant (to include plant incorporated protectants). As previously described in Section 1.3, the EPA regulates herbicide use, to include all herbicides that would be used with MON 87429 corn, under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA). While APHIS has no statutory authority to regulate herbicide use, a general overview of potential herbicide use with MON 87429 corn is provided.

MON 87429 corn hybrids would provide resistance to four differing herbicide MOAs, based on the Herbicide Resistance Action Committee (HRAC)[28] classification system, and five different herbicides:

1. Auxin Mimics/Synthetic Auxins – HRAC GROUP 4 (dicamba and 2,4-D)
2. Enolpyruvyl Shikimate Phosphate Synthase (EPSPS) Inhibitors – HRAC GROUP 9 (glyphosate)
3. Acetyl CoA Carboxylase (ACCase) Inhibitors – HRAC GROUP 1 (quizalofop-p-ethyl)
4. Glutamine Synthetase Inhibitors – HRAC GROUP 10 (glufosinate)

MON 87429 corn hybrids, resistant to glyphosate, glufosinate, dicamba, 2,4-D, and quizalofop-p-ethyl, to the extent they are adopted, would influence the types and amount of herbicide active ingredients used on U.S. crops. The current scientific literature supports that using herbicide MOA mixtures, as would be used in stacked trait HR crops, are more successful in slowing the evolution of herbicide resistant weeds, rather than herbicide MOA rotations (Beckie and Reboud 2009; Gage et al. 2019). Tank mixing exposes weeds to differing herbicide MOAs simultaneously, decreasing the probability that a plant inherently resistant in a population will be selected after herbicide exposure (Evans et al. 2016). Herbicide rotations

[28] The global Herbicide Resistance Action Committee (HRAC) is an international body founded by the agrochemical industry, helps to protect crop yields and quality worldwide by supporting efforts in the fight against herbicide-resistant weeds. https://www.hracglobal.com/

and sequences (or cycling) also reduce selection pressure on weeds by employing herbicides with different MOAs in successive growing seasons, or within the same season. Growers of MON 87429 corn hybrids would have the option to utilize up to two or more differing herbicide MOAs in a tank mix during a crop cycle, and rotate herbicide MOAs across crop cycles—subject to EPA use limits and mixing restrictions.

FIFRA allows for the tank mixing of pesticides when it is not prohibited on the label. Current labels for glyphosate, glufosinate, dicamba, 2,4-D, and quizalofop-p-ethyl allow for tank mixing and provide mixing guidance. More commonly, tank mixes of two herbicide active ingredients—with differing MOAs—are used, pre- or/and post emergent. Where the prevalence and variety of weed and HR weed species present were particularly problematic, there could be use of three or more herbicides (differing MOAs) during a crop cycle, in tank mixes, or/and in sequences. The application rates, seasonal/annual use limits, and tank mixing of glyphosate, glufosinate, dicamba, 2,4-D, and quizalofop-p-ethyl would be subject to EPA label requirements and use limits. Bayer states that glufosinate, quizalofop-p-ethyl, glyphosate, dicamba, and 2,4-D use on MON 87429 corn hybrids will follow the current labeled use patterns for these individual herbicides (Monsanto 2019; Bayer-CropSci 2022). Bayer states the use of dicamba on MON 87429 corn will follow current EPA registration label use requirements for corn. The maximum annual use rate would be a total of 0.75 lbs. a.e. per treated acre per crop year. Maximum application rate would be 0.5 lb. a.e. per acre, with no more than 2 applications per growing season (Bayer-CropSci 2022). Use restrictions would include (US-EPA 2010):

- Application prohibited if corn is more than 36 inches tall or within 15 days before tassel emergence, whichever comes first.
- Application prohibited when soybeans are growing nearby if any of these conditions exist: corn is more than 24" tall; soybeans are more than 10" tall; soybeans have begun to bloom.

Most HR corn varieties grown today are resistant to glyphosate, and to a lesser extent glufosinate, dicamba, and 2,4-D. As of the end of 2021, glyphosate was applied to 79% of corn crops, comprising 31.2% of total herbicide use (lbs a.i./acre). 2,4-D, dicamba, and glufosinate use with corn has been comparatively limited (see Table 4-4). 2,4-D was used on approximately 9% of corn cropland (2.6% of total herbicide use), dicamba was used on approximately 19% of corn cropland (1.7% of total herbicide use), and glufosinate-ammonium on only 2% of corn cropland (0.36% of total herbicide use). Historically, quizalofop-p-ethyl has not been applied to corn because, as a grass-family crop, quizalofop-p-ethyl—which is used to control grass weeds—would injure corn. Annual use data for quizalofop-p-ethyl on corn was unavailable at the time this writing.[29]

[29] Enlist™ corn is a 2,4-D resistant variety that also provides resistance to FOP herbicides, including quizalofop-p-ethyl, due to the similar mechanisms by which synthetic auxins (2,4-D) and the aryloxyphenoxypropionate (quizalofop-p-ethyl) classes of herbicides can be degraded. DuPont™ registered Assure® II Herbicide, which contains the active ingredient quizalofop-p-ethyl, that can be used as a foliar spray to control certain grassy weeds in field corn containing the Dow Enlist™ 2,4-D resistant trait Dupont. 2018. *Dupont™ Assure® II Herbicide [EPA Reg.*

Because 2,4-D, dicamba, and glufosinate use with corn has been comparatively limited, there could be increased use of these herbicides with MON 87429 corn hybrids, relative to the level of MON 87429 corn adoption, and grower choice in the specific herbicides used. MON 87429 corn hybrids could likewise facilitate an increase in use of quizalofop-p-ethyl. Thus, to the extent this variety is grown, MON 87429 corn hybrids would contribute to an overall shift in the types of herbicides used in corn production, with hybrids facilitating more glufosinate, dicamba, 2,4-D, and quizalofop-p-ethyl use (e.g., see Table 4-4). An increased use of these herbicides, grower option to utilize these herbicides, would be expected to entail a decrease in use of other herbicides with similar spectrums of weed control. Because most corn varieties currently produced are already glyphosate resistant, around 80% of corn acres are treated with glyphosate (US-EPA 2019f), and MON 87429 corn progeny, where adopted, would in most instances likely replace varieties already resistant to glyphosate, any increase in glyphosate use would be expected to be minimal. Minor annual fluctuations in total herbicide use on corn will occur due to variances in the use rates in lbs a.i./acre among herbicides, annual acreage planted to corn, the types of weeds and HR weeds present in U.S. corn crops, and the particular HR crop varieties growers elect to produce. There would be limited use of glyphosate in MON 87429 corn hybrid seed production. The volume of hybrid corn seed produced in the United States comprised around 189,511 seed corn acres in 2019, compared to around 90 million acres of field corn, sweet corn, and popcorn production (USDA-NASS 2020).

Dicamba and 2,4-D Resistant Soybean and Cotton

During the 2015 and 2016 growing seasons there were no registered dicamba products for over-the-top (OTT) application to dicamba resistant cotton and soybean crops. After the registration of OTT dicamba products for use on these crops in late 2016, there was an increase in dicamba use in the United States (US-EPA 2020m). Prior to the registration of dicamba for Xtend® and Enlist™ soybeans and cotton, about 35 million acres of agricultural land were treated annually with 6 million pounds of dicamba active ingredient (5-yr average; 2012–2016). Field corn and winter and spring wheat were the crops with the largest number of acres treated with dicamba, at an average of 19.8 million acres treated per year (2012–2016). Other sites with substantial use from 2012–2016 include cotton, fallow land, pasture land, sorghum, and soybeans (pre-plant only) (US-EPA 2020m).

The share of soybean acreage planted with dicamba-resistant seeds increased to 33% as of 2018, at which time approximately 29.9 million acres were dicamba-resistant (Table 4-10). However, in some states such as Mississippi, dicamba-resistant soybean accounted for almost 80% of planted acres (US-EPA 2020n). Total cotton acres treated with dicamba increased to around 7 million acres as of 2018, comprising 56% of cotton acres (Table 4-11).

Table 4-10. Annual Average Soybean Acres Planted by Seed Trait, 2013–2014 and 2017–2018

Variety	Acres	% Acres	Acres	% Acres
	2013–2014		2017–2018	
Conventional	3,690,000	4%	3,530,000	4%
Glyphosate Resistant (a)	76,100,000	90%	40,700,000	46%

No. 352-541]. E.I. DuPont de Nemours and Company. Retrieved from https://www.enlist.com/content/dam/hdas/enlist/pdfs/DuPont%20Assure%20II%20Section%203%20label.pdf .

Other Herbicide- Resistant (b)	4,680,000	6%	15,200,000	17%
Dicamba-Resistant (c)	0	-	29,900,000	33%
U.S. Total Soybean Acres	84,400,000		89,400,000	

a. Includes varieties with combined resistance to glyphosate and sulfonylurea herbicides.

b. Includes varieties with combined resistance to glufosinate and/or sulfonylurea herbicides.

c. Includes varieties with combined resistance to dicamba, glyphosate, and sulfonylurea herbicides.

*Note: Dicamba resistant seed was available in 2016, but postemergence dicamba was not registered until after the 2016 growing season. 2016 was considered a transition year for dicamba resistant soybean.

Source: (US-EPA 2020z)

Table 4-11. Annual Average Cotton Acres Planted by Seed Trait, 2013–2014 and 2017–2018

Variety	Acres	% Acres	Acres	% Acres
	2013–2014		2017–2018	
Conventional	730,000	7%	780,000	6%
Glyphosate-Resistant	8,630,000	82%	2,210,000	16%
Glufosinate-Resistant	150,000	1%	0	-
Glufosinate & Glyphosate-Resistant	1,030,000	10%	1,810,000	16%
Dicamba, Glufosinate, and Glyphosate-Resistant	0	-	7,070,000	56%
2,4-D, Glufosinate, and Glyphosate- Resistant	0	-	670,000	5%
U.S. Total Cotton Acres	10,550,000		12,540,000	

Source: (US-EPA 2020aa)

In 2017 and 2018, growers used dicamba on 8% and 17% of all U.S. soybean and cotton acres (dicamba-resistant and non- dicamba-resistant) prior to crop emergence, respectively, and on 17% and 34% of all U.S. soybean and cotton acres after crop emergence (dicamba-resistant crops), respectively (US-EPA 2020n). This comprised around 4.2 million to 4.5 million acres of cotton (post-emergent use), and 15.1 million to 15.2 million acres of soybean (post-emergent use). Postemergence dicamba has primarily been used to target herbicide-resistant Palmer amaranth and redroot pigweed, although it is effective at controlling a range of broadleaf weed species (US-EPA 2020q).

As of 2019, the number of dicamba-resistant soybeans planted in the United States comprised around 60% of soybean crops, approximately 60 million acres (Hettinger 2019b). As of 2020, around 70% of cotton acres, approximately 8.5 million acres, were planted with dicamba-resistant seed (US-EPA 2020aa).

From 2007 to 2016, before use of OTT dicamba use was allowed on dicamba resistant soybeans and cotton, around 130,000 to 164,000 pounds dicamba a.i. was applied each year to cotton, while an average of 590,000 to 172,000 pounds of dicamba a.i. was applied to soybeans (Figure 4-17, Table 4-12). For 2017, around 10.64 million pounds of dicamba were applied to soybeans, and 3.06 million pounds were applied to cotton. In 2019, 9.75 million pounds dicamba a.i. were applied to soybean, and in 2018 (latest data) 5.58 million pounds of dicamba a.i. were applied to cotton. This comprised a 30-fold increase in cotton, and approximately 20-fold increase in dicamba use in soybean.

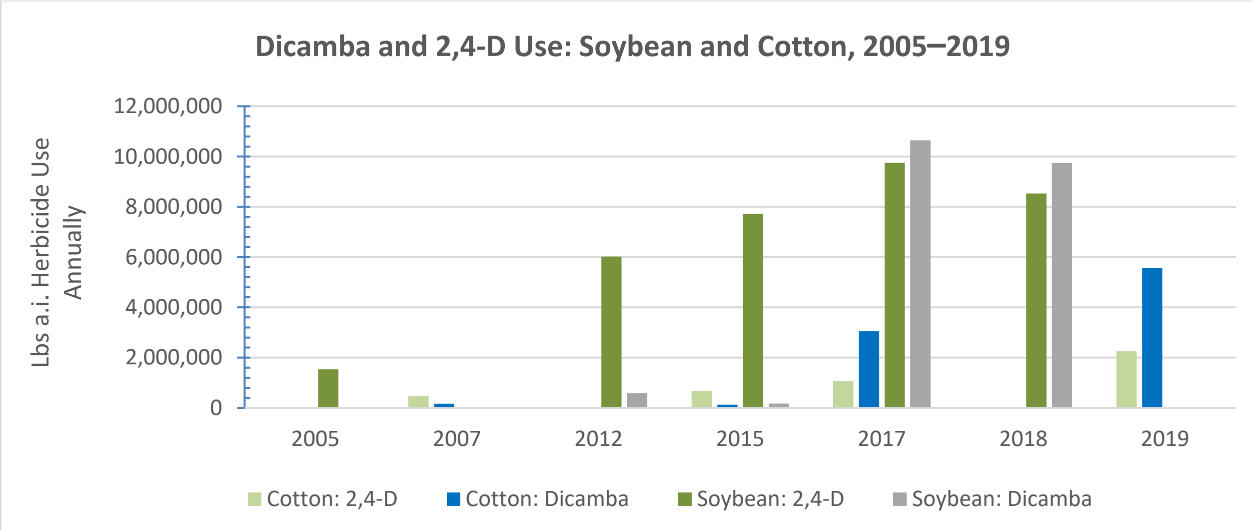

Figure 4-17. Dicamba and 2,4-D Use, 2005–2019

Table 4-12. Dicamba and 2,4-D Use: U.S. Cotton and Soybean

	Pounds a.i. of Herbicide Use Annually						
	2005	**2007**	**2012**	**2015**	**2017**	**2018**	**2019**
Cotton: 2,4-D	-	475,000	-	683,000	1,072,000	-	2,255,000
Cotton: Dicamba	-	164,000	-	130,000	3,061,000	-	5,575,000
Soybean: 2,4-D	1,539,000	-	6,021,000	7,715,000	9,756,000	8,529,000	-
Soybean: Dicamba	-	-	590,000	172,000	10,643,000	9,742,000	-

Beginning in 2016, the EPA registered three dicamba products with significantly lower volatility for OTT application to DT cotton and soybean – Xtendimax™ with VaporGrip™ Technology (diglycolamine salt; Bayer; EPA Reg. No. 524-617), FeXapan™ with VaporGrip™ Technology (diglycolamine salt; Corteva; 352-913) and Engenia™ (bis aminopropyl methylamine or BAPMA salt; BASF; 7969-345) (USEPA 2016a, 2016b, 2017). In April 2019 Tavium™ with VaporGrip™ (diglycolamine salt co-formulated with s-metolachlor; Syngenta; 100-1623) was registered.
Source: (US-EPA 2020n; USDA-NASS 2023)

Of note, not all acres planted with dicamba-resistant soybeans have been treated with dicamba. In 19 States, more acres were planted with dicamba-resistant seed than were actually sprayed with dicamba (Wechsler et al. 2019). For instance, in Mississippi (2019 crop year), 79% of soybean acres were planted with dicamba-resistant seeds, but only 54% of these acres were treated with dicamba (Wechsler et al. 2019). In some cases, farmers may only use dicamba if glyphosate-resistant weeds appear. In other cases, dicamba-resistant seeds are planted to prevent yield losses from unintended exposure to dicamba drift (Wechsler et al. 2019).

In considering the herbicides that will be used in MON 87429 corn production, and potential contribution to shifts in use of these herbicides on U.S. cropland, glufosinate, for example, is applied on other major crops such as cotton, canola, potato, and soybean. Apples, cherries, grapes, oranges, peaches, pears, pistachios, and walnuts are also treated with glufosinate, some at rates greater than 1.0 lbs a.i./acre (US-EPA 2016c). Similarly, 2,4-D is used in many places including on turf, lawns, aquatic sites, forestry sites, and on a variety of field, fruit, and vegetable crops. Dicamba is likewise widely used on turf and lawns. Quizalofop-p-ethyl is used to control annual and perennial grass weeds in potatoes, soybeans, sugar beets, peanuts vegetables, cotton, and flax. Glyphosate is widely used in agriculture, for residential/commercial property weed control, and in forestry.

To what extent, and in what combinations growers may elect to use glufosinate, dicamba, 2,4-D, glyphosate, and/or quizalofop-p-ethyl with MON 87429 corn is not foreseeable. The potential effect of stacked-trait HR crops on associated herbicide use patterns is not clearly understood, due to lack of quantitative data, as these varieties of HR crops are relatively new. Most stacked-trait HR canola, corn, cotton, and soybean varieties entered U.S. and international markets within the last ten years, many of these within the last seven years (ISAAA 2022). There is no specific quantitative data on herbicide use patterns with individual stacked-trait HR crop varieties (e.g., tank mixes and herbicide rotation strategies) that APHIS is aware of. While stacked-trait HR crops may provide a potentially valuable tool in the management of weeds and development of weed resistance, increased herbicide use with these crops—relative to non-HR crops—could potentially increase risks to water and air quality, as well as to flora and fauna in proximity to stacked-trait HR crop fields, to include aquatic environments (Schütte et al. 2017; Gage et al. 2019).

4.3.1.3.5 Herbicide Drift and Volatilization

Herbicides applied to crops can move off-site when environmental conditions are favorable for spray or vapor drift. Off-site movement can result in injury to adjacent crops as well as to nearby non-crop plants, both wild and cultivated on residential and commercial properties. In general, herbicide spray/vapor drift out of the target area will be greater with low relative humidity, high temperatures, wind, and temperature inversions. Drift potential is also a function of the inherent volatility—vaporization potential—of an herbicide mixture. The potential for vapor drift depends, in part, on the vapor pressure of the herbicide formulation, which is a measurement of the tendency of a compound to evaporate under standard meteorological conditions.

Among the herbicides that would be used with MON 87429 corn, the synthetic auxin herbicides dicamba and 2,4-D can present more of a concern in terms of spray and vapor drift, relative to other herbicides, due to their functions as plant hormones, and potential effects on a wide variety of broad-leaf crop and non-crop plants at low dosages (Gage et al. 2019). Use of dicamba, and to some extent 2,4-D, with the introduction of dicamba resistant and 2,4-D resistant cotton and soybean crops in 2016 presented some issues with late season (summer) over the top (OTT) application on these crops (US-EPA 2020q, x, 2021d). Spray drift and volatilization with both herbicides during late season application has had impacts on crops not resistant to dicamba and 2,4-D. Current soybean and cotton crops on which dicamba and 2,4-D are used, marketed under the Xtend® and Enlist™ traits, are provided in Table 4-13.

Table 4-13. Recently Commercialized Stacked-Trait HR Seed Products

Crop	Product name	Manufacturer	Resistant to:	Deregulated	Commercialized
Corn	Enlist	Dow	2,4-D choline, glyphosate, and select ACCase inhibitors	2014	2018

Cotton	Enlist	Dow	2,4-D choline, glyphosate, and glufosinate	2015	2016
	Xtend	Bayer	Dicamba, glyphosate, and glufosinate	2015	2016
Soybeans	Enlist	Dow/Corteva	2,4-D choline, glyphosate, and glufosinate	2014	2019
	Xtend	Bayer	Dicamba and glyphosate	2015	2016

Source: (Wechsler et al. 2019)

In brief, issues involving dicamba drift increased after the introduction of dicamba-resistant crops into the U.S. market in 2016. Dicamba spray and vapor drift has resulted in injury to adjacent crops, as well as wild and cultivated plants on residential and commercial properties, leading in many cases to subsequent litigation and state imposed fines for crop injury (Gage et al. 2019). Prior to the 2016 registrations for dicamba, dicamba use on soybeans and cotton was limited to preplant and preharvest soybeans and on preplant and postharvest cotton (US-EPA 2020m). Historically, most dicamba applications occurred in late winter or early spring for pre-plant or fallow removal of broadleaf vegetation prior to planting crops. The new uses registered in 2016 under FIFRA section 3(c)(7)(B) expanded the timing of dicamba applications to post-emergence OTT applications to dicamba-resistant soybean and cotton crops (US-EPA 2020m). Due to an increased number of applications of dicamba across increased acreage of dicamba-resistant soybean and cotton, the likelihood of offsite movement and injury to surrounding sensitive plants through drift and/or volatility likewise increased—and occurred. Additionally, spraying dicamba on green plant tissues, as in post emergent applications, can increase dicamba emissions more than 300% over those observed when dicamba herbicides were sprayed onto other surfaces such as bare soil (Mueller and Steckel 2021).

In 2016, the EPA received reports of crop injury alleged to be caused by off-target movement from the use of dicamba. The EPA concluded the 2016 incidents were related to misuse of previously registered, more volatile dicamba pesticide products on dicamba resistant cotton and dicamba resistant soybeans (US-EPA 2018). In 2017, there were approximately 2,708 reported cases of off-target movement of dicamba to other crops, with an estimated impact on around 3.6 million acres of non-dicamba resistant soybeans (Figure 4-18), approximately 4% of the total 90.2 million acres planted in 2017. In response, the EPA issued modification of dicamba product labels and application requirements for the 2018 growing season. In 2018, the Association of American Pesticide Control Officials (AAPCO) reported that approximately 1,400 official complaints of alleged dicamba injury [damage due to off-site movement of dicamba] were reported to state regulatory authorities" (US-EPA 2018). Only 16 of 34 registered states report regularly to AAPCO and EPA, so it is likely that this number underestimated dicamba-related crop damage (US-EPA 2018).

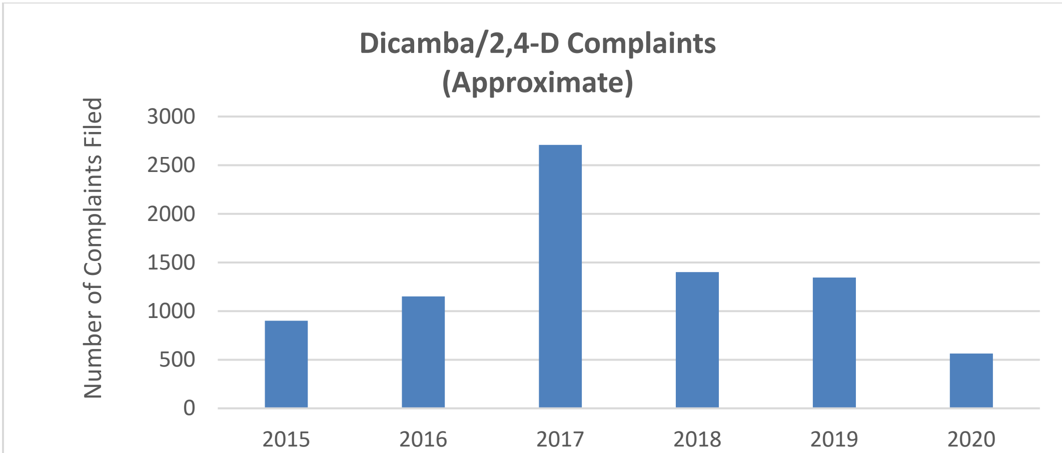

Figure 4-18. Approximate Number of Reported Dicamba and 2,4-D Drift Complaints for 16 States, 2015–2020

The majority of states reported agricultural herbicide drift complaints. States included in this figure are: AL, AR, AZ, IA, IL, IN, ND, MO, OK, GA, SC, MS, NC, NE, TN, and SD. Incidents occurred in other states for these years although data were incomplete for every year and not included. Dicamba is registered for OTT use in 34 states.
Source: (Unglesbee 2019a; Hartzler and Jha 2020; Unglesbee 2020b; US-EPA 2020m; AAPCO 2021)

Farmer responses to the USDA's Soybean Production Practices and Costs Report for 2018 suggest that approximately 4% percent of soybean fields were damaged by off-target dicamba movement. The largest share of fields damaged were in Nebraska and Illinois, where damage from dicamba was reported on approximately 1 in every 13 fields (Wechsler et al. 2019). Some of the states with the least damage to soybeans were also the states where the most dicamba was sprayed. For instance, while over half of soybean fields in Mississippi were treated with dicamba, only 3% of soybean fields were damaged by off-target dicamba movement in 2018. This was attributed to the fact that 73% of the soybean crops planted in Mississippi were dicamba-resistant. However, federal- and state-level restrictions on dicamba use may also have played a role in reducing damages (Wechsler et al. 2019).

In 2019, Arkansas fielded 121 dicamba drift complaints, 11 for 2,4-D, and another 10 listed as dicamba or 2,4-D (Unglesbee 2019a). In Illinois, 724 complaints were filed, and in Indiana, about 178. Missouri's Department of Agriculture investigated at least 18 dicamba complaints and one 2,4-D in 2019. In Tennessee, pesticide regulators received a handful of dicamba injury complaints and 15 2,4-D complaints (Unglesbee 2019a). Most of these complaints were not in row crops, but rather for nurseries, vineyards, gardens, trees, and landscape ornamentals (Unglesbee 2019a).

In 2020, the Arkansas State Plant Board received 336 complaints, 106 of which alleged dicamba injury, six that alleged dicamba and/or 2,4-D, and eight that alleged 2,4-D injury alone (Unglesbee 2019a). Missouri logged at least 68 pesticide drift complaints during the growing season, 23 were alleged dicamba drift and five alleged 2-4, D drift. The alleged damage totals are 427 acres of soybeans from dicamba and 1,080 acres of cotton from 2,4-D. There were also alleged drift damages to residential trees, gardens, and flowers (Unglesbee 2019a).

In Indiana, state regulators received 152 drift complaints as of June, 2020, with 51 specifically alleging dicamba injury (Unglesbee 2020b). Missouri logged 68 pesticide drift complaints in 2020, 23 were alleged dicamba drift and five are alleged 2-4, D drift. The Illinois Department of Agriculture had received 104 pesticide misuse complaints as of July 3, 2020, with 25 specifically alleging dicamba misuse (Unglesbee 2020b). As of February 2020, the Missouri Department of Agriculture had a backlog of over 600 complaints from farmers related to dicamba drift from another farm harming their crops.

In 2020, the EPA concluded that its 2020 label restrictions on dicamba resistant plants would (1) reduce run-off potential and risk but not eliminate, (2) eliminate off-site exposure from spray drift with 90% certainty of protection of non-listed plants, and (3) eliminate off-site exposure from volatility with > 95% certainty of protection of non-listed plants when considering the combined impact of all mandatory volatile emission control measures (volatility reducing adjuvant [VRA], application cut-off dates, and in-field 57-ft omnidirectional application setbacks) (US-EPA 2022a). Despite the new control measures, the EPA received nearly 3,500 incident reports for the 2021 growing season of damage to non-dicamba resistant soybean, numerous other crops, and a wide variety of non-target plants in non-crop areas including residences, parks, and wildlife refuges (US-EPA 2021d, 2022a). These incidents were reported by various stakeholders including states, academic researchers, media, impacted individuals, and companies. The EPA continues to monitor and evaluate new incident report submissions and the analysis will be updated as new information becomes available (US-EPA 2022a).

A 2016–2020 EPA/WSSA survey of midwestern state farmers growing specialty crops (states of ND, SD, MN, WI, MI, OH, IN, IL, MO, IA, NE, KS) found almost half of respondents reporting crop injury from dicamba and 2,4-D drift (Table 4-14). Moderate (13% to 18% of those surveyed) to severe (8% to 14% of those surveyed) damage to specialty crops was reported for all years (Table 4-15).

Table 4-14. Summary of Midwestern State Herbicide Drift Survey on Specialty Crops

Inquiry	Percent of Growers
Did dicamba cause plant damage on your farm?	47%
Did 2,4-D cause plant damage on your farm?	44%
Did glyphosate cause plant damage on your farm?	20%
Did an UNKNOWN herbicide cause plant damage on your farm?	27%
Did OTHER cause plant damage on your farm?	10%

* Specialty crops in the survey: Green, snap, or lima beans; Green peas; Edamame / Food-grade soybean; Dry edible beans; Dry edible peas; Tomatoes; Potatoes; Peppers; Cucumber/Melon; Pumpkins/Squash; Lettuce/Greens; Grapes; Peaches; Apples; Blueberries; Brambles; Strawberries; Flowering annuals; Ornamental perennials; Landscape trees and shrubs; Christmas trees.
Source: (WSSA/EPA 2020)

Table 4-15. Level of Herbicide Damage to Specialty Crops, 2016–2020

Year	2020	2019	2018	2017	2016
N=	**238**	**231**	**232**	**231**	**231**
No drift damage	55%	47%	46%	52%	58%
Minor drift damage	17%	22%	20%	21%	16%
Moderate drift damage	18%	17%	17%	13%	13%
Severe drift damage	10%	13%	14%	11%	8%

NA - no specialty crops grown	0%	1%	3%	4%	5%

Specialty crops in the survey: Green, snap, or lima beans; Green peas; Edamame / Food-grade soybean; Dry edible beans; Dry edible peas; Tomatoes; Potatoes; Peppers; Cucumber/Melon; Pumpkins/Squash; Lettuce/Greens; Grapes; Peaches; Apples; Blueberries; Brambles; Strawberries; Flowering annuals; Ornamental perennials; Landscape trees and shrubs; Christmas trees
Source: (WSSA/EPA 2020)

The 2016–2020 EPA/WSSA surveys also found that growers used a variety of tactics to avoid/prevent crop injury from herbicide spray and vapor drift (Table 4-16).

Table 4-16. Actions Taken to Manage the Risk of Herbicide Drift Damage

Inquiry	No. of Respondents	Percentage
Used Field Watch or a similar registry for sensitive crops	183	65%
Approached a neighboring herbicide applicator preemptively with drift concerns	171	60%
Sought information on herbicide damage symptoms, testing labs, or steps for reporting	114	40%
Attended a workshop about managing herbicide drift risks	83	29%
Changed or moved crops due to drift concerns	50	18%
Planted a buffer zone or tree line to provide protection from drift	107	38%
None of these	21	7%
Other	35	12%

Number of respondents = 283. Specialty crops in the survey: Green, snap, or lima beans; Green peas; Edamame / Food-grade soybean; Dry edible beans; Dry edible peas; Tomatoes; Potatoes; Peppers; Cucumber/Melon; Pumpkins/Squash; Lettuce/Greens; Grapes; Peaches; Apples; Blueberries; Brambles; Strawberries; Flowering annuals; Ornamental perennials; Landscape trees and shrubs; Christmas trees
Source: (WSSA/EPA 2020)

It should be noted that not all farmers file a complaint when herbicide drift injury has occurred, for various reasons; hence, actual incidences of drift and crop injury are likely underreported in currently available data. In a 2019/2020 survey, 40% of Midwestern state farmers reported they could see no benefit in filing a complaint, and 51% were concerned with creating bad relationships with neighboring farms; further reasons are summarized in Table 4-17.

Table 4-17. Summary of Herbicide Drift Survey on Specialty Crops, 2019–2020

Reasons for not filing a complaint (N=99)	Percentage
I filed a complaint any time I had damage	6%
Drift was caused by activities on our own operation	3%
Process involved too much time and paperwork	10%
Could see no benefit in filing a complaint	40%
Consequences to offender are not meaningful	32%
Damage was minor	23%
Unable to identify the source of the drift	26%
Concerned with creating bad relationships with neighboring farms	51%
Concerned with ability to market crops	4%

Resolved the problem without the state's assistance	9%
Another party filed the complaint on my behalf	1%
None of the provided reasons	4%
OTHER	15%

*Number of respondents = 99. Specialty crops included in the survey: Green, snap, or lima beans; Green peas; Edamame / Food-grade soybean; Dry edible beans; Dry edible peas; Tomatoes; Potatoes; Peppers; Cucumber/Melon; Pumpkins/Squash; Lettuce/Greens; Grapes; Peaches; Apples; Blueberries; Brambles; Strawberries; Flowering annuals; Ornamental perennials; Landscape trees and shrubs; Christmas trees. Source: (WSSA/EPA 2020)

Synthetic Auxin Herbicides and Crop Injury

Synthetic auxin herbicides, which function as plant hormones, can injure a wide variety of broadleaf plants at very low levels of drift, including twisting or epinasty of stems and cupping of leaves (Sciumbato et al. 2004; Gage et al. 2019). Several broadleaf crops, including soybean and cotton, are very sensitive to these compounds. Injury to soybean, for example, has been documented at the low rate of 0.03 g/hectare (ha) (0.012 g/acre) of dicamba (Solomon and Bradley 2014). Robinson et al. (2013) observed visible injury (<5% of the crop) at a 0.06 g/ha (0.02 g/acre) dose of dicamba. Three other studies applied dicamba at rates of less than 1 g/ha (0.40 g/A) and observed plant injury; Johnson et al. (2012) observed >25% injury at 0.6 g/ha (0.02 g/acre), Solomon and Bradley (2014) observed at least 10% injury at 0.028 g/ha (0.011 g/acre), and Weidenhamer et al. (1989) reported injury, foliar aberrations, at 0.06 g/ha (0.02 g/acre)—percent of crop injury was not reported. Because visible injury was reported at the lowest dicamba dose in each of these studies, a No Observed Effects Dose was unable to be estimated from the existing published literature (Kniss 2018).

Besides susceptible cotton and soybean crops, vegetable and fruit crops, orchards, vineyards, and residential and commercial gardens can be damaged by off-target movement of synthetic auxins (Dittmar et al. 2016; Streibig and Green 2017). For example, tomato (*Lycopersicon esculentum* Mill. 'Marglobe") and lettuce (*Latuca sativa* L.) crops may be injured with as little as 0.001% of the labeled rate of 2,4-D butyl ester (Van Rensburg and Breeze 1990). Depending on the susceptibility of plants, off-target injury can occur at a considerable distance from the point of application. Thus, as synthetic auxin herbicide resistance traits become more widely utilized in crops, the potential for off-target movement and injury to non-resistant plants can also increase.

As an example: Crops resistant to 2,4-D and dicamba could be a cause of concern for sweet potato (*Ipomoea batatas*) producers owing to the potential effects of herbicide spray or vapor drift. A field study was conducted in 2016 and 2017 to assess the impacts of reduced rates of combinations of glyphosate with 2,4-D or dicamba on sweet potato growth and production (Miller et al. 2020). Reduced rates of 1/10x, 1/33x, 1/66x, and 1/100x the rate of glyphosate at 1 lb/acre plus 2,4-D choline at 0.94 lb/acre and glyphosate at 1 lb/acre plus diglycolamine salt of dicamba at 0.5 lb/acre were applied to Beauregard sweet potato at 10 or 30 days after transplanting. With respect to visual injury, glyphosate plus dicamba proved to be more injurious than glyphosate plus 2,4-D, particularly within the lower rate range. Typical auxin injury symptomology was evident 35 days after application. With respect to U.S. No. 1 and total (U.S. No. 1, canner, and jumbo grade) sweet potato yield, the largest negative impact was observed with herbicide application at the upper rate ranges, particularly 1/10x and 1/33x rates. In most cases, injury was greater at the later application timing, presumably due to larger plants having greater leaf surface area for herbicide interception (Miller et al. 2020). Sweet potato producers with multi-crop farming operations were cautioned by the researchers to thoroughly follow all sprayer cleanout procedures when previously spraying auxin herbicides and glyphosate, or to devote different equipment to spraying Xtend and Enlist crops (Miller et al. 2020). In addition, it was recommended that proper consideration be given to planting these crops near sweet potato production fields and applications of dicamba and 2,4-D; under environmental conditions that are not conducive to off-site spray or vapor movement (Miller et al. 2020).

Farmers whose crops have been injured may be entitled to compensation for pesticide contamination under chemical trespass or nuisance law. Thus, potential claims/litigation and associated costs, and time requirements in tending to the damage—prevention/mitigation of damage—can be a concern, as well as increasing tensions between neighbors in rural communities.

Herbicide Drift and Volatilization: HR Weed Development

Herbicide spray drift/volatilization may also result in the development of herbicide resistant weeds. Palmer amaranth and waterhemp populations were recurrently exposed to glyphosate, 2,4-D, and dicamba spray drift in a wind tunnel study over two generations. Herbicide drift exposure was found to select for resistant biotypes with reduced herbicide sensitivity. Waterhemp was observed to develop glyphosate, 2,4-D, and dicamba resistance as a result of spray drift (Vieira et al. 2020). Palmer amaranth evolved glyphosate and 2,4-D resistance after being recurrently exposed to spray drift of both herbicides (Vieira et al. 2020).

4.3.1.3.6 Summary and Uncertainties

Stacked-trait HR crop varieties are recognized as a potentially useful tool for the management of weeds and allaying or preventing the further development of HR weed populations. Growers will select a particular HR crop variety based on weed/HR weed populations present; the potential for high yield; efficacy of the herbicide(s) used with the HR crop; costs of pesticide inputs; and ease and flexibility in weed management. MON 87429 corn hybrids, with 4 transgenes conference resistance to 4 different herbicide MOAs (a total of 5 herbicides), are intended to provide growers an additional weed management tool and improve the management of herbicide resistant and hard-to control weeds. Glufosinate, dicamba, and 2,4-D are considered effective broadleaf weed management tools, particularly in cropping systems with glyphosate-resistant weeds (US-EPA 2020aa, 2020z). Quizalofop-p-ethyl can be effective in managing grass weeds. Stacked-trait HR technologies, such as MON 87429 corn, may fill efficacy gaps for weed control and help diversify weed management options (Gage et al. 2019). By employing IWM practices with stacked-trait HR crops, growers can potentially preserve the utility of HR traits, herbicide MOAs, and reduce the potential for weeds to evolve resistance (Green 2014; Gage et al. 2019). While there may be benefits to those who use MON 87429 for weed and HR weed management, there is also, however, the potential for harm to neighboring agricultural interests resulting from dicamba spray and vapor drift.

Stacked-Trait Herbicide Resistant Crops and Herbicide Use

In utilizing stacked-trait HR varieties growers can tank mix two or more herbicides (differing MOAs targeting a similar weed spectra), as well as rotate herbicide MOAs with these varieties during a crop cycle. How a stacked-trait HR variety utilizing four different MOAs may contribute to a shift or increase in annual herbicide use is uncertain; there is as yet insufficient quantitative data on the relationship between stacked-trait HR crops and herbicide use that would provide for an accurate quantitate analysis. Growers may elect to use only one herbicide during a production season or may use two or more herbicide MOAs in a tank mix where weed and/or HR weeds were particularly problematic (discussed further below). Hence, there could be increased herbicide use with MON 87429 corn hybrids in some areas where weeds and HR weeds were difficult to manage, although this would, in general, be limited to EPA label annual use restrictions, as well as for economic reasons. Commercially available pre-mix herbicides have been extensively studied by the chemical companies with the objective to enhance weed control while minimizing crop injury. One example of a commercial product is Enlist Duo®, which is comprised of both 2,4-D and glyphosate. Many labels, for example the new dicamba products registered for use in dicamba-resistant soybeans (Xtend), have statements such as "use approved tank mix products as directed by the label or website". This statement prohibits all tank mixes except for the ones the manufacturer has approved and specifies in their EPA approved labels, or website providing herbicide mixing requirements.

The potential use of multiple herbicide MOAs in tank mixes considered, in addition to EPA label use restrictions (e.g., mixing, annual use rates), due to cost and efficiency, it is expected that overall herbicide use with MON 87429 corn hybrids would be limited to what was needed for effective weed and HR weed management. Maximum annual use would be limited to EPA label use restrictions. Which herbicides (glufosinate, dicamba, 2,4-D, quizalofop-p-ethyl, and/or glyphosate) growers will elect to use with MON 87429 corn hybrids during a crop cycle cannot be foreseen. Much of this will be determined by weed and HR weed pressures present on individual farms, crop rotation practices, and the efficacy of weed and HR weed management programs employed on individual farms—as well as collectively in a given area. Annual herbicide use on U.S. corn acres will normally fluctuate relative to the particular HR varieties growers elect to produce, weed and herbicide resistant weed species present in fields (in both biotech and non-biotech cropping systems), and variances in U.S. corn acres planted each year.

Due to weed resistance issues across multiple herbicide families, growers may consider specific herbicides for in-crop weed management as needed that include for example dicamba, glyphosate, 2,4-D, and/or glufosinate depending on the herbicide resistant weeds present. Glyphosate still offers value for broad spectrum control of grass and broadleaf weeds but requires additional herbicide MOAs for effective control of glyphosate resistant and troublesome weed species. A recent growers survey in the state of Nebraska indicated 80% to 93% of growers use multiple herbicide MOAs in their weed management program and perceive use of a residual preemergence herbicide followed by glyphosate tank-mixed with other postemergence herbicide in glyphosate-resistant crop as one of the most effective weed control measures (Sarangi and Jhala 2018).

Another factor in attempting to assess potential herbicide use is that not all stacked-trait HR crops may be treated with herbicides enabled by the stacked traits. As discussed previously, less than half the acres planted in 2018 with glyphosate- and dicamba-resistant soybeans were treated with dicamba in the United States.

As glufosinate, dicamba, 2,4-D, and quizalofop-p-ethyl would be preferentially used in lieu of other herbicides, MON 87429 corn production would also be expected to contribute, to some extent, to annual reductions in use of other herbicides that delivered comparable spectrums of weed control. Because most dent corn grown is already glyphosate resistant (glyphosate is used on around 80% of corn acres), it is expected that there would little to no increase in glyphosate use with MON 87429 corn.

Any increase in seasonal/annual herbicide use with stacked-trait HR crop varieties, namely via tank mixing of multiple herbicides, could potentially increase risks to water and air quality, as well as to other crop and non-crop plants. In general, shifts in the use of specific herbicides and any increase in herbicide use with MON 87429 corn or any other stacked-trait HR variety could create public health or/and environmental concerns. Potential environmental and human health risks—discussed in the following sections of this EIS—are relative to the specific herbicide a.i., its mode of action in biological systems, the potential toxicity of the a.i. to various taxa, its environmental mobility and persistence, as well as the toxicity of herbicide formulations as there may be synergistic effects that derive from such formulations. It should also be noted that any increased herbicide use, potential risks to flora and fauna would in general, be temporal in nature; during the spring and early summer months when herbicides are most commonly applied.

The EPA conducts human health and ecological risk assessments prior to registering an herbicide. These risk assessments inform EPA label use requirements. Detailed ecological and human health risk assessments for the herbicide active ingredients that may be used with MON 87429 corn hybrids have been conducted by the EPA, and incorporated here by reference: Glyphosate (US-EPA 2019f); Dicamba (US-EPA 2022b, a); Glufosinate (US-EPA 2016c); 2,4-D (US-EPA 2017b); and Quizalofop (US-EPA 2014a). All use of these herbicides would be subject to EPA label use requirements. The use requirements and restrictions associated with these labels (FIFRA registrations) include a suite of mandatory control measures that address the potential for spray drift, volatile emissions, and runoff (e.g., see (US-EPA 2023b).

Another consideration is that absent prevention of further development of HR weeds—which stacked-trait HR crops can potentially facilitate—herbicide use could increase to control those HR weed populations that may emerge in the coming years. HR weeds have increased steadily in the United States since the mid-1980s, although the trend in increase has appeared to taper off since 2015 (Heap 2022). As of the end of 2020, there were 165 unique cases of HR weeds in the United States (weed species by herbicide MOA) (Heap 2022). As HR weed populations develop, and increase in prevalence and diversity, farmers must use additional herbicides with different MOAs for their control. As one farmer noted: "From a postemergence standpoint, we had to start managing Palmer amaranth with residual herbicides. Resistance increased our herbicide costs probably four-fold compared to when we were just spraying glyphosate. It's taking a lot out of the bottom line" (Robinson 2020). Hence, the potential benefits of a stacked-trait HR crop allying/preventing HR weed development can outweigh single HR trait or conventional crops. This, however, will be relative to the efficacy of IWM programs implemented using stacked-trait HR crop varieties relative to single HR trait and non-biotech conventional crops (e.g., rotation of herbicide MOAs and non-chemical strategies), discussed further below. Of note, single trait HR varieties comprise only around 10% of U.S. corn acres, and non-biotech conventional varieties only around 8% (USDA-ERS 2022).

Weed and HR Weed Management in U.S. Cropping Systems

Synthetic chemicals will remain a primary method for weed control for the foreseeable future, and the risk of weed populations developing resistance to the herbicidal activity of these chemicals will be ever present. Considering the adoption rate of HR crops over the last 20 years, and stacked-trait crops (USDA-ERS 2022), utilization of stacked-trait HR corn (as well as other stacked-trait HR crop varieties) is expected to be a preferred strategy for weed and HR management for many crop producers in the United States.

The need for the management of further development of HR weed populations, and current HR weeds, is well recognized, and tank mixing of differing herbicide MOAs considered an effective strategy in this respect. However, the efficacy provided by stacked-trait HR crops in the management of HR weed development is dependent on multiple factors (Gressel et al. 2017; Hicks et al. 2018; Comont et al. 2020). Varieties of corn comprised of multiple HR traits became available to commercial markets, globally, about 10 years ago (ISAAA 2022). While stacked-trait crop varieties that allow use of mixtures of herbicides with multiple MOAs (two-, three-MOAs) are emerging as a potentially beneficial strategy for weed and HR weed management, they must be utilized with other non-chemical methods in IWM programs; most weed scientists agree that it is unlikely HR crop varieties in and of themselves, absent the combination of judicial use of herbicides and non-chemical methods, will be sufficient to keep up with the capacity of weeds to evolve resistance to herbicides (Gressel et al. 2017; Green 2018; Heap and Duke 2018; Beckie et al. 2019). Owen (2016) and Gressel et al. (2017), for example, suggest that unless diverse chemical and non-chemical IWM approaches to HR weed management are widely adopted, it is inevitable that development of resistance to multiple herbicide MOAs in weeds will continue to increase. Where HR weed populations do develop, costs to crop producers can escalate in the management of HR weeds.

Studies have shown that use of mixtures of herbicide MOAs and, to a lesser extent the use of herbicide rotations, can effectively constrain selection for resistance (Beckie and Reboud 2009; Evans et al. 2016; Comont et al. 2020). However, these practices are still seen as limited when herbicides are the sole weed control tactic employed—used in the absence of non-chemical strategies (Evans et al. 2016; Gage et al. 2019). A recent report by Comont et al. (2020) evaluating the weed blackgrass (*Alopecurus myosuroides*), suggests that, while the use of mixtures has been found to be effective in preventing evolution of target site resistance (TSR), it may impose a greater selective pressure for development of non-target site resistance (NTSR). These studies found that use of herbicide rotations and herbicide mixtures were significant positive predictors of the level of NTSR development within populations, indicating that both practices preferentially selected for a generalist NTSR mechanism. In contrast, a significant negative effect of herbicide mixing on the frequency of TSR was observed (Comont et al. 2020). Thus, using mixtures to combat the evolution of "specialist" TSR resistance may promote the evolution of a "generalist" NTSR resistance mechanism. Comont et al. (2020) concluded that effective resistance management is contingent on understanding the evolutionary potential for specialist TSR versus generalist NTSR resistance, as these differing mechanisms of resistance may significantly alter the response of weeds to IWM practices. In this respect, the future control of weeds will become increasingly reliant on rapid and accurate resistance diagnostics in weeds in order to select the best combinations of chemical and non-chemical strategies to mitigate the evolution of resistance (Hicks et al. 2018; Comont et al. 2020).

Fundamentally, current weed management strategies are founded on the theoretical prediction that increasing the diversity of herbicide MOAs used can reduce the rate of evolution of herbicide resistance in weeds (Hicks et al. 2018). However, it is not inevitable that using a combination of MOAs will reduce the rate of evolution of resistance. The concept of combination treatment is based on the assumption that resistance to each MOA is driven by mutations at specific loci, TSR (Powles and Yu 2010; Hicks et al. 2018). However, much of the evolved resistance is driven by more general, nonspecific NTSR mechanisms. Examples include increased herbicide active ingredient (a.i) sequestration, or increased herbicide a.i. metabolism, the latter referred to as metabolic resistance (MBR) (Hicks et al. 2018; Comont et al. 2020). Metabolic resistance occurs when a plant increases the rate of metabolism, inactivating an herbicide a.i., which renders the plant resistant. This differs from a highly specific gene mutation associated with an herbicide's targeted site of action in the plant. NTSR type mechanisms can confer resistance to multiple herbicide MOAs within a given weed species; cross-resistance to different herbicide MOAs.

In general, weed scientists suggest managing the evolution of weed resistance with temporal herbicide cycling/rotation, and use of a combination of differing herbicide MOAs ((Menalled et al. 2016; Owen 2016; Beckie et al. 2019; Gage et al. 2019; WSSA 2020b), and others), in addition to non-chemical practices, in an IWM program—the use of multiple strategies, including cultural, mechanical, chemical, and biological methods to manage weed populations. In theory, and it has been demonstrated to some extent, the rate of evolution for herbicide resistance should be slowed more effectively by combinations—simultaneous use of differing MOAs—than by alternation/rotation of MOAs (e.g., (Diggle et al. 2003; Beckie and Reboud 2009; Lagator et al. 2013)); however, this has yet to be tested at large scales and under the scenarios where weed resistance has already evolved to some herbicide MOAs (Hicks et al. 2018).

Notably, there has been widespread occurrence of resistance to multiple herbicide MOAs developing over the last two decades (Heap 2022). As of 2020, there were 60 species (within the same population) resistant to 2 MOAs, 21 species resistant to 3 MOAs, 13 species resistant to 4 MOAs, 8 species resistant to 5 MOAs, and 1 species resistant to 7 MOAs (Heap 2022). While both TSR and NTSR contribute to the evolution of multiple resistance, the number of reported occurrences of multiple resistance, globally, suggests a potentially significant role for multiple herbicide resistance to be driven by NTSR mechanisms (Hicks et al. 2018; Comont et al. 2020; Shyam et al. 2021). In an aggregate sense, looking at the total number of reported cases of multiple resistance in weed species, globally (not necessarily within the same population), 106 species have been reported to develop resistance to 2 different herbicide MOAs, 55 species to 3 different MOAs, 15 species with development of resistance to 5 MOAs, 6 species with developed resistance to 8 MOAs, and 1 species developed resistance to 11 different MOAs (Table 4-18).

Table 4-18. Increase in Number of Weeds with Multiple Herbicide Resistance, 2000–2020

	Reported Resistance to MOAs Within the Same Plant Population: Number of Species		Total No. of Reported Cases of MOA Resistance for a Given Species (not within the same plant population)	
MOAs	**2000**	**2020**	**2000**	**2020**
2	26	60	53	106
3	5	21	28	55
4	3	13	10	31

5		8	6	15
6			3	12
7	1	1	2	9
8				6
9			1	4
10				1
11			1	1

Source: (Heap 2022)

Data is given for (1) occurrence of multiple resistance within the same population, and (2) cumulative resistance—total number of reported cases—MOA resistance for a given species, globally. Resistance to different MOA's may be found in separate plant populations, even in separate countries, thus cumulative number of MOA's recorded globally for a given species.

Weed Resistance to Dicamba, 2,4-D, and Glufosinate

Weed resistance to post-emergence herbicides such as dicamba, 2,4-D, and glufosinate was observed to be on the rise during 2021 (Unglesbee 2021a). In some surveyed fields, Palmer amaranth populations were requiring 8 times the labeled rate of dicamba to die, with some populations requiring 4 times the rate of 2,4-D for control (Unglesbee 2021a). University of Tennessee weed scientist Larry Steckel noted "They're slipping even more than they did last year," referring to 2,4-D, dicamba, and glufosinate based herbicides; Roundup Ready 2 Xtend® (dicamba), XtendFlex® (dicamba and glufosinate), and Enlist E3™ (2,4-D and glufosinate) (Unglesbee 2021a).

With increased application of these herbicides, there is the possibility for increased selection pressure for development of dicamba, 2,4-D, and glufosinate resistant weeds, which would have adverse impacts on growers of conventional and non-HR crops who are currently depending on these herbicides for weed control.

Cross-resistance of weeds to both dicamba and 2,4-D can also be a concern (both synthetic auxins; 2,4-D is a phenoxy herbicide, dicamba a benzoic acid). LeClere et al. (2018) identified a dicamba-resistant *Kochia scoparia* L. Schrad (kochia) biotype in western Nebraska and found that it is additionally cross-resistant to other auxin herbicides, including 2,4-D and fluroxypyr. The researchers identified a 2-nt base change in this biotype (TSR), which results in a glycine to asparagine amino acid change within a highly conserved region of an AUX/indole-3-acetic acid (IAA) protein, KsIAA16. They found that the single dominant KsIAA16R resistance allele is the causal basis for dicamba resistance in this population. Resistance to both tribenuron-methyl and 2,4-D, and cross resistance to dicamba, has also been confirmed in poppy (Rey-Caballero et al. 2016). Similarly, cross-resistance between 2,4-D and dicamba was found in an F-box receptor mutant of *Arabidopsis thaliana* (Gleason et al. 2011). Kansas State University weed scientists confirmed a Palmer amaranth (*Amaranthus palmeri*) population that resists both dicamba and 2,4-D (KSU 2019). This was the first confirmed case of resistance to dicamba and 2,4-D in Palmer amaranth, a problematic weed with a variety of herbicide resistant biotypes identified in U.S. cropping systems (Heap 2022).

Iowa State University extension suggests that biotypes that have been selected by one of the herbicides,2,4-D or dicamba, had cross-resistance to the other about 50% of the time. When cross-resistance was present, in most biotypes the level of resistance was lower to the herbicide not responsible for selection than for the herbicide that selected the resistance (i.e., a population selected by repeated 2,4-D use had a lower level of resistance to dicamba) (ISU-Ext 2021). While cross-resistance between 2,4-D and dicamba is not a given, it occurs frequently enough to reinforce the need for IWM practices to sustain the value of these herbicides.

A primary issue for current and future crop protection and production is identifying effective herbicide MOA mixes and rotations to control weed populations that have not developed resistance, as well as those weed populations that have developed resistance. This applies to both conventionally bred non-HR crops as well as stacked-trait HR crops (Evans et al. 2016; Hicks et al. 2018). The widespread and continued emergence of HR weed populations, and the diversity of herbicide MOAs to which weeds are evolving resistance, has become a concern in terms of sustaining the efficiency of herbicides in crop production, and ensuring food security (Godfray et al. 2010; MacLaren et al. 2020). Herbicide resistant weeds are now one of the principal challenges to achieving maximal crop yields. As previously mentioned; yield loss from weed interference, in the absence of weed-control measures, can range from 15% to 57% (Bridges 1992; Soltani et al. 2017; WSSA 2020a). On an annual basis, potential loss in value for corn from weed interference is $27 billion, and for soybean is $16 billion, based on data from 2007 to 2013. Overall, average percent yield loss with no weed control is around 52%, and can be as high 15% with weed control (Bridges 1992; WSSA 2020a). In general, weeds cause average yield losses of around 35%, worldwide (Oerke 2006); this figure could be much higher without effective herbicide use.

The efficacy of MON 87429 corn stacked-trait hybrids in the management of weeds and HR weed development will depend on the extent to which such stacked-trait varieties are utilized as part of diversified IWM programs. It is possible that stacked-trait HR varieties, as part of IWM programs, may prove effective in preventing/allaying the further development of resistant weed populations, and controlling current HR weed populations. However, the rapid increase of HR weeds over the last several decades demonstrates that HR crop technologies are sustainable only as a component of broader integrated weed management systems (Duke 2015; Owen 2016; Gould et al. 2018; Beckie et al. 2019; Gage et al. 2019). Where stacked-trait varieties are not integrated into weed management programs employing diverse non-chemical strategies—such as cover crops, crop rotation, and harvest weed seed control (Owen 2016; Gressel et al. 2017; Creech 2018; ISU-Ext 2018; Gage et al. 2019), they could potentially exacerbate issues with the development and management of HR weed populations.

While stacked-trait HR crops are expected to add a new tool to the weed management toolbox for control of weeds and development of weed resistance, indiscriminate use or overreliance on this technology alone may result in more complex weed issues—namely in the emergence of weed populations resistant to multiple herbicide MOAs, via TSR, NTSR (e.g., metabolic resistance), or both. Land managers, to include agricultural and non-agricultural sites, must implement various nonchemical control strategies (e.g., cultural, biological, and mechanical means) to the fullest extent possible to sustain the diminishing efficacy of the existing herbicide MOA portfolio, and effectively manage resistance evolution in weeds (Owen 2016; Gage et al. 2019; Nandula 2019). Successful management of development of HR weeds in stacked-trait MON 87429 corn cropping systems would depend on the extent and efficacy of implementation of EPA guidance (US-EPA 2017a), and IWM strategies recommended by weed scientists (e.g., (Gressel et al. 2017; Heap and Duke 2018; Beckie et al. 2019; Gage et al. 2019)) and the Weed Science Society of America (WSSA 2020b). In 2017 the EPA issued PR Notice 2017-2, *Guidance for Herbicide-Resistance Management, Labeling, Education, Training and Stewardship* (US-EPA 2017a), which provides registrants and growers information on slowing the development and spread of HR weeds with the use of registered herbicides. In addition, the EPA has issued specific requirements for glufosinate resistance management (US-EPA 2016b).

Bayer implements a product stewardship program to ensure that products, services, and technologies are safe and sustainable, that their use is environmentally responsible (Bayer 2022b). Bayer endorses the FAO Code of Conduct on Pesticide Management (FAO 2022), CropLife International Plant Biotechnology Code of Conduct (CropLife 2022), Excellence Through Stewardship (ETS) and Responsible Care programs (ETS 2022), and provides guidance to reduce the development of HR weed populations (Bayer 2022a). This includes training as mandated by the EPA as a condition of registration for products containing the herbicide dicamba for use in dicamba-resistant soybean and cotton crops (Bayer 2022b).

It is expected that the referenced EPA herbicide use labels and reporting requirements, EPA guidance, and recommended IWM strategies, which address management of development of HR weed populations, would be implemented in production of MON 87429 corn hybrid crops. FIFRA makes it unlawful to use any registered pesticide in a manner inconsistent with its labeling, established by the EPA. The proper implementation of these legal requirements is supported by applicator education and training requirements such as those offered by land-grant colleges and universities, and local offices of the Cooperative Extension System. Licensing is required for commercial applicators applying any type of pesticide product.[30]

As discussed, use of dicamba has also been increasingly restricted by states (e.g., use cut-off dates), and state restrictions are expected to continue, as needed. FIFRA Section 24(a) establishes that states have the right to regulate federal pesticides through state legislatures or rulemaking procedures (Unglesbee 2020c). Even though a federal registration may have been obtained for a given pesticide product allowing the distribution and sale of the product within the United States, a state may have additional requirements that must be met before the pesticide product can be distributed or sold within that state.[31]

There may also be economic and liability risks farmers would seek to avoid that would lead them to elect to not apply herbicides that may have drift or volatilization impacts on other crops, or non-crop plants, or apply the herbicide judiciously only under optimal conditions. For example, there have been state imposed fines for crop damage resulting from herbicide spray or volatilization drift that can range from thousands to tens of thousands of dollars (e.g., (Steed 2020, 2021)).

Of note, while the EPA issued labels, and has modified label requirements for OTT use of dicamba on dicamba resistant crops, and certain states imposed additional restrictions on use, some farmers have simply not abided by EPA or state requirements for use of dicamba. For example, in Arkansas, settlement offers on fines for farmers believed by the Plant Board to have violated the state's ban on spraying dicamba in 2018 and 2019 amounted to more than $1.1 million. The Arkansas Plant Board sent out

[30] For an example see North Carolina Department of Agriculture and Consumer Service's website at http://www.ncagr.gov/SPCAP/pesticides/license.htm#COMMERCIAL%20AND%20PRIVATE%20CERTIFICATION%20&%20LICENSING
[31] U.S. EPA: https://www.epa.gov/pesticide-registration/pesticide-registration-manual-chapter-18-other-federal-or-state-agency

$592,000 in settlement offers (fines) to 18 farmers between April 17 and May 15, 2020 for dicamba use violations (Steed 2020). One farmer in Arkansas reached a fines settlement with the state ($476,900) for 14 cases of violations involving dicamba drift, one count for spraying dicamba on days banned by the state, and 84 instances of dicamba use at higher volumes than allowed under state and federal regulations, among other violations (Steed 2021). Six other farmers also reached fine settlements with the state for illegal uses of dicamba. The egregious violation most often cited in settlement offers has been for spraying dicamba after the state's cutoff dates, in 2018 and 2019. Arkansas regulators received more than 1,500 complaints of dicamba damage since 2016 (Steed 2021). This is an example of one state alone. More recently, in 2023, Bayer initiated a lawsuit suing four farmers in Missouri for illegally spraying older versions of dicamba on its dicamba resistant soybean, as well as doing so after the state's cutoff date for spraying the herbicide.[32]

4.3.2 Physical Environment

4.3.2.1 Soil Quality

Overview

Relative to crop production, concerns regarding soils are the potential for agronomic practices and inputs to affect soil fertility; erosional capacity; off-site transport of topsoil (sediments), pesticides, and fertilizers; and disturbance of soil biodiversity. While soil erosion occurs through natural processes, tillage, cover crops, crop rotation, and pesticide and fertilizer inputs can influence the biological, physical, and chemical properties of soil, and have a substantial impact on soil fertility and erosional capacity. Loss of soil quality occurs through declines in soil organic matter (SOM), minerals (e.g., magnesium, calcium), essential nutrients (e.g., nitrogen, phosphorus, potassium), soil biota, and physical alteration of soil structure (e.g., compaction).

Soil Erosion on U.S. Croplands

Due to the rate of soil formation—on the order of millimeters per year—soil is considered a nonrenewable resource that requires conservation for sustainable crop production. Soil erosion not only increases fertilizer requirements and production costs, it leads to impaired air and water quality (Magleby et al. 1995; Baumhardt et al. 2015; USDA-NRCS 2018b). Excessively eroding cropland soils are concentrated in the Midwest, Southern High Plains of Texas, and Northern Plain States, to include the Corn Belt (Figure 4-19).

[32] Bayer sues four Missouri farmers for illegally spraying dicamba, saving and replanting seeds from the company's genetically-engineered crops: https://investigatemidwest.org/2023/03/29/bayer-sues-four-missouri-farmers-for-illegally-spraying-dicamba-saving-and-replanting-seeds-from-the-companys-genetically-engineered-crops/

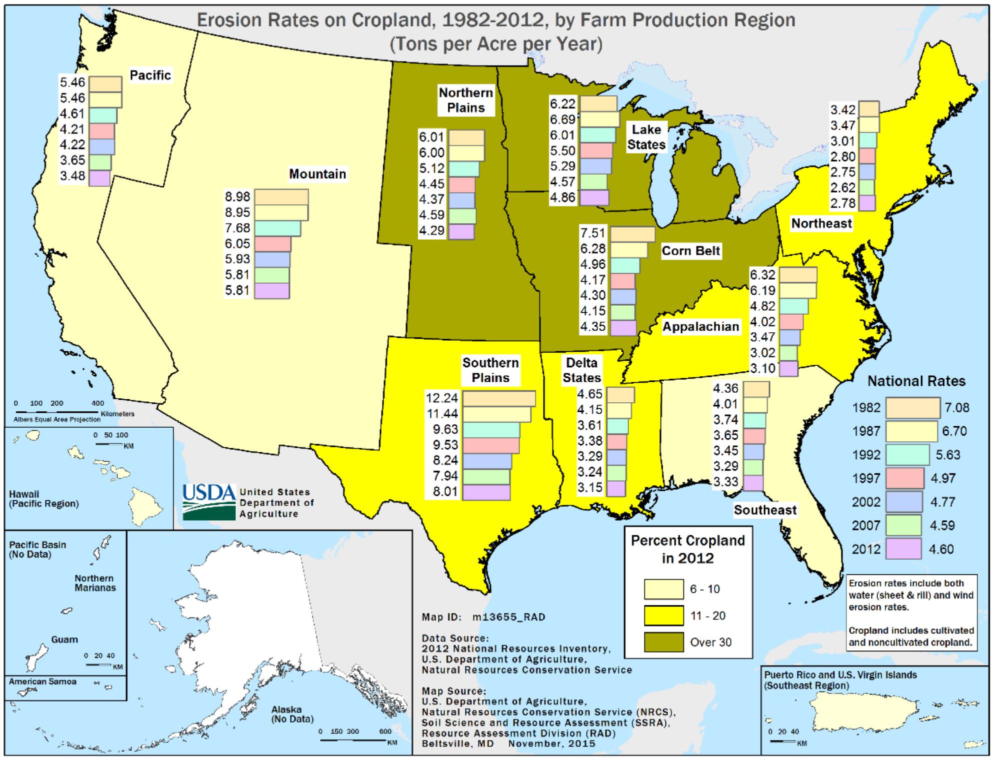

Figure 4-19. Locations and Status of U.S. Croplands Subject to Water and Wind Erosion

*Cropland in this figure includes both cultivated and uncultivated cropland.
Source: (USDA-NRCS 2018a)

Since 1985, conservation programs have specifically targeted highly erodible lands in the United States; as conservation tillage and cover cropping practices increased, soil erosion has declined (USDA-NRCS 2010, 2018b). Soil erosion rates on U.S. cropland decreased 34% between 1982 and 2015 (USDA-NRCS 2018b). In 1982, total annual water erosion (sheet and rill) on cultivated cropland was 4.18 tons per acre per year, versus 3.03 in 2015, a 27% reduction. For wind erosion, erosion rates on cultivated cropland reduced from 3.53 to 2.15 tons per acre over the same time period, a 39% reduction (USDA-NRCS 2018b). Any decrease in erosion of cropland soils carries with it a corresponding decrease in run-off and introduction of non-point source pollution (NPS) pollutants such as sediments, fertilizer, and pesticides into surface waters.

The share of acreage for major crops—wheat, corn, soybeans, and cotton—using conservation tillage has increased over the past two decades in the United States. Conservation tillage, which includes no-till and mulch till, reduces soil disturbance and preserves more crop residue relative to conventional tillage, in which a plow or other implement turns over most of the soil before planting. Conservation tillage promotes soil health and reduces soil erosion and nutrient runoff (USDA-ERS 2021).

In USDA surveys, during the years 2017–2021, farmers reported employing conservation tillage on the majority of acres of wheat (68%), corn (76%), and soybeans (74%). Conservation tillage is less common on cotton fields (43% of acres) (USDA-ERS 2021). No-till production, a type of conservation tillage in which farmers plant directly into remaining crop residue without tilling, has increased for wheat, corn, soybean, and cotton over the past two decades (Figure 4-20). For corn acres, specifically, no-till increased from 16% in 2001 to 36% in 2021. Mulch till, which aims to reduce soil disturbance through fewer and less intensive tillage operations than conventional production, accounted for about half of conservation tillage acres on corn (USDA-ERS 2021).

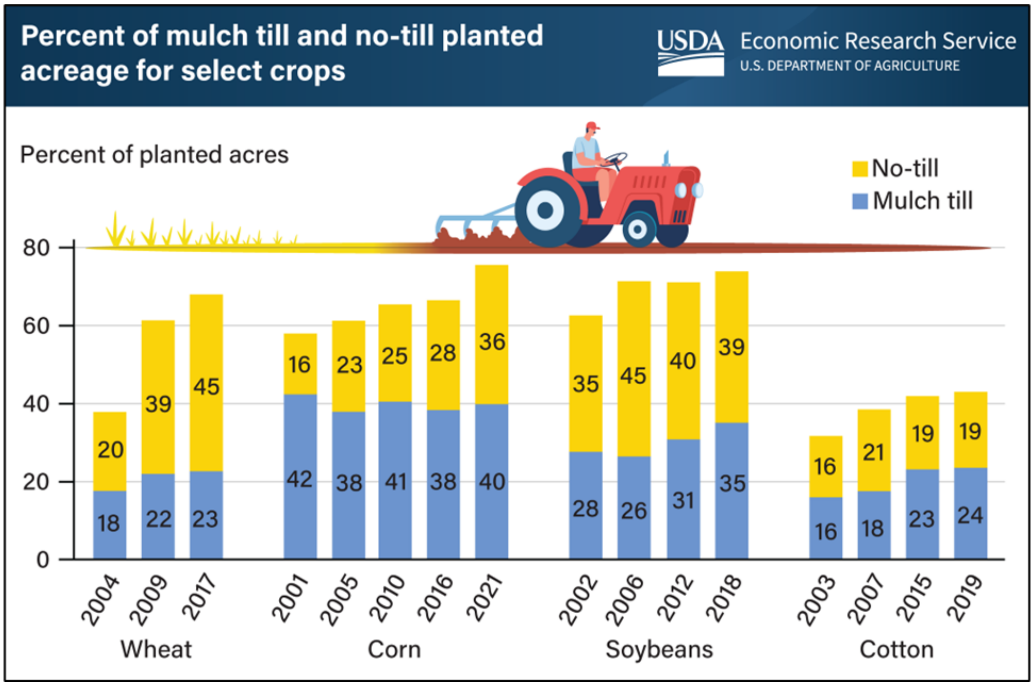

Figure 4-20. Conservation Tillage Practices, 2001–2021

Source: (USDA-ERS 2021)

4.3.2.1.1 Potential Effects on Soils

Land management practices used for cultivation of corn and other crops can affect soil quality and erosion relative to the tillage, pesticide application, crop rotation, soil amendment, and cover cropping practices.

In general, HR crops are correlated with use of conservation tillage practices, which help sustain soil health and water retention, and reduce runoff (Fernandez-Cornejo et al. 2014b; Claassen et al. 2018); there are no adverse effects on soil quality unique to HR crops that have been identified over the last 20 years. The agronomic practices and inputs used for MON 87429 corn production that can impact soil quality (e.g., tillage, pesticide use, irrigation, cover cropping) would be no different from those currently used in corn production. Any potential impacts on soils resulting from MON 87429 corn/progeny cultivation would be the same or similar as for other corn varieties. It is unlikely that the HR trait genes/gene products, which were derived from naturally occurring soil bacteria (e.g., *Sphingobium, Streptomyces, Stenotrophomonas, Agrobacterium*), would have adverse effects on soil quality/fertility (discussed further in Section 4.3.3.1). The protein products are expressed at relatively low levels in plant tissues (e.g., DMO ~35 µg/g dw, PAT 6 µg/g dw, EPSPS 54 µg/g dw, FT_T 440 µg/g dw), and would have a transient presence in soil, being degraded by soil proteases on the order of days, to a few weeks at most (Geisseler and Horwath 2008; Vranova et al. 2013).

4.3.2.2 Water Resources

Agronomic inputs such as pesticides and fertilizers, and in many areas practices such as tillage and irrigation, are necessary for efficient corn production. These inputs and practices can, however, lead to the impairment of surface waters through runoff of pesticides, fertilizers (nutrients), and topsoil (Bricker et al. 2008; CENR 2010). Groundwater can also be impacted by agronomic inputs via leaching, as well as through irrigation withdraw. In many areas of the Midwest corn yields can either be increased by irrigation, or irrigation is necessary for production. As of 2017, around 12 million of corn was irrigated, approximately 14% of total annual corn production in the United States (USDA-NASS 2019b).

While water pollutants derive from various sources, the EPA National Water Quality Assessment finds that agricultural non-point source (NPS) pollution is a leading cause of impairment of surveyed rivers and streams, the third largest source for lakes/ponds, the second largest source of impairments to wetlands, and a major contributor to contamination of surveyed estuaries, coastal areas (US-EPA 2019i). The most common NPS contaminants in agricultural runoff are sediment, nutrients such as nitrogen and phosphorus, and pesticides (Table 4-19), all of which can adversely affect aquatic ecosystems. None of the herbicides used with MON 87429 corn, or any other HR crop currently produced, are listed as sources of impairment of surface waters by EPA (US-EPA 2019i).

Table 4-19. Causes of Impairment in Assessed Waters, 2020

	Rivers, Streams		Lakes, Reservoirs, Ponds		Bays, Estuaries		Wetlands	
	Miles	*Rank*	*Acres*	*Rank*	*Miles*	*Rank*	*Acres*	*Rank*
Nutrients	118,831	3rd	3,943,395	2nd	18,279	2nd	67,849	6th
Sediment	138,874	2nd	502,200	12th	400	18th	1,237	15th
Pesticides	18,069	16th	412,672	13th	7,543	8th	202	21st

Source: (US-EPA 2019i)

Shown are national water quality data reported by the States to EPA under Section 305(b) and 303(d) of the Clean Water Act. The data shown is the most current available, which varies widely among states, spanning the years from 2004 to 2016. The EPA lists around 34 different factors that are the cause impairment of U.S. waters. For rivers and streams, the EPA lists sediments as the second most frequent cause of impairment, nutrients third, and pesticides sixteenth. For lakes, reservoirs, and ponds, nutrients are second, sediments twelfth, and pesticides thirteenth. For bays and estuaries, nutrients are second, sediments eighteenth, and pesticides 8th. For wetlands, nutrients are sixth, sediments fifteenth, and pesticides twenty-first.

Sediment in agricultural runoff can adversely affect aquatic ecosystems by covering fish breeding substrates, increased turbidity, and impairing growth of aquatic plants. Nutrient runoff (e.g., nitrogen and phosphorus) from agricultural fields can contribute to eutrophication of surface waters, to include estuaries. Eutrophic conditions in surface waters cause impairments to human uses and living resources as a result of harmful algal blooms and hypoxic/anoxic conditions,[33] which lead to algal and invertebrate imbalances, fish kills, fish consumption warnings, declines in tourism, and impacts on fisheries (Bricker et al. 2008; CENR 2010). U.S. Geological Survey (USGS) studies have found that some the most

[33] Hypoxia means low dissolved oxygen concentrations. Anoxia means a total depletion of dissolved oxygen. Both conditions are harmful to aquatic biota.

impaired streams are in those areas with the greatest agricultural land use—primarily in the central United States, to include the Corn Belt (Munn et al. 2018) (Figure 4-21). Watersheds with a high potential to discharge nitrogen and phosphorus from agriculture sites to estuaries are located primarily in the midwestern Unites States, the Mississippi River basin, and Southern Seaboard regions (Wiebe and Gollehon 2006; CENR 2010; US-EPA 2020ac).

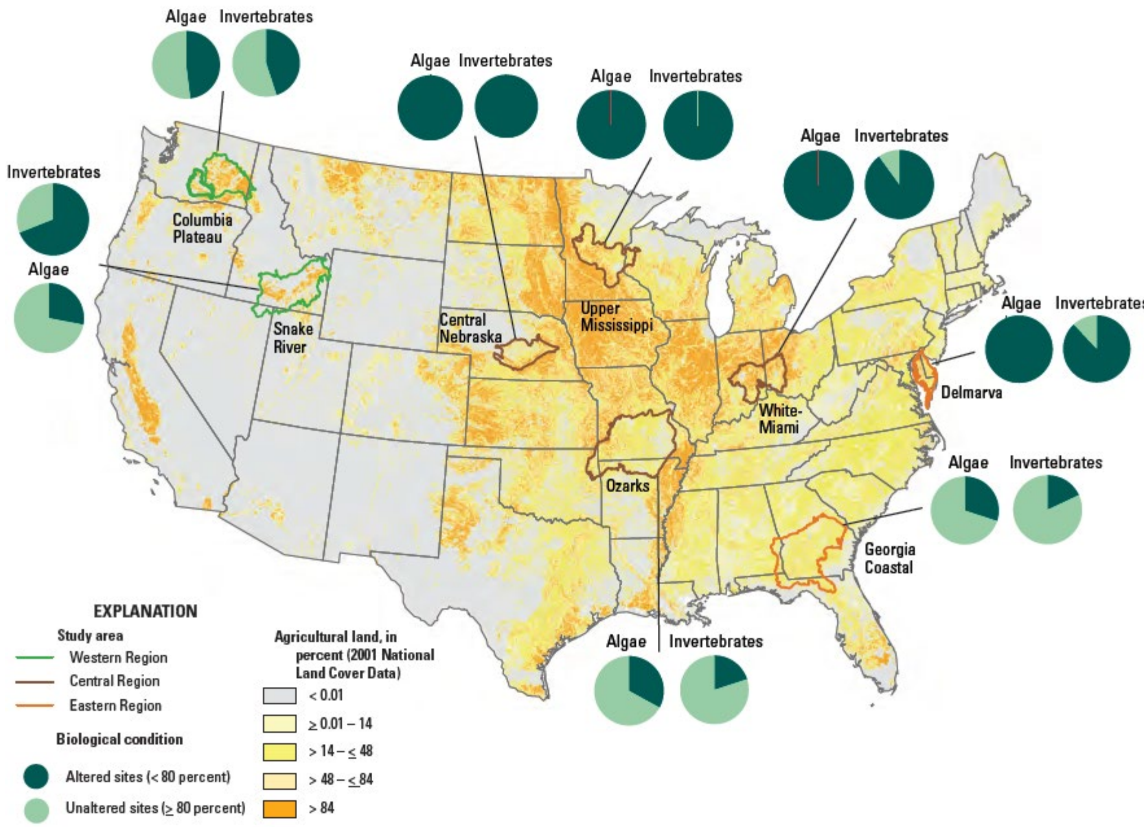

Figure 4-21. Areas of Impaired Rivers and Streams in the United States

Based on USGS surveys conducted from 2003 to 2011. Biological conditions in streams decreases as agricultural intensity increases in a watershed. Generally, biological condition was highest in the Western Region where the agricultural intensity is the lowest; conversely, biological conditions were lowest in the Central Region where agricultural intensity is highest. Assessing biological condition involves comparing the observed number of taxa at a site to the number of taxa expected based on a set of regional reference sites. A stream with a score greater than 80% implies an unaltered stream, whereas a stream with a score less than 80% implies an altered biological condition. Source: (Munn et al. 2018)

Human uses impacted by impairment of surface waters include commercial and recreational fishing, shellfish harvesting, fish consumption, swimming, aesthetics, and tourism (CENR 2010). The top four causes of these types of use impairments were listed as agriculture (crops and animal operations), wastewater treatment plants, urban runoff, and atmospheric deposition (Bricker et al. 2008; Boesch 2019). Excess nutrients in surface waters can have major economic impacts, in the range of $2 billion per year in damages related to impacts on recreational water usage, waterfront real estate, and drinking water treatment (Dodds et al. 2009). In all regions where crops are produced controlling non-point sources of water pollutants remains a primary focus (US-EPA 2020v, u).

The U.S. corn belt lies within the Mississippi River basin, which spans 1,245 million square miles across 31 states. Nitrogen and phosphorus run-off in the Mississippi River basin is particularly problematic for Gulf of Mexico ecosystems and fisheries (Wiebe and Gollehon 2006; US-EPA 2019a, i). Agricultural sources contribute around 70% of the nitrogen and phosphorus delivered to the Gulf of Mexico, versus 9% to 12% contribution from urban sources (Alexander et al. 2008). Corn, specifically, can account for around 45% of U.S. crop acreage receiving manure, and 65% of the nitrogen fertilizer applied by farmers each year (Ribaudo et al. 2011). Nitrogen run-off from crops in the Mississippi River basin is the single largest source of nutrient pollution contributing to the Gulf of Mexico's "dead zone" (Figure 4-22).

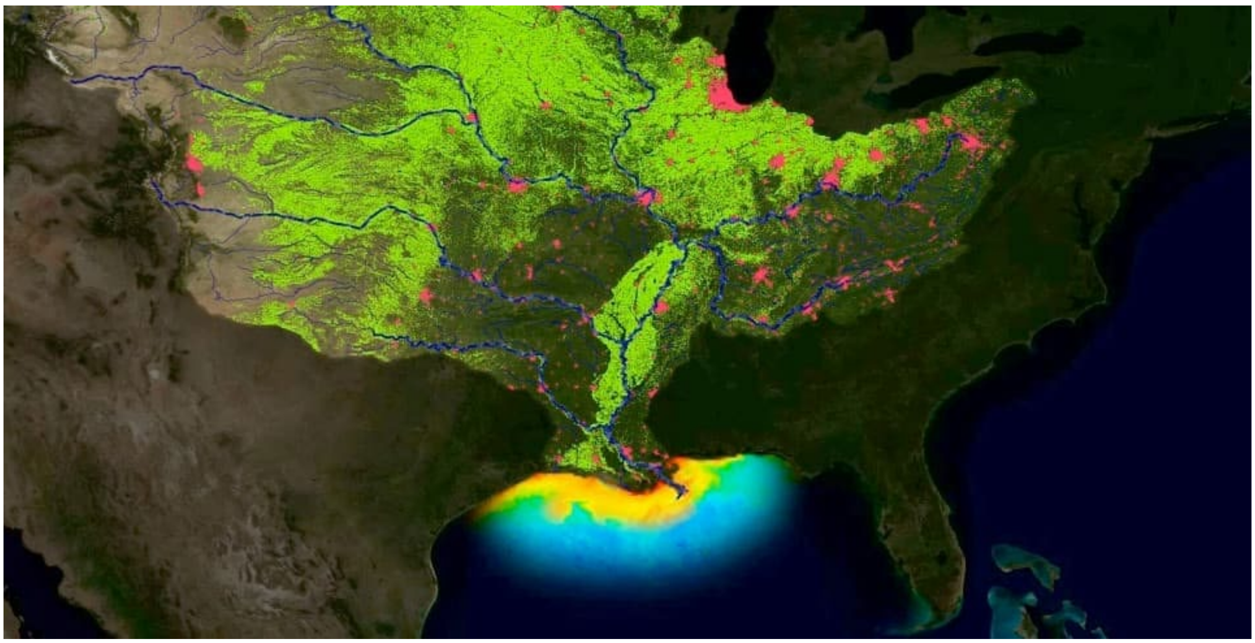

Figure 4-22. Agricultural Run-Off: Mississippi River Watershed

This image from a NOAA Environmental Visualization Lab animation illustrates how run-off from farms (green areas) and cities (red areas) drains into the Gulf of Mexico. This run-off contains nutrients from fertilizers, wastewater treatment plants, and other sources, which leads to hypoxic "dead zones" on an annual basis; areas in the GOM where the oxygen concentration is so low that aquatic biota can suffocate and die. The largest hypoxic zone in the United States, and the second largest hypoxic zone worldwide, forms in the northern Gulf of Mexico near New Orleans.
Source: (NOAA 2019)

Surface Waters and Sources of Pesticide Inputs

Pesticides are widely used outside the agricultural sector (Nowell et al. 2021). Common outdoor nonagricultural (urban) applications include use on lawns and gardens; ornamental plants; commercial landscaping and turf; building facades; golf courses; and roadways, railways, and fence lines (Shamim et al. 2014). In 2012, 42 million kg of conventional pesticides were used in nonagricultural applications in the United States, consisting of 25, 12, and 5 million kg of herbicides, insecticides, and fungicides, respectively; this constitutes about 11% of total conventional pesticide use in the United States, with the remainder used in agriculture (Atwood and Paisley-Jones 2017).

Pesticides can be delivered to surface waters by runoff, spray drift, atmospheric deposition, and direct application to aquatic environments. In urban areas, impervious surfaces contribute to pesticide loss rates to streams that exceed those in agricultural areas (Wittmer et al. 2011), and delivery of runoff to urban streams is exacerbated by stormwater drainage systems (Walsh et al. 2005).

Among pesticides, herbicides are used in large quantities, and most are water soluble so are prone to runoff from terrestrial environments (Fairchild 2011). Consequently, they are frequently detected in surface waters (Stehle et al. 2019; USGS 2021). For herbicides, the most susceptible non-target taxa are vascular and nonvascular aquatic plants. Direct effects may be structural (e.g., biomass reduction, species composition) or functional (e.g., photosynthesis rates) (Nowell et al. 2021). Herbicides can temporarily inhibit the growth of non-target algae and macrophytes, although populations typically recover once exposure is reduced (Fairchild 2011). However, effects on community structure and function may occur if high herbicide concentrations are sustained (Farruggia et al. 2016).

A U.S. Geological Survey (USGS) 2013 Regional Stream Quality Assessment (RSQA), part of the National Water-Quality Assessment (NAWQA), indicate that herbicides are commonly detected in Midwest surface waters. 2,4-D has been detected up to 14.4 µg/L, although most detections were significantly less (USGS 2021). Dicamba was detected at a maximum concentration of 1.1 µg/L, and glyphosate in the range of 4.78 and 6.78 µg/L. Glufosinate was not detected in these studies, < 0.02 µg /L (below the limit of detection). Quizalofop-p-ethyl or quizalofop-ethyl was not evaluated in these studies.

Recent studies by Nowell et al. (2021) evaluated the potential toxicity of pesticides in U.S. urban streams to investigate whether there is a common "urban pesticide signature." Water samples were collected weekly from 271 streams across five major U.S. regions over a 6–12 week period and measured concentrations of 108 pesticide active ingredients (a.i.) and 117 pesticide degradates. Samples for pesticide analysis were collected as part of the USGS, RSQA,[34] which targeted streams in five U.S. regions: the Midwest (MW) in 2013, Southeast Piedmont (SEP) in 2014, Pacific Northwest (PNW) in 2015, Northeast (NE) in 2016, and the California Central Coast (CACC) in 2017. Land use in the 271 drainage basins ranged from undeveloped to highly urbanized.

In this particular study, the only herbicides used with MON 87429 corn evaluated were 2,4-D and dicamba. 2,4-D was detected in approximately 85% of "mixed sites", 12.5% of "undeveloped sites", 60% of "agricultural sites", and 90% of "medium-high urban sites", albeit at low concentrations; the highest reporting level being 42 µg/L (Northeast U.S.), with the highest reported levels of 6.4 or less in all other U.S. urban centers evaluated µg/L. 2,4-D was detected in 41% of samples from the Northeast, 50% of samples from the Southeast, 90% of samples from the Midwest, 21% of samples from the Pacific Northwest, and 12% of samples from California.

Dicamba was detected in 3.6% of "mixed sites" surface waters; the highest reporting level being 1.5 µg/L (Nowell et al. 2021). Detection frequencies were in 0.4% of samples from the Northeast, and 1.3% of

[34] See the Regional Stream Quality Assessment (RSQA) website for further data: https://webapps.usgs.gov/rsqa/#!/

samples from the Southeast. Dicamba was not detected in samples from the Midwest, Pacific Northwest, and California.

An urban pesticide signature emerged from the five RSQA studies, comprised of 16 pesticides. Only 2,4-D was among the 16 pesticides identified as meeting the criteria for consistent detection in urban streams. The presence of a common urban pesticide signature in U.S. urban streams likely reflects the relatively homogeneous nature of urban pesticide applications, which are dominated by turf and ornamentals, landscape maintenance, structural pest control, and rights-of-way. The consistency among urban signature pesticides demonstrates that there is a large degree of commonality in urban pesticide contamination across time and space in small urban U.S. streams. This consistency is all the more notable given that the five RSQA studies were relatively short-term, collected weekly discrete samples, and were done in different years and in areas of the U.S. with contrasting climates and demographics (Nowell et al. 2021).

4.3.2.2.1 Water Quality Regulation

Point and Non-Point Source Discharges

Pollutant sources are classified by the EPA and state agencies as NPS and point source. NPS pollution is the most significant source of pollution, overall (US-EPA 2020a). NPS contaminants in runoff originate from sources such as construction sites (e.g., residential and commercial development, construction of roads/highways), impervious surfaces (parking lots, roads/highways, rooftops), and crop fields and livestock rearing facilities. NPS pollutants include fertilizers and pesticides applied to residential, commercial, and agricultural sites, and sediments from the built environment, croplands, as well as unmanaged landscapes. The most common NPS contaminants in agricultural run-off are sediment, nutrients such as nitrogen and phosphorus, and pesticides.

Point source pollutants are discharged from any identifiable, singular source, such as a pipe, drain, or vessel. Factories and sewage treatment plants are examples of point sources. Factories, such as oil refineries, pulp/paper mills, and chemical manufacturers typically discharge one or more pollutants in EPA regulated effluents. Livestock rearing facilities (e.g., dairy and beef cows, pigs, chickens) are other sources of point source pollution. Waste from livestock operations has been a long-standing concern with respect to contamination of water resources, particularly in terms of nutrient pollution, microbial pathogens, and pharmaceuticals present in the waste (Burkholder et al. 2007).

The Clean Water Act (CWA) established the National Pollutant Discharge Elimination System (NPDES) for regulation of point sources (US-EPA 2019j). Under the NPDES program, factories, certain livestock rearing facilities (concentrated animal feeding operations (CAFOs)), sewage treatment plants, and other point sources must obtain a permit from the state and EPA before they can discharge their waste or effluents into any body of water. Prior to discharge, the point source must use the latest technologies available to treat its effluents and reduce the level of pollutants.

NPS pollution, which is the primary type of discharge from cropping systems, is not regulated under the CWA/NPDES permit program; rather, it is left largely to voluntary controls implemented by states and local authorities. Hence, most crop production activities do not require a Section 404 permit, even when they involve discharges of dredged or fill materials into waters of the United States. To be exempt, the farming activity must be part of an ongoing farming operation, cannot be associated with bringing a wetland into agricultural production, or converting an agricultural wetland to a non-wetland area. While the CWA does not provide for direct regulation of nonpoint sources, Section 319 of the CWA created a federal grant program that provides money to states, tribes, and territories for developing and implementing NPS management programs.

The EPA determines, for pesticides, use requirements that are intended to be protective of water quality, including drinking water and aquatic life (US-EPA 2019g, h). The EPA provides label use restrictions and guidance for product handling that is intended to prevent impacts to surface waters and groundwater. Water quality as related to drinking water is addressed in Section 4.3.4–Human Health and Worker Safety

4.3.2.2.2 Potential Effects on Water Resources

The potential impacts of crop production on water quality primarily derive from the collective/aggregate inputs from crop fields—e.g., millions of acres—into regional surface waters. Impacts on surface waters are generally temporal and minor as evaluated from an individual commercial corn cropping system. However, certain pesticides—depending on mobility and persistence characteristics—can leach into groundwater at sites where pesticides are mixed or applied. As previously reviewed, collectively, runoff of nutrients, pesticides, and topsoils from croplands can have adverse impacts on surface waters and nearshore coastal waters. Because the agronomic practices and inputs utilized for MON 87429 corn/hybrid production would not substantially differ from other corn varieties, the sources of potential impacts on water resources, namely NPS pollutants in agricultural run-off, would not substantially differ (e.g., sediments, fertilizers, insecticides, herbicides, fungicides).

Cultivation of MON 87429 corn hybrids, where adopted, would contribute to shifts in the types and patterns of herbicides used on corn (prior Table 4-4), facilitating the use of glyphosate, glufosinate, dicamba, 2,4-D, and quizalofop-p-ethyl in lieu of other herbicides. As discussed in Section 4.3.1.3.4, as use of stacked-trait HR varieties increases, how they may, or may not, contribute in a collective manner to increased annual herbicide use on U.S. corn acres is uncertain. Herbicide use would be influenced by the extent and type of weeds and HR weeds present on individual farms. Any increase in herbicide use with MON 87429 corn hybrid production could—in combination with current stacked-trait HR crops and those stacked-trait HR crops adopted in the future—potentially contribute to increased risks to surface water and groundwater quality in areas where stacked-trait HR crops are grown. Relative to run-off, there could also be risks to downstream estuaries and nearshore environments.

In general, herbicides may cause biological impairments of water bodies if they occur in water or sediment at sufficient concentrations. Most commonly, they enter surface water in runoff or groundwater in leachate, but, because they have relatively low toxicity to fish and invertebrates (US-EPA 2021a), acute toxicity is likely only when herbicides are deliberately or accidentally applied directly to water bodies (US-EPA 2021b). The only herbicides used with MON 87429 corn that present a potential risk of toxicity to fish and invertebrates are 2,4-D esters and quizalofop-p-ethyl, albeit at relatively high concentrations (US-EPA 2021a). All herbicide use would be subject to EPA and state use requirements/restrictions, which are intended to be protective of water quality and aquatic biota (US-EPA 2019h).

The development of HR weeds continues in many areas of the United States (Heap 2022). Where HR weeds are particularly problematic and other strategies are not effective, growers may forego conservation tillage and use more aggressive tillage practices to control HR weeds, which can increase soil erosional capacity, and, potentially, agricultural run-off. Where growers are concerned about weeds resistant to multiple herbicides, they are more likely to use tillage on a greater proportion of their fields, potentially as an emergency stop-gap measure (Dentzman and Burke 2021). Dentzman and Burke (2021) found in a survey of 787 farmers in the Pacific Northwest that concern about weeds resistant to multiple herbicides increased the likelihood of use of more tillage to manage weeds. In some areas of the South, cotton growers have returned to more aggressive conventional tillage to control glyphosate resistant Palmer amaranth populations (Morrison 2014; Sosnoskie and Culpepper 2014). Stacked-trait HR varieties, such as MON 87429 corn hybrids, could potentially help prevent, or curtail, the further development of HR weed populations, thereby limiting the need for tillage in control of resistant populations, as well as use of additional herbicides for control of HR weeds.

There is no association between MON 87429 corn and increased water demand, relative to its phenotype (Monsanto 2019). Thus, potential impacts on surface or groundwater use would be no different than that with most other dent corn varieties.

4.3.2.3 Air Quality

National Ambient Air Quality Standards

Air pollution, which can present risks to environmental and human health, is inherently a problem resulting from the collective emissions from myriad sources. The source categories that are the largest contributors to most air pollutants are: vehicle emissions; stationary power generation; industrial and agricultural emissions; residential heating and cooking; the manufacturing, distribution, and use of chemicals; and natural processes (Unger et al. 2010; IARC 2016). Environmental impacts include adverse effects on wildlife, water quality, and soils. Human health effects associated with exposure to atmospheric pollutants include asthma, bronchitis, lung cancer, cardiovascular disease, and skin diseases (e.g., dermatitis, eczema, psoriasis) (Araviiskaia et al. 2019).

To protect environmental and public health the EPA, pursuant to the Clean Air Act (CAA), establishes National Ambient Air Quality Standards (NAAQS) that aim to limit atmospheric emissions (US-EPA 2019e). NAAQS are established for six criteria pollutants: ozone (O_3), nitrogen dioxide (NO_2), carbon monoxide (CO), sulfur dioxide (SO_2), lead (Pb), and particulate matter (PM). In addition to criteria pollutants, the EPA regulates 187 hazardous air pollutants under the CAA, such as ammonia and hydrogen sulfide, as well as greenhouse gas emissions. To help regulate emissions the EPA has categorized primary emissions sources into: point, mobile, biogenic, and area. Point sources include major industrial facilities such as chemical plants, oil refineries, and power plants. Mobile sources include cars, trucks and buses and off-road equipment such as ships, airplanes, and agricultural and construction equipment. Area sources are defined as smaller operations such as dry cleaners and gas stations. Biogenic sources are comprised of vegetation, soils, and animals. All areas of the nation are classified based on their status with regard to attainment of NAAQS.

Crop production practices, on a regional scale, can generate air pollutants that can contribute to challenges in maintaining NAAQS. Agricultural emission sources from corn production include smoke from agricultural burning (PM); fossil fuel combustion associated with equipment used in tillage, pesticide application, and harvest (CO_2, NO_x, SO_x); soil particulates from tillage (PM); soil nitrous oxide (N_2O) and ammonia (NH_3) emissions from the use of fertilizers/manure; and atmospheric emissions through the volatilization of pesticides, and gases from manure (Aneja et al. 2009; Hill et al. 2019; US-EPA 2019c).

While the EPA establishes NAAQS, the standards do not set emission control requirements for any particular industry, including agriculture.[35] States enforce the NAAQS through creation of State Implementation Plans (SIPs), which are designed to achieve EPA-established NAAQS. The EPA designates a region as being in attainment for a criteria pollutant if atmospheric concentrations of that pollutant are below the NAAQS, or being in nonattainment if criteria pollutant concentrations violate the NAAQS.

Pesticides

Apart from NAAQS emissions, spray drift, and volatilization of pesticides from soil and plant surfaces, can result in the introduction of constituent chemicals into the air, which can present risks to human health (Section 4.3.4) and wildlife (Section 4.3.3), non-crop plants (Section 4.3.3.2), and nearby crops (Section 4.3.6).

Volatilization is dependent on pesticide chemistry, exposed soil structure and wetness, dew, and temperature (US-EPA 2020f). Drift is more likely to occur with fumigants (gasses), dusts, or when liquid pesticides are applied as a very fine mist (NPIC 2020a). Certain pesticide ingredients persist in the atmosphere for only a short period of time (e.g., photochemical degradation), while others can last longer (e.g., weeks). Some pesticides can give off volatile organic compounds (VOCs), which can react with nitrogen oxides (NOx) and carbon monoxide (CO) to produce a pollutant called tropospheric ozone. Pesticide use accounts for about 6% of total tropospheric ozone formation (UC-IPM 2006; Zeinali et al. 2011).

VOCs and semi-volatile compounds (SOCs) from pesticides can also reach high altitudes and move long distances attached to particulate matter (PM). Scientists from the National Park Service and other federal agencies found that SOCs released in the atmosphere as far away as Europe and Asia can reach the forests and national parks on the west coast of the United States in less than a week (Ackerman et al. 2008). Out of over 100 SOCs evaluated, 70 were detected in snow, water, vegetation, sediments, and/or fish. These included insecticides, DDT, PCBs, and PAHs (Ackerman et al. 2008). Pesticide concentrations (dieldrin [banned], chlordane [banned], DDT [banned], chlorpyrofos [currently used], and lindane [currently used]) were highest in parks and park watersheds closest to agricultural areas (Ackerman et al. 2008). Particles traveling across the United States from the Midwest to the Atlantic Ocean and Europe travel in what is called an atmospheric boundary layer; the Gulf Stream can transport particles from Florida to Maine (NPIC 2020g). Atmospheric PM–SOCs can enter ecosystems when they are deposited as rain or snow. The transport and fate of pesticide-based emissions in ecosystems is complex, depending on the character of the chemical emission and deposition, distribution in environmental media, and uptake, transport, and degradation of the chemical compound in biota.

[35] Many types of stationary engines exist and are found on farms, including diesel engines, spark ignited engines, and reciprocating internal combustion engines. Air quality requirements vary for stationary engines, depending on whether the engine is new or existing, where the engine is located, and what type of ignition system is used. The National Emission Standards for Hazardous Air Pollutants (NESHAP) for Reciprocating Internal Combustion Engines (RICE) are outlined in the Code of Federal Regulations under 40 CFR 63 Subpart ZZZZ.

The EPA, in addition to label use requirements, introduced initiatives to help pesticide applicators minimize off-target pesticide drift through a voluntary Drift Reduction Technology Program, which encourages the manufacture, marketing, and use of spray technologies that reduce pesticide drift (US-EPA 2020d). The EPA also, through the National Emission Standards for Hazardous Air Pollutants (NESHAP), established standards to reduce emissions of hazardous air pollutants (HAP) from facilities that manufacture pesticide active ingredients used in herbicides, insecticides, and fungicides (US-EPA 2020h).

4.3.2.3.1 Potential Effects on Air Quality

MON 87429 corn hybrids, if adopted by growers, would be expected to replace HR corn varieties currently cultivated, as opposed to augmenting current corn crops—no increase in acreage is expected. Because there would be little to no increase in acreage resulting from MON 87429 corn seed or hybrid production, nor substantial differences in the agronomic practices and inputs used, no changes to emission sources (i.e., tillage, fossil fuel burning equipment, the application of fertilizers and pesticides), nor significant changes in the volume of NAAQS emissions from U.S. corn production would be expected. In general, the contribution of MON 87429 corn hybrid production to the aggregate emissions of NAAQS pollutants from U.S. cropping systems is expected to be similar to what currently occurs with other corn crops.

Cultivation of MON 87429 corn hybrids, where adopted, would contribute to shifts in the types and patterns of herbicides used, facilitating the use of glyphosate, glufosinate, dicamba, 2,4-D, and quizalofop-p-ethyl in lieu of other herbicides. As use of stacked-trait HR varieties increases, how they may, or may not, contribute in a collective manner to increased annual herbicide use on U.S. corn acres, via tank mixing of differing herbicide MOAs, is uncertain. Increased volume of herbicide use could pose risks to air quality through herbicide drift and volatilization. While an increase in herbicide use could occur through tank mixing of different herbicide MOAs, increasing the volume of total herbicides applied in one application, all herbicides used with MON 87429 corn have annual use limits—maximal EPA permitted amounts for use during a crop season (e.g., (US-EPA 2014a, 2016c, 2018, 2019f; Lingenfelter and Curran 2022)).

Relative to the efficacy of MON 87429 corn hybrids in weed management: Effective IWM can reduce/eliminate the need for tillage in weed control. On average, farmers who switch from continuous conventional till to continuous no-till save more than four gallons of diesel fuel per acre each year (Creech 2018). To the extent MON 87429 corn hybrids facilitate effective IWM programs, and preclude the need for tillage, benefits to air quality would be expected.

4.3.3 Biological Resources

4.3.3.1 Soil Biota

Soil biota consist of microorganisms (bacteria, fungi, archaea and algae), soil animals (protozoa, nematodes, mites, springtails, spiders, insects, and earthworms), and plants (e.g., algae) living all or part of their lives in or on the soil (Fortuna 2012). Soil biota play a key role in the formation and turnover of soil organic matter (including mineralization), biodegradation of anthropogenic substances (e.g., pesticides), nutrient cycling, suppression of plant diseases, promotion of plant growth, soil structure formation, and most biochemical soil processes (Gupta et al. 2007; Fortuna 2012; Parikh and James

2012). Plant roots, including those of corn, release a variety of compounds into the soil creating a unique environment for microorganisms in the rhizosphere (root zone). Millions of species of soil organisms exist but only a fraction of them have been cultured and identified (Fortuna 2012).

Some microorganisms can cause plant diseases that can result in substantial economic losses in crop production. Soil borne corn crop diseases include fungal corn rusts, corn leaf blights, ear smuts, ear and kernel rot fungi, and maize mosaic viruses. Soils are commonly treated to control plant pathogens (Strunk and Byamukama 2019).

Potential changes to the soil microbial community as a result of cultivating biotech crops has been of much research interest since their introduction in the late 1990s (e.g., (Motavalli et al. 2004; Locke et al. 2008; Kremer and Means 2009)). Potential direct impacts could possibly include changes to the structural and functional community near the roots of plants due to altered root exudation or the transfer of novel proteins into soil, or a change in microbial populations due to the changes in agronomic practices used to produce biotech crops (e.g., pesticides, tillage practices). The majority of these studies have focused on Bt crops due to their insecticidal activity. Most studies have found no significant effect of Bt crop traits on soil community structures (Kowalchuk et al. 2003; Hannula et al. 2014; Zaman et al. 2015; Xie et al. 2016; Yasin et al. 2016).

Relative to crop production, the main factors affecting soil biota populations and diversity are soil type (texture, structure, organic matter, aggregate stability, pH, and nutrient content), plant type (providers of specific carbon and energy sources into the soil), and agricultural management practices—crop rotation, tillage, pesticide and fertilizer application, and irrigation (Kowalchuk et al. 2003; Garbeva et al. 2004; Gupta et al. 2007). Pesticides used on corn crops can, relative to the application rates, physicochemical properties, and frequency of exposure of soil biota to a pesticide, potentially impact soil communities. Climate, particularly the water and heat content of soil, is a principal determinant of soil biological activity.

4.3.3.1.1 Potential Effects on Soil Biota

Transgenes and Gene Products

The introduced herbicide resistance transgenes and gene products in MON 87429 corn, which are derived from common soil-borne biota and plants (Table 4-20), are not expected to have any effects on soil biota or community structures in corn fields—no different than conventionally bred corn plants. For example: Glufosinate-ammonium resistance is conferred through introduction of a modified gene (*pat*) from *Streptomyces viridochromogenes*, a naturally occurring soil bacterium; dicamba resistance is conferred through introduction of a modified gene (CS-*dmo*) from *Stenotrophomonas maltophilia*, which occurs in soils, water, and sediment; 2,4-D and quizalofop resistance is conferred through introduction of a modified gene (CS-*ft_t*) from *Sphingobium herbicidovorans*, primarily found in soils; glyphosate resistance is conferred through introduction of a modified gene (CS-*cp4 epsps*) from *Agrobacterium* sp. strain CP4, also soil dwelling. The introduced siRNA is a modified partial sequence from corn (*Zea mays*). Thus, the genetic elements and organisms from which they were derived naturally occur in or are associated with soils.

Table 4-20. Summary of Genetic Elements in MON 87429 Corn

Gene	Function	Source Organism	Common Name
P2-*Ea.Ubq*	transcription	*Erianthus ravennae*	plume grass
CS3-*pat*	glufosinate resistance	*Streptomyces viridochromogenes*	soil bacterium
T4-*Fba*	polyadenylation of mRNA	*Setaria italica*	foxtail millet
P-*Clj.Ubq*	transcription	*Coix lacryma-jobi*	adlay millet
TS5-*APG6*	directs protein to chloroplast	*Arabidopsis thaliana*	thale cress
CS-*dmo*	dicamba resistance	*Stenotrophomonas maltophilia*	soil bacterium
T-*Mt*	polyadenylation of mRNA	*Oryza sativa*	rice
P-*Ad.Ubq*	transcription	*Arundo donax*	giant reed
TS-*MDH*	directs protein to chloroplast	*Arabidopsis thaliana*	thale cress
CS-*ft_t*	quizalofop and 2,4-D resistance	*Sphingobium herbicidovorans*	soil bacterium
T-*Nam*	no apical meristem (Nam) protein	*Oryza sativa*	rice
P-*35S*	promoter	*Caulimovirus*	cauliflower mosaic virus
L6-*Cab*	regulates gene expression	*Triticum aestivum*	wheat
I7-*Ract1*	regulates gene expression	*Oryza sativa*	rice
TS-*CTP2*	directs protein to the chloroplast	*Arabidopsis thaliana*	thale cress
CS-*cp4 epsps*	glyphosate resistance	*Agrobacterium sp. strain CP4*	soil bacterium
T-*Grp3*	polyadenylation of mRNA	*Oryza sativa*	rice

The decay rate and environmental availability of transgene DNA/RNA in soils is affected by soil microbial activity, as well as pH, temperature, extracellular nuclease activity, the valence and concentration of cations, water content, and size and characteristics of the DNA/RNA (Greaves and Wilson 1970; Antheunisse 1972; Keown et al. 2004). The majority of species of soil microbiota, such as bacilli, non-coryneform rods, streptomycetes, and fungi produce nucleases that degrade free RNA and DNA (Antheunisse 1972). Both free DNA and RNA have been found to be fully degraded in soils and mineralized to nitrogen, within about 30 days (Greaves and Wilson 1970; Keown et al. 2004; Levy-Booth et al. 2008).

While bacteria may potentially be exposed to the transgenes (Lorenz and Wackernagel 1994), horizontal gene transfer from a MON 87429 corn plant to bacterial, fungal, or invertebrate species is unlikely to occur.

Herbicides

Some pesticides used on corn crops can, relative to the application rates, mode of action (potential toxicity), and frequency of exposure of soil biota to a pesticide, potentially impact soil communities (Stevenson et al. 2002; Locke and Zablotowicz 2004). A recent global assessment of the impact of plant protection products on soil functions and soil ecosystems concluded that most agricultural inputs can cause transient changes in the amount, activity, diversity, and community structures of soil organisms (FAO 2017). Changes in community structure are in fact the most common type of effects observed with pesticides (FAO 2017).

In general, the herbicides intended for use with MON 87429 corn may have temporary effects on soil organisms/communities, such as increases/decreases in biomass, enzymatic activity, soil respiration, and variations in species composition (Tu 1992; Lupwayi et al. 2004; Singh and Singh 2016; Tarla et al. 2020). The challenge lies in interpreting these changes relative to whether such changes reflect adaptive responses in soil organisms/communities, or potentially harmful effects, such as decreased species diversity, impeded soil functions, and diminished soil productivity (FAO 2017). There is limited evidence that the observed effects of pesticides on soil organisms have led to significant and long-lasting decreases in soil functions (FAO 2017). However, the inability to clearly link the effects of pesticides on soil organisms and soil functions is a limitation of the current literature (FAO 2017).

To date, scientific studies on the impact of glyphosate (Locke et al. 2008; Hart et al. 2009; Kremer and Means 2009; la Cecilia and Maggi 2018; Mandl et al. 2018; Hagner et al. 2019) and glufosinate (Bartsch and Tebbe 1989; Gyamfi et al. 2002; Sessitsch et al. 2005; Dennis et al. 2018; Mandl et al. 2018) on soil microorganisms have provided contrasting results. Some studies found little effects, while others reported potentially adverse effects on biota diversity, and the structure and function of soil communities.

For example, Dennis et al. (2018) found that neither glyphosate nor glufosinate influenced total microbial enzyme activity or beta-glucosidase activity; and that while herbicide addition temporarily impaired the ability of soil organisms to utilize three organic acids and an amino acid, their effects were otherwise negligible. Studies by Hart et al. (2009) found that neither glyphosate resistant corn nor glyphosate had significant impacts on denitrifying bacteria and fungi. Busse et al. (2001) reported that field rate applications of glyphosate should have little to no effect on soil microbial communities in ponderosa pine plantations. Kremer and Means (2009) reported changes in microbial components of glyphosate resistant soybean and corn rhizospheres: increases in the proportion of manganese (Mn)-oxidizing bacteria; decreases in the pseudomonad component that antagonizes fungal pathogens; and increases in agrobacteria that may be involved in Mn oxidation and microbial community shifts due to apparent selection by glyphosate exudation.

For glufosinate, studies by Dennis et al. (2018) and Zablotowicz et al. (2008) observed no effects at one, two, and four times the recommended use rate of glufosinate (10, 20, and 40 ppm) on soil fluorescein diacetate FDA activity (indicative of microbial activity in soil), after two, four, and seven days exposure. Some studies indicate that low-levels of exposure to Basta and Liberty—herbicide active ingredient glufosinate–ammonium—exert both positive and negative effects on the relative abundances of various bacterial taxa (Gyamfi et al. 2002; Sessitsch et al. 2005; Pampulha et al. 2007), while others demonstrate that similar application rates of Basta (Ernst et al. 2008) and Liberty (Schmalenberger and Tebbe 2003) have no effect on microbial community structure. Gyamfi et al. (2002) found that the herbicide Basta caused minor shifts in the rhizosphere eubacterial community structures that were possibly due to the enrichment of microbes involved in the herbicide degradation, and the inhibition of sensitive organisms.

Similarly, the reported effects of 2,4-D on microbial community size and structure are inconsistent (Macur et al. 2007; Rose et al. 2016; de Castro Marcato et al. 2017). Some studies observed that 2,4-D application at conventional rates temporarily reduced culturable bacteria and increased culturable fungi; other analyses did not detect any community shifts in soil treated with 2,4-D at 10 mg/kg soil (Macur et al. 2007).[36] The only consistent finding is that microbial growth-dependent methods detect higher numbers of 2,4-D degrading organisms at conventional application rates of 5–10 mg/kg soil (Macur et al. 2007; Zabaloy et al. 2011). Rose et al. (2016) reported that the single recommended rate application of

[36] 2,4-D application rates commonly used in agriculture range from 2–50 mg/kg

2,4-D typically had limited effects on soil functions such as nitrogen transformation, and soil enzymatic activities involved in organic matter and nutrient cycling.

Contrasting results have been observed by various researchers evaluating the impact of quizalofop-p-ethyl on soil microbial biomass and enzymatic activities. Application of quizalofop-p-ethyl in peanut fields showed short-lived as well as transitory effects on microbial biomass carbon and fluorescein diacetate hydrolyzing activity, while dehydrogenase activity remained almost stable under various doses of herbicide application (Saha et al. 2016). However, soil application at field recommended or elevated doses had detrimental effects on ammonia-oxidizing microorganism and denitrification processes(Saha et al. 2016). In laboratory in vitro studies quizalofop-p-ethyl, applied two to three times at the recommended rates, was found to have limited inhibitory effects on the plant growth promoting activities *of Klebsiella* species. Quizalofop-p-ethyl added to a liquid culture of Klebsiella sp. strain PS19 was however found to decrease the phosphate solubilizing activity of strain PS19 relative to an untreated control. The study revealed that the higher rates of herbicides decreased the plant growth promoting activity but it did not completely inhibit the metabolic activities of strain PS19 (Ahemad and Saghir Khan 2011). Majumdar et al. (2010) reported decreased dehydrogenase and fluorescein diacetate activity—indicative of soil microbial enzymatic activity— in jute fields treated with quizalofop-p-ethyl. It was reported that the enzyme activities, microbial biomass carbon, and basic soil respiration rate in herbicides treated plots started recovering after15 days of their application (Majumdar et al. 2010). Field studies by Singh et al. (2015) reported a stimulatory effect of quizalofop-p-ethyl on soil *Azotobacter* and *Pseudomonas* populations (30 days after application) in a mustard field.

There are few studies examining the potential effects of dicamba on soil biota. Of them, none have reported significant adverse impacts on soils (Yeomans and Bremner 1985; Oleszczuk et al. 2014; Mosqueda et al. 2019).

Most herbicides, used at typical application rates, are generally considered to have no major long-term effect on soil biota populations or biogeochemical processes (Tu 1992; Subhani et al. 2000; Lupwayi et al. 2004; Wolmarans and Swart 2014; FAO 2017). There is currently limited evidence that the observed effects of herbicides on soil organisms, which are primarily changes in community structure/species composition, have led to long-lasting impairment of soil functions (FAO 2017). While the application of herbicides may in some instances lead to the local suppression of a taxonomic unit of soil organisms, the resiliency of soil organisms, or ability to adapt, and functional redundancy across various taxa, serve to limit the effects of herbicides on soil ecosystem processes (FAO 2017). Many herbicide active ingredients, to include glyphosate and 2,4-D, serve as carbon and energy sources for soil microbiota (Sviridov et al. 2015; Singh and Singh 2016). Dicamba likewise appears to serve as a carbon and energy source for some soil taxa (Voos and Groffman 1997). For the herbicides that will be used with MON 87429 corn, soil microbial degradation is a primary process by which they are degraded in the environment (Fogarty and Tuovinen 1995; Hsiao et al. 2007; Cycoń et al. 2011; Singh and Singh 2016; la Cecilia and Maggi 2018; Zhou et al. 2018). The field dissipation half-life for glufosinate ranges from around 3 to 20 days (avg. 13 days) (TOXNET 2019). Biodegradation half-life of glyphosate in soil is around 2 to 7 days under aerobic conditions. Dicamba has a field half-life ranging from 8 to 592 days, with a typical half-life being 1 to 4 weeks (TOXNET 2019). For 2,4-D, an average half-life of 4 days has been observed (NPIC 2020b). Reported half-lives for quizalofop-p-ethyl range from around half a day to

4 days, although under certain conditions a half-life of 60 days was observed (Mantzos et al. 2017; TOXNET 2019).

The herbicides to be used with MON 87429 corn have a long history of use in U.S. agriculture; impacts on soil biota have not been raised as a significant concern with any of the herbicide active ingredients that will be used with MON 87429 corn. Rather, it is the particular agronomic practices employed, such as the types of crop rotations, fallowing, tillage, and cover cropping practices, that are the primary determinants of soil microbial activity (Nielsen and Calderón 2011; FAO 2017). Fundamentally, the vast majority of soil organisms have yet to be identified, and a comprehensive understanding of the potential effects of herbicides on soil biota communities is not possible at this time (FAO 2017).

4.3.3.2 Plant Communities

Plant diversity in surrounding field areas is an important component of a sustainable agricultural system (Scherr and McNeely 2008; CBD 2020b). Hedgerows, woodlands, fields, and other surrounding habitat serve as important reservoirs for beneficial insects (although plant pests as well). By providing habitat, pollen and nectar resources, and serving as hosts, plants adjacent to corn fields can support a suite of beneficial arthropod species that serve as pollinators of insect-pollinated crops, and biological control agents, insects that prey on corn plant pests, such as lady beetles, spiders, and parasitic wasps (Scherr and McNeely 2008; Nichols and Altieri 2012). However, for corn production, pollinators would not be as valued from an agronomic perspective, as corn is primarily wind and hand pollinated. Surrounding plant communities can also help regulate run-off, reduce soil erosion, and improve water quality. Hence, effective management of surrounding plant communities can provide benefits to corn crop production via control of insect pests and agricultural run-off (Altieri and Letourneau 1982), and provide pollinator services to other plants that benefit from insect pollination (Nichols and Altieri 2012).

Field borders comprised of grasses, forbs, legumes, and shrubs can provide valuable food resources and cover for wildlife such as bobwhite quail, rabbits, fox, and box turtles (Pierce and Milhollin 2020). Field borders located next to shrubby and woodland habitats can provide food and cover for wildlife associated with forested areas, such as white-tailed deer, wild turkey, and various avian species (Pierce and Milhollin 2020).

How plant types in field borders are managed (e.g., grasses, forbs, legumes, shrubs, trees) can affect insects pest and weed populations, and crop yield. A key question for landowners in establishing and managing field borders is to determine whether net income will be greater than if the border areas were planted with crops. Another concern for crop producers is whether the potential increase of insects and weeds will result in decreased yields to the surrounding crop (Pierce and Milhollin 2020).

Federal policy provides financial incentives for landowners to manage some cropland field borders for wildlife habitat—such as the USDA Conservation Reserve Program. Landowners may be eligible for payments, cost-share or other incentives in exchange for removing field borders from crop production. The economic question for landowners is: How much will conservation program payments offset the loss of future net revenue on the enrolled acres for the life of contract?

Members of plant communities in and around cornfields that adversely affect corn cultivation are generally characterized as weeds, and these plants controlled to maximize crop yield and quality—as previously discussed. Most relevant to environmental review of biotech cropping systems are those sexually compatible plant communities with which the biotech crop plant can interbreed, discussed following in 4.3.3.4–Gene Flow and Potential Weediness of Corn.

4.3.3.2.1 Potential Effects on Plant Communities

MON 87429 hybrid production would be expected to have similar impacts on vegetation surrounding MON 87429 corn/hybrid fields as other crops, relative to the particular herbicides that would be used with this variety. When crops are sprayed with herbicides, sublethal doses may reach non-target plants in adjacent habitats through spray drift, runoff, and/or volatilization. Sublethal effects could include negative effects on leaves (photosynthesis), seed production, delays in flowering times, and reductions in flower production. Typically, less than 1% of herbicide applied to crops is lost to groundwater leaching, approximately 1%–4% is carried away in surface runoff, with losses via spray drift and volatilization ranging between 5%–25% (Boutin et al. 2014; Prueger et al. 2017).

As previously discussed, herbicides used on any crop can potentially move off site via run-off, or spray/volatilization drift. Relative to MON 87429 corn, which would facilitate use of glyphosate, glufosinate, quizalofop-p-ethyl, 2,4-D, and dicamba, some formulations of dicamba and 2,4-D, owing to their inherent chemistries, vapor pressures, have been more prone to offsite movement via spray drift and vaporization. As auxin (plant hormone) mimic herbicides, dicamba and 2,4-D can affect plants at low doses. Dicamba spray or vapor drift has presented issues for both crop producers (e.g. vineyards, cotton, soybean, tomato) and property owners outside the agricultural sector (Unglesbee 2018b, 2019a). 2,4-D can likewise present problems with spray and vapor drift, although most 2,4-D formulations are considered low-volatile (e.g., BEE and 2-EHE esters). Given these factors, focus is given here to these herbicides and potential impacts on non-target plants.

The total amount of dicamba and 2,4-D used on U.S. farmland each year could increase in the United States as a result of increased planting of MON 87429 corn hybrids. Both dicamba and 2,4-D are synthetic auxins that mimic plant hormones, which disrupt growth and metabolic processes in a wide variety of broadleaf plants at relatively low doses. For example, a dose equivalent to 0.005% of the labeled use rate for dicamba can injure soybean, and 0.1% of the labeled use rate for 2,4-D injure grapes (Hartzler 2016). Numerous species of trees, vines, shrubs, and herbaceous broadleaf plants have shown sensitivity to dicamba and 2,4-D (Dintelmann et al. 2019). Synthetic auxins can cause injuries such as leaf twisting, stunting, leaf cupping, curved stems, vein discoloration, reduced flower production, fruit delay or abortion, and in extreme cases plant dieback and death. In trees, dicamba and 2,4-D drift can cause severe injuries including deformed foliage, branch dieback, and arrested nut development. Injuries can vary widely due to many factors including but not limited to species, plant age, growth stage, and herbicide dose (Dintelmann et al. 2019).

Herbicide Use with HR Soybean, HR Cotton, and HR Corn

While dicamba herbicides (and to a certain extent certain 2,4-D formulations) have always presented some issues with drift and volatilization, the level of incidence and injury to non-crop plants increased after the adoption of dicamba and 2,4-D resistant crops, which facilitate over-the-top (OTT) use of these herbicides later into the growing season when temperatures are higher (Unglesbee 2018b, 2019a; US-EPA 2021d, e, 2022a). Unpredictable weather events such as temperature inversions can also facilitate herbicide spray and vapor drift. Xtend soybeans and cotton, which are resistant to dicamba and glyphosate, were commercialized in 2016. Enlist cotton, which is resistant to 2,4-D choline, glyphosate, and glufosinate was commercialized in 2016, and Enlist soybean, resistant to glyphosate, glufosinate, and 2,4-D in 2019. Enlist Duo corn, resistant to glyphosate and 2,4-D was commercially available in 2014, and SmartStax Enlist corn resistant to glyphosate, glufosinate, 2,4-D and ACCase-FOP herbicides was commercialized in 2018 (Table 4-21). Note that while these crops and the respective herbicides that could be used with them became commercially available for sale and use, it does not mean they were necessarily planted that year.

Table 4-21. Stacked-Trait 2,4-D, Glyphosate, Dicamba, and Glufosinate Resistant Crops

Crop	Stacked-Trait Herbicide Resistant Traits	Trade Name	Year Commercialized in the United States
Corn	Glyphosate and glufosinate	SmartStax	2010
Corn	Glyphosate and 2,4-D	Enlist Duo	2014
Corn	Glyphosate, glufosinate, 2,4-D and ACCase-FOP	SmartStax Enlist	2018
Soybean	Glyphosate and glufosinate	Liberty-Link	2009
Soybean	Glyphosate and dicamba	Roundup Ready Xtend	2016
Soybean	Glyphosate, glufosinate and 2,4-D	Enlist E3	2019
Soybean	Glufosinate	LibertyLink	2009
Cotton	Glyphosate and dicamba	Roundup Ready Xtend	2016
Cotton	Glyphosate, glufosinate and 2,4-D	Enlist	2016
Cotton	Glyphosate and glufosinate	GlyTol Liberty Link	2014

Source: (ISAAA 2022)

As dicamba and 2,4-D resistant crops were adopted subsequent to commercial availability, use of these herbicides increased in most of these cropping systems (Table 4-23). For example: In 2015, approximately 172,000 lbs of dicamba a.i. was applied to soybean, and 130,000 lbs dicamba a.i. applied to cotton. In 2018, 6,716,000 lbs a.i. dicamba applied to soybean, and in 2019, 5,575,000 dicamba a.i. applied to cotton. In 2015, approximately 683,000 lbs of 2,4-D a.i. was applied to cotton, and in 2019, 2,255,000 lbs a.i. applied (Table 4-22). In general, dicamba use in soybean increased some 7,619% from 2012 to 2018, and dicamba use in cotton increased about 3,299% from 2007 to 2019. Glufosinate use in soybeans—subsequent to introduction of glufosinate resistant Liberty-Link and Xtend soybeans—also increased, from 2,313,000 lbs a.i. in 2015 (5% of total herbicide use), to 9,759,000 lbs a.i. in 2018 (18% of total herbicide use).

Table 4-22. Herbicide Use in Corn, Soybean, and Cotton

	Corn			
	2010	**2014**	**2016**	**2018**
	lbs a.i./Yr			
Glyphosate	**64,359,000**	**61,364,000**	**82,264,000**	**66,586,000**
Treated Acres, % of Area Planted	77%	77%	81%	76%
Portion of Total Herbicide Use	35.33%	34.81%	36.39%	31.01%
Glufosinate	**515,000**	**234,000**	**298,000**	**488,000**
Treated Acres, % of Area Planted	1%	1%	1%	1%
Portion of Total Herbicide Use	0.28%	0.13%	0.13%	0.23%

Dicamba	**998,000**	**1,304,000**	**2,363,000**	**2,929,000**
Treated Acres, % of Area Planted	10%	10%	15%	17%
Portion of Total Herbicide Use	0.55%	0.74%	1.05%	1.36%
2,4-D	**2,936,000**	**4,231,000**	**6,162,000**	**5,308,000**
Treated Acres, % of Area Planted	8%	8%	12%	12%
Portion of Total Herbicide Use	1.61%	2.40%	2.73%	2.47%
Total Herbicides Applied	**182,150,000**	**176,291,000**	**226,042,000**	**214,721,000**
Total Acres Planted	**88,192,000**	**90,597,000**	**94,004,000**	**88,871,000**

	Soybean			
	2012	**2015**	**2017**	**2018**
	lbs a.i./Yr			
Glyphosate	**109,336,000**	**106,935,000**	**93,509,000**	**95,719,000**
Treated Acres, % of Area Planted	*98%*	89%	86%	87%
Portion of Total Herbicide Use	82.22%	71.17%	58.03%	52.00%
Glufosinate	**1,253,000**	**2,313,000**	**6,424,000**	**9,759,000**
Treated Acres, % of Area Planted	*3%*	5%	13%	18%
Portion of Total Herbicide Use	0.94%	1.54%	3.99%	5.30%
Dicamba	**87,000**	**172,000**	**6,810,000**	**6,716,000**
Treated Acres, % of Area Planted	*NR*	NR	15%	14%
Portion of Total Herbicide Use	0.07%	0.11%	4.23%	3.65%
2,4-D	**6,524,000**	**7,715,000**	**9,756,000**	**8,529,000**
Treated Acres, % of Area Planted	*15%*	17%	19%	17%
Portion of Total Herbicide Use	4.91%	5.13%	6.05%	4.63%
Total Herbicides Applied	**132,979,000**	**150,246,000**	**161,144,000**	**184,060,000**
Total Acres Planted	**77,198,000**	**82,660,000**	**90,162,000**	**89,167,000**

	Cotton			
	2007	**2015**	**2017**	**2019**
	lbs a.i./Yr			
Glyphosate	**17,311,000**	**14,386,000**	**14,388,000**	**22,451,000**
Treated Acres, % of Area Planted	91%	88%	80%	93%
Portion of Total Herbicide Use	66.04%	54.63%	48.72%	51.64%
Glufosinate	**77,000**	847,000	1,150,000	746,000
Treated Acres, % of Area Planted	2%	13%	17%	8%
Portion of Total Herbicide Use	0.29%	3.22%	3.89%	1.72%
Dicamba	**164,000**	**130,000**	**1,999,000**	**5,575,000**
Treated Acres, % of Area Planted	7%	6%	33%	40%
Portion of Total Herbicide Use	0.63%	0.49%	6.77%	12.82%
2,4-D	**475,000**	**683,000**	**1,072,000**	**2,255,000**
Treated Acres, % of Area Planted	9%	10%	12%	**20%**
Portion of Total Herbicide Use	1.81%	2.59%	3.63%	5.19%
Total Herbicides Applied	**26,214,000**	**26,334,000**	**29,529,000**	**43,477,000**
Total Acres Planted	**10,827,200**	**8,580,500**	**12,717,500**	**13,735,700**

Note: The data presented are approximate values, although provide a general trend in herbicide use.

Source: (USDA-NASS 2023)

One of the reasons dicamba use increased in HR soybean and cotton was to control glyphosate resistant weeds (Wechsler et al. 2019). In other cases, dicamba-resistant seeds were planted to prevent yield losses from unintended exposure to dicamba via spray or vapor drift. In the latter case, for example, not all acres planted with dicamba-resistant soybeans have been treated with dicamba. In 2018, across 19 states, more acres were planted with dicamba-resistant seed than were actually sprayed with dicamba. In Mississippi, 79% of soybean acres were planted with dicamba-resistant seeds, but only 54% of these acres were treated with dicamba (Wechsler et al. 2019). In some cases, farmers may apply dicamba only if glyphosate-resistant weeds are present.

Acreage/Areas Potentially Affected by Herbicide Use with MON 87429 HR Corn

Soybean and corn, which are commonly rotated together, are primarily grown in the central United States and east coast mid-Atlantic states (Figure 4-23, Figure 4-24). Cotton is grown in southeastern and southern states (Figure 4-25). These are the areas in which dicamba and 2,4-D resistant soybean and, cotton have been grown, MON 87429 corn crops would be grown, and these herbicides predominantly used. There are no dicamba resistant corn varieties yet grown in the United States. In terms of total acreage, in 2020, 194 million acres of corn, soybeans, and cotton combined were planted.

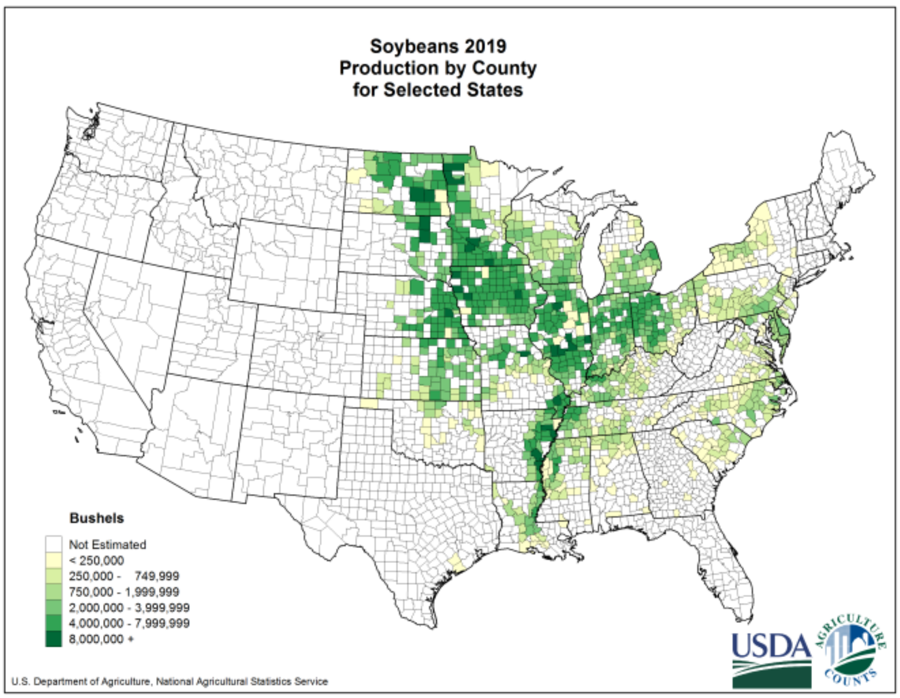

Figure 4-23. Areas of Soybean Production in the United States

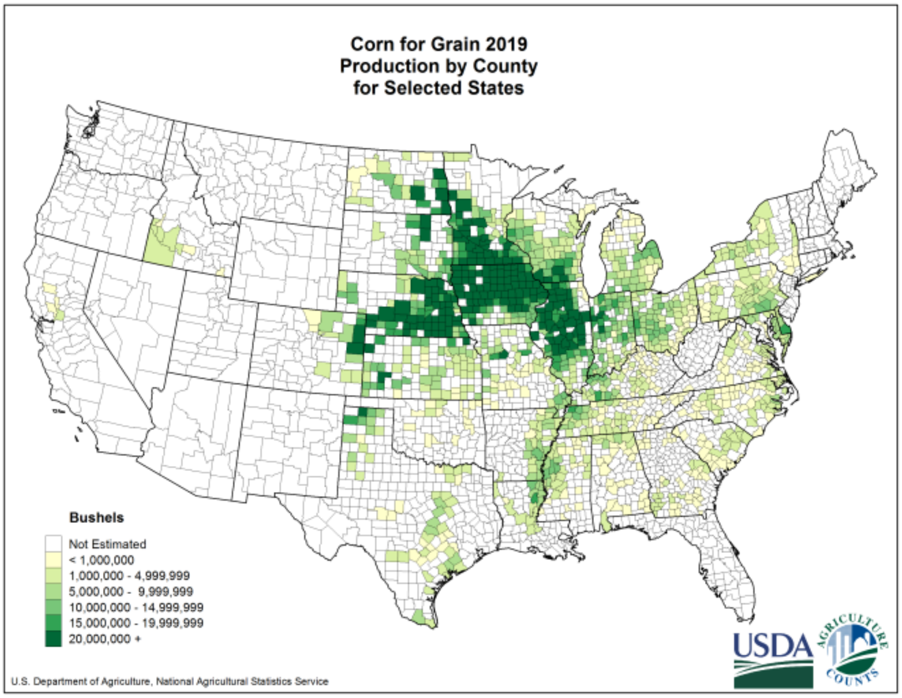

Figure 4-24. Areas of Corn Production in the United States

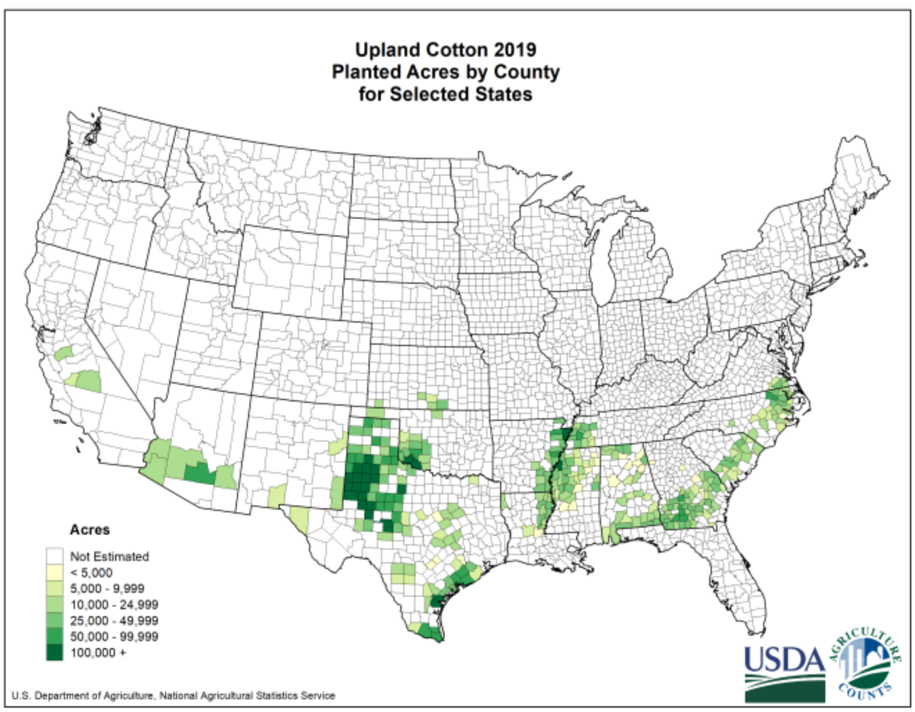

Figure 4-25. Areas of Cotton Production in the United States

There is limited annual data on acreage planted to specific brands of dicamba and 2,4-D resistant soybean and cotton, however, some general numbers are provided. Glyphosate and dicamba-resistant Roundup

Ready 2 Xtend soybeans accounted for around 60% of the soybeans planted in the United States in 2019, approximately 54 million to 60 million acres (Hettinger 2019b; Unglesbee 2019d). XtendFlex soybeans, resistant to over-the-top use of glyphosate, dicamba, and glufosinate, became commercially available in 2021. Bayer estimated farmers planted Xtend (tolerance to glyphosate and dicamba) and XtendFlex soybeans on more than 55% of the U.S. soybean acres in 2021, approximately 48.5 million acres (SF 2021). In 2021, Corteva Agriscience estimated Enlist E3 soybeans, resistant to 2,4-D choline, glyphosate, and glufosinate comprised around 35% of U.S. soybean acreage, approximately 30.9 million acres (Begemann 2021). The states with the most dicamba-resistant seed use have been Mississippi, Tennessee, and Kansas—where approximately 79%, 71%, and 69% of soybean acreage has been planted with these varieties, respectively (Wechsler et al. 2019).

Enlist cotton acres were estimated to be 1.5 million acres in 2018, up from 500,000 in 2017 (Unglesbee 2018a). Cotton with XtendFlex technology, resistant to glyphosate, dicamba, and glufosinate, was planted on 73% of U.S. cotton acres—approximately 9.8 million acres—in 2018 (Fava and Hallahan 2019). XtendFlex cotton and Roundup Ready 2 Xtend soybeans (resistant to glyphosate and dicamba) were planted on an estimated 60 million acres in 2019, which is equal to the land area of Illinois and Indiana combined (Fava and Hallahan 2019).

During 2020, more than 90% of total upland cotton planted in the U.S. were resistant to auxinic herbicides such as dicamba and 2,4-D, with 73.3% acreage planted with dicamba-resistant cotton, and 19.51% with 2,4-D-resistant cotton (Vulchi et al. 2022). Although there was a reduction in total area planted with upland cotton from 2019, adoption of both traits increased in 2020, indicating the value these traits provide to the grower (Vulchi et al. 2022).

Drift Damage Identification, Reporting, and Management

Injuries to non-crop plants from pesticide use can be reported to the Ecological Pesticide Incident Reporting Portal at http://npic. orst.edu/eco/, state pesticide regulatory agencies, or the product's manufacturer who is required by law to submit reports of adverse effects to EPA (the contact information for product manufacturer is on the product’s label). Ecological incidents are when adverse effects involve non-target entities such as: wildlife and plants (non-crop harm from herbicide use). Information reported to the portal may be directly sent in its entirety to the EPA.

There is no data on how frequently the Ecological Pesticide Incident Reporting Portal is used, on submitted reports, or how well known this resource is to the general public. If a farmer or landowner suspects that the injury to their plants is herbicide drift related, the first step is to file a complaint with their state’s pesticide regulatory enforcement agency.

It is possible that only a small percentage of actual damages to non-crop plants and private lands are reported to the Ecological Pesticide Incident Reporting Portal or state agencies. Even with crops, not all cases of injury are apparently reported. One survey of Missouri farmers, pesticide applicators, and crop advisors estimated that over 73% of dicamba injury in 2019 went unreported (Bradley 2019). Another study that surveyed growers for dicamba injury to non-dicamba resistant soybeans found that of the survey respondents reporting injury (51%), only 7% actually filed a complaint (Werle et al. 2018). Apart from the underreported incidences of observed dicamba injury, the injuries to non-crop species, such as trees on private residences, forested lands, and other natural areas are likely not often recognized, and thus unreported.

Herbicide Label Use Requirements and State Restrictions

The potential for off-target injury to non-crop plants associated with dicamba and other herbicide use is well recognized by the agricultural community and EPA (Unglesbee 2018b, 2019a; Hartzler and Jha 2020; US-EPA 2021d, e, 2022a). The revised EPA labels for dicamba products registered for use in soybean and cotton include restrictions intended to minimize off-target movement (e.g., (US-EPA 2020t, n, 2023a)). For example, the EPA established two federal cutoff dates for use of the three dicamba herbicides, June 30th for soybeans and July 30th for cotton, as well restrictions on uses in specific states.

Some states have added further use restrictions in addition to the EPA label requirements for the use of OTT dicamba to help address offsite movement unique to the local environment. For example, in 2020 Arkansas required a May 25th cutoff date (date by which dicamba could no longer be used OTT on soybean and cotton) and a requirement to not tank mix dicamba with glyphosate (Unglesbee 2020c). The state's plant board voted to keep that restriction in place for 2021 (Unglesbee 2020a). Illinois, Indiana, and Minnesota implemented a June 20th cutoff date for soybean while North and South Dakota have a June 30th cutoff date for soybean (Table 4-23). In Illinois, North Dakota, and Tennessee, dicamba use was also restricted to certain times of day when dicamba is less likely to drift. State officials in Indiana and Illinois contributed these types of restrictions to a substantial drop in dicamba investigations, from 723 complaints in 2019 in Illinois to 124 in 2020, and from 250 complaints in 2019 in Indiana to 73 in 2020 (Unglesbee 2020a).

Table 4-23. Select States: Example of Dicamba Use Restrictions in 2020

	Dicamba Cannot be Applied		
	Later than…	*If temperature is over…*	*Unless the time is between…*
Arkansas	May 25th		
Illinois	June 20th	85°F	
Louisiana	June 15[2]		
Minnesota	June 20th	85°F	
Indiana	June 20th		
North Dakota	June 30th	85°F	1 hour after sunrise and 1 hour before sunset

Note: These types of state restrictions can change on an annual basis.
Source: (Unglesbee 2020a, 2021b, c).

Alternately, some states planned on using FIFRA Section 24 labels to further expand EPA's dicamba labels (Unglesbee 2020a). Several states, including North Carolina, Oklahoma, and Texas, attempted to expand the federal dicamba labels in 2021. These states submitted Section 24 labels with extended spray cutoffs to EPA to accommodate double-planted soybeans and late-planted cotton acres. However, the EPA rebuffed those moves, arguing that permitting more expanded use of dicamba would be unsafe and open the agency up to legal liability (Unglesbee 2021c).

If states wish to impose further restrictions on dicamba products, or any other federally registered pesticides, they can do so under section 24(a) of FIFRA (US-EPA 2020p). Section 24(a) establishes that states have the right to regulate federally registered pesticides through state legislatures or rulemaking procedures.

Bayer states the use of dicamba on MON 87429 corn will follow current EPA registration label use requirements for corn. The maximum annual use rate would be a total of 0.75 lbs. a.e. per treated acre per crop year. Maximum application rate would be 0.5 lb. a.e. per acre, with no more than 2 applications per growing season (Bayer-CropSci 2022). Use restrictions would include (US-EPA 2010):

- Application prohibited if corn is more than 36 inches tall or within 15 days before tassel emergence, whichever comes first.

- Application prohibited when soybeans are growing nearby if any of these conditions exist: corn is more than 24" tall; soybeans are more than 10" tall; soybeans have begun to bloom.

Use of dicamba and 2,4-D based herbicides with MON 87429 corn hybrids would be expected to present the same risks for spray and vapor drift, injury to wild plants, and ornamental plants on residential and commercial properties, as with other crops on which registered dicamba and 2,4-D products are used. Much of the potential risks with these herbicides (as well as other herbicides) will depend on the particular formulations used, EPA and state use requirements/restrictions, and strict adherence of applicators to EPA and state use requirements and restrictions.

Aquatic Plants

Herbicides used on crops and non-crop sites can affect aquatic plants as well via run-off. The U.S. Geological Survey (USGS) conducted a study comprising 100 streams during May–August 2013. A total of 183 pesticide compounds (94 parent pesticides and 89 degradates) were detected in one or more samples, consisting of 98 of the 124 herbicides evaluated, 71 of the 88 insecticides evaluated, and 14 of the 16 fungicides. Corn and soybean herbicides, namely atrazine, metolachlor, acetochlor, and their degradates tended to have the highest detection frequencies and concentrations, consistent with past studies in the Midwest (see review by (Nowell et al. 2018). Other herbicides frequently detected in streams at agricultural sites were dimethenamid and its degradates, sulfentrazone, propazine, 2,4-D, prometon, and glyphosate. Notably, the herbicides 2,4-D, glyphosate, and prometon were detected at higher concentrations and more often in streams at urban sites, as opposed to agricultural sites. For agricultural sites, glyphosate occurrence was found in 41% of samples, atrazine in 57% of samples, metolachlor 32%, and acetochlor 16% of samples.

The USGS study found that spatially intensive, short-term temporal use of certain pesticides, the herbicides metolachlor, acetochlor, and atrazine; the insecticides imidacloprid, fipronil, and organophosphates; and the fungicide/degradate carbendazim can have acute but likely reversible effects on aquatic plant biomass (Nowell et al. 2018). For aquatic plants, acute but likely reversible effects on biomass were predicted in 75% of streams, with potential longer-term effects on plant communities in 9% of streams. Relatively few pesticides in water—atrazine, acetochlor, metolachlor, imidacloprid, fipronil, organophosphate insecticides, and carbendazim—were predicted to be major contributors to potential toxicity (Nowell et al. 2018). Specifically, the compounds responsible for acute-plant benchmark exceedances were triazine (at 73% of sites), acetanilide (19% of sites), 2,4-D (5%), and sulfonylurea (3%) herbicides.

Agricultural streams had the highest potential for effects on plants, especially in May–June, corresponding to high spring-flush herbicide concentrations. Maximum herbicide concentrations in streams were significantly related to their agricultural use intensity (e.g., in lbs a.i./acre), and to the percentage of cropland treated in the basins studied (Nowell et al. 2018). Thus, not surprisingly, there is a direct correlation between the amount of herbicide used, the total area treated the herbicide, and the concentration of herbicides in surface waters (Nowell et al. 2018).

The USGS study concluded that during spring/summer there could be potential for acute, but short-term effects on aquatic plant growth. In the streams evaluated, the potential reversibility, recovery of aquatic plants, can limit the adverse effects of herbicides, on the aquatic environment. In general, herbicides can temporarily suppress the growth of algae and aquatic plants (macrophytes), but populations tend to recover once exposure is reduced (Fairchild 2011). However, effects on community structure and function may occur if high herbicide concentrations are sustained (Farruggia et al. 2016).

Potential Exposure Through Atmospheric Deposition

In the particulate phase, dicamba is removed from the atmosphere through wet (rainfall, snow) and dry (gravity) deposition. Herbicide spray and vapor drift can theoretically result in potential injury to aquatic biota if the level of deposition resulting from drift exceeds a threshold for causing harm (Riter et al. 2021).

A recent study by Bish et al. (2019b) used high-volume air samplers to determine concentrations of dicamba in air after treatment to soybean. The highest levels of 22.6 to 25.8 ng/m^3 were detected in the first 8 h after treatment (HAT). When applied simultaneously, the DGA plus VaporGrip and BAPMA salt of dicamba were detected at similar levels over the time course. The highest concentrations for each formulation occurred 0.5 to 8 HAT. Concentration of the DGA plus VaporGrip was 22.6 ng/m^3 whereas that of the BAPMA salt was 25.8 ng/m^3. Both formulations showed similarly rapid dissipation in air, with dicamba concentrations decreasing from >20 ng m^3 at 0.5 to 8 HAT to <7 ng/m^3 at 8 to 16 HAT. By 24 to 48 HAT, dicamba concentrations were approximately 2 ng m^3 and remained at that concentration through 72 HAT (Bish et al. 2019b).

Another potential route of herbicide exposure is rainfall. Studies conducted by the University of Missouri and USDA-ARS quantified atmospheric concentrations and mass fluxes of dicamba in 12 soybean production regions of Missouri. Dicamba was routinely detected in weekly deposition samples collected during agriculturally intensive spray periods. Observed concentrations were indicative of both local (<1 km) and long-distance transport (>1 to 1000 km) of air-borne dicamba. High deposition events (>100 µg/m^2)[37] occurred annually in southeast Missouri, and peak dicamba concentrations at these sites (12.5-84.0 µg/L) were sufficient to injure non-dicamba resistant soybean (Oseland et al. 2022).

The highest concentration detected in 2019 was 84 µg/L (Oseland et al. 2022). The highest concentration detected in 2020 was 37 µg/L (Oseland et al. 2022). Weekly detection frequency of dicamba ranged from 21% to 95% in 2019 and from 26% to 89% of the sampled weeks in 2020 (Oseland et al. 2022).

For both years of the study, highest mass fluxes on a weekly and annual basis occurred at the three sites in southeast Missouri. All these sites had peak weekly fluxes >140 µg/m^2, with the highest weekly mass flux in 2019 observed to be 1,098 µg/m^2 and the highest in 2020 to be 354 µg/m^2.

Ecological Risk Assessments for the Herbicides Used with Mon 87429 Corn

All of the herbicides active ingredients that would be used with MON 87429 corn are currently labeled for use on a variety of crops as well as in non-agricultural settings (e.g., residential and commercial properties). The ecological risks of pesticide use on plants, to include risks from aggregate uses, are assessed by the EPA as part of the pesticide registration process and are regularly reevaluated by EPA for each pesticide to maintain its registered status under FIFRA. The EPA has conducted ecological risk assessments (ERAs) for glufosinate (US-EPA 2016c), dicamba (US-EPA 2022a), 2,4-D (US-EPA 2017b), quizalofop-p-ethyl (US-EPA 2014a), and glyphosate (US-EPA 2019f), and these risks assessments incorporated here by reference as part of hazard assessment for plants. The reader is referred to these ERAs for a more detailed discussion of the potential effects of these herbicides on aquatic plants. The EPA uses these risk assessments in establishing herbicide label use requirements that are intended to limit the adverse effects on non-target plants.

4.3.3.3 Animal Communities

4.3.3.3.1 Birds, Mammals

Intensively cultivated lands, such as commercial cornfields, provide less suitable habitat for wildlife than natural areas. As such, the types and numbers of terrestrial animal species found in and near cornfields will be less diverse as compared to unmanaged lands. Cornfields can, however, provide both food and cover for wildlife, including a variety of birds as well as large and small mammals. The types and numbers of birds that inhabit cornfields vary regionally and seasonally but for the most part the numbers are low. Bird species commonly observed in corn fields include (Best et al. 1990):

- Red-winged blackbird (*Agelaius phoeniceus*)
- Grackle (*Quiscalus quiscula)*
- Horned lark (*Eremophila alpestris*)
- Brown-headed cowbird (*Molothrus ater*)
- Vesper sparrow (*Pooecetes gramineus*)
- Ring-necked pheasant (*Phasianus colchicus*)
- Wild turkey (*Meleagris gallopavo)*
- American crow (*Corvus brachyrhynchos*)
- Blackbird (*Turdus merula*)
- Various quail species.

Following harvest, it is also common to find large flocks of migratory bird species foraging in cornfields, such as Canada geese (*Branta canadensis*), snow geese (*Chen caerulescens*), sandhill cranes (*Grus canadensis*), and various other species (Taft and Elphick 2007; Sherfy et al. 2011).

A variety of larger mammals forage on corn at various stages of plant growth. Large- to medium-sized mammals that are common foragers of cornfields include (Fleharty and Navo 1983; ODNR 2001):

- White-tailed deer (*Odocoileus virginianus*)
- Raccoon (*Procyon lotor*)
- Wild boar (*Sus scrofa*)
- Woodchuck (*Marmota monax*)

The most notable of these is the white-tailed deer which often inhabit woodlots adjacent to cornfields and frequent corn fields for both food and cover, especially in mid-summer. Agricultural crops, particularly corn and soybean, comprise a major portion of deer diets in Midwestern agricultural regions; deer are considered responsible for more corn damage than any other wildlife species (MacGowan et al. 2006). Cornfields are vulnerable to deer damage from emergence through harvest, although damage to corn at the tasseling stage most directly impacts yield (Stewart et al. 2007). Losses to crop yield from feeding by raccoons have also been documented (Beasley and Rhodes Jr. 2008). Mature corn has been shown to constitute up to 65% of the diet of raccoons in some areas prior to harvest (MacGowan et al. 2006).

As with larger mammals, small mammal use cornfields for shelter and forage. Some of the more common small mammals common to corn fields are (USDA-NRCS 1999; U-Illinois-Ext 2000; Sterner et al. 2003).

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

4.3.3.3.2 Fish

There are around 790 species of freshwater fish in the United States (Warren and Burr 1994). In Iowa alone, over 150 species of freshwater fish have been identified (Iowa-DNR 2020). More native fishes (at least 375 species) occur in the Mississippi basin than in all of Europe. Nongame fishes constitute around 89% of U.S. fish species. Many of the gamefish (e.g., trout, bass, catfish) are used for human consumption. Of the states with the most fish species, the majority are concentrated in the South and, to a lesser extent, the Midwest. Most of the states where corn is grown have well over 100 different freshwater species. Different water bodies—ponds, lakes, marshes, streams, rivers—will support distinct fish communities.

As of 2008, nearly 40% of the fish species in freshwater habitats were at some level of imperilment (Figure 4-26). In midwestern and southeastern states where corn is commonly grown, all states had 40 or more species classified as imperiled (Jelks et al. 2008). Threats defined include not only physical habitat loss but also perturbations caused by factors such as sedimentation, chemical pollution, dewatering, and anthropogenic modifications to natural channels or flow regimes. Under the Endangered Species Act (ESA), plant and animal species may be listed as either endangered or threatened. “Endangered” means a species is in danger of extinction throughout all or a significant portion of its range. “Threatened” means a species is likely to become endangered within the foreseeable future. States have their own ESA-type laws, so species can have different Threatened/Endangered statuses at the federal and state levels. The USGS typically refers to the federal status unless otherwise noted. "Imperiled" or "at risk" are not legal terms under ESA, but biological terms used by scientist in assessing environmental health. Generally speaking, imperiled species are animals and plants that are in decline and may be in danger of extinction. Those terms can include species that are at low populations and near extinction but still not legally protected under ESA.

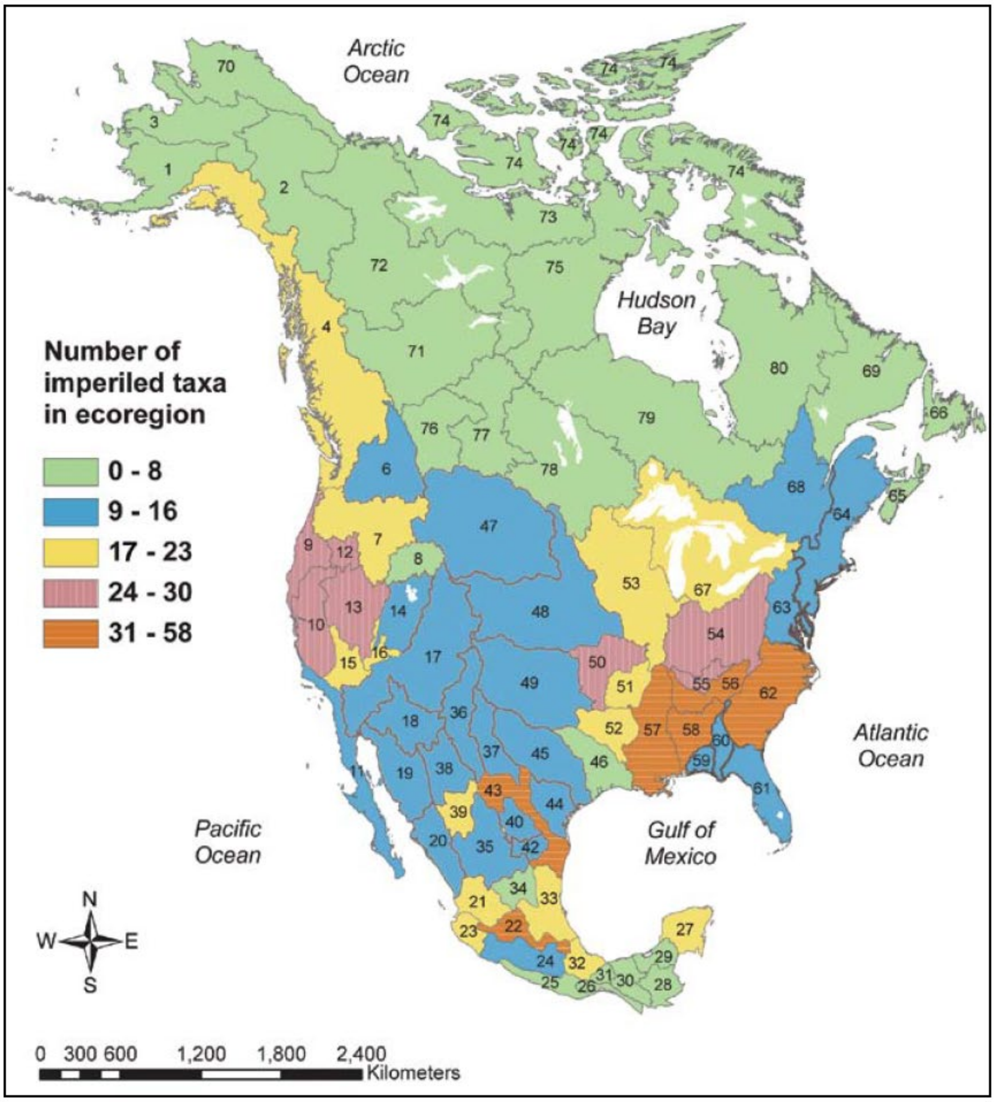

Figure 4-26. Number of Imperiled Freshwater and Diadromous North American Fish Taxa by Ecoregions
Source: (Jelks et al. 2008)

4.3.3.3.3 Invertebrates

Although certain terrestrial invertebrates in corn fields are considered pests, such as the European corn borer (*Ostrinia nubilalis*) and the corn rootworm (*Diabrotica* spp.), the majority are beneficial, performing valuable functions; they pollinate plants, contribute to the decay and processing of organic matter, reduce weed seed populations through predation, cycle soil nutrients, and prey on other insects and mites that are considered to be plant pests (Landis et al. 2005). Some of these beneficial species include the convergent lady beetle (*Hippodamia convergens*), carabid beetles, caterpillar parasitoids (e.g., *Macrocentrus cingulum*), and predatory mite (*Phytoseiulus persimilis*) (Landis et al. 2005; Shelton 2019). Earthworms, termites, ants, beetles, and millipedes contribute to the decay of organic matter and the cycling of soil nutrients (Ruiz et al. 2008).

4.3.3.3.4 Potential Effects on Animal Communities

MON 87429 corn is compositionally (apart from the HR traits) and nutritionally similar to other dent corn varieties (Bayer 2019a). Consumption of MON 87429 corn grain or other plant parts by wildlife, whether vertebrates or invertebrates, would provide the same general nutritional benefits as other dent corn varieties.

MON 87429 corn differs, however, from other varieties in the four herbicide resistant trait genes, and gene products produced. MON 87429 corn hybrids would influence the types of herbicides used in U.S. crops, and thereby the potential exposure of wildlife to these herbicides. Thus, conceptually, the potential risks to wildlife, as a matter of hazard assessment, would be from (1) exposure to the HR trait genes and gene products via consumption of the kernel or other plant parts, this type of feeding largely limited to granivorous insects, foraging birds, rodents, and larger mammals, and (2) exposure to the herbicides MON 87429 corn facilitates use of. Exposure to herbicides could result from consumption of plant material immediately after spraying, or exposure to spray drift or vapors during and post-application. As discussed above under 4.3.1.3–Potential Effects on U.S. Corn Production, there could be increased herbicide use with MON 87429 corn hybrids. Hence, conceptually, there could be increased risk presented to wildlife if there is increased herbicide use with this crop variety.

APHIS has previously evaluated the *pat*, *dmo*, and *cp4 epsps* trait genes and gene products in previous EAs and EISs (USDA-APHIS 2020d), and provides a summary of the safety of these trait gene/gene products later in this EIS in Section 4.3.4; no risks to vertebrate or invertebrate wildlife communities have been identified. The *ft_t*/FT_T trait could be considered somewhat novel in that it is a modified version of the R-2,4-dichlorophenoxypropionate dioxygenase gene (*Rdpa*) from the soil bacteria *Sphingobium herbicidovorans*. Rdpa is a type of bacterial enzyme that are classified as aryloxyalkanoate dioxygenases (AADs); similar enzymes (e.g., AAD-1, AAD-12) have been used in prior soybean, corn, and cotton crops to confer 2,4-D resistance (Wright et al. 2010; USDA-APHIS 2020d). APHIS has previously reviewed the genes and gene products *aad-1*/AAD-1 and *aad-12*/AAD-12; APHIS found no risks to wildlife associated with these transgenes and gene products (e.g., petitions 09-233-01p, 13-262-01p, 11-234-01p (USDA-APHIS 2020d)). None of the trait proteins possess any allergenic characteristics (Monsanto 2019). These transgenic trait proteins would be digested—broken down by gastric fluids and proteases into smaller chains of amino acids, in vertebrate and invertebrate digestive systems, and considered physiologically benign (Berg et al. 2002; Klowden 2013; Holtof et al. 2019). Based on the similarity of the *ft_t*/FT_T trait to other AAD enzymes, it is unlikely that the introduced *ft_t*/FT_T trait would present any risk to wildlife.

Herbicides: Beneficial Insects, Birds, Herbivorous Mammals

Relative to the particular herbicides used with MON 87429 corn, discussed in this EIS, there could be some indirect effects on animal communities via impacts on non-target vegetation that provides food and habitat for wildlife—this could include trophic level impacts, such as impacts on insects that feed on vegetation, and subsequent potential effects on birds that feed on insects—the majority of birds rely on insects for at least part of their diets (CCE 2022).

As previously discussed, herbicide spray and vapor drift can adversely impact neighboring crops, as well as non-crop plants in natural areas, and on residential/commercial properties. As of 2016 the EPA received reports of off-target movement of dicamba impacting crops and natural areas (US-EPA 2021d). In brief, over the last several years reports have emerged of herbicide spray/vapor drift causing damage to trees and native plants across the Midwest and South, from forests, nature preserves, state parks, and wildlife refuges, to residential and resort properties (Unglesbee 2018b; Hettinger 2020).

The synthetic-auxin herbicides dicamba and 2,4-D have typically been applied early in the growing season, however, with the more recent transgenic cotton and soybean crop varieties, these herbicides have been used later in the season when temperatures are warmer and more plant species are leafed out. Issues with spray/vapor drift can be compounded by late spring/summer application for post-emergent weed control. Trees, shrubs, and flowering plants that are sources of nuts, seeds, pollen, nectar, and cover for wildlife are particularly sensitive during the spring application periods when plants are in the stages of budding and leaf emergence. Herbicide drift is of higher risk during the mid-summer and later summer months when air temperatures are warmer. As previously discussed, in some states dicamba use is typically restricted during late summer, owing to the risk of volatilization and drift.

One of the reasons dicamba and 2,4-D drift can be an issue is that synthetic auxins, which function as plant hormones, can affect a wide variety of broadleaf plants at relatively low doses. For example, a dose equivalent to 0.005% of the labeled rate of dicamba can injure soybean, and it only takes about 0.1% of the labeled rate of 2,4-D to injure grapes (Hartzler 2016). Drift of sprays or vapors of dicamba, and some formulations of 2,4-D, owing to their efficacy as auxin mimic herbicides, and effects on a wide variety of broadleaf plants at low doses, could potentially result in off-target effects on plants in natural areas, or on residential or commercial properties, as a result of the use of these herbicides. Herbivorous animals that depend on plants for sustenance (e.g., deer, rabbit, squirrel, birds) could be affected by poor quality plant material, resulting from herbicide spray or vapor drift, and the need for animals to spend more time foraging to acquire sufficient food.

The potential effects of herbicide drift offsite on nearby plants and associated populations of beneficial insects (e.g. pollinators, predators and parasitoids) and birds can be of concern (Bohnenblust et al. 2016; NAS 2020). As an example, in 2019 and 2020, the Audubon Society led a community science project to monitor and document dicamba herbicide damage to vegetation on public lands in Arkansas (NAS 2020). Audubon staff and trained volunteers made 363 observations of apparent dicamba injury on a variety of plants across 20 eastern Arkansas counties. Plant species impacted, which included sycamore, oak, pawpaw, redbud, and trumpetvine, were growing on public lands such as university research farms, wildlife management areas, city parks, cemeteries, and along county and state roads. Observations of injury included three state natural areas that harbor the endangered species Red-cockaded Woodpecker and Pondberry (NAS 2020).

Herbicide drift into areas downwind of crop fields and injury to flowering of plants can result in decreased visitation by pollinators and other beneficial insects. For example, one study found that when field margin plants were exposed to dicamba doses from simulated drift, the floral and pollinator resource capacity of the landscape was reduced by 20% (WSSA 2018). This type of drift-induced damage could decrease populations of pollinator and natural enemy communities in areas where dicamba, or other herbicides prone to drift, are used (Bohnenblust et al. 2016). Insects pollinate around 87.5% of all plants

(90% of flowering plants) (Ollerton et al. 2011), and pollinators provide pollination services to dozens of crop varieties, such as canola, cucumber, pear, and squash (Mirocha et al. 1996; Klein et al. 2007).

Research has been done on the specific impacts of herbicide drift on bird habitat and food sources, herbicides prone to drift can harm plants that birds, and the prey of birds, such as insects, depend on (Knuffman et al. 2020; NAS 2020). Around 96% of terrestrial bird species rear their young on insects (CCE 2022). The effects of herbicide drift on plants that harbor insects important to birds can include reduced flowering and seed production, reduced number of flowers/seeds, lower fecundity, and modify plant morphology and development (Ruhl 2008; Bohnenblust et al. 2016; Wells et al. 2019).

Bohnenblust et al. (2016) examined the effects of dicamba drift on the crop species alfalfa (*Medicago sativa*), which requires insect pollination to produce seeds, and the native plant species common boneset (*Eupatorium perfoliatum*), which is attractive to a wide range of pollinator species. The researchers found that exposure to drift-level doses of dicamba reduced flowering in both plant species. Herbicide-damaged common boneset experienced significantly reduced visitation by insect species, including honeybees (pollinators) and syrphid flies (natural enemies). This study found that both plant species were susceptible to very low doses of dicamba—that just 0.1% to 1% of the expected field application rate can negatively influence flowering. By extension, Bohnenblust et al. (2016) concluded that other broadleaf plant species are likely similarly susceptible to this sort of damage from drift-level doses of dicamba.

Plants and trees can support an impressively diverse number of lepidopteran species, providing food sources and reproductive habitat for birds (Table 4-24). Reduced caterpillar biomass or survival on herbicide-affected plants could impact food resources for birds; insectivorous birds might need to travel farther to collect sufficient caterpillars or other insects to feed their young (Knuffman et al. 2020). In North America, more than 100 species of birds depend on caterpillars as part of their diet, and insect larvae provide a majority of the diets for birds like the Tennessee Warbler, Red-eyed Vireo, and Rose-breasted Grosbeak. The yellow-billed and black-billed cuckoos have the ability to ingest up to 100 tent caterpillars per day (Renault 2020).

Table 4-24. Plant Genera Supporting *Lepidoptera* Species in the Mid-Atlantic United States

Rank	Plant genus	Common name	Lepidoptera richness
1	*Quercus*	Oak	534
2	*Prunus*	Cherry; Plum	456
3	*Salix*	Willow	455
4	*Betula*	Birch	411
5	*Populus*	Poplar; Cottonwood	367
6	*Malus*	Crabapple	308
7	*Vaccinium*	Blueberry; Cranberry	294
8	*Acer*	Maple	297
9	*Alnus*	Alder	255
10	*Carya*	Hickory	235
11	*Ulmus*	Elm	215
12	*Pinus*	Pine	201
13	*Crataegus*	Hawthorn	168
14	*Rubus*	Blackberry; Raspberry	163

15	*Picea*	Spruce	150
16	*Fraxinus*	Ash	149
17	*Tilia*	Basswood	149
18	*Pyrus*	Pear	138
19	*Rosa*	Rose	135
20	*Corylus*	Filbert	131

Source: (Tallamy and Shropshire 2009)

On average, native plants support significantly more caterpillar species than non-native plants (Burghardt et al. 2008; Tallamy 2021). Native woody plants used as ornamentals support 14-fold more Lepidoptera than introduced ornamental species (Tallamy and Shropshire 2009). Fifteenfold more native Lepidoptera occurred on native ornamentals than on introduced ornamentals (Tallamy and Shropshire 2009). In general, woody plants (e.g., trees, shrubs) support many more Lepidoptera species than do herbaceous species (e.g., plants with flexible, green stems with few to no woody parts). This may be due to the fact that woody plants in general are both longer lived and larger than most herbaceous plants and thus may be easier targets for insectivorous birds to exploit (Tallamy and Shropshire 2009).

Research and empirical evidence indicates that the majority of phytophagous insect species are restricted to eating vegetation from plant lineages with which they share an evolutionary history, or, more precisely, plants that produce specific secondary metabolic compounds (e.g., see review by (Tallamy and Shropshire 2009)). In other words, caterpillars and other insect larvae, an important food source for birds, are particular about what they feed upon (Tangley 2015). Up to 90% of all phytophagous insect species are specialists that have evolved in concert with only one or a few plant lineages (Bernays and Graham 1988; Janzen 1988; Novotny et al. 2006). Many species of generalists, with a large list of hosts over the entire range of the species, actually specialize on only one or a few host lineages locally (Fox and Morrow 1981; Tallamy and Shropshire 2009). Thus, most lepidopteran populations may be functionally constrained to exploiting a limited group of plants. Such restricted interactions typically require evolutionary time spans to develop (Kennedy and Southwood 1984), and have provided the ability of specialists to track their hosts in time and space, to circumvent physical and chemical defenses through behavioral and physiological adaptations, and to convert their host's tissues to insect biomass quickly and efficiently (Strong et al. 1984; Lewinsohn et al. 2005). The evolution of specialized abilities to eat the tissues of one particular plant lineage usually, in turn, decreases an insect's ability to eat other plants that differ in phenology, chemistry, or physical structure (Ehrlich and Raven 1964; Tallamy and Shropshire 2009).

To survive, birds need insects and both require sufficient healthy plants for food and habitat (Tallamy and Shropshire 2009; Baisden et al. 2018). Aerial insectivores (birds that forage on aerial insects) have experienced significant population declines in North America. Various hypotheses have been proposed for these declines, but current evidence suggests multiple factors could be operating in combination during their annual migratory cycles between breeding and nonbreeding areas. Potential drivers include decreased prey abundance, direct or indirect impacts of environmental contaminants, habitat loss, phenological changes due to warming climate, and conditions on migratory stopover or wintering grounds (Spiller and Dettmers 2019). While no single threat appears to be the cause of aerial insectivore declines, existing evidence suggests that several of these factors could be contributing to the declines at different times in the lifecycle. Based on current evidence, Spiller and Dettmers (2019) proposes that changes in the availability of high-quality prey, with variability across breeding and nonbreeding grounds, reduce various combinations of fledging success, post-fledging survival, and nonbreeding season body condition of aerial insectivores, resulting in species and geographic differences in population trends.

Declines in abundance of insectivorous birds have been correlated with agricultural intensification in the United States (Murphy 2003), the United Kingdom (Chamberlain et al. 2000; Donald et al. 2001; Benton et al. 2002), and across Europe (Reif 2013), suggesting that certain agricultural practices can affect birds through decreases in food quality or quantity. Some insectivores, such as swallows, often use agricultural landscapes for foraging, and habitat as well (see review by (Spiller and Dettmers 2019)).

Monarch Butterfly

In 2018, the Center for Biological Diversity (CBD) released a report describing a potential threat to monarch butterflies (*Danaus plexippus plexippus*) posed by an increased use of dicamba (Donley 2018). Monarchs rely on nectar from flowering plants throughout their migration—any significant reduction in the flowering of plants along the migration route could impact adults' ability to make the migration, survive the winter, and breed again in the spring (Donley 2018). Milkweed (*Asclepias* spp.) is the sole host plant for the monarch butterfly; it is the only plant adults lay eggs on, and on which monarch caterpillars feed (USDA-FS 2020). Thus, the plant is intrinsically tied to monarch reproductive success. Dicamba's ability to damage or kill milkweed is well established: milkweed is listed as a weed effectively controlled by dicamba on the label of dicamba products (US-EPA 2020t).

Prior to the introduction of glyphosate resistant crops in the late 1990s, about 50% of Iowa's crop fields were infested with low densities of milkweed (Hartzler 2018). A decade later both the number of fields infested and the amount of milkweed in fields declined by more than 80% (Hartzler 2010). Hoey et al. (2016) evaluated the response of common milkweed to low doses of dicamba, and the influence dicamba injury had on oviposition by monarchs. Doses simulating drift equivalent to 0.1% and 1.0% of the labeled rate (0.5 lb/acre) caused distortion of leaves that emerged following application, but the emergence rate of leaves was not affected. The investigators did not determine milkweed biomass; although it is suspected some reduction would occur, much less than 50% (Hartzler 2018). The study by Hoey et al. (2016) found that egg laying by monarchs was not affected by dicamba injury to milkweed.

The decline in the monarch population is complex with many contributing factors; such as habitat fragmentation, loss of habitat in both the overwintering and summer reproduction areas, the availability of late season nectar plants, climate change, neonicotinoids, and disease and predators (Agrawal 2019). Most studies on monarch butterfly migratory dynamics have not shown that suppression of milkweed, alone, by glyphosate or other herbicides to be the cause of monarch decline (NAS 2016; Agrawal 2019). One recent found that monarch numbers began falling decades before glyphosate-based herbicides were used in agriculture (Boyle et al. 2019). Factors such as climate change, deaths during migration and loss of overwintering habitat in Mexico have also been implicated. Dr. Anurag Agrawal, Professor of Ecology and Evolutionary Sciences and Faculty Fellow at the Atkinson School of a Sustainable Future at Cornell University, concluded that the planting of milkweed would be beneficial, although this in and of itself would not increase populations or save monarch populations from decline (Maeckle 2016). However, herbicides as contributing factor remains a debate. These factors considered, the availability of nectar producing plants, populations of which could be damaged or reduced by the drift of herbicide spray or vapors, could be of concern relative to potential effects on migrating monarch populations. Bob Hartzler, a weed scientist with Iowa State University, is of the opinion that herbicide use, including dicamba, and monarchs can co-exist, but it requires appropriate herbicide product selection and responsible application to protect resources adjacent to crop fields (Hartzler 2018).

Due to the population decline in monarch butterfly, the Natural Resources Conservation Service (NRCS) and others—including the USFWS—have developed a collaborative landscape level partnership to benefit the monarch butterfly (USDA-NRCS 2020b). The primary focus of the partnership is the design and application of selected NRCS conservation practices to benefit the monarch butterfly. Much of this work focuses on planting and enhancing stands of milkweed and high-value nectar producing plants. Other actions implemented by the NRCS include the application of conservation practices in the use of pesticides that are of benefit to the monarch butterfly.

Aquatic Biota

Herbicides used on crops and non-crop sites can potentially affect aquatic animals via run-off. Herbicide use patterns change as new biotech crops and uses are approved, and uses are discontinued or restricted by the EPA. Among aquatic stressors, pesticides rank 16th, with pathogens, sediment, nutrients, oxygen depletion, temperature, metals, and polychlorinated biphenyls (PCBs) being the top seven stressors for rivers and streams—in that order (US-EPA 2019i). Among pesticides, atrazine, DDT (banned), dieldrin (banned), chlordane (banned), chlorpyrifos (banned on food crops), diazinon (banned), toxaphene (banned), and unspecified pesticides have been the most common cited contaminants in impaired rivers and streams. For bays and estuaries, pesticides have ranked as the 8th most common cause of impairment, following PCBs (banned), nutrients, mercury (regulated), turbidity, dioxins (no longer produced in the United States), toxic organics, and metals (US-EPA 2019i).

The U.S. Geological Survey (USGS) conducted a study comprising 100 streams in the Midwestern United States during May–August 2013. While this is 2013 data (most recent available for majority of herbicides relative to aquatic environments), herbicide use patterns have not substantially changed (e.g., see Table 4-4). A total of 183 pesticide compounds (94 parent pesticides and 89 degradates) were detected in one or more water samples, consisting of 98 of the 124 herbicides evaluated, 71 of the 88 insecticides evaluated, and 14 of the 16 fungicides. Corn and soybean herbicides, namely, atrazine, metolachlor, acetochlor, and their degradates—these herbicides historically used in the greatest quantities—tended to have the highest detection frequencies and concentrations, consistent with past studies (see review by (Nowell et al. 2018)). Other herbicides frequently detected at agricultural sites were dimethenamid and its degradates, sulfentrazone, propazine, 2,4-D, prometon, and glyphosate. Of note, the herbicides 2,4-D, glyphosate, and prometon were detected at higher concentrations and more often at urban sites, as opposed to agricultural sites. At agricultural sites, glyphosate occurrence was found in 41% of samples, atrazine in 57% of samples, metolachlor 32%, and acetochlor 16% of samples (Nowell et al. 2018).

Herbicides are developed to control plants and thereby target physiological processes that are specific to plants (e.g., plant hormone disruption, amino acid/protein synthesis pathways, photosynthesis inhibitors). As a result, most herbicides do not present a significant hazard to aquatic animals, in terms of direct effects (Solomon et al. 2013). Exceptions to this general rule are uncouplers of oxidative phosphorylation and some herbicides that interfere with cell division—processes common among plants and animals (Solomon et al. 2013).

Most herbicides that occur in surface waters are found at very low concentrations in the ng/L range (parts per trillion; ppt), which for the majority of herbicides are levels well below that which would elicit a physiological response in fish, crustaceans, or amphibians (Solomon et al. 2013; USGS 2016). For example, in the USGS study, 2,4-D was detected in the range of 60 ng/L (ppt), dicamba 500 to 2,400 ng/L (ppt), and glyphosate around 200 ng/L (ppt) (Nowell et al. 2018). However, concentrations can spike into the µg/L (parts per billion; ppb) range following rain events that flush herbicides into nearby surface waters with potentially transient adverse effects on some aquatic species. Glufosinate has been detected in the range of 0.26 µg/L (ppb) (Scribner et al. 2007). Other studies have found 2,4-D surface water concentrations around 0.16 µg/L, and dicamba 0.11 µg/L (Belden et al. 2007).

Table 4-25 provides example data of typical concentrations of herbicides detected in surface waters, and EPA Aquatic Life Benchmark Criteria toxicity thresholds. There are various chemical forms of herbicides used in developing commercial herbicide products (e.g., 2,4-D dimethyl salt, 2,4-D choline salt, dimethylamine salt, dicamba sodium salt, dicamba diglycoamine salt). Each chemical form will differ in toxicity, as well as the particular herbicide formulation the active ingredient is mixed with.

Table 4-25. Example Herbicide Concentrations Detected in Surface Waters and Toxicity to Aquatic Biota

Pesticide	Concentration Reported (µg/L)	EPA OPP Aquatic Life Benchmarks (µg/L): Fish		Invertebrates		Non-vascular Plants	Vascular Plants	Microalgae*
		Acute[1]	Chronic[2]	Acute[3]	Chronic[4]	Acute[5]	Acute[6]	Acute[3]
2,4-D				12,500			299	
2,4-D acids and salts		> 40,800	23,600	12,500	16,050	3,880	299	
2,4-D esters		130	79	1,100	200	152	330	
2,4-D, 2-ethylhexyl ester	0.16		79	1,700		152	330	33,000
2,4-D, Butoxyethyl ester		214			200			
2,4-D, Diethanolamine salt		> 40,800			16,050		299	
2,4-D, Dimethylamine salt			23,600			3,880		
2,4-D, Isopropyl ester		130		1,100				
2,4-DB		7,150	1,660	12,500	1,500	932	83	
2,4-DB-DMAS		7,150	1,660	12,500	1,500	932	83	
Dicamba acid	0.11	14,000		> 50,000		61	> 3250	3,700
Dicamba, dimethylamine salt		488,500		781,500				
Dicamba, sodium salt		253,600		17,300				
Glufosinate ammonium	< 0.26	> 156,000	50,000	325,500	31,000	72	1,470	7,900
Glufosinate degradates **		> 49,450		18,500		53,000	> 97200	
Glyphosate		21,500	25,700	26,600	49,900	12,100	11,900	
Glyphosate degradate ***		249,500		341,500				
Glyphosate isopropylamine salt	0.2	34,700						12,540
Quizalofop ethyl		230	11	1,060		> 1770	> 82.8	
Quizalofop-p-ethyl	< 2.04	360	10	175	26,600	41,000	35	41,000

* *Pseudokirchneriella subcapitata* ** 2-acetamido-4-methylphosphinico-butanoic acid (NAG), 2-methylphosphinico-acetic acid (MPA), 3-methylphosphinicopropionic acid (MPP), Methylphosphinico-formic acid (MPF) *** Aminomethyl phosphoric acid (AMPA) 1. Benchmark = Toxicity value x LOC. For acute fish, toxicity value is generally the lowest 96-hour LC50 in a standardized test (usually with rainbow trout, fathead minnow, or bluegill), and the LOC is 0.5. 2. Benchmark = Toxicity value x LOC. For chronic fish, toxicity value is usually the lowest NOEAC from a life-cycle or early life stage test (usually with rainbow trout or fathead minnow), and the LOC is 1. 3. Benchmark = Toxicity value x LOC. For acute invertebrate, toxicity value is usually the lowest 48- or 96-hour EC50 or LC50 in a standardized test (usually with midge, scud, or daphnids), and the LOC is 0.5. 4. Benchmark = Toxicity value x LOC. For chronic invertebrates, toxicity value is usually the lowest NOAEC from a life-cycle test with invertebrates (usually with midge, scud, or daphnids), and the LOC is 1. 5. Benchmark = Toxicity value x LOC. For acute nonvascular plants, toxicity value is usually a short-term (less than 10 days) EC50 (usually with green algae or diatoms), and the LOC is 1. 6. Benchmark = Toxicity value x LOC. For acute vascular plants, toxicity value is usually a short-term (less than 10 days) EC50 (usually with duckweed) and the LOC is 1.

Source: Toxicity Data (US-EPA 2020e). Herbicide Concentration Data (Belden et al. 2007; Scribner et al. 2007; Nowell et al. 2018).

In general, herbicides—to include chemical forms of 2,4-D, glyphosate, glufosinate, dicamba, and quizalofop-p-ethyl— primarily present a potential hazard to aquatic animals by impacting aquatic plants and algae, which can in turn affect food webs or/and aquatic habitats. While indirect effects might occur when aquatic plants are intentionally controlled by direct treatment of surface waters with an herbicide (e.g., 2,4-D and glyphosate are registered for use to control dense growths of algae or aquatic weeds via direct application to surface waters), indirect effects via run-off from fields (containing any residual herbicide) into surface waters appears to be unlikely, as runoff and subsequent concentrations in surface waters are, for the most part, much less than those that could directly affect plants (Solomon et al. 2013; Nowell et al. 2018).

Meador and Frey (2018) evaluated 10 stressors including riparian area disturbance, riparian vegetative cover, instream fish cover, streambed sedimentation, streamflow variability, total nitrogen, total phosphorus, dissolved oxygen, pesticides, and bed sediment contaminants. Fish community response variables included a measure of observed/expected taxonomic completeness; species-specific tolerances to nitrogen, phosphorus, dissolved oxygen, and water temperature; the percent of species classified as macrohabitat generalists; and an index of pesticide toxicity to fish. Their analyses indicated that fish communities primarily responded to increased streambed sedimentation, habitat disturbance, and total nitrogen (Meador and Frey 2018).

Relyea (2005) conducted a mesocosm study that examined herbicide application rates that translated to 0.12 mg 2,4-D/L, and 3.8 mg glyphosate/L (the only herbicides in this study relevant to MON 87429 corn). Species richness was reduced by 22% with Roundup (glyphosate), whereas 2,4-D had no effect. Roundup and 2,4-D had no effects on zooplankton, insect predators, or snails. Moreover, the herbicide 2,4-D had no effect on tadpoles. However, Roundup (glyphosate) eliminated two species of tadpoles and nearly exterminated a third species, resulting in a 70% decline in the species richness of tadpoles (Relyea 2005), discussed further below.

Glyphosate and Potential Effects on Amphibians

The toxicity of glyphosate to amphibians, due to widespread use of the herbicide, has been a topic of research interest. Amphibians may have increased sensitivity compared with other vertebrates due to their developmental and life history characteristics, and reliance on both the aquatic and terrestrial environments.

A large number of laboratory studies have been conducted on commercial formulations of the glyphosate herbicides containing either a POEA (polyethoxylated tallow amine (also polyoxyethyleneamine, POEA)) surfactant or an undisclosed surfactant possessing a toxicity similar to POEA (e.g., Roundup Original, Roundup Original MAX, Roundup Weathermax, Vision, Cosmo-Flux). These lab studies found LC50 values ranging from 0.4 to 11.6 mg a.e./L (ppm)(see review by Relyea (2012)). Based on the standard toxicity classifications used by the EPA, these commercial formulations range from slightly toxic (10 mg/L < LC50 < 100 mg/L; ppm) to highly toxic (0.1 mg/L < LC50 < 1 mg/L; ppm).

In a USGS survey of Midwestern surface waters, the glyphosate detection frequency was 87%, with 41% of samples in the 200 ng/L range (ppt) (Nowell et al. 2018). Other studies have found median concentration in rivers, streams, lakes, and ponds around 30 ng/L (ppt), although maximum detections have been in the range of 300 ug/L (ppb) for lakes and ponds (Battaglin et al. 2014; Nowell et al. 2018).

Much of the toxicity of commercial glyphosate formulations has been attributed to the surfactant portion, particularly POEA—rather than glyphosate itself—which has a range of LC50 96-h values between 0.65 and 7.4 mg a.e./L (ppm) (Annett et al. 2014).

Current literature suggests that the sensitivity of amphibians to glyphosate-based herbicides is formulation-, species-, and life stage–specific (Relyea 2012; Annett et al. 2014). Glyphosate-based herbicides with POEA or other tallowamine surfactants are moderately toxic or even highly toxic to larvae, but so are some new glyphosate-based herbicide formulations that contain unspecified surfactants. Overall, glyphosate-based herbicides can be classified as moderately toxic and glyphosate as slightly toxic to practically nontoxic to amphibian larvae (Wagner et al. 2013; US-EPA 2015b, 2019f).

If and how glyphosate-based herbicides and other pesticides may contribute to amphibian population declines is not entirely clear due to lack of sufficient data on how natural populations are affected by active ingredients, surfactants, degradation products, and other factors. Amphibian declines are a global phenomenon that has continued unabated in the United States since at least the 1960's. Declines are occurring even in protected national parks and refuges. The average decline in amphibian populations is 3.79% per year, although the decline rate is more severe in certain regions of the United States, such as the West Coast and the Rocky Mountains (USGS 2020).

Research suggests that amphibian populations are declining worldwide, and that there is no single individual factor—thus no simple solution—to halting or reversing these declines (USGS 2020). While every region in the United States has suffered amphibian declines, threats differ among regions, and include:

- Human influence from the Mississippi River east, including the metropolitan areas of the Northeast and the agricultural-dominated landscapes of the Midwest
- Disease, particularly a chytrid fungus in the Upper Midwest and New England
- Pesticide applications east of the Colorado River
- Climate changes across the Southern U.S. and the West Coast

U.S. EPA Ecological Risk Assessments

All of the herbicide active ingredients that would be used with MON 87429 corn are currently labeled for use on a variety of other crops as well as in non-agricultural settings (e.g., residential and commercial properties). The risks of pesticide use on wildlife, to include risks from aggregate uses, are assessed by the EPA as part of the pesticide registration process and are regularly reevaluated by EPA for each pesticide to maintain its registered status under FIFRA. The EPA has conducted ecological risk assessments (ERAs) for glufosinate (US-EPA 2016c), dicamba (US-EPA 2022a), 2,4-D (US-EPA 2017b), quizalofop-p-ethyl (US-EPA 2014a), and glyphosate (US-EPA 2019f), and these risks assessments incorporated here by reference as part of hazard assessment for wildlife. The reader is referred to these ERAs for a more detailed discussion of the potential effects of these herbicides on wildlife. The EPA uses these risk assessments in establishing herbicide label use requirements that are intended to limit the risks of exposure of wildlife to pesticides, and adverse effects on wildlife communities. Based on current data and EPA label use requirements, the use of glufosinate, dicamba, 2,4-D, quizalofop-p-ethyl, and glyphosate in production of MON 87429 corn/hybrids would present minimal risks to wildlife when used according to EPA label requirements.

Synopses on potential herbicide toxicity are provided below, for more detailed analyses see the EPA ERAs referenced above.

Glyphosate

Glyphosate is one of the most widely used herbicides in the United States. Glyphosate products are registered for use in a wide array of both agricultural and nonagricultural settings. Agricultural uses include stone and pome fruits, citrus fruits, berries, nuts, vegetables, legumes, cereal grains, and other field crops. Glyphosate products are also registered for use on the following glyphosate-resistant crops: corn, soybean, cotton, canola, sugar beets, and alfalfa. Registered non-agricultural uses include tree injections, residential spot treatments, aquatic areas, forests, rights-of-way, recreational turf, ornamentals, non-food tree crops, and Conservation Reserve Program land (US-EPA 2019f). There are over 750 products containing glyphosate for sale in the United States, to both crop producers and general public (NPIC 2020c).

Technical grade glyphosate is considered of low potential toxicity to mammals via acute oral, inhalation, and dermal routes of exposure. Studies indicate that the surfactant polyoxyethyleneamine or polyethoxylated tallow amine (both abbreviated POEA), used in some commercial glyphosate-based formulations, may however be more toxic by the oral route of exposure than glyphosate itself (NPIC 2020d). Technical grade glyphosate ranges from slightly toxic to practically non-toxic to freshwater fish and invertebrates, as well as estuarine and marine organisms. Formulated glyphosate products range from moderately toxic to practically non-toxic to freshwater fish. Surfactants in the class of polyoxyethylenamines (POEA) are used in some glyphosate formulations. POEA is moderately toxic to very highly toxic to freshwater fish (NPIC 2020d). Glyphosate is considered no more than slightly toxic to birds, and is practically nontoxic to honeybees (US-EPA 2015b; NPIC 2020d).

Glufosinate

Glufosinate is registered for use on a variety of crops, including apples, berries, canola, citrus, corn, cotton, currants, grapes, grass grown for seed, potatoes, rice, soybeans, sugar beets, and tree nuts. Non-crop use sites include golf course turf, residential lawns, industrial and residential landscape plantings, utility and roadside rights-of-way, and timber site preparation for tree plantings. Glufosinate is registered for use on transgenic canola, corn, cotton, and soybeans (US-EPA 2016c). There are over 30 products containing glufosinate for sale in the United States, to both crop producers and general public.**Error! Bookmark not defined.**

Various studies with terrestrial and aquatic plants, birds, and aquatic animals exposed to either technical grade or formulated glufosinate have been conducted. Glufosinate is classified as practically nontoxic to mammalian and avian species on an acute oral exposure basis (US-EPA 2016c). The available data indicate that technical grade glufosinate is practically non-toxic to freshwater and estuarine/marine fish and freshwater invertebrates and is moderately toxic to estuarine/marine invertebrates, including mollusks, on an acute exposure basis. Technical grade glufosinate is practically nontoxic to honey bees on both an acute contact and oral exposure basis (US-EPA 2016c).

Dicamba

Dicamba salts have registered uses on right-of-way areas, asparagus, barley, corn, grasses grown in pasture and rangeland, oats, proso millet, rye, sorghum, soybeans, sugarcane, and wheat. Golf courses and residential lawns are also registered (US-EPA 2009). More than 1,100 products sold in the United States that include dicamba, to both crop producers and general public (NPIC 2020f).**Error! Bookmark not defined.**

When used according to EPA label instructions, dicamba is considered to pose minimal hazards to mammals as applied to corn crops (NPIC 2020e). On an acute exposure basis, dicamba is slightly toxic to practically non-toxic to fish and mammals, moderately toxic to practically non-toxic to aquatic invertebrates and birds, and practically non-toxic to honey bees (US-EPA 2022a). Chronic effects from dicamba exposure have been shown in mammals (reduced weight and delayed sexual maturation), birds (reduced number of offspring), and honey bees (reduced weight, survival, and adult emergence). No effects have been observed for fish or aquatic invertebrates (up to the highest concentration tested in those species studies) (US-EPA 2022a).

2,4-D

2,4-D is registered for use on a variety of food/feed sites including field, fruit, and vegetable crops. 2,4-D is also registered for use on turf, lawns, roadsides, aquatic, and forestry applications. Residential homeowner may use 2,4-D on lawns (US-EPA 2017b). Agricultural uses include wheat, field corn, soybeans, summer fallow, hay other than alfalfa, filberts, sugarcane, barley, seed crops, apples, rye, cherries, oats, millet, rice, and pears (US-EPA 2017b). There are over a thousand products with 2,4-D in them that are sold in the United States, to both crop producers and general public (NPIC 2020b).**Error! Bookmark not defined.**

2,4-D generally has moderate toxicity to mammals (US-EPA 2019b), and is classified as moderately toxic to practically non-toxic to birds on an acute oral basis (US-EPA 2017b). All chemical forms for 2,4-D are considered low in toxicity for acute oral, inhalation, and dermal exposures (NPIC 2020b). The available acute toxicity data on 2,4-D indicate that the acid and amine salts are practically non-toxic to freshwater or marine fish (US-EPA 2019b). The esters are highly to slightly toxic to marine or freshwater fish. Thus, potential toxicity to fish and aquatic invertebrates can vary widely depending on chemical form (US-EPA 2019b). Available data from a honey bee acute toxicity study indicated that technical 2,4-D is practically non-toxic to the honey bee (US-EPA 2019b). LC50 values for 24-hour exposures in honey bees (*Apis mellifera*) were estimated to be 104 and 115 µg per bee. Researchers estimated the LD50 at greater than 10 µg/bee, so 2,4-D is considered practically non-toxic. Effects on bee longevity varied according to dose and 2,4-D form (WHO 1989).

2,4-D is not considered hazardous to beneficial insects due to its low insecticidal activity and an adequate safety margin when products containing 2,4-D are used at recommended levels (WHO 1989).

Quizalofop-p-Ethyl

Quizalofop-p-ethyl occurs as a mixture of two different isomers: quizalofop-ethyl and quizalofop-p-ethyl. Quizalofop-p-ethyl is the pesticidal active isomer, and all quizalofop products currently in the marketplace contain this isomer; there are no pesticide registrations for products containing quizalofop-ethyl (US-EPA 2014a).

Quizalofop-p-ethyl is a systemic herbicide registered for use to control annual and perennial weeds in various food/feed and non-food/non-feed crops. Quizalofop-p-ethyl uses include grains, legumes, cotton, garlic, mint, soybean, sugar beets, sunflower, pineapple, and Chinese cabbage. Other uses include cottonwood and poplar plantations and uncultivated areas such as fencerows, roadsides, and paved areas. There are no registered residential uses of quizalofop (US-EPA 2014a).

Quizalofop-p-ethyl is considered slightly toxic to mammals on an acute exposure basis, thus, adverse effects on mammals are not expected (US-EPA 2014a). Quizalofop-p-ethyl is practically nontoxic to birds. However, quizalofop-p-ethyl is classified as highly toxic on an acute basis to freshwater fish and invertebrates, as well as estuarine/marine invertebrates (US-EPA 2014a). Hence, relative to the half-life in soils, run off could be a concern. Quizalofop-p-ethyl is practically nontoxic to bees (US-EPA 2014a).

4.3.3.4 Gene Flow and Potential Weediness of Corn

Gene flow from transgenic crops to conventional and organic cropping systems can adversely affect farmers' net returns on crops, and domestic and international trade.[38] Gene flow from transgenic plants to sexually compatible wild relative species is a topic of concern if the transgene may confer weediness traits to, a wild relative species that could lead to introgression of the trait gene into a wild population,[39] and thereby adversely affect agricultural interests and/or the environment.

4.3.3.4.1 Factors Governing Gene Flow among Crop Plants and Wild Relative Species

Gene flow between sexually compatible transgenic crop plants and conventionally bred crop plants, as well as wild plants, is possible, and an important consideration in the design of field trials, crop seed production, and cultivation of transgenic and conventional crops.

[38] The term "gene flow" can be synonymous with "outcrossing" and the terms are used here interchangeably. Neither term implies the long-term persistence or introgression of gene(s) into a recipient population. A hybrid is the offspring of two genetically dissimilar but sexually compatible species, generally within the same genus, although hybrids between different genera are possible.

[39] Introgression is the permanent incorporation of a gene(s) from one species into the genome of another. Introgression typically follows hybridization and the repeated backcrossing of interspecific hybrids. A prerequisite for introgression from a crop plant gene to a wild relative population is the occurrence of hybrids sufficiently fit to produce progeny, and for such hybrids to repeatedly reproduce—in the wild or under controlled laboratory conditions.

In commercial corn crops gene flow occurs via pollination, delivery of pollen from the male tassel of the plant to the silks of the ear of corn. The physical and biological processes and mechanisms by which pollen mediated gene flow occurs is not unique or different for transgenic or conventionally bred crops. Hence, the likelihood of occurrence of pollen mediated gene flow among all corn varieties (conventional, transgenic, and organic) and wild relative species is generally the same—except for certain lines of corn that have been bred for sterility, which are typically used for breeding purposes. Transgenic plants are no more or less likely to hybridize with wild relatives than their conventionally bred counterparts (Ellstrand 2014). The rate and success of pollen mediated flow is dependent on numerous factors such as the presence, abundance, and distance of sexually compatible plant species; overlap of flowering times among populations; whether the plant is self-pollinated or cross-pollinated; biology and amount of pollen produced; weather conditions, including temperature, wind, and humidity; and the physical and spatial barriers separating the crop from sexually compatible wild relative species.

Gene flow can also be mediated by seed inadvertently entering the environment during transport or being incorporated into a crop field's soil during harvest (e.g., volunteer transgenic plants, discussed below). Seed-mediated gene flow depends on many factors, including the absence, presence, and extent of seed dormancy; various dispersal pathways (animals, humans, water, wind); and environmental conditions—which facilitate or deter seed germination. Seed mediated gene flow from the occurrence of volunteer transgenic plants is an important consideration, as volunteer plants can occur where seed is spilled, or from volunteer plants occurring in subsequent crops planted in the same field. Such transgenic volunteer plant populations can serve as reservoirs from which a transgene could be passed into the genome of a wild relative, or subsequent crop, if the volunteer population is not detected and eliminated.

The salient environmental concern is whether the flow of a transgenic trait gene (i.e., herbicide resistance, insect resistance) to a wild relative species will have adverse ecological consequences. For a significant environmental impact to occur, gene flow would have to lead to the production of a fertile hybrid plant that produces viable offspring, and the resulting transgenic-wild plant hybrid having some type of competitive advantage that can lead, ultimately, to introgression of the transgenic trait gene into a wild plant population. Gene flow itself does not necessitate the increased fitness or persistence of a hybrid population. The transgenic trait gene in a wild relative or other crop plant may very well prove detrimental to the hybrid, or have no effect (Ellstrand et al. 2007; Ellstrand 2014; Goldstein 2014). The ecological consequences of a transgenic trait gene in a wild species depends on the type of trait, the stability of the gene in the genome, the fitness conferred to the hybrid through expression of the trait gene, and ecological factors in the area of the hybrid (Felber et al. 2007; Ellstrand 2014).

It is generally assumed traits that impart increased fitness will persist in populations and those that impart negative effects on plant fitness will not. If a resulting transgenic-wild type hybrid had a competitive advantage over wild populations, it could persist in the environment and potentially disrupt the local ecology. Where the transgenic trait does not provide fitness, and is not deleterious to survival of the hybrid, the transgene may still persist in wild populations with no effects on the local ecology. This could be the case for a number of introduced traits.

In respect to the occurrence of a transgenic-wild type hybrid, gene flow from a transgenic crop plant to wild or weedy relative species does not necessarily constitute an environmental harm in and of itself, nor does it inherently imply environmental damage (Ellstrand 2014). The salient issue is what the resultant ecological consequences of such gene flow to a wild population may be (Ellstrand 2014). Current understanding suggests that the presence of a transgenic trait outside the area of cultivation will likely have little or no adverse consequences unless:

(1) the transgenic trait confers novel or enhanced fitness or weediness to the transgenic-wild relative hybrid, resulting in the evolution of increased weediness or invasiveness in wild type hybrids, or

(2) the transgenic trait confers to transgenic-wild relative hybrid progeny reduced fitness, resulting in a selective disadvantage in wild relative populations (Kwit et al. 2011; Ellstrand 2014).

Hence, in evaluating potential environmental impacts it is not the risk of gene flow itself that is the chief concern, but rather the environmental consequences that could occur as the result of such an event, whether the transgene will persist in a wild population, and whether hybrid or introgressed populations will have adverse effects on ecosystem dynamics.

4.3.3.4.2 Gene Flow among Corn (*Zea mays* L.) and Wild Relative Species

Corn (*Zea mays* L. ssp. *mays*) is one of the oldest domesticated food plants in the world, the origins of which date back to around 5,000 – 3,600 years ago in southern Mexico (de Wet et al. 1978; Eubanks 1995). How corn (*Zea mays* L. subsp. *mays*) evolved is still a matter of investigation, although most investigators agree that corn most likely descended from an annual species of teosinte (*Zea mays* ssp. *parviglumis*), a closely related wild grass endemic to Mexico (Wilkes 1967; Iltis and Doebley 1980; Piperno and Flannery 2001). Teosinte is the common name applied to several distinct wild *Zea* species closely related to corn (*Zea mays* L. ssp. *mays*). Cultivated corn (*Zea mays* L. subsp. *mays*) is sexually compatible with teosinte (*Zea* spp.), with a few exceptions. The closest relative of *Zea* in the United States is among the genus *Tripsacum*, with which corn does not readily hybridize (discussed further below).

Teosinte

Wild teosinte relatives of corn comprise a group of annual and perennial species that occur within the tropical and subtropical areas of Mexico, Guatemala, Costa Rica, Honduras, El Salvador, and Nicaragua (Sánchez González et al. 2018). The natural geographic distribution of teosinte extends from the Western Sierra Madre of the State of Chihuahua, Mexico to the Pacific coast of Nicaragua and Costa Rica, including the western part of Mesoamerica. The Mexican annuals *Zea mays* ssp. *parviglumis* and *Zea mays* ssp. *mexicana* show a wide distribution in Mexico, while *Zea diploperennis*, *Zea luxurians*, *Zea perennis*, *Zea mays* ssp. *huehuetenangensis*, *Zea vespertilio* and *Zea nicaraguensis* have more restricted and distinct ranges, representing less than 20% of the total occurrences (Sánchez González et al. 2018).

Except for *Z. perennis*, *Zea mays* and teosinte cross readily, and their hybrids are fully fertile (de Wet and Harlan 1972). Hybridization and introgression between *Z. mays* and the subspecies *Z. mays* subsp. *mexicana* occurs in Mexico, and has probably been taking place since the advent of corn domestication wherever these two taxa are sympatric (de Wet et al. 1978; Ellstrand et al. 2007). Hybrids appear to maintain their unity of type in the wild (de Wet and Harlan 1972). In general, humans select in the direction of corn (*Zea mays*), and nature strongly favors teosinte over their hybrid, which is less well adapted for natural seed dispersal (de Wet and Harlan 1972). The rate at which domesticated corn crop genes may enter teosinte populations will be limited by genetic barriers, phenological differences, and the relative fitness of the hybrids (Ellstrand et al. 2007).

Teosinte does not appear to be present in the United States other than in botanical gardens or at research stations. The USDA Plants Database lists *Zea mexicana* (Syn. *Z. mays* ssp. *mexicana*) as present in Florida, Alabama, and Maryland, having been introduced from Mexico (USDA-NRCS 2019d). Teosinte has, apparently, occasionally been cultivated in the Southern United States for forage (Hitchcock 1951). The documentation cited for occurrence in Florida only shows distribution of native or naturalized populations in Miami-Dade, Orange, and Levy Counties (Wunderlin et al. 2019). While citations were provided in the USDA Plants Database for distribution in Maryland and Alabama, current Maryland plants databases have no listed *Zea* species, other than *Z. mays* (UMD 2005; MPAWG 2016), nor are any *Zea* species or subspecies other than *Z. mays* (corn) listed in Alabama (Kral et al. 2019).

Zea perennis is listed as occurring in Texas and South Carolina. It is described as having been cultivated at academic research stations in Texas, and established on James Island, South Carolina (Hitchcock 1951). It is not known if the James Island population has persisted. There are no *Zea* species found in the comprehensive online South Carolina Plant Atlas (USC 2019); which catalogues over 3000 species.

Teosinte identified as *Zea mays* ssp. *parviglumis* is listed as having occurred in Miami-Dade County, Florida (Wunderlin et al. 2019), an area that is now largely urban. *Zea diploperennis* and *Zea luxurians* are also listed in the USDA Plants database, but there is no information about the presence of any wild populations in the United States.

Experts familiar with the teosinte collections in the United States, some of whom were involved with revision of the Manual of Grasses for North America (Roché et al. 2007), are not aware of any naturalized or native populations of teosinte currently growing in the United States (USDA-APHIS 2013).

Tripsacum

The closest relative of *Zea* in the United States is the genus *Tripsacum* (OECD 2020). Three species have been identified: *T. dactyloides*, Eastern gamagrass, is known to occur in the eastern half of the United States, *T. lanceolatum*, Mexican gamagrass, occurs in the southwest of the United States, and *T. floridanum*, Florida gamagrass, is native to South Florida and Cuba (USDA-NRCS 2019d; OECD 2020). *T. dactyloides* is the only *Tripsacum* species of widespread occurrence and agricultural importance in the United States, and commonly is grown as a forage grass (USDA-NRCS 1996). *T. fasciculatum* and *T. latifolium* occur in Puerto Rico (USDA-NRCS 2019d). *Tripsacum* species (2n=18) can be represented by diploid, triploid, tetraploid, and higher ploidy levels.

Although not closely related cytologically (e.g., differing numbers of chromosomes), gene exchange can take place between *Z. mays* and *Tripsacum* (de Wet et al. 1978). Certain species of *Tripsacum* can and have been crossed with *Zea mays* or at least some accessions of each species can cross under experimental lab conditions, but only with difficulty. The resulting hybrids are male sterile and usually female sterile (de Wet et al. 1978; Leblanc et al. 1996; Lee et al. 2017; Iqbal et al. 2019). Hybrids between *T. dactyloides* and *Z. mays,* specifically*,* have been found to be male sterile, but female fertile (de Wet and Harlan 1972). Attempts at artificially induced introgression from *Tripsacum* species into *Z. mays* failed to produce either teosinte-like offspring or the combination of characteristics assumed to indicate introgression during the evolution of several South American races of corn (Mangelsdorf and Reeves 1959; de Wet and Harlan 1972). The probability of natural introgression from *Tripsacum* in the direction of *Z. mays* seems to be low (de Wet et al. 1978).

Hybrid combinations with *Z. mays* (as pollen donor) and *T. dactyloides* are known to give rise to recovered *Z. mays* within three or more further backcrosses with *Z. mays*. It is, however, not too likely that this process commonly occurs in nature (de Wet et al. 1978). With each successive backcross, the offspring become more *Z. mays* like, and less capable of surviving in competition without the help of humans. Hybrids have been observed to not only produce low yields, but are also partially female sterile (de Wet et al. 1978).

In summary, gene exchange is possible between *Zea* and *Tripsacum*, and several South American races of corn, where teosinte is absent, exhibit past evidence of hybridization (de Wet et al. 1978). Natural introgression between *Zea* and *Tripsacum*, however, appears unlikely (de Wet et al. 1978). Hybrids between *Z. mays* and *Tripsacum*, as well as their derivatives when backcrossed with *Z. mays*, are poorly adapted for survival in competition with both their wild and cultivated parents (de Wet et al. 1978). Although hybridization of *Tripsacum* and *Z. mays* has been accomplished in the laboratory using special techniques under highly controlled conditions (Wozniak 2002; Lee et al. 2017), pollen-directed gene flow from corn (*Zea mays*) to wild *Tripsacum* species is considered an unlikely event (Wozniak 2002; Lee et al. 2017). APHIS is unaware of any reported cases of hybridization among naturally occurring *Tripsacum* and *Z. mays* in the United States.

4.3.3.4.3 Corn as a Weed or Volunteer

In the United States, there are no *Zea* species listed on the Federal Noxious Weed List (7 CFR part 360) (USDA-NRCS 2019e). Corn (*Zea mays*), as a highly domesticated crop plant with limited seed dispersal and dormancy, does not readily form persistent feral populations nor does it present as a weed outside of areas of cultivation (USDA-APHIS 2020c).

Corn frequently occurs as a volunteer plant in subsequent crops planted in the same field. Corn seed can remain in fields as a result of harvester inefficiency, dispersal by birds and other foraging wildlife, or from fallen ears. When seeds survive to the next growing season, volunteer plants develop within subsequent crops rotated with corn, such as soybean, dry beans, sugar beets, as well as subsequent corn crops.

Volunteer corn is more of agronomic/economic than environmental concern; the presence of volunteers can result in minor to significant yield impacts on subsequent crops planted in the same field, depending on the density of the volunteer corn (Nicolai et al. 2018; Jhala et al. 2019). In controlled agronomic studies, volunteer corn densities ranging from 800 to 13,000 plants per acre resulted in yield losses of 0 to 54% in soybean and 0 to 13% in corn (Nicolai et al. 2018). Similarly, soybean yield reductions have been found to range from 10 to 41% where early-emerging volunteer corn densities ranged from 0.5 to 16 plants m^2, although no soybean yield loss occurred with a late-emerging cohort of volunteer corn (Marquardt et al. 2012). Thus, the potential impact of volunteer corn on the yield of subsequent crops can be substantial. Successful control of volunteer corn is accomplished with the use of various combinations of cultivation practices and use herbicides with differing modes of action (Jeschke and Doerge 2010; Nicolai et al. 2018).

4.3.3.4.4 Probability and Potential Effects of Gene Flow

MON 87429 corn, if grown for commercial purposes, would present the same potential risk for gene flow, specifically the propensity for and frequency of gene flow, as current corn varieties. Accordingly, a determination of nonregulated status for MON 87429 corn and subsequent commercial production would not be expected to present more or less risk for gene flow to wild relative species, or other corn crops, as do current corn varieties.

The T-DNA insert in MON 87429 corn is comprised of gene cassettes conferring herbicide resistance. MON 87429 corn contains one copy of the T-DNA inserted into a single chromosomal locus that shows an expected pattern of inheritance. The observed inheritance pattern in corn predicts the segregation of these genes and/or traits as a single unit, and at a single genetic locus (Monsanto 2019).

Pollen-mediated gene flow in corn is primarily determined by wind, synchrony in flowering times between the viable pollen donor and recipient plant, and proximity of the recipient plant. No statistically significant differences were detected in days to flowering in MON 87429 corn, it is unchanged in its flowering phenology (Monsanto 2019). The viability and morphology of MON 87429 corn pollen was compared to that of the conventional control and four commercial reference lines grown under similar agronomic conditions. No statistically significant differences were detected between MON 87429 corn and the conventional control for percentage of viable pollen, pollen diameter, or pollen morphology (Monsanto 2019). These results suggest that, in the absence of glyphosate applications to specifically induce the non-viable pollen phenotype, the insertion and expression of the gene cassettes for herbicide resistance did not affect pollen characteristics that would contribute to increased or decreased pollen fertility and related fecundity, and/or pollen morphology that could impact pollen dispersal in such a way as to facilitate cross-hybridization.

As reviewed above, teosinte (*Zea* spp.) do not appear to be present in the United States other than in botanical gardens or at research stations. The closest relative of *Zea mays* in the United States is the genus *Tripsacum*. Three species have been identified: *T. dactyloides*, Eastern gamagrass, in the eastern half of the United States, *T. lanceolatum*, Mexican gamagrass, occurs in the southwest of the United States, and *T. floridanum*, Florida gamagrass, is native to South Florida and Cuba. *T. dactyloides* is the only *Tripsacum* species of widespread occurrence and agricultural importance in the United States, which is commonly grown as a forage grass (USDA-NRCS 1996).

While conceptually possible, the likelihood of *Tripsacum* populations comprised of the herbicide resistant trait genes developing is considered remote, for two reasons. First, in contrast with corn and teosinte (*Zea* spp.), which may hybridize relatively easily under certain conditions, the potential for hybridization and successful introgression of *Z. mays* genes into *Tripsacum* populations is rare (de Wet and Harlan 1972; de Wet et al. 1978; Eubanks 1995). Special techniques are required to hybridize *Z. mays* and *Tripsacum*; hybrids of *Tripsacum* species with *Zea* species do not commonly occur outside of a laboratory. Offspring are often sterile or have reduced fertility, and are unable to withstand even mild winter conditions (de Wet and Harlan 1972; de Wet et al. 1978; Eubanks 1995).

Second, while corn pollen can travel as far as 1⁄2 mile (800 m) in a wind of 15 miles per hour (27 km/h) (Nielsen 2016), most pollen is deposited within a short distance of the corn plant. Numerous studies show the majority (84%-92%) of pollen grains travel less than 16 feet (5 meters) (Pleasants et al. 2001). At a distance of 200 feet (60 m) from the corn plant, the pollen concentration averages only about 1%, compared with pollen samples collected about 3 feet (0.9 m) from the pollen source (Burris 2002; Brittan 2006). The number of outcrosses is reduced to one-half at a distance of 12 feet (3.6 m) from the pollen source, and at a distance of 40 to 50 feet (12 to 15 m), the number of outcrosses is reduced by 99%. Thomison (2004) showed cross-pollination between cornfields could be limited to 1% or less by a separation distance of 660 feet (200 m), and to 0.5% or less by a separation distance of 984 feet (300 m). However, cross-pollination frequencies could not be reduced to 0.1% consistently, even with isolation distances of 1,640 feet (500 m). Considering these data, and standard corn field margins and buffers zones, cross pollination of MON 87429 corn with other corn crops is considered unlikely.

Based on all of these factors, it is unlikely successful hybridization of MON 87429 corn and *Tripsacum* species would occur. In the rare event such hybrids developed, and were capable of reproducing, it is unlikely that the herbicide resistant traits extant in MON 87429 corn would present any risk to communities of *Tripsacum* species or their ecological role in the communities of other plants (e.g., fitness, fecundity). *Tripsacum dactyloides* is tolerant of many of the herbicides used to control weeds in maize production such as atrazine, metolachlor, cyanazine, nicosulfuron, rimsulfuron, 2,4-D, and dicamba. Hybrid *Tripsacum* species can be controlled via use of other selective herbicides, such as imazapic (Cook et al. 2020).

Volunteer MON 87429 Corn

Corn crops are most commonly rotated with soybean, wheat, cotton, rye, alfalfa, and hay (SARE/CTIC 2012; Monsanto 2019). All volunteer corn in subsequent crops can cause yield losses. Volunteer corn can also complicate management of corn root worm and grey leaf spot disease in subsequent rotations of both corn and soybeans (Chahal et al. 2014; Hefty 2018; Jhala et al. 2020).

Research by South Dakota State University, the University of Minnesota, and the University of Nebraska-Lincoln (UNL) show volunteer corn ranging from 800 to 13,000 plants per acre can steal up to 54% soybean yield and 13% corn yield (Corteva 2021). Clumps of volunteer corn from dropped ears are more competitive. UNL research found 3,500 corn clumps per acre reduced soybean yields by 40%, while the same population of single plants cut yields by 10% (Corteva 2021). Volunteer corn and other crop plants are controlled using herbicides or/and tillage. Group 1 grass herbicides (ACCase inhibitors) can be used to control corn volunteers in soybean.

Costs incurred by volunteer plants vary widely and depend on yield loss in the crop due to volunteer plants, and the cost of herbicide, or/and cost of tillage, to control volunteer plants. For example, based on 2016 soybean grain and herbicide prices, soybean yield gains from volunteer corn control could increase net return by > $60/acre (Alms et al. 2016). Growers who use conventional tillage may be inclined to rely on tillage, with lesser reliance on herbicides, to control corn volunteers with tillage, while growers using conservation may be more inclined to prefer herbicide options.

For corn, factors contributing to the occurrence of volunteer corn include pre-harvest seed loss, stalk and root lodging characteristics, and ear-drop. All of these can contribute to the occurrence of volunteer corn. Because there are no substantive differences between MON 87429 corn and conventional corn in terms of growth rate, lodging, seed loss, final stand count, and other agronomic characteristics (Monsanto 2019), MON 87429 corn is no more likely to occur as a volunteer in subsequent crops after its planting than conventional corn. If volunteer MON 87429 corn occurs, pre-plant tillage can be used for control when most volunteers have already emerged. Various pre-plant, pre-emergent, and post-emergent herbicide options—discussed below—are available for control of MON 87429 corn volunteers, depending on the rotation crop, and its herbicide resistance properties. However, because MON 87429 corn is resistant to glufosinate, glyphosate, and to ACCase FOP herbicides—post emergent herbicides used to control corn volunteers—these will not be effective in removing emerged volunteer corn arising from previous plantings of MON 87429 corn hybrids. Thus, there will be fewer herbicide options for the control of MON 87429 corn/hybrid volunteers.

The Monsanto petition provided data comparing herbicide injury in MON 87429 corn to a conventional control corn from treatment with herbicides at a range of EPA-approved labeled rates at the 3-leaf growth stage, under greenhouse conditions. A visual injury rating scale of 0% (no injury) to 100% (plant death) was used, based on assessments of chlorosis, necrosis, malformation, stunting, and biomass reduction. The cyclohexanedione ACCase inhibitor herbicides (so-called DIM herbicides) clethodim (Select Max®) and sethoxydim (Poast®) are grass-specific herbicides and were both highly effective (95% or greater injury) against both MON 87429 corn and the control, whereas paraquat (Gramoxone®) resulted in an injury rating at the lower rate of 47.5% and 49.0%, and 81.0% and 93.9% at the higher rate, for MON 87429 corn and the control, respectively (Monsanto 2019). Thus, Poast® (sethoxydim), and Select® 2EC (clethodim) herbicides could provide effective post-emergence control of MON 87429 corn, and are labeled for use in 10 field crops that include soybean, cotton, sugar beet, and alfalfa, as well as for 11 vegetable rotation crops (Monsanto 2019). For preplant control of volunteer corn in soybean rotations, including MON 87429 corn, Gramoxone® (paraquat, a Class 22 photosystem I electron diverter) tank mixed with residual herbicides such as metribuzin (a Class 5 photosynthesis II inhibitor) or linuron (a Class 7 photosystem II inhibitor at site A) would also provide effective control (Bayer-CropSci 2019). Likewise, before planting another corn crop, control options include Gramoxone® alone (with lower levels of control), or with Tricor® (metribuzin) for better control (Ikley et al., 2017; Steckel et al., 2009). Gramoxone® and other contact herbicides tend to only kill off the above ground leaves, however, while viable growing parts of the plant remain safely below the ground until about the V6 growth stage (Hefty 2019). Thus, regrowth can occur depending on the growth stage at treatment.

Imazamox (Raptor®) is an ALS inhibitor, and another option for post-emergence control of volunteer corn (at 2-8 inches) in soybean, alfalfa, dry beans, peas, lima bean, snap bean, clover, and edamame. However Chahal et al. (2014) found poor post-emergent control (57%) with imazamox for two types of herbicide resistant corn including those resistant to glyphosate and glufosinate. For volunteer control of corn in wheat crops, including MON 87429 corn, additional post-emergence herbicide options are available such as Powerflex® (pyroxsulam), GoldSky® (florasulam+ pyroxsulam + fluroxypyr), and Perfectmatch® (clopyralid+ fluroxypyr+ pyroxsulam) (Ikley 2020). Pryoxsulam and florasulam are both Class 2 ALS or AHAS inhibitors, while clopyralid and fluroxypyr are both Class 4 synthetic auxins (WSSA 2020b).

In summary, based on the agronomic field data (Monsanto 2019), MON 87429 corn is unlikely to persist as a problematic volunteer plant with adverse impacts on crop production. There are no differences between MON 87429 and conventional corn in terms growth rate, lodging, seed loss, final stand count, and other agronomic characteristics (Monsanto 2019). Extensive post-harvest monitoring of field trial plots planted with MON 87429 corn under USDA-APHIS authorizations did not reveal any differences in survivability or persistence of MON 87429 corn relative to other varieties of corn currently being grown. MON 87429 corn volunteers can be managed using a variety of currently available cultural methods including tillage, as well as herbicides.

4.3.3.5 Biodiversity

Biodiversity in the context of agriculture encompasses the variety of species of animals, plants, fungi, and microorganisms that exist in a given agricultural setting, the interrelation among these species, the health of species populations, and the role of species diversity and interrelation in the function of ecosystems.

Production of corn inherently entails conversion of natural areas, typically rich in biodiversity, into less diverse agroecosystems to produce food, feed, fiber, and industrial products. Effects on the environment depend on the intensity of cultivation over time and space; the practices and inputs applied, such as tillage and cover cropping, and fertilizer and pesticides (NRC 2010). With approximately 90 million acres of land in the United States planted to corn, the scale of potential impacts on biodiversity in areas proximate to croplands becomes obvious (NRC 2010). In general, tillage, crop monoculture, fertilizers, and pesticide use often have adverse effects on soils, water quality, air quality, and biodiversity. Crop rotations, integrated pest management, no-till systems, and other more environmentally friendly management practices can help ameliorate some of the adverse impacts, although the challenge between production of sufficient food, feed, fiber, and industrial products, and limiting impacts on the environment and biodiversity, will always remain (Hanson et al. 2008; NRC 2010).

Various taxa contribute to essential ecological functions upon which agriculture depends, such as pollinators, soil biota, and predators of crop pests (CBD 2020b). An invaluable function of biodiversity is the support of diverse populations of beneficial insects on farms. In one study of corn farms across the Northern Great Plains, Lundgren and Fergen (2014) found that farms with lower insect biodiversity had more plant pests, and that more bio-diverse cornfields had fewer plant pests. The results from their study also suggest that designing cropping systems with high diversity requires fewer insecticide inputs, which can also save farmers money. Farming practices that promote insect biodiversity can facilitate control of plant pests.

Relative to HR crops, by facilitating conservation tillage (discussed in 4.3.1.2.1 – Tillage), and achieving optimal yield—which can alleviates pressure to convert additional land into crop production—HR crops can potentially contribute to reducing the impacts of crop production on biodiversity (NRC 2010; Carpenter 2011). Conservation tillage practices that leave greater amounts of crop residue serve to increase the diversity and density of local bird and mammal populations (Sharpe 2010). The increased use of conservation tillage practices can benefit birds, mammals, and other wildlife through sustaining water quality, the availability of waste grain, retention of cover in fields, and increased populations of invertebrates (Sharpe 2010; Towery and Werblow 2010).

4.3.3.5.1 Potential Effects on Biodiversity

The herbicide resistant trait proteins in MON 87429 corn are unlikely to present any risks to plant, animal, fungal, or bacterial communities. The same or functionally similar proteins and genetic elements are derived from naturally occurring soil bacteria and plants (reviewed in Table 4-20).

As to the herbicides that may be used with MON 87429 corn, the potential effects on local biodiversity, areas proximate to MON 87429 corn fields, would be relative to the off-target effects of the herbicides on surrounding plants. It should be noted that the herbicide active ingredients that could be used with MON 87429 corn are used on a wide variety of crops, as well as in non-agricultural settings (residential and commercial property, forestry), discussed in section 4.3.1.2.3 – Pesticides. For example, glufosinate is registered for use on a variety of crops, including apples, berries, citrus, currants, grapes, grass grown for seed, potatoes, rice, sugar beets, and tree nuts. 2,4-D, used since the 1940s, has various registered uses, including for turf/lawns, aquatic sites, forestry sites, and field, fruit, and vegetable crops. Dicamba was first approved for use in the United States in 1962 and has been registered for use on corn, wheat, cotton, soybeans, a wide range of grass crops, as well as for non-crop areas. In general, any potential effects on local biodiversity that may differ from other registered uses of these herbicides would be relative to the degree of any off-site movement, and geographic scale of MON 87429 corn production.

Plants are key components of ecosystems, providing the raw material (primary production)[40] upon which food chains are built. Different plant parts provide a range of resources for various fauna; leaves and stems may be browsed, pollen and nectar provide resources for pollinating insects, and the fruits and seeds are important food for a large number of organisms (Marshall 2001). Plants have other functions in addition to providing food for herbivores. They provide cover, reproduction sites, and structure within habitats. Plants also form a substrate for bacteria, fungi, and algae, both above ground and in the soil (Marshall 2001).

As discussed above for potential effects on plant communities (Section 4.3.3.2), dicamba and 2,4-D drift can more readily damage non-crop plants, to include trees, and thereby potentially impact communities of wildlife dependent on such plants (e.g., insects, herbivorous mammals and reptiles, birds). Use of dicamba and 2,4-D, owing to the potential for drift and their functions as synthetic auxins, have greater potential for reducing biodiversity in field edges and nearby non-crop habitat through damage to plants, relative to the other herbicides that may be used with MON 87429 corn hybrids (discussed in 4.3.3.2.1). Dicamba drift issues, in part, have resulted from the ability to use OTT applications later in the growing season on dicamba resistant crops—this is when temperatures are warmer and thereby volatility higher. Hence, effects of spray and vapor drift on plants and associated biota at later stages of life cycles and interactions can occur. Due to lack of data, and uncertainty as to which herbicides will preferentially be used with MON 87429 corn hybrids, it is unclear to what extent, and for how long, any injury to nearby non-crop plants could potentially impact biodiversity in areas where herbicide drift/volatilization occurs.

The above considered, as discussed for animal communities, while herbicides that would be used with MON 87429 corn present minimal direct hazard to wildlife in the event of inadvertent exposure, movement of herbicides off-site can present risks to non-crop plants in natural areas, and on residential and commercial properties, that animal communities depend on. Any increase in herbicide use across the agricultural landscape, could likewise increase potential impacts on plant communities, and indirect effects on animal communities that rely on the plant communities as a food and habitat resource.

4.3.3.6 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 threatened and endangered and species and the ecosystems on which they depend as key components of America's

[40] Primary productivity, in ecology, is the rate at which energy is converted to organic substances by photosynthetic producers (photoautotrophs), which obtain energy and nutrients by harnessing sunlight, and chemosynthetic producers (chemoautotrophs), which obtain chemical energy through oxidation. Nearly all of Earth's primary productivity is generated by photoautotrophs.

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 threatened or endangered because of any of the following factors:

- The present or threatened destruction, modification, or curtailment of its habitat or range;
- Overutilization for commercial, recreational, scientific, or educational purposes;
- Disease or predation;
- The inadequacy of existing regulatory mechanisms; and
- The natural or manmade factors affecting its survival.

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

4.3.3.6.1 Requirements for Federal Agencies

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 (a process is known as a Section 7 Consultation).

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

APHIS regulatory authority over biotechnology derived organisms under the PPA is limited to those where the Agency has reason to believe the biotechnology derived organism could pose a plant pest risk, or where APHIS does not have sufficient information to determine that the organism is unlikely to pose a plant pest risk. In this case, Bayer has requested that the USDA-APHIS consider that MON 87429 corn does not pose a plant pest risk. After completing a PPRA, if APHIS determines that MON 87429 corn seeds, plants, or parts thereof do not pose a plant pest risk, then this MON 87429 corn 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 this MON 87429 corn is no longer regulated. APHIS analyzed the potential effects of MON 87429 corn on TES and/or critical habitat. As part of this process, APHIS thoroughly reviewed data related to MON 87429 corn to inform the ESA effects analysis and, if necessary, the biological assessment. For each transgene the following information, data, and questions are considered by APHIS:

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

As discussed in Section 1.3 – Coordinated Framework for the Regulation of Biotechnology, APHIS regulates plant pest risks under the authority of the PPA and implementing regulations at 7 CFR part 340; for biotechnology derived plants, this means the plant itself. The EPA regulates pesticide use with the plant, to include PIPs. APHIS met with USFWS officials on June 15, 2011, to discuss and clarify whether APHIS has any obligations under the ESA regarding analyzing the effects on TES that may occur from use of pesticides associated with biotechnology derived crops. As a result of these joint discussions, USFWS and APHIS have agreed that it is not necessary for APHIS to perform an ESA effects analysis on pesticide use associated with biotechnology derived crops because the EPA has both regulatory authority over the labeling of pesticides under FIFRA, and the technical expertise to assess pesticide effects on the environment. APHIS has no statutory authority to authorize or regulate the use of pesticides by corn growers. Under APHIS' current Part 340 regulations, APHIS only has the authority to regulate MON 87429 corn and other biotechnology derived organism as long as APHIS believes they may pose a plant pest risk. APHIS has no regulatory jurisdiction over any other risks associated with biotechnology derived organisms including risks resulting from the use of pesticides on those organisms.

In terms of herbicide use with MON 87429 corn, the EPA's Endangered Species Protection Program (ESPP) carries out EPA's responsibilities under FIFRA in compliance with the ESA. The EPA is responsible for reviewing information and data to determine whether a pesticide product can be registered for a particular use. As part of that determination, the EPA determines if listed species or their designated critical habitat may be affected by use of the product. All pesticide products that the EPA determines "may affect" a listed species or its designated critical habitat may be subject to the ESPP.

When EPA determines that use limitations are necessary to ensure that legal use of a pesticide will not harm listed species or their critical habitat, the EPA may seek to change the terms of the pesticide registration to establish either generic or geographically specific pesticide use limitations.

Based on the 2020 EPA Ecological Assessment for dicamba use on dicamba resistant cotton and soybean (US-EPA 2020o), the EPA arrived at "…no effects determinations for 22 of the 23 listed species and 1 critical habitat that overlap with the action. There was one listed species within the action area, the Eskimo curlew where EPA made a May Effect but Not Likely to Adversely (NLAA) Effect determination.” The EPA initiated informal consultation with the USFWS, and USFWS has concurred on the NLAA determination (US-EPA 2020o).

When geographically specific use limitations are necessary, the EPA issues Endangered Species Protection Bulletins as part of the EPA's ESPP, and pesticide use requirements. Bulletins set forth geographically specific pesticide use limitations for the protection of threatened and endangered (listed) species and their designated critical habitat. Pesticide labels refer the pesticide user to the EPA’s Bulletins Live! Two website, which contains enforceable use limitations for a pesticide to ensure its use will not jeopardize the continued existence of a listed species or adversely modify designated critical habitat (US-EPA 2020w).

4.3.3.6.2 Potential Effects of MON 87429 Corn on TES

Based on the information submitted by Bayer (Monsanto petition) and reviewed by APHIS, MON 87429 corn, with the exception of resistance to herbicides, is agronomically and compositionally comparable to conventional corn (Monsanto 2019). The petition presented results of agronomic field trials for MON 87429 corn. The results of these field trials demonstrate that there are no differences in agronomic practices between MON 87429 corn and conventional corn, apart from use of specific herbicides. The common agronomic practices that would be carried out in the cultivation of MON 87429 corn are not expected to deviate from current practices, including the use of EPA-registered pesticides. MON 87429 corn is not expected to directly cause a change in U.S. corn acreage, or the areas devoted to corn production. It is expected that MON 87429 corn will replace other varieties of HR corn without expanding the acreage or area of corn production.

Corn can be grown in all 50 states and U.S. territories. The issues discussed herein focus on the potential environmental consequences of approving the request for nonregulated status of MON 87429 corn on TES and critical habitat in the areas where corn is currently cultivated. APHIS obtained and reviewed the USFWS list of TES species (listed and proposed) for all 50 states and U.S. territories where corn is produced from the USFWS Environmental Conservation Online System (USFWS 2021).

For its analysis on TES plants and critical habitat, APHIS focused on the agronomic differences between MON 87429 corn and corn 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 PAT (glufosinate resistance), DMO (dicamba resistance), FT_T (quizalofop and 2,4-D resistance), and EPSPS (glyphosate resistance) proteins in MON 87429 corn, and the ability of the plants to serve as a host for a TES.

4.3.3.6.3 Threatened and Endangered Plant Species and Critical Habitat

The agronomic data provided by Bayer (Monsanto petition) were used in the APHIS analysis of the weediness potential for MON 87429 corn and evaluated for the potential to impact TES and critical habitat. Agronomic studies evaluated the weediness and invasiveness potential of MON 87429 corn with respect to conventional corn (Monsanto 2019). No differences were detected between MON 87429 corn and conventional corn in growth, reproduction, or interactions with plant pests and diseases, other than the intended effect of resistance to glufosinate, dicamba, quizalofop ethyl, 2,4-D, and glyphosate. As discussed in this EIS, due to domestication, there are no weed risks associated with corn. Corn has been cultivated globally without any report that it occurs as a serious weed or that it forms persistent feral populations. Volunteer corn plants can be easily controlled with herbicides or mechanical means if needed.

APHIS evaluated the potential of MON 87429 corn to cross with a listed species. As discussed in Gene Flow and Weediness (4.3.3.4), the potential for gene movement between MON 87429 corn and related *Zea* and *Tripsacum* species is limited. Except for *Zea perennis*, *Zea mays* and teosinte cross readily, and their hybrids fully fertile. Teosinte does not, however, appear to be present in the United States other than in botanical gardens or at research stations. There are no federally listed *Zea* species in the United States (USFWS 2021). Based on these factors, APHIS determined that MON 87429 corn will have no effect on threatened or endangered plant species or on critical habitat in the United States.

4.3.3.6.4 Threatened and Endangered Animal Species

Threatened and endangered animal species that may be exposed to the gene products in MON 87429 corn would be those TES that inhabit corn fields and feed on MON 87429 corn. As discussed in Section 4.3.3 – Biological Resources, cornfields are generally considered poor habitat for animals in comparison with uncultivated lands, although the use of cornfields by birds and mammals is not uncommon. Some birds and mammals use cornfields at various times throughout the corn production cycle for feeding and reproduction. Most birds and mammals that utilize cornfields are ground foraging omnivores that feed on corn seed, sprouting corn, and the corn remaining in the fields following harvest.

Of the TES birds, whooping crane (*Grus americana*), Mississippi sandhill crane (*Grus canadensis pulla*), piping plover (*Charadrius melodus*), and interior least tern (*Sterna antillarum*) may transit and feed in corn fields during migration (Krapu et al. 2004; Sherfy et al. 2011; USFWS 2011). The whooping crane, in particular, spends the majority of its foraging time during migration in agricultural fields (CWS-USFWS 2007; Jorgensen and Dinan 2016). During migration, about 90% of the sandhill crane diet consists of corn when corn is available (NGP 2019).

As discussed in Section 4.3.3.3 – Animal Communities, various large and small mammals may feed on corn, particularly white-tailed deer, raccoons, mice, and voles. There are no listed raccoon species in the United States. There are two listed deer species in the United States. Key deer (*Odocoileus virginianus clavium*) are highly localized in the Florida Keys (USFWS 2021). Listed populations of Columbian white-tailed deer (*Odocoileus virginianus leucurus*) are found in certain areas associated with the Columbia River in Washington (USFWS 2021). These locations are well south and west, respectively, of the regions where corn crops are typically planted (Section 4.3.1). Of the mice, voles, and their relatives in the Cricetidae family, listed species include: the Amargosa vole (*Microtus californicus scirpensis*), which is listed as endangered and occurs in California (USFWS 2021); the Florida salt marsh vole (*Microtus pennsylvanicus dukecampbelli*), which occurs in salt marsh habitat on the Gulf Coast of Florida (USFWS 2021); the endangered Key Largo woodrat (*Neotoma floridana smalli*) of Florida Key's climax hardwood hammocks (USFWS 2021); and the northern and southern subspecies of the endangered, tidal marsh dwelling, salt marsh harvest mouse (*Reithrodontomys raviventris*) (USFWS 2013, 2021).

APHIS considered the potential risks to threatened and endangered animals from consuming MON 87429 corn. Composition data, including major nutrients in grain (protein, amino acids, total fat, linoleic acid, carbohydrates, acid detergent fiber, neutral detergent fiber and ash), major nutrients in forage (protein, total fat, carbohydrates, acid detergent fiber, neutral detergent fiber and ash) and anti-nutrients in grain (phytic acid and raffinose) were submitted to FDA as part of the voluntary food/feed safety and nutritional assessment for MON 87429 corn (BNF No. 000173; (US-FDA 2022)). The results of the compositional assessment found MON 87429 corn is compositionally equivalent to conventional corn varieties (Monsanto 2019).

As discussed in those sections addressing human health, animal health and welfare, and wildlife, there are no health hazards associated with the trait genes and gene products. Therefore, there is no expectation that exposure to the PAT, DMO, FT_T, and EPSPS proteins will have any effect on TES.

APHIS considered the possibility that MON 87429 corn could serve as a host plant for a threatened or endangered species (i.e., a listed insect or other organism that may use the corn plant to complete its lifecycle). APHIS is not aware of any TES for which corn serves as a host plant (USFWS 2011).

Considering the compositional and nutritional similarity between MON 87429 corn and other dent corn varieties currently grown, and the lack of any health hazard presented by the introduce HR trait proteins, APHIS has concluded that exposure to and consumption of MON 87429 corn would have no effect on threatened or endangered animal species.

4.3.3.6.5 Summary

After reviewing the possible effects of a determination of nonregulated status, and subsequent commercial production of MON 87429 corn, APHIS has not identified any stressor that could affect listed TES or species proposed for listing. APHIS also considered the potential effect of MON 87429 corn on designated critical habitat and habitat proposed for designation and could identify no differences from effects that would occur from the production of other corn varieties. Corn is not sexually compatible with, nor serves as a host species for, any listed species or species proposed for listing. Consumption of MON 87429 corn by any listed species or species proposed for listing would pose no health risks.

Based on these factors, APHIS has concluded that a determination of nonregulated status of MON 87429 corn, and subsequent commercial production of this corn variety, will have no effect on listed species or species proposed for listing, and would not affect designated habitat or habitat proposed for designation. Because of this no-effect determination, consultation under Section 7(a)(2) of the Act or the concurrences of the USFWS or NMFS are not required.

4.3.4 Human Health and Worker Safety

Human health considerations relative to biotechnology derived crops, specifically, are those related to (1) the safety and nutritional value of foods derived from biotech crops, and (2) the potential health effects of pesticides that may be used in association with biotech crops. As for food safety, consumer health concerns can be in regard to the potential toxicity or allergenicity of the introduced genes/proteins, the potential for altered levels of existing allergens in modified plants, or the expression of new antigenic proteins. Occupational exposure to pesticides is also considered.

4.3.4.1 Food Safety

As summarized in Section 1.3–Coordinated Framework for the Regulation of Biotechnology, the FDA created a voluntary premarket food safety consultation process in the 1990's. This consultation process enables developers to engage with the FDA to ensure the safety of foods derived from new plant varieties prior to commercial distribution (US-FDA 1992a, 2006).

The safety assessment of biotech crop plants includes characterization of the physicochemical and functional properties of the introduced gene(s) and gene products, determination of the safety of the gene products (e.g., proteins, enzymes), and compositional assessment of the crop plant. Compositional assessments compare the biotech crop plant with non-transgenic, conventional varieties of that crop, and evaluate characteristics such as protein, fat, carbohydrates, ash, minerals, dietary fiber, essential and non-essential amino acids, fatty acids, vitamins, and antinutrients.

Safety and compositional assessments comparing biotech and non-biotech crops are typically performed using the principles and guidelines outlined in the Codex Alimentarius (Codex), established by the World Health Organization and Food and Agriculture Organization of the United Nations, and Organization for Economic Co-operation and Development (OECD) consensus documents for specific crop varieties (e.g., for corn (OECD 2020)). The FDA participates and exercises leadership in the Codex Commission, by working closely with the U.S. Codex Office at the U.S. Department of Agriculture. The Codex is a set of international standards, principles, and guidelines for the safety assessment of foods derived from plants that were modified using biotechnology based techniques (WHO-FAO 2009). These standards help countries coordinate and harmonize review and regulation of foods derived from modified plants to ensure public health and facilitate international trade. The Codex is comprised of over 180 member countries, to include the United States. Most governments incorporate Codex principles and guidelines in their review of foods derived from modified crop plants.

In addition to the FDA consultation, foods derived from biotechnology derived plant varieties undergo a review among international agencies before entering foreign markets, such as reviews by the European Food Safety Agency (EFSA 2020) and the Australia and New Zealand Food Standards Agency (ANZFS 2020). These reviews likewise adhere to Codex standards.

4.3.4.2 Safety of the Herbicide Resistance Traits

PAT Safety Evaluations: Glufosinate-Ammonium Resistance

PAT, as an introduced trait in crop plants, can be encoded by the *bar* gene derived from the naturally occurring soil bacterium *Streptomyces hygroscopicus*, and by the *pat* gene derived from *S. viridochromogenes*. *Streptomyces* are gram-positive bacteria of the actinomycetal order with more than 600 species described in soils, sediments, and seawater (Labeda et al. 2012; Bontemps et al. 2013). The gene encoding the PAT protein in MON 87429 was isolated from *Streptomyces viridochromogenes,* which occurs predominantly in soils (Liu et al. 2013; GCM 2019). Because the PAT enzyme occurs naturally in soils, it stands to reason that wildlife and humans, globally, have been and are potentially exposed, incidentally, to the *pat* gene and PAT enzyme through environmental sources on a daily basis (e.g., incidental ingestion, inhalation).

APHIS has evaluated and deregulated 11 varieties of corn comprised of either the *pat* or *bar* genes, as well glufosinate resistant varieties of soybean, cotton, canola, beet (USDA-APHIS 2020d). There are no human health risks associated with exposure to PAT; the enzyme has a long history of safe use in commercially produced corn, soybean, and cotton varieties. The FDA has previously consulted on PAT, and the *pat* and *bar* genes encoding for expression of PAT for over 30 glufosinate resistant crop varieties (US-FDA 2022); these include canola, corn, cotton, soybean, and sugar beet. None of these modified crop varieties have been identified as presenting any risk to human health. Previous evaluations of PAT have shown that it does not share amino acid sequence similarity to known toxins, nor does it possess characteristics associated with food allergens (Herouet et al. 2005; ILSI-CERA 2011b).

Due to the negligible human health risks associated with PAT, the EPA issued an exemption from the requirement of a tolerance for PAT when used as plant-pesticide inert ingredients in all food commodities (40 CFR § 174.522).

CP4 EPSPS Safety Evaluations: Glyphosate Resistance

MON 87429 corn contains an *epsps* gene from *Agrobacterium* sp. strain CP4 (*cp4 epsps*) that expresses an EPSPS enzyme. EPSPS occurs naturally in plants and microorganisms, thus, humans and wildlife are potentially exposed to EPSPS through environmental sources on a daily basis, worldwide. Various biotechnology derived corn, canola, cotton, and soybean crop plants comprised of *epsps*/EPSPS have been reviewed for potential adverse environmental (ILSI-CERA 2011a) and human health effects (Han 2016). No forms of EPSPS have been reported to present any risk to human or animal health (US-EPA 2007; Han 2016; US-FDA 2022). Previous evaluations of *epsps* genes and their EPSPS enzyme products have shown that the EPSPS protein does not share any amino acid sequences similar to known toxins or allergens (ILSI-CERA 2011a). EPSPS has been previously evaluated by FDA in over 20 varieties of modified plants (e.g., corn, soybean, sugarbeet). The FDA stated on conclusion of these consultations that they had no further questions concerning the safety of food and food products derived from these varieties (US-FDA 2022).

Due to the negligible human health risks associated with CP4 EPSPS, the EPA granted an exemption from the requirement of a tolerance for CP4 EPSPS when used as plant-pesticide inert ingredients in all food commodities (40 CFR § 174.523).

Dicamba Monooxygenase (DMO) Safety Evaluations: Dicamba Resistance

DMO is a type of Rieske non-heme iron oxygenase (RO), an enzyme that commonly occurs in bacteria. Homologs of ROs have been investigated in plant species, such as corn, pea, rice, and spinach, as well as in insects, nematodes, and vertebrates (e.g., see reviews by (Harayama et al. 1992; Chakraborty et al. 2017)). Although found in various taxa, studies have shown that ROs occur more commonly in thermophilic bacteria compared with archaea and eukaryotes.

The donor organism for the *dmo* gene, *Stenotrophomonas maltophilia*, is an aerobic bacterium ubiquitous in the environment. It has been isolated from soil, water, animals, invertebrates, and plant matter (including food plants) (Brooke 2012). Because *Stenotrophomonas maltophilia* is ubiquitous in soils and commonly associated with plants (Ryan et al. 2009; Deredjian et al. 2016), humans and wildlife are potentially exposed to DMO on a regular basis. The safety of DMO has been previously reviewed in various crops (e.g., (FSANZ 2013; Health-CA 2015; Wang et al. 2016)); there is no risk to humans or other animals by consumption of foods containing DMO.

The FDA has previously consulted with developers on DMO use in corn (BNF 148), soybean (BNF 125), and cotton (BNF 135) crops, and concluded that food and feed from these crops were not materially different in composition, safety, or other parameters that would require premarket review or approval by FDA (US-FDA 2022). The safety of DMO has also been evaluated by industry and international authorities; the weight of evidence from these studies indicate that the various forms of DMO proteins introduced into dicamba resistant soybean, cotton, and corn are safe for food and feed consumption (Wang et al. 2016).

R-2,4-dichlorophenoxypropionate dioxygenase (FT_T): 2,4-D and Quizalofop Ethyl Resistance

The *ft_t* gene in MON 87429 corn is a modified version of the R-2,4-dichlorophenoxypropionate dioxygenase gene (*Rdpa*) from the soil bacteria *Sphingobium herbicidovorans*. The FT_T enzyme provides resistance to aryloxyalkanoate herbicides, which includes the aryloxyphenoxypropionate acetyl coenzyme A carboxylase (ACCase) inhibitors (so called "FOP" herbicides such as quizalofop-p-ethyl) and some synthetic auxins, such as 2,4-D. Members of the genus *Sphingobium*, from which the *ft_t* gene was derived, have been isolated from a wide variety of habitats including soils and freshwater (Enya et al. 2007; van Bruggen et al. 2014; Chaudhary et al. 2017). *Sphingobium herbicidovorans* occurs primarily in soils (Hausinger 2004). Hence, human and animal exposures to *Sphingobium herbicidovorans* and associated RdpA enzyme commonly occur. Alpha-ketoglutarate-dependent dioxygenases (e.g., RdpA) have been identified in a broad range of organisms including bacteria, fungi, plants, and vertebrates, the latter two commonly consumed by humans and other animals (Hausinger 2004). APHIS is unaware of any reports of adverse health effects associated with RpdA. Digestion studies indicate that 99.2% to 99.7% of the FT_T is digested by pepsin— the primary digestive enzyme in the human stomach that breaks down proteins into polypeptides—within 2 minutes (Monsanto 2019). Bioinformatics analyses demonstrated that the FT_T protein does not share amino acid sequence similarities with any known allergens, gliadins, glutenins, or toxins that could have adverse effects on human or animal health (Monsanto 2019). The enzyme has only been found to be associated with the metabolism of herbicides, namely highly limited substrate specificity for cleavage of the ether bond in the herbicides 2,4-D and MCPA (Müller and Hoffmann 2006; Leibeling et al. 2013). FT_T being a modified form of RdpA with greater specificity—exhibits enantio- and substrate specific properties for 2,4-D (Müller and Hoffmann 2006); based on enzyme functional data available to the scientific community there is no indication that FT_T (RdpA) has any other function (BRENDA 2020).

4.3.4.3 Pesticides, Tolerance Limits for Foods, and Exemptions from the Requirement for a Tolerance

The EPA regulates the sale, distribution, and use of pesticides under FIFRA (Section 1.3 – Coordinated Framework). The EPA also regulates certain biotechnology derived microorganisms that are used as bioremediation agents, and for the production of various industrial compounds, including biofuels, under the Toxic Substance Control Act (TSCA). Before a pesticide may legally be used in the United States the EPA must evaluate the pesticide to ensure that it will not result in an unreasonable risk to human health or the environment. Pesticides that complete this evaluation are issued a "registration" that permits their sale and use according to requirements established by the EPA.

Before a pesticide can be used on a food crop, the EPA, pursuant to the FFDCA and Food Quality Protection Act of 1996 (FQPA), also establishes a tolerance limit, which is the amount of pesticide residue allowed to remain in or on each treated food commodity (21 U.S. Code § 346a –Tolerances and exemptions for pesticide chemical residues). Pesticide tolerance limits established by the EPA are to ensure the safety of foods and feed for human and animal consumption (US-EPA 2015a). If pesticide residues are found above the established tolerance limit, the commodity will be subject to seizure by the government.

Section 408(c)(2)(A)(i) of the FFDCA allows the EPA to establish an exemption from the requirement for a tolerance if the EPA determines that the exemption is "safe." Safe is defined as meaning that there is a "reasonable certainty that no harm will result from aggregate exposure to the pesticide residue." To make a safety finding, the EPA considers, among other things: the toxicity of the pesticide and its break-down products, aggregate exposure to the pesticide in foods and from other sources, and any special risks posed to infants and children. Some products regulated under FIFRA are exempted from the requirement to have a tolerance.

Both the FDA and USDA monitor foods for pesticide residues to enforce tolerance limits and ensure protection of human health. The USDA Pesticide Data Program (PDP) collects data on pesticides residues on agricultural commodities in the U.S. food supply, with an emphasis on those commodities highly consumed by infants and children (USDA-AMS 2020b). The Monitoring Programs Division administers PDP activities, including the sampling, testing, and reporting of pesticide residues on agricultural commodities in the U.S. food supply. The program is implemented through cooperation with state agriculture departments and other federal agencies. The EPA uses PDP data to prepare pesticide dietary exposure assessments pursuant to the FQPA. PDP data:

- enable the EPA to assess dietary exposure;
- facilitate the global marketing of U.S. agricultural products; and
- provide guidance for the FDA and other governmental agencies to make informed decisions.

The EPA has established food tolerance limits for glufosinate, dicamba, 2,4-D, glyphosate, and quizalofop-p-ethyl at 40 CFR part 180, as listed below.

- 40 CFR §180.227 – Dicamba; tolerances for residues.
- 40 CFR §180.142 – 2,4-D; tolerances for residues.
- 40 CFR §180.473 – Glufosinate ammonium; tolerances for residues.
- 40 CFR §180.441 – Quizalofop ethyl; tolerances for residues.[41]
- 40 CFR §180.364 – Glyphosate; tolerances for residues.

[41] Quizalofop ethyl is a 50/50 racemic mixture of R- and S-enantiomers. Quizalofop-P-ethyl, the purified R-enantiomer, is the pesticidally-active isomer. Since the toxicological profiles of quizalofop ethyl and quizalofop-P-ethyl are similar, the available toxicity studies are adequate to support both compounds. For the purposes of EPA's final rule, both quizalofop ethyl and quizalofop-P-ethyl are collectively referred to as "quizalofop ethyl."

Due to the negligible risk PAT poses to human health, the EPA issued a permanent exemption for the requirement of a tolerance limit in all food commodities in the United States (40 CFR §174.522).

The USDA Pesticide Data Program's (PDP) 29th Annual Summary for calendar year 2020 found that when pesticide residues are found on foods, they are nearly always at levels below the tolerance, or maximum amount of a pesticide allowed to remain in or on a food, that is set by the EPA. In 2020, over 99% of the samples tested had residues below the tolerances established by the EPA. Residues exceeding the tolerance were detected in only 0.49% of the total samples tested (9,600 samples (USDA-AMS 2020b).

4.3.4.4 Worker Safety

Agriculture is one of the most hazardous industries in the United States. Worker hazards include those associated with pesticide mixing and application, and the operation of machinery. Agricultural operations are covered by several Occupational Safety and Health Administration (OSHA) standards including Agriculture (29 CFR 1928), General Industry (29 CFR 1910), and the General Duty Clause. Further protections are provided through the National Institute of Occupational Safety and Health (NIOSH).

Farmworkers are exposed to pesticides in a variety of ways. Workers who perform tasks in treated areas are vulnerable to exposure from direct spray, aerial drift, or contact with pesticide residues on the crop or soil. Workers who mix, load, or apply pesticides can be exposed to pesticides due to spills, splashes, and defective or inadequate protective equipment.

To address the potential hazards associated with exposure to pesticides during field application and handling, the EPA issued the Worker Protection Standard (WPS) (40 CFR Part 170) in 1992. The WPS contains requirements for pesticide safety training, notification of pesticide applications, personal protective equipment, restricted entry intervals following pesticide application, decontamination supplies, and emergency medical assistance. The Occupational Safety and Health Administration (OSHA) also requires employers to protect their employees from hazards associated with pesticides.

On November 2, 2015, the EPA revised the WPS to decrease pesticide exposure incidents among agricultural workers, handlers, and their families (80 FR 211, November 2, 2015, p. 67495). The revised WPS requirements went into effect during 2017–2018. On October 30, 2020, the EPA finalized updates to the Application Exclusion Zone (AEZ) provisions under the Worker Protection Standard regulation (US-EPA 2020b).

4.3.4.5 Potential Impacts on Human Health

As reviewed below, there are no public health issues associated with the production or consumption of MON 87429 corn, or products derived from MON 87429 corn. Any risks to public health would be those associated with the potential contribution of crop production to impacts on air and water quality via runoff of pesticides and fertilizers into surface waters, leaching of pesticides into groundwater, and drift of pesticides offsite—as discussed in this EIS. Production of MON 87429 corn hybrids would present no more risks to public health as cultivation of other crops on which pesticides are used. Potential risks to worker safety would be primarily in relation to pesticide mixing and application.

Human health risk assessments for the herbicide active ingredients that may be used with MON 87429 corn hybrids have been conducted by the EPA: glyphosate (US-EPA 2019f); dicamba (US-EPA 2022b); glufosinate (US-EPA 2016c); 2,4-D (US-EPA 2017b); and quizalofop-p-ethyl (US-EPA 2014a). These human health risk assessments are incorporated here by reference. The EPA evaluated the toxicology, residue chemistry, and occupational and residential exposure studies for each of these herbicides, from which label use restrictions and requirements were determined. When used in a manner compliant with label use requirements and restrictions, these herbicides are expected to present minimal risk to human health.

MON 87429 Corn Food Products and Consumption

Direct consumption of corn in the United States is primarily that of corn on the cob (sweet corn; *Zea mays* convar. *saccharata* var. *rugosa*), frozen or canned sweet corn, popcorn (flint corn; *Zea mays* var. *everta*), and in certain areas grits or hominy (specific varieties of dent corn; *Zea mays* var. *indentata*). Humans also consume corn products such as corn meal, corn oil, and corn syrup in food items such as cereals, salad dressings, and snack foods. While most dent corn is grown for animal feed and production of fuel ethanol, certain dent corn hybrids with specific starch properties are used for food purposes—generally referred to as food grade corn.

There are various dent corn varieties that have been developed—bred—for specific purposes/markets and given designations to distinguish which markets the grain is suited for. For example, HAE – High Available Energy Corn (Pork & Poultry Feed); HTF – High Total Fermentable Corn (Dry-Grind Ethanol); HES – High Extractable Starch Corn (Wet Milling); WX – Waxy Corn (starch for industrial and food uses); WH – White Food Corn; and YFC – Yellow Food Corn. Hence, varieties of dent corn designated WX, HES, WH, and YFC are used for food purposes. These are typically contracted and sold to wet-millers and dry-millers for processing into tortilla chips, corn starch, grits, corn syrup, corn oil, and other products.

MON 87429 corn could potentially be used for production of food grade hybrids and processed into starch, grits, meal, flour, oil, and/or sweetener products. The predecessor line, MON 87427 corn, was approved for use to produce food grade hybrids under tradenames such YieldGard VT Pro™, Roundup Ready® 2, and Genuity® Triple PRO® (EUginius 2020).

Safety and compositional analyses of MON 87429 corn grain demonstrate that it is nutritionally equivalent to other dent corn varieties (Monsanto 2019). These analyses were conducted consistent with guidelines outlined in the Codex Alimentarius, established by the World Health Organization and Food and Agriculture Organization of the United Nations, and Organization for Economic Co-operation and Development (OECD).

Bayer completed a Biotechnology Consultation on Food from GE Plant Varieties with the FDA, evaluating the safety of MON 87429 corn, in July 2022. Based on the information Bayer presented to the FDA, the FDA had no further questions concerning the safety of human or animal food derived from MON 87429 corn (BNF No. 000173; (US-FDA 2022)).

As previously reviewed (Section 4.3.4.2), there are no risks to human health associated with the PAT, DMO, FT_T, and CP4 ESPS trait proteins. None of the trait proteins possess any characteristics that would indicate potential allergenic properties (Monsanto 2019). The introduced trait proteins would be digested—broken down by gastric acid and proteases into amino acids—in the digestive system, and physiologically benign (Berg et al. 2002; Klowden 2013; Holtof et al. 2019).

The National Bioengineered Food Disclosure Law (NBFDL), passed by Congress in July of 2016, directed the USDA to establish a national mandatory standard for disclosing foods that are or may be bioengineered. The mandatory compliance date was January 1, 2022. The NBFDL standard requires food manufacturers, importers, and certain retailers to ensure bioengineered foods are appropriately disclosed to consumers. The standard, however, does not require disclosures for foods with up to 5% presence of unintentional or technically unavoidable bioengineered substances. It is expected that food products derived from MON 87429 corn would be labeled subject to the requirements of the NBFDL, and consumers would choose to consume such food products based on preference. Individuals concerned about consuming corn products associated with a bioengineered corn variety may also consume certified under the USDA's National Organic Program (NOP) (USDA-AMS 2020a).

Drinking Water Quality

Approximately 70% of the U.S. population receives drinking water from surface waters, the remainder from groundwater. As reviewed in 4.3.2.2 – Water Resources, pesticides applied to croplands, or any other area, can potentially make their way into groundwater or surface water systems that serve as drinking water supplies, which could adversely affect public health. Consequently, protecting source water supplies from pesticides, or any other chemical contamination, is important to ensuring public health. Whether a pesticide poses a potential human health risk in drinking water depends on the potential toxicity of the pesticide to mammals (humans), the concentration of the pesticide in the source water, and how much exposure and individual could receive on an acute and chronic basis.

The Safe Drinking Water Act (SDWA) requires federal agencies to protect sources of drinking water. The EPA implements the SDWA and sets limits for potential drinking water contaminants in order to protect public health. The National Primary Drinking Water Regulations (40 CFR part 141) set enforceable maximum contaminant levels for potential contaminants in drinking water, or required ways to treat water to remove contaminants. These primary standards and treatment techniques protect public health by limiting the levels of contaminants in drinking water (US-EPA 2022c).

The EPA works with states, tribes, local utilities, and many other stakeholders to implement programs that maintain drinking water quality (e.g., Source Water Protection Program, Sole Source Aquifer Program). The SDWA gives individual states the opportunity to set and enforce their own drinking water standards if the standards are at a minimum as stringent as EPA's national standards. The EPA Office of Pesticide Programs (OPP) conducts drinking water assessments (DWAs) for pesticides in surface water (US-EPA 2020g). The U.S. Geological Survey (USGS) also monitors and assesses the quality of the water used as sources of drinking water. The USGS National Water-Quality Assessment (NAWQA) is a leading source of scientific data and knowledge for development of science-based policies and management strategies to protect and improve water resources (USGS 2019).

About 10% of people in the United States—approximately 13 million households—rely on water from private wells. Private wells serving fewer than 25 individuals are not regulated under the SDWA (US-EPA 2021c). People who rely on private wells need to take precautions to ensure their drinking water is safe. The EPA offers information regarding the importance of testing private wells and guidance on technologies that may be used to treat or remove any contaminants (US-EPA 2021c).

The EPA also establishes human health benchmarks for pesticides (HHBP) that are registered for use on food crops and uses these benchmarks to determine whether the presence of a pesticide may increase the likelihood of adverse health impacts and to help prioritize monitoring efforts (US-EPA 2021f). HHBPs are levels of certain pesticides in water at or below which adverse health effects are not anticipated as a result of exposure. HHBPs provide information that can be used by states, tribes, and public health officials to characterize potential health risks if contaminants are detected through monitoring. The EPA has developed HHBPs for 430 pesticides to inform: (1) whether the detection level of a pesticide in drinking water or source waters for drinking water may indicate a potential public health risk; and (2) the prioritization of water monitoring efforts (US-EPA 2021f). The reader is referred to the EPA HHBP program for more information and specific data on the 430 pesticides evaluated in the program (US-EPA 2021f).

There are no unique risks presented to water quality that would derive from the cultivation of MON 87429 corn and use of glyphosate, dicamba, glufosinate, 2,4-D, or quizalofop-p-ethyl. As discussed above, the EPA implements the SWDA with states, via National Primary Drinking Water Regulations (legally enforceable standards and treatment techniques that apply to public water systems), and Source Water Protection Program and Sole Source Aquifer Program. The USGS conducts research and surveys as part of the National Water-Quality Assessment Project that help to protect water resources (USGS 2019).

Potential Herbicide Exposure via Spray Drift and Volatilization

Pesticide drift can pose public health risks when spray or volatile particulates are carried by the wind to other areas, such as to nearby homes, schools, and playgrounds (Lee et al. 2011; Deziel et al. 2017; Tamaro et al. 2018; Agost and Velázquez 2020; Upadhayay et al. 2020). Farm workers in adjacent fields could also be at risk of exposure. The drift of spray or volatile particulates is recognized as a primary cause of pesticide exposure affecting people and wildlife (Lee et al. 2011).

The EPA has estimated that 1% to 10% of agricultural pesticides applied move offsite from the intended target crop via spray drift or volatilization. On an annual basis, an estimated 70 million pounds of pesticides have been lost to pesticide drift (US-EPA 2014b).

Residents living closer to pesticide-treated agricultural lands tend to have higher levels of pesticide residues/metabolites in their households and/or biological tissue samples (Dereumeaux et al. 2020). Exposure to pesticide drift can result in both acute and chronic human health effects (Bernardes et al. 2015; Upadhayay et al. 2020).

Measures to prevent or limit drift include using drift-reduction technologies; reducing application rates; limiting the times of day/year a pesticide can be applied; improving training of pesticide applicators; and improving pesticide labels so that directions for use are clear, flexible, practical, and enforceable (US-EPA 2020d). Methods to reduce volatilization include developing low-volatile pesticide formulations and restricting application in unfavorable atmospheric conditions.

The EPA's voluntary Pesticide Drift Reduction Technology (DRT) program encourages the manufacture, marketing, and use of safer spray technology and equipment scientifically verified to reduce pesticide drift. The EPA evaluates the potential for drift as a routine part of pesticide risk assessments and is using new approaches for estimating drift impacts on communities living near fields where crops are grown, farmworkers, water sources, and the environment (US-EPA 2020i). In collaboration with experts at the USDA, universities, industry, and state and international partners, the EPA is examining new studies and improving scientific models and methods for estimating pesticide drift, potential exposure, and risks from drift (US-EPA 2020i).

Newer label requirements for dicamba, which is prone to spray drift and volatilization, include use of an approved Volatility Reduction Adjuvant (VRA) in the spray solution. An approved Drift Reduction Adjuvant (DRA) must also be included in the spray solution, unless otherwise indicated (e.g., www.xtendimaxapplicationrequirements.com). Other requirements and restrictions apply to nozzle type/adjustments, tank mixes, weather conditions, applicator training, and record keeping (US-EPA 2020t).

Any risks of potential human exposures to the herbicides used with MON 87429 corn would be the same as those with use of these herbicides on other crops. MON 87429 corn hybrids, resistant to glyphosate, glufosinate, dicamba, 2,4-D, and quizalofop-p-ethyl, would, however, to the extent MON 87429 corn is adopted, facilitate use of these herbicide active ingredients in lieu of other herbicide active ingredients. Hence, potential risks to human health unique to MON 87429 corn production would be relative to the potential toxicities of these particular herbicide active ingredients, the types and severity of physiological effects these herbicide active ingredients may have, and their use patterns.

Worker Health

Cultivation of MON 87429 corn hybrids would present no more or less risks to agricultural workers than cultivation of other corn varieties. The OSHA standards (29 CFR part 1928), National Institute of Occupational Safety and Health (NIOSH) agricultural safety and health program, and EPA WPS regulations are expected to provide protections to agricultural workers, pesticide handlers, and other persons via training, pesticide safety and hazard communication requirements, personal protective equipment requirements, and provision of supplies for routine washing and emergency decontamination. Agricultural workers, owners/managers of agricultural establishments, commercial (for-hire) pesticide handling establishments, and crop production consultants are provided guidance for compliance with WPS regulations (US-EPA 2016a). The WPS offers occupational protections to over 2 million agricultural workers and pesticide handlers who work at over 600,000 agricultural establishments.

On November 2, 2015, the EPA revised the WPS to decrease pesticide exposure incidents among agricultural workers, handlers, and their families (80 FR 211, November 2, 2015, p. 67495). The revised WPS requirements went into effect during 2017–2018. On October 30, 2020, the EPA finalized updates to the Application Exclusion Zone (AEZ) provisions under the Worker Protection Standard regulation (US-EPA 2020b).

4.3.5 Livestock Health and Welfare

The term livestock is defined in different ways, although for the purposes of this EIS livestock means all domesticated animals reared in an agricultural setting to produce commodities such as meat (e.g., pork, poultry, fish), eggs, milk, leather, and wool. Horses, which provide labor, are also considered livestock in the United States.

Dent corn products accounts for roughly 60% to 85% of feed grain in the United States on an annual basis; it is a primary feed source for beef and dairy cattle, poultry, and hogs. Animal feed derived from dent corn comes not only from the grain, but also from silage (the above-ground portions of the corn plant), stalk residues in fields that might be grazed, and residuals derived from corn refining and milling, such as corn gluten feed, corn gluten meal, corn germ meal, corn steep liquor, and amino acids.

4.3.5.1 Potential Effects on Livestock Health and Welfare

If used for animal feed, MON 87429 corn or hybrids would be expected to be beneficial to animal health and welfare, as are most other dent corn varieties. Compositional assessments were conducted for major nutrients in MON 87429 grain (protein, amino acids, total fat, linoleic acid, carbohydrates, acid detergent fiber, neutral detergent fiber and ash), forage (protein, total fat, carbohydrates, acid detergent fiber, neutral detergent fiber and ash), and for anti-nutrients in grain (phytic acid and raffinose). Compositional assessments comparing MON 87429 corn and conventionally bred corn were performed using principles and guidelines outlined in the OECD consensus document for corn composition (OECD 2020). These principles are accepted globally and have been employed in previous assessments of modified corn products. The results of the compositional assessments found that there were no nutritional differences between MON 87429 corn and non-modified corn comparators (Monsanto 2019).

As mentioned, Bayer completed a Biotechnology Consultation on Food from GE Plant Varieties with the FDA, evaluating the safety of MON 87429 corn, in July 2022. Based on the information Bayer presented to the FDA, the FDA had no further questions concerning the safety of human or animal food derived from MON 87429 corn (BNF No. 000173; (US-FDA 2022)).

4.3.6 Socioeconomics

4.3.6.1 Domestic and International Markets

4.3.6.1.1 U.S. Corn Commodities

The production of corn and the various corn derived commodities utilized by the food, feed, fuel, and industrial sectors is a major component of the U.S. economy. In the 2020 crop year the United States produced 14.2 billion bushels of corn with a market value of $59.6 billion (NCGA 2021). The primary dent corn commodities are animal feed and fuel ethanol, which account for around 38% – 48%, and around 27% of dent corn use, respectively (PRX 2019; USDA-ERS 2019d; NCGA 2021). The remainder is processed into a variety of industrial and food products. During processing, corn is either wet or dry milled depending on the desired end products:

- Wet millers process corn into high fructose corn syrup (HFCS), glucose and dextrose, starch, corn oil, beverage alcohol, industrial alcohol, and fuel ethanol. When the component parts of the kernel are separated during wet milling, this process releases protein, fiber, vitamins, and minerals, which serve as feed products for cattle, fish, hogs, and poultry. Four major feed products are produced during refining: Steepwater (a protein supplement for cattle or as a binder in feed pellets), germ meal, gluten feed, and gluten meal.

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

Both the dry-milling and wet-milling methods of corn processing generate economically valuable co-products, the most prominent of which are distillers' dried grains with solubles (DDGS), which is used as a feed ingredient for livestock (USDA-ERS 2019d). In the United States, feed for both dairy and beef cattle has been the primary use of DDGS, but increasingly larger quantities of DDGS are making their way into the feed rations of hogs and poultry (USDA-ERS 2019d).

Animal Feed

In the United States, around 10.3 billion food-producing animals are raised annually to supply market demand for meat, eggs, milk, and dairy products; these include broiler chickens, turkeys, egg-laying hens (layers), hogs, dairy cows, cattle, fish, and sheep (AFIA-IFEEDER 2017).[42] Dent corn products are the most highly consumed grain in food animal diets; a primary feed for beef and dairy cattle, poultry, and hogs. In general, dent corn accounts for around 90% to 95% of total feed grain production. The other three major feed grains produced are sorghum, barley, and oats (USDA-ERS 2019d). Animal feed derived from dent corn comes not only from the grain, but also from silage (the above-ground portions of the corn plant), stalk residues in fields that might be grazed, and residuals derived from corn refining and milling, such as corn gluten feed, corn gluten meal, corn germ meal, corn steep liquor, and DDGS (Figure 4-27).

[42] Note that the COIVD-19 epidemic skewed animal feed consumption data since 2019, pre-pandemic data is provided that gives a general approximation U.S. food animal production and animal feed consumption via diet [See: http://ifeeder.org/wp-content/uploads/210301-FINAL-REPORT-IFEEDER-Animal-Feed-Food-Consumption-COVID-19.pdf]

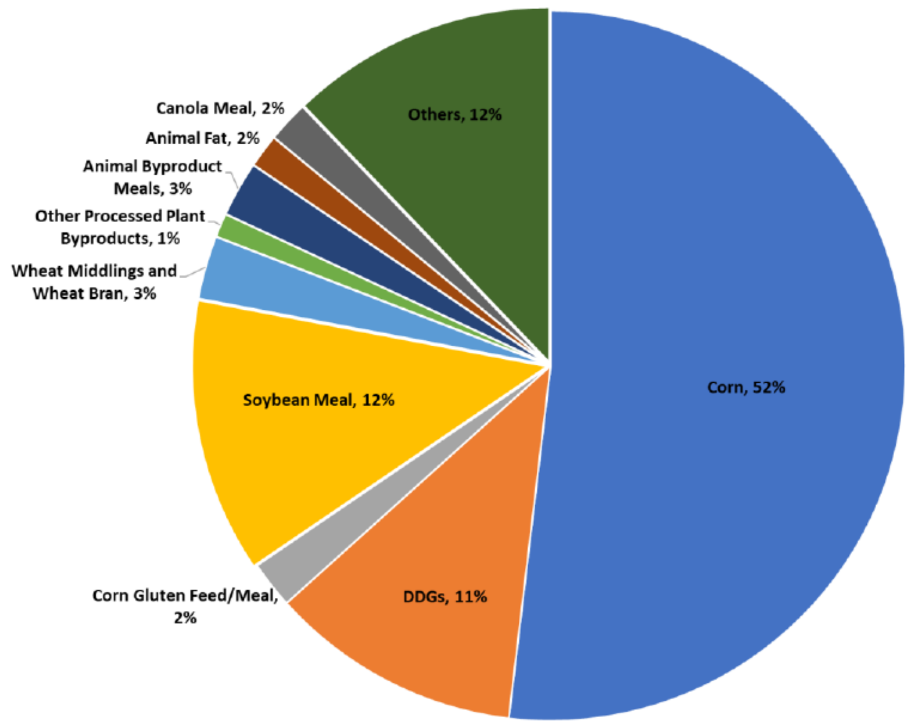

Figure 4-27. Estimated U.S. Food Animal Diet Composition (Without Harvested Forages), 2019

Source: (AFIA-IFEEDER 2019)

In terms of volume, in 2016, livestock, poultry, and farmed fish consumed a total of 228.3 million tons of animal feed (Table 4-26), of this; 118.7 million tons of corn grain, 29.7 million tons of DDGS, 20 million tons of wet distillers grains, 4.1 million tons of corn gluten feed, and 388,615 tons of corn gluten meal.

Table 4-26. U.S. Food Animal Feed Consumption: General Example, 2016

	Total Feed (millions of tons)	No. of Animals (millions)	Corn Grain/Corn Products as % of Diet
Cattle	74.7	24.2	98.1
Broiler Chickens	56.3	8,700	49.3
Swine			
sows		6	
nursery pigs	46.3	54.9	77.8
hogs		108.4	
Dairy Cows	23.8	9.3	79.9
Chickens			
egg layers		290.5	
pullets	16.4	72.6	63.4
breeder layers		58.2	
Turkeys	9.9	238.8	53.7
Horses	7. 8	8.8	14.3
Aquaculture			

catfish		493.9	
shrimp		1.4	
trout	0.708	186.9	32.4
tilapia		44.5	
striped bass		7.4	
yellow perch		25.9	
Sheep			
lambs	0.157	3.3	85.3
ewes		3.1	
Total	**228.3 million**	**10.34 billion**	

Source: (AFIA-IFEEDER 2017)

Cattle

Among livestock feed grains, corn is the most valued for several reasons. Corn grain is recognized as giving the highest conversion of dry matter into meat, milk, and eggs in relation to other cereal grains. Corn grain is used in beef cattle production because of its advantages in improving growth. However, corn grain does not typically comprise a large portion of cattle diets until the end of their life cycle in a period called "finishing". The majority of a beef animal's life in the United States will be spent on grass consuming forages (whole plants). Depending on the region of the country and the prices and availability of different feeds, corn grain may make up 60% to 85% of a grain-finished animal's diet during the finishing phase.

Poultry

Cereal grains generally constitute a large proportion (>50%) of poultry diets and contribute largely carbohydrates and to some extent proteins (Dei 2017). They are mainly a dietary source of energy, but this can vary widely between grain types and animal species. The most common feed grains for poultry are corn, wheat, barley, and sorghum or milo. Corn gluten, in particular, is high in protein and energy as well as a concentrated source of xanthophyll pigments, which make it popular in poultry production (Larbier et al. 1994). The DDGS is high in protein, trace elements, and vitamins, as well as increased availability of phosphorus, thereby making it popular feed ingredient for poultry production (Fetuga et al. 1979).

Swine

Corn and soybean meal have been industry standards for supplying energy and protein in swine diets. Grains such as corn, barley, wheat, and oats have traditionally supplied energy, while protein has come from meals produced from oilseeds such as soybeans (Boggess et al. 2020). Corn grain, DDGS, corn gluten feed, and corn gluten meal are all feed ingredient used for swine (Boggess et al. 2020). Most swine are fed diets containing ground corn mixed with protein, vitamins, and mineral supplements. These mixed diets are usually fed to growing-finishing swine (from 50 pounds to market weight).

Fish

For farmed fish, ingredients already in use include soybeans, barley, rice, peas, canola, lupine, wheat gluten, corn gluten, yeast, insects, and algae (NOAA 2020). Herbivorous fish eat feed mixtures that may contain plant proteins (e.g., soy, corn), vegetable oils, minerals, and vitamins. Rich in highly digestible amino acids and containing no anti-nutritional factors, corn gluten meal works as a partial replacement for fish meal in aquaculture diets.

U.S. corn production is projected to grow in the coming years, supply and use are both projected to increase around 7.0% by 2028 (USDA-ERS 2019a). Expanding meat production to feed a growing global population is expected to increase demand for animal feed. Rising incomes, particularly in emerging economies, are projected to increase global meat demand, and bolster demand for corn based feed, as well as U.S. exports of corn products (USDA-ERS 2019a).

Ethanol

The Renewable Fuel Standard (RFS) is a federal program that requires transportation fuel sold in the United States to contain a minimum volume of renewable fuels. It originated with the Energy Policy Act of 2005 and was expanded by the Energy Independence and Security Act of 2007. Congress created the RFS program to reduce greenhouse gas emissions and expand the nation's renewable fuels sector while reducing reliance on imported oil. The EPA implements the program in consultation with the USDA and the Department of Energy (US-EPA 2020y).

The RFS requires renewable fuel to be blended into transportation fuel in increasing amounts each year, with a target of 36 billion gallons by 2022. The four renewable fuel categories under the RFS are: biomass-based diesel, cellulosic biofuel, advanced biofuel, and conventional biofuel, the latter of which typically refers to ethanol derived from corn starch. The RFS began mandating the use of corn ethanol in U.S. fuels in 2006.

U.S. corn processing capabilities allow for production of fuel ethanol and DDGS on a level currently unmatched by any other country. The ethanol industry was comprised of approximately 202 plants in 27 states with a production capacity of 17.46 billion gallons as of 2021. The United States produced 13.9 billion gallons of corn ethanol in 2020, this comprised 54% of global corn ethanol production (RFA 2021). The gross value of the U.S. ethanol industry output in 2020 was $22.9 billion (RFA 2021).

Industrial Products

Corn wet-mill and dry-mill products are used in the production of a variety of industrial products, such as soaps, paints, plastics, adhesives, rubber tires, batteries, cosmetics, dyes, lubricants, textiles, and wallboard and wallpaper (ICGA 2021).

4.3.6.1.2 Herbicide Resistant Crops

Globally, the adoption of HR corn has mainly resulted in lower costs of production, although yield gains from improved weed control have arisen in Argentina, Brazil, the Philippines, and Vietnam (Brookes and Barfoot 2018; Brookes and Barfoot 2020b). The adoption of HR and IR crops in the United States has generally reduced costs and improved profitability at the farm level (Fernandez-Cornejo et al. 2014b; Klümper and Qaim 2014; Brookes and Barfoot 2020b). For HR corn specifically, farmers in the United States have realized higher incomes due to their use of HR corn varieties, totaling, in aggregate, approximately $10.8 billion from 1996 –2018 (Brookes and Barfoot 2020b). The average gross farm income benefit with HR crops (after deduction of cost of the technology), has been around $12.1/acre ($30.1/hectare) (Brookes and Barfoot 2020b).

4.3.6.1.3 International Trade

The United States is the world's largest corn producer, providing over a third of the total supply of corn in the world market. Between 10% and 20% of the U.S. corn crop is exported on an annual basis (USDA-ERS 2019d). Dent corn is the largest component of global coarse grain trade (corn, sorghum, barley, oats, rye, millet, and mixed grains), generally accounting for about two-thirds of the volume over the past decade (USDA-ERS 2019d). Dent corn grain exports represent a principal source of demand for U.S. producers and make the largest net contribution to the U.S. agricultural trade balance of all the agricultural commodities, reflective of the importance of corn exports to the U.S. economy.

In the 2021–2022 crop marketing year, (Sept. 1–Aug. 31) the United States exported 62.7 million metric tons (2.5 billion bushels) of corn to 62 different countries (USGC 2022b). As the global demand for meat increases, so does the demand for livestock feed, and in turn, corn products. Projected increase in U.S. corn exports over the next decade is largely due to a strong global demand for feed grains in support of meat production, particularly in those countries where climate and geography restrict local production of these feed materials (USDA-ERS 2019a).

The U.S. capacity for production of fuel ethanol and DDGS is currently unmatched by any other country. The United States produces more ethanol and DDGS than domestic consumers and industry can use, providing ample export supply. As a result, the United States dominates trade in these two corn-based commodities. In 2018/2019,[43] 1.55 billion gallons of U.S. ethanol—548 million bushels in corn equivalent—were exported to 69 countries (USGC 2020). DDGS exports increased from 5 million tons in 2009 to more than 11 million metric tons, to 53 countries, in 2022 (USGC 2022a). U.S. corn processed into fuel ethanol and DDGS generates around $4 to $5 billion in trade annually (USDA-FAS 2019).

4.3.6.1.4 Crop Identity Preservation

As crops and production systems have diversified to meet market demands over the last several decades, the need for maintaining segregation and preservation of the identity of a crop and crop products has increased. This is due to the wide variety of food, feed, and industrial commodities that are produced in the United States, and the specific supply chains used for these commodities.

Identity preservation (IP) refers to a system of production, handling, and marketing practices that maintains the integrity and purity of agricultural commodities (Sundstrom et al. 2002). IP typically involves independent, third-party verification of the identification, segregation, and traceability of a product's unique, value-added characteristic (USDA-AMS 2019). Crop varieties with unique product quality traits, such as high-oleic canola, and food grade corn varieties are utilized for different purposes, and require IP programs to channel these types of crop products to specific markets. Similarly, commodities produced consistent with USDA organic standards must be segregated in the marketplace in order to receive premium prices. The introduction of crops developed using biotechnology can also require IP programs, as markets differ in their acceptance or preference for these commodities.

[43] Pre-COVID-19 data more accurately reflects average exports.

Verification is provided at every stage; including seed identity, crop production, and post-harvest processing, distribution, and marketing. Buyers are assured that the identity of the crop product is preserved throughout all stages of production. For example, FoodChain ID, an Iowa based certification firm, specializes in IP food and feed products for producers, food or feed manufacturers, and retailers that includes testing, validation, inspection, documentation, and certification, with a proprietary certifying seal (FoodChain-ID 2020).

Seed certification programs such as that used by the Association of Official Seed Certifying Agencies (AOSCA) play a major role in maintaining seed purity standards at levels established by the industry for national and international trade (Sundstrom et al. 2002; Elbehri 2007). Similarly, commodity traders, marketing organizations, and food processors have established purity and quality standards for specific product end-uses.

Low-level and Adventitious Presence

The low-level presence (LLP) or adventitious presence (AP) of biotechnology-derived trait material in internationally traded conventional, organic, or biotech crop commodities are important considerations in the trade of corn. LLP refers to the unintended presence, at low levels, of biotech crop material that is authorized for commercial use or sale in one or more countries, but not yet authorized in an importing country. AP refers to instances when trace amounts of biotech crop material that has not been approved for commercial use by any country is found in post-harvest crop material or food supply.

Asynchronous approvals and zero tolerance policies can result in the diversion of trade by some exporters (Van Eenennaam and Young 2014), and rejection or market withdrawals by importers of corn (e.g., (FOEU 2014; Frisvold 2015)). Consequently, incidents of LLP or AP can lead to income loss for exporters and consequently for producers, and consumers in importing countries can potentially face higher domestic prices when an import is rejected or directed to another trading partner (Atici 2014).

Biotechnology-derived corn commodities are excluded for importation by some countries, and other countries may lag approval of new biotech corn varieties. As of 2020, 72 countries had adopted biotech crops; 29 countries had authorized planting, and 43 countries had authorized importing (ISAAA 2020). In general, LLP or compromise of corn commodity identity can cause disruptions in international trade when biotech trait material is inadvertently incorporated into food or feed shipments. As such, biotech crop producing countries take measures necessary in the production, harvesting, transportation, storage, and post-harvest processing of biotech crop commodities to avoid the potential for LLP in conventional or organic commodities.

Product Stewardship

Bayer implements a product stewardship program to ensure that products, services, and technologies are safe and sustainable, and that product use is environmentally responsible (Bayer 2022b). Bayer endorses the FAO Code of Conduct on Pesticide Management (FAO 2022), CropLife International Plant Biotechnology Code of Conduct (CropLife 2022), Excellence Through Stewardship (ETS) and Responsible Care programs (ETS 2022), and provides guidance for prevention of development of HR weed populations (Bayer 2022a). This includes training as mandated by the EPA as a condition of registration for products containing the herbicide dicamba for use in dicamba-resistant soybean and cotton crops (Bayer 2022b).

4.3.6.2 Potential Socioeconomic Impacts

MON 87429 corn hybrids could be used to produce food, feed, fuel ethanol, and/or industrial commodities. To the extent MON 87429 corn hybrids facilitate effective management of weeds and HR weed development, it would be expected to support growers achieving optimal yields and net-returns on crop production, and supplying U.S. and global market demand for corn products. These factors considered, the impacts of MON 87429 corn on the corn industry and consumer markets would be expected to be largely beneficial.

There could be, however, potential economic impacts associated with any herbicide spray and vapor drift, as previously discussed, on crop and non-crop areas (e.g., dicamba and to some extent 2,4-D), summarized further below. In brief, herbicide spray or vapor drift can damage nearby crop and non-crop plants. Spray/vapor drift from dicamba damaged an estimated 3.6 to 5 million acres of crops, trees, and vegetable farms in 2016 (UM-IPM 2018; CBD 2019), across 24 states (Unglesbee 2017). In 2017, there were approximately 2,708 instances of dicamba-related injury (Hettinger 2019a; Unglesbee 2019c). In 2018, there were approximately 1,400 reported cases of dicamba drift (US-EPA 2018), and in 2019 over 1,000 reported cases (Unglesbee 2019b). In 2021, the EPA continued to receive reports of off-target movement of dicamba. The EPA received nearly 3,500 reports alleging effects from off-target movement of dicamba onto various nontarget vegetation, including cotton and soybean varieties that are not dicamba-tolerant, ornamental plants, other crops (sugarbeet, rice, sweet potato, peanut, grapes, cucurbits, vegetables, fruit trees, caneberries) and natural areas (US-EPA 2021d).

4.3.6.2.1 Summary of Potential Benefits and Costs an HR Crops

Crop producers will adopt and maintain production of a biotech plant variety that provides specific traits, over a conventionally bred variety absent those traits, relative to the benefits they can derive from the biotech crop (Fernandez-Cornejo et al. 2000; Fernandez-Cornejo et al. 2014b). Based on a 2010 USDA Agricultural Resource Management Survey, farmers indicate that they adopted biotech corn, soybean, and cotton varieties primarily to achieve optimal yields, to save pest and weed management time to make other practices easier (e.g., rotating crops, conservation tillage), and to reduce pesticide input costs (Figure 4-28).

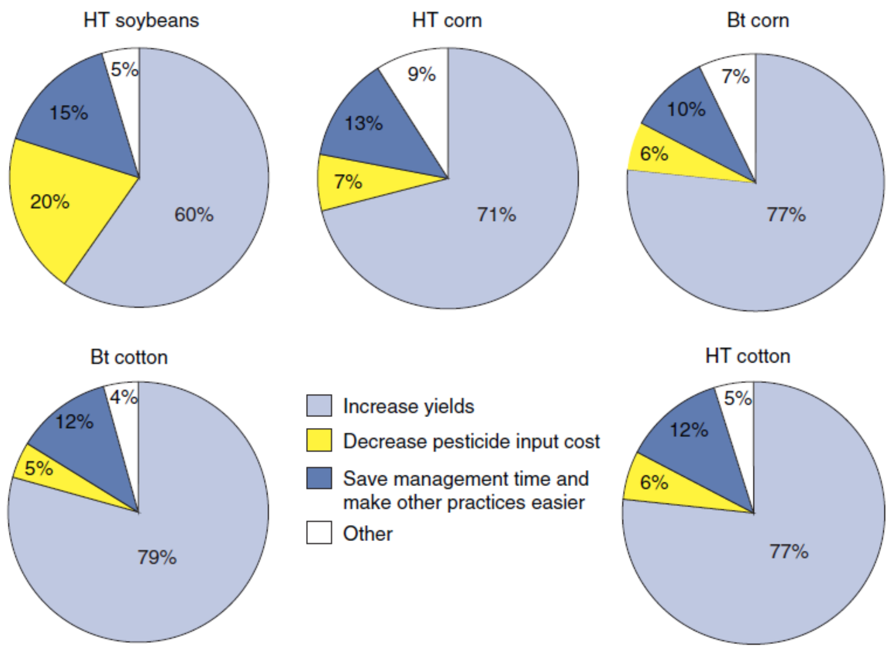

Figure 4-28. Common Reasons Growers Adopt Biotechnology Derived Corn Varieties

Sources: (Fernandez-Cornejo et al. 2014b)

The use of HR corn, cotton, and soybeans by U.S. farmers increased substantially subsequent to commercialization of HR crops—since the mid and late 1990s (see prior Figure 4-5). Currently, most corn, cotton, and soybean crops grown in the United States are of an HR variety (USDA-ERS 2022). In 2022, approximately 90% percent of U.S. corn acres were planted with HR seeds (USDA-ERS 2022).

HR soybean use increased the most rapidly, largely because weed resistance to herbicides called ALS inhibitors had developed in the 1980s. By comparison, HR corn use increased relatively slowly, perhaps because corn farmers can use an herbicide called atrazine, which is an effective alternative to glyphosate. Atrazine is safe for corn and can be applied both before and after corn plants start growing. However, it cannot be used on soybeans or cotton (Wechsler 2018). As of 2021, atrazine comprised 25% of total herbicide use on corn (discussed in Section 4.3.1.2.3 – Pesticides).

The profitability of biotech crops for individual farmers depends largely on the value of maximum yield achieved relative to the associated costs of pesticide and seed—biotech crop seed generally costing more than conventionally bred crop seed. Fundamentally, farmers may adopt, but will not continue production of a biotech plant variety where that variety does not provide economic and other benefits over those of conventionally bred crop. The adoption of biotech crops in the United States has generally reduced costs and improved profitability at the farm level (Fernandez-Cornejo et al. 2014b; Klümper and Qaim 2014; Brookes and Barfoot 2020b). As previously mentioned, U.S. farmers have realized higher incomes with HR corn varieties, totaling approximately $10.8 billion from 1996 –2018 (Brookes and Barfoot 2020b). The average gross farm income benefit with HR crops is around $12/acre ($30/hectare) (Brookes and Barfoot 2020b).

In 2018, the net economic benefits at the farm level for biotech crops, globally, amounted to $18.9 billion, with aggregate benefits totaling $225.1 billion for the period 1996 – 2018 (Brookes and Barfoot 2020b). Seventy-two per cent of the gains have derived from yield and production gains with the remaining 28% coming from cost savings (Brookes and Barfoot 2020b). Agricultural biotechnology has also made important contributions to increasing global production levels for the four main crops, adding 278 million metric tons and 498 million metric tons, respectively, to the global production of soybeans and corn since the introduction of biotechnology derived crops in the mid-1990s (Brookes and Barfoot 2020b). In terms of investment, for each extra dollar invested in biotech crop seeds (relative to the cost of conventional seed), farmers gained an average $3.75 in extra income. In developing countries, the average return has been $4.41 (U.S. dollars) (Brookes and Barfoot 2020b).

The primary impact of HR crop technology has been to provide more cost effective and less labor intensive weed control, as opposed to protecting yields. The improved weed control has, nevertheless, delivered higher yields in some cropping systems (Brookes and Barfoot 2020b). In general, some researchers have found no significant difference between the yields of conventional and HR crops, others found that HR crops had higher yields, while still others found that HR crops had lower yields (e.g., see review by (Fernandez-Cornejo et al. 2014a)). An additional benefit from HR crops has been the facilitation of no tillage production systems, which reduces tillage costs (Brookes and Barfoot 2020b).

The use of HR and IR crop technology has helped limit agriculture's footprint on land use by facilitating farmers' production of sufficient crop—biomass—without needing to use additional land. This is largely due to IR crops (and to some extent HR crops) facilitating protection of crop yield. For example, to maintain global production at 2018 levels, without IR and HR crops, would have required farmers to plant an additional 12.3 million hectares (ha) of soybeans (5.1 million acres), 8.1 million ha of corn (2.4 million acres), 3.1 million ha of cotton (1.3 million acres), and 0.7 million ha of canola (0.3 million acres) (Brookes and Barfoot 2020b), an area equivalent to the size of New York State and Maine combined.

Overall, there is considerable quantitative data that describes that positive economic benefits of HR crops (Klümper and Qaim 2014; Brookes and Barfoot 2018; Brookes and Barfoot 2020b). From an empirical standpoint, HR crop varieties are valued by U.S. crop producers. As mentioned, currently, approximately 90% of U.S. corn, 94% of cotton, and 95% of soybean acres are planted with HR seeds (USDA-ERS 2022). Thus, the majority of producers of these crops have elected to utilize HR varieties. Biotechnology-derived varieties incorporating two or more traits, such as stacked-trait HR/IR varieties, are now common, and are expected to remain preferred crop varieties in the coming years.

In relation to potential unintended costs that can be incurred with HR crops, over reliance on the use of glyphosate, and the lack of crop and herbicide rotation by farmers contributed to the development of glyphosate resistant weeds (discussed in Section 4.3.1.2 – Agronomic Practice and Inputs). This added costs to crop production systems compared to about 15 years ago, discussed in the following section, although relative to the current conventional crop varieties, HR crop technology continues to offer important economic benefits (Brookes and Barfoot 2020b).

4.3.6.2.2 Herbicide Resistant Weed Costs

Over 90% of U.S. acreage used for production of major crops (e.g., corn, cotton, soybean) is treated with herbicides, so as to control weeds (Fernandez-Cornejo et al. 2014c). A primary concern currently facing

U.S. crop producers, and the agricultural industry in general, is the emergence of HR weed populations resulting from the repeated, widespread use of a single herbicide MOA (discussed in 4.3.1.2.3 – Pesticides). This is not unique to biotechnology-derived crop varieties; development of HR weed populations has routinely occurred with non-biotech crops and associated herbicide use since the introduction of herbicides in the 1950s, and can continue to occur with any crop on which an herbicide is repeatedly used. Considering that a substantial portion of corn, soybean, and cotton crops are currently planted to HR varieties, such cropping systems and the agronomic practices employed can potentially affect the development of resistant weed biotypes: Either contribute to the effective management of weeds and allaying/prevention of development of weed resistance, or, in the absence of effective IWM programs, exacerbate the development of herbicide resistance in weed populations over the long-term.

In a 2016 /2017 National Cover Crop Survey, 59% of U.S. farmers reported having HR weeds on some of their fields, and that percentage is expected to continue to increase (SARE 2020). Most corn growing states have from around 3 to 8 different species of weeds that are herbicide resistant (Heap 2022). There have been no herbicides with completely novel MOAs developed and commercialized over the last several decades. Consequently, there are no herbicides with novel MOAs with which to control HR weeds. The resistance exhibited by HR weeds includes various MOAs, such as ALS inhibitors, synthetic auxins, photosynthesis inhibitors, and amino acid synthesis inhibitors (Heap 2022). Problematic is the fact that many HR weed populations have developed resistance, and continue to, to more than one herbicide MOA. For example, in U.S. corn crops, as of 2020, there have been 16 instances with a weed population developing resistance to 2 herbicide MOAs, 5 confirmed weed populations with resistance to 3 MOAs, 3 with confirmed resistance to 4 MOAs, and 1 species (tall waterhemp) with confirmed resistance to 5 MOAs.

The presence of HR weeds in crop fields increases the cost of production and can reduce net returns (Fernandez-Cornejo and Osteen 2015). HR weeds cost farmers money due to yield loss (the result of competition from HR weeds), and expenditures on additional herbicides and labor required to control HR weed populations. The extent to which HR weed control affects net returns is highly variable and depends on the type and abundance of a problem weed or weeds present; costs associated with herbicides to control HR weeds, extent of tillage used (e.g., fuel and labor costs), other manual practices used in eliminating HR weeds (e.g., hand pulling); and the cost of seed. The economic consequences of development of HR weeds and their management can be considerable.

A USDA–ERS study estimated the impacts of glyphosate-resistance on corn and soybean production in 2010 and 2012. The results suggest that corn growers who had reported a glyphosate-resistant weed infestation in 2010 realized significantly lower total returns (-$67.29/acre) than similar corn growers who had not reported such an infestation (Livingston et al. 2015). The results suggested that lower yields and higher chemical and fuel costs might have contributed to the shortfall in net returns (Livingston et al. 2015). In general, the occurrence of HR weeds normally drives up overall herbicide costs, as more expensive residual herbicides are used to control HR weeds. Oftentimes an extra post-emergence herbicide treatment is employed (SARE 2020). The USDA-ERS analyses suggested that proactively managing for weed resistance may be more cost effective in the long run (Livingston et al. 2015). Similarly, Weirich et al. (2011) investigated the effect of grower adoption of glyphosate weed resistance management programs and found them initially more costly, but by protecting yields and net economic returns, and reducing resistant weed problems, weed management costs were offset over the long term.

In general, HR weeds may be costing U.S. growers as much as $2 billion a year in decreased yields, increased input costs, and decreased land values (Van Deynze et al. 2020). Herbicide resistance can increase grower chemical costs by 30% to 40% due to the need to control HR weed populations and protect yield (Weaver 2019). Reported costs to farmers for control of HR weeds range from $14 to $150 per acre, dependent on the HR weed species present (e.g., Palmer amaranth can reach 6 ft in height at maturity, once it reaches 6-8 inches in height there is no herbicide that can effectively control it (GROW 2021)), prevalence of HR weed populations, and number of herbicide MOAs to which an HR weed is resistant (Hurley et al. 2010; Hembree 2011; Livingston et al. 2015; Bayer-CropSci 2018; Heap 2022).

To mitigate or prevent development of HR weeds, and associated control costs, it is recommended producers of both HR and non-HR crops employ IWM tactics that include the judicious and diversified use of differing herbicide MOAs, herbicide rotations, crop rotations, cover crops, tillage as may be needed, and scouting practices (e.g., (Owen 2016; Heap and Duke 2018; Beckie et al. 2019; Korres et al. 2019), and others). As reviewed in 4.3.1.3–Potential Effects on U.S. Corn Production, stacked-trait HR crop varieties, as part of an IWM program, are considered a useful tool to facilitate management of weeds and development of HR weed populations. Liu et al. (2020) evaluated, using economic models, the cost-benefit of utilizing a single HR crop, and stacked-trait HR crop. For an HR crop with resistance to one herbicide MOA, a post-emergent herbicide application, the model found failure after 7 years of practice due to evolved weed resistance, at which time crop yield and grain quality were affected negatively. A program relying on a single herbicide MOA post application led to weed control failure in less than 4 years if the field already contained HR weeds (Liu et al. 2020). In contrast, the studies by Liu et al. (2020) found that use of a three-way stacked HR crop with POST applications, and two-way stacked HR crop using a residual herbicide PRE followed by one POST application, were more sustainable over a 20 year time frame.

Fundamentally, it is the producers of HR and non-HR crops that decide which set of IWM practices and herbicides used will best support the long-term sustainability and profitability of the particular crop (s) they are producing.

4.3.6.2.3 Herbicide Spray and Vapor Drift: Potential Costs

As previously discussed (4.3.1.3.5–Herbicide Drift and Volatilization) herbicide spray and vapor drift can damage nearby crop and non-crop plants. The economic impacts associated with previous instances of dicamba spray/vapor drift, have been significant.

Spray/vapor drift from dicamba damaged an estimated 3.6 to 5 million acres of crops, trees, and vegetable farms in 2016 (UM-IPM 2018; CBD 2019), across 24 states (Unglesbee 2017). In 2017, there were approximately 2,708 instances of dicamba-related injury (Hettinger 2019a; Unglesbee 2019c). In 2018, there were approximately 1,400 reported cases of dicamba drift (US-EPA 2018), and in 2019 over 1,000 reported cases (Unglesbee 2019b). In 2021, the EPA continued to receive reports of off-target movement of dicamba. The EPA received some 3,500 reports alleging effects from off-target movement of dicamba onto various nontarget vegetation, including cotton and soybean varieties that are not dicamba-resistant, ornamental plants, other crops (sugarbeet, rice, sweet potato, peanut, grapes, cucurbits, vegetables, fruit trees) and natural areas (US-EPA 2021d). These events namely in association with increased production of dicamba-resistant cotton and soybean.

Costs due to crop loss from herbicide draft can range from hundreds to tens-of-thousands of dollars; significantly more—millions of dollars—in some instances. Crop producers whose fields have been affected by dicamba drift have been observed to have lost between 5% to 30% of yield (Barth 2016).

Dicamba drift damages are not federally insurable; federal crop insurance only covers weather-related perils, such as flooding or drought, not chemical-related issues. Liability insurance may cover yield loss, but the challenge is pinpointing the dicamba source when drift occurs (GMRC 2019). To recover costs from herbicide drift damage growers must first file an "incident report" with their state agricultural authority. Once an incident report is filed, states will decide whether to open an investigation to determine if a pesticide was misused or if any state or federal law was violated. Crop producers or other property owners may consider whether to pursue a private action to recover damages. Recovery for damage caused by herbicide drift may be sought under several legal paths; including negligence; liability; and, occasionally, chemical trespass or nuisance.

A 2016–2020 WSSA/EPA surveys of midwestern state farmers growing specialty crops (ND, SD, MN, WI, MI, OH, IN, IL, MO, IA, NE, KS) found that surveyed growers reported crop injury from herbicide spray and vapor drift; 47% reported plant damage from dicamba drift, and 44% from 2,4-D drift (WSSA/EPA 2020). Approximately 9% to 12% reported damages ranging from $10,000 to $50,000, and 27% to 28% reporting damages in the $1,000-$10,000 range (Table 4-27).

Table 4-27. Estimated Total Financial Loss Due to Herbicide Drift Damage

Survey Metric	2019	2020
No herbicide drift	36%	34%
< $1,000	25%	22%
$1,000-$9,999	27%	28%
$10,000-$49,999	9%	12%
$50,000-$99,999	1%	2%
$100,000-$499,999	1%	1%
$500,000-$1 million	1%	1%
Number of Survey Respondents	162	175

Specialty crops included in the survey: Green, snap, or lima beans; Green peas; Edamame / Food-grade soybean; Dry edible beans; Dry edible peas; Tomatoes; Potatoes; Peppers; Cucumber/Melon; Pumpkins/Squash; Lettuce/Greens; Grapes; Peaches; Apples; Blueberries; Brambles; Strawberries; Flowering annuals; Ornamental perennials; Landscape trees and shrubs; Christmas trees.
Source: (WSSA/EPA 2020)

There has also been reported damage to soybean research plots at academic research centers. The University of Missouri's Fisher Delta Research Center, and University of Nebraska, Kansas State, and the University of Arkansas have reported that they've seen symptoms of dicamba exposure in their test plots. No acreage or estimated financial costs were reported (Charles 2019).

Impacts are not limited to crops such as soybeans and cotton; specialty crops, such as fruits and tree nuts, vegetables, culinary herbs and spices, as well as nursery, floriculture, and horticulture crops[44] can also be damaged by dicamba drift (Delvalle 2022; USDA-AMS 2022). Arkansas, Mississippi, Missouri, Nebraska, Tennessee, and Virginia have each reported injury to various types of trees, ornamental species, garden plants, flowers, and berries as a result of dicamba drift (Bradley 2018). As of June 1st, 2018 approximately 150 ornamental trees, 30 fruit trees, 250 vegetable plants, and 150 berry species were reported with probable dicamba injury in these six states, along with approximately 50 acres of hardwood/shade trees (Bradley 2018). The value, net sales, of horticultural crops alone in 2019 was $13.78 billion (USDA-NASS 2019e).

During 2018–2019, an owner of Vermilion Valley Vineyards and Ohio Vineyard Management lost 5 acres of vines due to off-target herbicide drift (Williams 2021). Three of the lost acres were planted with Moscato Giallo, a rare grape variety that is difficult to obtain. It was estimated that it may take a decade for the fully replanted block to mature, with lost revenue extending years into the future (Williams 2021). A proprietor of Stony Run Winery in Pennsylvania also experienced herbicide drift related symptoms, from leaves shriveling and curling up on the ends, which takes about four to six weeks to recover, to complete destruction of primary buds for next year's crop (Williams 2021). Impacted by drift for five years in a row, reported losses for Stony Run Winery due to dicamba drift were $1.4 million in revenue (Williams 2021).

In 2022, Bader Farms (plaintiff), was awarded a total of $75 million due to dicamba drift and crop loss; $60 million in punitive damages, and $15 million in compensatory damages (Dowell 2022). The owner incurred extensive damage to their peach orchard due to dicamba drift from neighboring dicamba resistant cotton crops (Gillam 2020). The dicamba damage to Bader Farms was substantive—injuring more than 30,000 peach trees, about 40% of the crop, and resulted in $1.5 million in loss of sales (Gray 2016; Randles 2017).

In June 2021, a group of Texas vineyards filed suit against Bayer and BASF, alleging that dicamba, used on the state's cotton fields, has damaged thousands of acres of wine grapes (Gray 2021). The case alleges that 95% of productive grape vines sustained damage across dozens of vineyards. The owners of 57 vineyards in the High Plains region stated they are trying to prevent damage to the state's $13 billion wine industry. The plaintiffs are seeking $560 million in punitive and economic damages (Romano 2022). Texas is the largest cotton cropping state in the United States in terms of acreage—around 5.7 million acres. The first dicamba-resistant cotton seeds were planted in 2016. An estimated 60-80% of cotton grown in Texas in dicamba resistant.

Ornamental plants on residential and commercial properties can also be affected, although the effects of herbicide drift on residential and commercial properties has not been well monetized. Dintelmann et al. (2020) conducted an experiment to determine the sensitivity of common garden annuals to sublethal rates of 2,4-D and dicamba with or without glyphosate. Sublethal rates corresponding to 1/10th, 1/100th, and

[44] Horticultural crops are classified as: Nursery Stock; Annual Bedding/Garden Plants; Sod, Sprigs or Plugs; Potted Flowering Plants; Herbaceous Perennial Plants; Propagative Materials; Food Crops Grown Under Protection; Foliage Plants; Cut Flowers; Transplants for Commercial Vegetable Production; Cut Christmas Trees (USDA-NASS 2019a).

1/300th of the full labeled rate of 2,4-D (1.0 lb/acre), 2,4-D plus glyphosate (1.0 lb/acre plus 1.0 lb/acre), dicamba (0.5 lb/acre), and dicamba plus glyphosate (0.5 lb/acre plus 1.0 lb/acre) were applied to Prelude wax begonia (*Begonia ×semperflorens-cultorum*), Wizard coleus (*Solenostemon scutellarioides*), Pinto zonal geranium (*Pelargonium ×hortorum*), Dazzler impatiens (*Impatiens walleriana*), Bonanza French marigold (*Tagetes patula*), Hurrah petunia (*Petunia hybrida*), Titan madagascar periwinkle (*Catharanthus roseus*), and Double Zahara zinnia (*Zinnia marylandica*). Visible injury, plant height, number of flowers, and dry weight were recorded at specific time intervals after treatment. When averaged across all annual plant species, the 1/10th rate of 2,4-D plus glyphosate resulted in 51% injury 28 days after treatment, whereas the 1/10th rate of dicamba plus glyphosate resulted in 43% injury. Treatments causing the greatest injury also resulted in the greatest reduction of dry weight, height, and flower production. Coleus was the most sensitive species in the study; dry weight was reduced by 16% and 18% compared with the nontreated controls from 1/300th rates of 2,4-D plus glyphosate and dicamba plus glyphosate, respectively. French marigold and geranium had greater sensitivity to treatments containing 2,4-D, but coleus and zinnia had greater sensitivity to treatments containing dicamba. Petunia exhibited a high tolerance to 2,4-D or dicamba applied alone (>6% injury) but was highly sensitive when glyphosate was added to 2,4-D and dicamba (<65% injury). The 1/100th and 1/300th rates that are likely to equate to sublethal rates in field settings, resulted in less than 15% injury across all flower species, except for coleus and petunia (Dintelmann et al. 2020).

The instances of herbicide drift on crop and non-crop plants considered above, the reported cases of injury to crop and non-crop plants are likely lower than the actual cases of injury, not all instances of drift injury are likely reported (Unglesbee 2019b; WSSA/EPA 2020).

As previously discussed, due to the agronomic and economic impacts derived from dicamba drift/volatility, on June 3, 2020, the Ninth Circuit Court of Appeals issued an order vacating he EPA's pesticide registrations for certain products containing dicamba, these were XtendiMax® with VaporGrip® Technology; Engenia®; and FeXapan®. The EPA subsequently issued a cancellation order for all three dicamba products on June 8, 2020, and issued new, revised, registrations in October (US-EPA 2020q). These registrations are only for use on dicamba-resistant cotton and soybeans and will expire in 2025. To manage off-site movement of dicamba, the EPA's 2020 registrations provided new control measures.

Bayer states the use of dicamba on MON 87429 corn will follow current EPA registration label use requirements for corn. The maximum annual use rate would be a total of 0.75 lbs. a.e. per treated acre per crop year. Maximum application rate would be 0.5 lb. a.e. per acre, with no more than 2 applications per growing season (Bayer-CropSci 2022). Use restrictions would include (US-EPA 2010):

- Application prohibited if corn is more than 36 inches tall or within 15 days before tassel emergence, whichever comes first.

- Application prohibited when soybeans are growing nearby if any of these conditions exist: corn is more than 24" tall; soybeans are more than 10" tall; soybeans have begun to bloom.

In 2020, the EPA established two federal cutoff dates stated on the dicamba herbicide labels registered for use for with HR cotton and HR soybean: June 30 for soybeans and July 30 for cotton (e.g., see (US-EPA

2020m, s, r)). All 3 dicamba herbicides are required to be used with a volatility-reducing adjuvant (VRA) to keep the tank mix pH at or above 5, which lowers the risk of volatility. New dicamba labels also include expanded buffer areas to reduce the potential for drift injury. For example, a required buffer of 240-foot downwind, for dicamba applications on HR cotton and HR soybean. A second buffer requirement is a 57-foot omnidirectional buffer, combined with a 310-foot downwind buffer to protect ESA listed endangered species. This buffer is only required for fields in counties that harbor federally recognized endangered species and are listed on the EPA's Bulletins Live! Two website.[45]

In 2023, the EPA approved additional labeling amendments that further restrict the use of OTT dicamba use in Iowa, Illinois, Indiana, and South Dakota (US-EPA 2023b). The Iowa, Illinois, and Indiana amendments were requested by product registrants following discussion with certain states. The revised EPA labeling prohibits the use of OTT dicamba application on dicamba-resistant crops after June 12 in Iowa, Illinois, and Indiana, and after June 20 in South Dakota. This restricts OTT dicamba application to earlier in the growing season, when temperatures are likely to be lower, and is intended to reduce the potential for dicamba to volatilize and drift off-site. These amendments follow amendments the EPA approved for Minnesota and Iowa in March 2022. If a state wishes to further restrict the OTT uses of dicamba, it may use FIFRA section 24(a) to do so, or pesticide registrants and states can work together to submit a label amendment containing state-specific restrictions for EPA approval (US-EPA 2023b).

4.3.6.2.4 Consumers

Potential beneficial impacts to consumers of commodities derived from MON 87429 corn would be similar to that of other dent corn crops; these would be cost-efficient food products, fuel ethanol, animal feed, and industrial products.

4.3.6.2.5 Identity Preservation Costs

MON 87429 corn would entail entry of an HR corn variety into agricultural commodities markets, this varietal comprised of 4 differing HR trait genes and gene products. MON 87429 hybrids, a dent corn variety, could be used for production of common animal feed, food, fuel, or industrial commodities. While MON 87429 corn would be a somewhat novel variety in terms of the HR traits, the entry of MON 87429 corn grain into the feed, food, and industrial commodities supply chains would not be considered an event that presented unusual or unique risks to protection of specialty and IP corn commodities. New varieties of common dent corn and specialty corn are expected to be continually developed and marketed to help crop producers meet demands for food, feed, fuel, and industrial commodities. Thus, entry of MON 87429 hybrids into domestic and foreign markets would contribute to the risks of commingling and LLP no differently than other modified crops, and specialty corn varieties that have and will enter the market. This type of market effect is not considered adverse in nature, rather, segregation and channeling of specific types of harvested grain (e.g., flint, flour, dent, pop, and waxy corn) to various supply chains is inherent to corn and other commodities markets. Identity preservation certification programs are well developed and an intrinsic aspect of crop production in the United States and abroad (Sundstrom et al. 2002).

[45] U.S. EPA, Bulletins Live! Two -- View the Bulletins [https://www.epa.gov/endangered-species/bulletins-live-two-view-bulletins]

4.3.6.2.6 Organic and Conventional Corn Markets

The introduction of MON 87429 corn trait material into conventional or organic cropping systems could occur (1) as a result of cross-pollination, gene flow into the plant itself, discussed in 4.3.3.4 – Gene Flow and Potential Weediness of Corn, or (2) the inadvertent mixing of post-harvest seed/grain with other harvested plant parts, which can have economic consequences for farmers and corn commodities markets.

Commingling of corn seeds (or any other seed crop), directed for specific commodity supply chains, generally results due to inadvertent loss of segregation of crop seed for specific markets/purposes during post-harvesting processing.[46] As previously discussed, management of gene flow and commingling is a basic component of commercial crop production to maintain the levels of genetic purity required for marketing certain types of conventional or organic agricultural commodities. Important for IP and organic markets, which are expected to maintain their crops and crop products free (or at *de minimis* levels) of the presence of biotechnology derived traits or other foreign material. The unintended presence of genes or gene products from an HR crop (or other crop traits) in on IP or other organic agricultural commodities could interfere with domestic markets and international trade. Consequently, the maintenance of crop product identity is fundamental to ensuring the sustainability of the mutual production of biotechnology derived, conventional, and organic cropping systems—the maintenance of identity of crop commodity produced and associated price premiums in the market.

Gene flow and commingling mitigation strategies in agriculture are well-established and can meet current domestic and international trade needs. Producers of conventional and biotechnology derived commodities may use practices prescribed by USDA's National Organic Program (NOP) (USDA-AMS 2020a), the Association of Official Seed Certifying Agencies (AOSCA) (AOSCA 2020), or individual contracts, as applicable. For all crop production systems, 100% purity (or 0% impurities) of any crop commodity or constituent is never possible, and costs increase exponentially to seek to achieve this goal (Van Deynze 2011; Kalaitzandonakes and Magnier 2013). As a result, farmers and agricultural groups have adopted process-based strategies, such as those developed by the USDA NOP and AOSCA[47] that allow a low and acceptable level of impurities, including pesticides, weed seed, or other varietal seed, in the final crop product (e.g., < 1% or <5%). Similarly, the American Seed Trade Association (ASTA), with 700-plus members, works with the global seed industry to ensure that practical standards are developed to support international markets, and seed innovation and protection (ASTA 2020).

The presence of biotechnology derived crop material in conventional crop products can and does occur in rare instances. On average, around 1% to 3% of conventional crop producers have reported crop commodity rejection by suppliers due to the presence of biotechnology derived crop material. Around 2% of IP cropping systems report rejection of their IP commodity as a result of the unintended presence of biotechnology derived trait material.[48]

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[46] This includes rented and borrowed equipment and equipment used by custom operators—planters, combines, balers, wagons, trucks, etc… If the equipment is to be used for planting, harvesting, or handling any non-biotech crops, it must be thoroughly cleaned and purged prior to use. Improperly cleaned equipment can contaminate a non-biotech crop.

[47] The Association of Official Seed Certifying Agencies (AOSCA) develops, monitors, and coordinates standards for seed purity.

[48] USDA Stakeholder Workshop on Coexistence: Panel Discussion on Economic Perspectives on Coexistence. Comment by Nicholas Kalaitzandonakes. March 12, 2015.

The organic industry is sensitive to the unintended presence of biotechnology derived material as it can compromise contractual requirements with businesses that market and sell their products. For example, from 2006 to 2010, nine of more than 9,000 certified organic farms collectively reported losses of $68,976, at an average reported loss of $7,664 for the nine organic farms that reported losses (USDA-NASS 2015). During the years 2011 – 2019, the incidence of affected organic farms ranged from around 0.1% to 0.7%. In 2014, 31 farms, out of a total of 14,093 certified organic farms (~0.2%) reported a total $506,552 in losses, with an average of $16,340 per farm. In 2015, 32 farms, out of 12,818 total certified organic farms (~0.1%), reported a total of $520,671 on losses due to the unintended presence of biotechnology derived crop material, with an average reported loss of $16,271 (USDA-NASS 2016). In 2015, certified organic farms sold a total of $6.2 billion in organic commodities. The total value of sales from all certified organic crops in 2015 was $3.5 billion.[49] In 2015, the total value of sales of certified organic field crops, of which there are biotechnology derived varieties (e.g., corn, cotton, soybean, canola) was $660 million (USDA-NASS 2015). In 2018 and 2019, 115 and 125 farms reported instances of united presence of biotechnology derived material in their crops, respectively (USDA-NASS 2019c). In 2019, there were 16,585 certified organic farms in the United States (latest data). This equates to approximately 0.7% of organic farms affected in 2019.

In general, as the number of organic farms and adoption of biotechnology derived crops increased over the period 2006–2019, the incidence of organic farms reporting economic losses increased from 0.1% to 0.7%, and has appeared to plateau around this level (USDA-NASS 2019c). Based on data from 2006 to 2019, the incidence of reported losses to organic production from the unintended presence of biotechnology derived trait material in organic crops or crop products would be expected to be limited, with affected organic farms comprising less than 1% of total organic farms.

Depending on the commodity, conventional and organic crop products may carry a market price premium (Greene et al. 2016). The economic impact to producers of organic and products marketed as "non-GMO" due to unintended presence would depend on the price premium impacted. For instance, organic commodities receive a price premium in the food and personal care products markets (e.g., from 30% to 500%) relative to the price of commodities derived from conventionally grown crops. Because "organic" and "non-GMO" commodities can always be sold as "conventional" commodities, it is the price premium above the conventional price that represents a measure of the value impacted by the unintended presence of biotechnology derived trait material.

The majority (~ 90%) of corn grown in the United States are biotechnology derived dent corn varieties. MON 87429 corn would be expected to replace other HR corn varieties, as opposed to augmenting current HR varieties grown. Thus, entry of MON 87429 corn into commerce, which would likely replace other HR varieties currently cultivated, would have little to no impact on organic and conventional corn commodities markets from the standpoint of unintended presence. The production systems for agricultural commodities derived from biotechnology-based and conventional/organic corn provides a range of ways to efficiently meet consumer needs, preferences, and market demands, both in the United States and abroad. Preserving agricultural commodity identity in the market through IP or similar certification programs is inherent to commodity production, segregation, and product streams (Sundstrom et al. 2002). Current IP, "non-GMO", and seed certification programs provide effective means for maintaining product

[49] This includes nursery and greenhouse crops, which skews the total sales data when evaluating food crops.

identity; however, commingling or contamination by pollen flow, to some extent, over the long-term, is unavoidable (expected to be rare). MON 87429 corn production and marketing would present no more or less challenges in maintaining crop commodity identities than other corn varieties.

4.3.6.2.7 Native American Indian Corn (Maize)

In addition to the commercial corn varieties described in this EIS, there are around 12,000 acres of traditional or Indian corn produced in the United States on Indian reservations (USDA-NASS 2023). Native American tribes are recognized by the United States Bureau of Indian Affairs (BIA) for federal government purposes. As of 2021, 573 Indian tribes were legally recognized by the BIA (BIA 2021). Traditional or Indian corn are distinct cultivars of *Zea mays*—heritage varieties—of various sizes, color, and drought tolerance. Traditional/Indian corn grown has been passed from generation to generation through seed saving by American Indian and Hispanic communities (Hill 2021). Traditional or Indian corn is culturally significant and may found be found produced on all reservations in the states of Alabama, Alaska, Arizona, California, Colorado, Connecticut, Florida, Idaho, Indiana, Iowa, Kansas, Louisiana, Maine, Massachusetts, Michigan, Minnesota, Mississippi, Montana, Nebraska, Nevada, New Mexico, New York, North Carolina, North Dakota, Oklahoma, Oregon, Rhode Island, South Carolina, South Dakota, Texas, Utah, Virginia, Washington, Wisconsin, and Wyoming (USDA-NASS 2019a).

As reviewed in 4.3.3.4–Gene Flow and Potential Weediness of Corn, current varieties of corn were developed from wild ancestors into a food crop over the last several thousand years by indigenous people in Central America and native American Indian tribes in the United States, as well as other breeders (academic and commercial over the last century). Tribes in each region developed unique strains of corn adapted to thrive in their local environments, and many of these strains are still cultivated today. Due to the importance of corn to Tribal populations over many generations, corn has been incorporated into the ceremonies and cosmology of many Tribes, and culturally and nutritionally important (Hill 2021). There were concerns in public comments that increased use of MON 87429 corn would make it more likely for cross-pollination events to occur, and therefore more difficult for Tribal farmers to protect their traditional crops from such harm (Hill 2021).

Tribal Nations highly value the cultural and food value of indigenous maize varieties to inquire to their tribe. Thus, the need for maintaining genetic purity and diversity among indigenous maize varieties; sustaining Tribal agricultural practices, food sovereignty, and traditional foods is important. The ability of each tribal nation to cultivate their own maize variety, and the recognition that Native traditional foods are important to the health and well-being of Native people, is a USDA program focus.[50] The USDA supports Tribal Nations' agriculture, food sovereignty, and traditional foods through various programs.[51] These include loan programs for beginning farmers and ranchers, farm operating loans, the plant pest and disease management and disaster prevention program, specialty crop block grants, and national organic certification cost share program, among others.

The movement of transgenic DNA sequences from a biotechnology derived crop to other crop plants has attracted attention because of its potential economic impacts. All corn varieties (e.g., field, sweet, flint)

[50] USDA Office of Tribal Relations [https://www.usda.gov/tribalrelations]

[51] 2016 USDA Resource Guide for American Indians & Alaska Natives, United States Department of Agriculture Office of Tribal Relations [https://www.usda.gov/sites/default/files/documents/2016-usda-tribal-guide.pdf]

are potentially susceptible to pollen-mediated gene flow—between the male tassel and female silk—typically by wind (cross pollination can also occur through incidental hand pollination). Two neighboring farms in close proximity may potentially observe crop-to-crop gene flow if one farm has biotechnology derived corn and the other has non-biotech corn. As reviewed in 4.3.3.4–Gene Flow and Potential Weediness of Corn, MON 87429 corn and hybrids, if grown for commercial purposes, would present the same potential risk for gene flow, specifically the propensity for and frequency of gene flow, as current corn varieties. While corn pollen can travel as far as 1⁄2 mile (800 m) in a wind of 15 miles per hour (27 km/h) (Nielsen 2016), most pollen is deposited within a short distance of the corn plant. Numerous studies show the majority (84%-92%) of pollen grains travel less than 16 feet (5 meters) (Pleasants et al. 2001). At a distance of 200 feet (60 m) from the corn plant, the pollen concentration averages only about 1%, compared with pollen samples collected about 3 feet (0.9 m) from the pollen source (Burris 2002; Brittan 2006). The number of outcrosses is reduced to one-half at a distance of 12 feet (3.6 m) from the pollen source, and at a distance of 40 to 50 feet (12 to 15 m), the number of outcrosses is reduced by 99%. Thomison (2004) showed cross-pollination between cornfields could be limited to 1% or less by a separation distance of 660 feet (200 m), and to 0.5% or less by a separation distance of 984 feet (300 m). However, cross-pollination frequencies could not be reduced to 0.1% consistently, even with isolation distances of 1,640 feet (500 m).

The utilization of best management practices by growers of biotech and non-biotech crops to minimize or prevent cross-pollination is critical to reducing exposure to potential harm. The potential for plant gene flow can be managed through a combination of containment strategies, buffer zones, and cooperation and communication among neighboring growers.

While there exists, under certain circumstances, the potential for gene flow, cross-pollination between biotechnology derived corn and non-biotech varieties, utilization of best management practices, coordination and cooperation with neighboring growers of adjacent corn crops can preclude the occurrence of cross-pollination. As reviewed above, when corn fields are physically separated by sufficient distances (e.g., around 1,000 feet) they are less likely to have pollen drift and gene flow. Gene flow can also be reduced by staggering planting times—when adjacent corn fields flower and release pollen at different times in the summer.

4.3.6.2.8 International Trade

U.S. corn exports—grain, ethanol, DDGS, corn oil, high fructose corn syrup, corn gluten feed and meal, corn starch, and corn groats/flour—averaged around 9.5 billion annually from 2015 to 2019 (USDA-FAS 2019). By facilitating achieving maximum yield and thereby domestic production, the potential impacts of MON 87429 corn on the commodities pricing and U.S. trade of corn commodities could be potentially beneficial. MON 87429 corn/hybrids would be subject to the same international regulatory requirements, discussed below, as currently traded corn varieties.

Biotechnology derived plant varieties undergo a review among international agencies before entering foreign markets, such as reviews by the European Food Safety Agency (EFSA 2020) and the Australia and New Zealand Food Standards Agency (ANZFS 2020). These reviews likewise adhere to Codex standards. MON 87429 corn was approved for food uses in Australia, Canada, and New Zealand in 2020, and Philippines in 2021; it was approved for animal feed in Canada in 2020, and Philippines in 2021 (ISAAA 2022).

International trade, for conventional and biotechnology derived crop commodities alike, is facilitated by the World Trade Organization (WTO) and the Organization for Economic Cooperation and Development (OECD). Standards and guidelines for the safety evaluation and trade of biotech crop commodities are established under international policy and agreements such as the Codex Alimentarius (FAO 2009), the FAO International Plant Protection Convention (FAO 2020), WTO Sanitary and Phytosanitary Measures (WTO 2020b), WTO Technical Barriers to Trade Agreement (WTO 2020a), and the Cartagena Protocol on Biosafety (CBD 2020a).

As with all biotechnology-derived crop commodities, there exist the potential for low level presence (LLP) occurring in countries importing U.S. corn products. LLP refers to trace amounts of biotechnology-derived grain (or other plant material) in a shipment that has been approved in the country of production/origin, but not in the country importing the grain/commodity. The issue of asynchronous approval (AA), and resulting LLP situations, can lead to trade delays, shipment rejection, and costs to traders (FAO 2014). Although biotechnology-derived crops go through rigorous testing and safety assessments before being approved for use in commercial markets, not all countries approve and adopt them at the same time. Countries may also approve import of a biotechnology-based crop commodity, while restricting planting of biotechnology-derived crops. LLP can reduce the predictability of trade flows and interfere with global trade operating efficiently, there is however no international agreement that defines specific percentages or quantities of LLP for acceptance in trade—as a result, policies vary from country to country, and trading bloc to trading bloc.

In general, developers have various legal, quality control, and marketing motivations to implement rigorous stewardship measures to ensure IP, prevent commingling, and avoid AA and LLP. By necessity, all international regulatory and industry standards and requirements must be met for marketing and trading of MON 87429 corn commodities. Bayer implements a product stewardship program that, in part, helps growers understand and meet their grain and grain byproduct marketing responsibilities and export approvals (Bayer 2022b).

The United States is a member of the World Trade Organization (WTO), which facilitates harmonizing the global rules of trade between nations. The Agreement on the Application of Sanitary and Phytosanitary Measures (the "SPS Agreement") entered into force with the establishment of the WTO on January 1, 1995, sets out the basic rules for food safety and animal and plant health standards. The SPS agreement recognizes three international organizations/frameworks that have established standards and guidelines related to SPS measures (WTO 2020b), these are; the Codex Alimentarius Commission (Codex), the World Organization for Animal Health (OIE), and the International Plant Protection Convention (IPPC). Any international trade of MON 87429 or products derived from it following a determination of nonregulated status would be subject to national phytosanitary requirements and be in accordance with international SPS standards, inclusive of the Codex (food safety) and IPPC (plant pests and disease).

4.3.7 Climate Change and Greenhouse Gas Emissions

The primary sources of greenhouse gas (GHG) emissions in the United States are: Transportation (around 28%–29%), Electricity production (25%–27%), Industry (22%–23%), Commercial and Residential (12%–13%), and Agriculture (10%–11%) (Figure 4-29). In 2019, U.S. GHG emissions totaled 6,577 million metric tons of CO_2 equivalent (CO_2–eq), or 5,788 million metric tons of CO_2-eq after accounting for sequestration from the land sector.

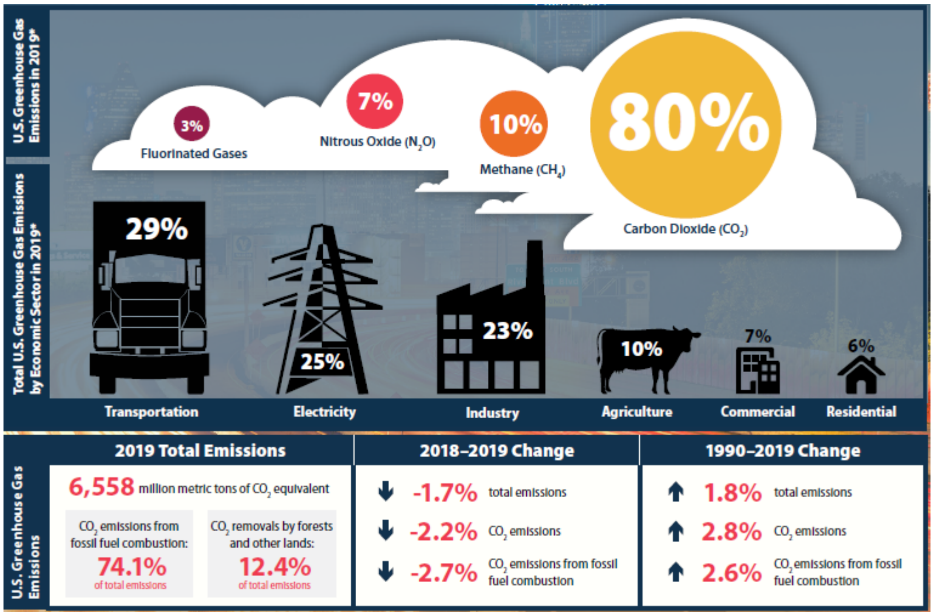

Figure 4-29. Sources of U.S. Greenhouse Gas Emissions

Source: (US-EPA 2020ac)

GHGs associated with agriculture are carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). N_2O emissions derive from fertilizer applications, CH_4 emissions from ruminant livestock production and rice cultivation, CH_4 and N_2O emissions from managed livestock waste, and CO_2 emissions from on-farm energy use. The management of cropped, grazed, and forestland can help offset GHG emissions by promoting the biological uptake of CO_2 through the incorporation of carbon into biomass, wood products, and soils—termed carbon sequestration. Net emissions equate to total GHG emissions minus CO_2 sequestration or removal of CO_2 from the atmosphere, including the net forest sink as well as the net soil sink from grazed lands and croplands.

Agricultural emission sources can be grouped into mechanical and non-mechanical (Table 4-28). Mechanical sources are equipment or machinery operated on farms, such as mobile machinery (e.g., harvesters), stationary equipment (e.g., boilers), and refrigeration and air-conditioning equipment. These sources emit CO_2, CH_4, and N_2O, or hydrofluorocarbons (HFCs) or perfluorocarbons (PFCs), and their emissions are determined by the properties of the source equipment and material inputs (e.g., fuel composition). Emissions from non-mechanical sources are larger than mechanical sources, with enteric fermentation (CH_4) and soils (N_2O) being the largest sources.

Roughly 60% of all N_2O emissions and 50% of all CH_4 emissions derive from non-mechanical agricultural activities, namely agricultural soil management practices and enteric fermentation livestock, respectively (US-EPA 2020l). The exact contribution of agriculture to global CO_2 emissions is difficult to quantify, because the biomass and soil carbon pools not only emit large amounts of CO_2, but also take up

CO_2 (sequester). Nevertheless, carbon sequestration offers most of the global emissions mitigation potential in agriculture (~89%).

Table 4-28. Agricultural Emissions Sources

Source	CO_2	CH_4	N_2O	HFCs and PFCs
Mechanical				
Purchased electricity[1]	x	x	x	
Pesticide Production and Use (use under mobile machinery below)	x			
Mobile machinery, fossil fuel combustion (e.g., tilling, seeding, harvesting, and transport)	x	x	x	
Stationary machinery (e.g., milling and irrigation equipment)	x	x	x	
Refrigeration and air-conditioning equipment:				x
Non-mechanical				
Tillage of soils:	x	x	x	
Addition of synthetic fertilizers, livestock waste, and crop residues to soils	x	x	x	
Addition of urea and lime to soils	x			
Enteric fermentation		x		
Rice cultivation		x		
Manure management		x	x	
Land-use change	x	x	x	
Open burning of crop residues left on fields	x	x	x	
Managed woodland (e.g., tree strips, timberbelts)	x			
Composting of organic wastes		x		
Oxidation of horticultural growing media (e.g., peat)	x			

[1] These gases are released during the combustion of fossil fuels, such as coal, oil, and natural gas, to produce electricity. N_2O emissions from stationary combustion sources result predominantly from the burning of coal at electric power plants (8 $MMTCO_2e$, or 60 percent of all nitrous oxide emissions from stationary combustion).
Source: (US-EPA 2020l)

At the farm scale, the magnitude of different emission sources and GHGs will vary widely depending on the type of farm, management practices, and natural factors at play. These factors include land cover; farm topography and hydrology; soil microbial density and ecology; soil temperature, moisture, organic content and composition; crop or livestock type; and land and waste management practices (CLI 2012). It can be difficult to accurately predict the relative magnitude of different sources for a given farm, although general sources and patterns of emissions can be expected (CLI 2012).

Together agricultural sources contributed about 10% of total anthropogenic emissions in 2019, around 628.6 million metric tons (MMt) of CO_2–eq (Table 4-29). Cropland agriculture is responsible for almost half (46%) of all emissions from the agricultural sector (USDA-NRCS 2020a). Methane emissions from enteric fermentation and manure management represent around 27% and 9% of total CH_4 emissions from anthropogenic activities, respectively. Of all domestic animal types, beef and dairy cattle are the largest emitters of CH_4. Rice cultivation and field burning of agricultural residues were minor sources of CH_4. Emissions of N_2O by agricultural soil management through activities such as fertilizer application and other agricultural practices that increased nitrogen availability in the soil was the largest source of U.S. N_2O emissions, accounting for around 75%. Manure management and field burning of agricultural residues are smaller sources of N_2O emissions. Urea fertilization and liming accounts for around 0.10% and 0.05% of total CO_2 emissions from anthropogenic activities, respectively (US-EPA 2020j).

Table 4-29. Emissions from Agriculture (MMT CO_2–Eq)

Gas/Source	1990	2005	2015	2016	2017	2018	2019
CO_2	**7.1**	**7.9**	**8.5**	**8.0**	**8.1**	**7.4**	**7.8**
Urea Fertilization	2.4	3.5	4.7	4.9	5.1	5.2	5.3
Liming	4.7	4.3	3.7	3.1	3.1	2.2	2.4
CH_4	**218.2**	**239.3**	**241.4**	**248.1**	**251.0**	**255.7**	**256.4**
Enteric Fermentation	164.7	169.3	166.9	172.2	175.8	178.0	178.6
Manure Management	37.1	51.6	57.9	59.6	59.9	61.7	62.4
Rice Cultivation	16.0	18.0	16.2	15.8	14.9	15.6	15.1
Field Burning of Agricultural Residues	0.4	0.4	0.4	0.4	0.4	0.4	0.4
N_2O	**330.1**	**329.9**	**366.2**	**348.4**	**346.4**	**357.9**	**364.4**
Agricultural Soil Management	315.9	313.4	348.5	330.1	327.6	338.2	344.6
Manure Management	14.0	16.4	17.5	18.1	18.7	19.4	19.6
Field Burning of Agricultural Residues	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Total	**555.3**	**577.1**	**616.1**	**604.4**	**605.5**	**621.0**	**628.6**

MMT = million metric tons
Source: (US-EPA 2020j)

Note the above figures do not fully account for carbon sequestration by crops, and soil management practices. Crop production systems can be both sources and sinks of GHGs, with the balance depending on a complex relationship of management practices, geographic region, and site-specific factors (e.g., weather conditions, soil type, proximity to surface and ground water bodies, topography). At the farm level, the following practices have overlapping and interacting effects on GHG emissions, particularly CO_2 and N_2O: tillage system, the timing of tillage and other field operations, crop residue management, crop selection and rotation, and the amount and timing of nutrient applications and other soil amendments. Cropland sources of CH_4 emissions include rice cultivation and the burning of agricultural residues.

Calculation of GHG emissions from crops involves evaluation of the life cycle of an agricultural product starting from the processes of extracting raw materials, through crop production, to the use of crop products and waste management (Vermeulen et al. 2012). Life-cycle analysis (LCA) of emissions can be assessed using the carbon footprint (CF) method (Pandey et al. 2011; Holka and Bieńkowski 2020). In identifying the most significant sources of GHG emissions in the canola production process, LCA is a useful tool to work towards solutions aimed at reducing emissions in crop production. The total energy required to grow a crop (LCA) can be calculated by accounting for the energy associated with the inputs required for production. Energy and GHG emissions from agricultural inputs can be divided into *primary* (e.g., fuel for machinery operations), *secondary* (e.g., production and transportation of inputs), and *tertiary* (e.g., raw materials to produce items such as machinery and buildings) sources.

4.3.7.1 Potential Effects–Climate Change and Greenhouse Gas Emissions

MON 87429 corn, and the agricultural inputs and management practices that would be used in cultivation of this variety would contribute to GHG emissions, and the potential for carbon sequestration, as do other corn cropping systems. Any GHG emissions/sequestration from cultivation of MON 87429 corn would be the same as/similar to current corn crops (US-EPA 2020j). The agronomic practices and inputs are the same as for other corn varieties, and apart from the HR traits, MON 87429 corn is phenotypically the same as most other corn varieties—in growth and nutrient utilization requirements.

GHG emissions directly impact the environment in which farmers operate, and agriculture stands to be significantly influenced by the effects of climate change (USDA 2012). Extremes in precipitation; more severe storms; soil moisture; nighttime air temperature; heat waves; humidity; drought spells; crop-growing region migration; weed range and infestation intensity; migration and increased incidence in plant insect pests and pathogens; effects on insect generations per season; and effects on pollinators and pollinator management; are all factors that will be influenced by a changing, warming, climate, and in turn effect crop production (USDA 2012).

To help protect future crop production from, and adapt to, the effects of climate change the USDA contributes to climate assessments, provides analyses of adaptation and mitigation options, cost-benefit analyses, and tools to support agriculture, forests, grazing lands, and rural communities. The Climate Change Program Office (CCPO) operates within the Office of Energy and Environmental Policy (OEEP) to coordinate agricultural, rural, and forestry-related climate change program and policy issues across the USDA. The CCPO ensures that USDA is a source of objective, analytical assessments of the effects of climate change and proposed response strategies.

In an effort to mitigate climate-related risks the USDA has established seven regional hubs for risk adaptation and mitigation to climate change (USDA 2020b). The USDA is taking steps to create modern solutions to the challenge of climate change. New uniform, science-based guidance on cover crop management helps producers prevent erosion, improve soil properties, supply nutrients to crops, suppress weeds, improve soil water content, and break pest cycles. The following are some of the USDA assessments that project climate impacts, adaptive strategies, and mitigation opportunities/strategies for the coming years:

- Climate Change and Agriculture in the United States: Effects and Adaptation (USDA 2012)
- Climate Indicators for Agriculture (Walsh et al. 2020)
- Climate Change, Global Food Security, and the U.S. Food System (Brown et al. 2015)
- Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II (USGCRP 2018)

The USDA released a Carbon Management Evaluation Tool (COMET-FARM) to help producers calculate how much carbon their land's soil and vegetation can remove from the atmosphere (USDA 2020a). The USDA also provides farmers guidance on tracking and mitigating GHG emissions. In 2014 the USDA released “Quantifying Greenhouse Gas Fluxes in Agriculture and Forestry: Methods for Entity-Scale Inventory” (Eve et al. 2014). Through the development of this guidance, the USDA prepared two primary products: 1. A comprehensive review of techniques currently in use for estimating GHG emissions and removals from agricultural and forestry activities; and 2. A technical report outlining the preferred science-based approach and specific methods for estimating GHG emissions at the farm or forest scale.

4.3.8 Compliance with Federal and State Laws and Regulations, Executive Orders, Policies, and Treaties

4.3.8.1 Federal Laws and Regulations

The environmental laws/regulations relevant to a determination of regulatory status are the National Environmental Policy Act of 1969 (NEPA), the Clean Water Act of 1972 (CWA), the Safe Drinking

Water Act of 1974 (SDWA), the Clean Air Act of 1970 (CAA), the Endangered Species Act of 1973 (ESA), and the National Historic Preservation Act of 1966 (NHPA). Compliance with the requirements of the ESA has been addressed in Section 4.3.3.6. Compliance with the requirements of NEPA and implementing regulations, CWA, SDWA, CAA, and NHPA, are specifically addressed in the following subsections.

4.3.8.1.1 National Environmental Policy Act (NEPA)

The National Environmental Policy Act (NEPA, 42 U.S.C. § 4321 et seq.) is a procedural statute intended to ensure Federal agencies consider the potential environmental impacts of their actions in the decision-making process. NEPA requires the Federal Government, in cooperation with state and local governments, and other concerned public and private organizations, to use all practicable means and measures to foster and promote the general welfare, create and maintain conditions under which man and nature can exist in productive harmony, and fulfill the social, economic, and other requirements of present and future generations of Americans (42 USC 4331 Sec 101. (a)). The purpose and function of NEPA is satisfied if Federal agencies have considered relevant environmental information, and the public has been informed regarding the decision-making process and potential outcomes of the Agency's decision. NEPA does not mandate particular results or substantive outcomes, rather, it is to provide for informed decision making (40 CFR § 1500.1(a)).

This EIS documents the potential environmental outcomes of the alternatives considered, approval or denial of the petition, consistent with the requirements of NEPA and CEQ implementing regulations at 40 CFR 1500–1508.

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

The CAA, CWA, and SDWA authorize the EPA to regulate air and water quality in the United States. Because MON 87429 corn is agronomically equivalent to currently utilized corn varieties, the potential sources of impacts on water resources and air quality are the same under both the No Action and Preferred Alternatives. MON 87429 corn and progeny production would entail the use of pesticides and fertilizers, and to some extent tillage, which will contribute to potential cumulative impacts on air quality, and potentially water quality. MON 87429 corn production could also utilize ground water resources for irrigation. The sources and degree of impacts would not significantly differ from that which occurs with current corn production. APHIS assumes use of all pesticides on MON 87429 corn and progeny will be compliant with EPA registration and label use requirements. As discussed in Chapter 4, the transgenes and gene products extant in MON 87429 corn present no known hazard to water or air quality. Considering these factors, approval of the petition would not lead to circumstances that resulted in non-compliance with the requirements of the CWA, CAA, and SDWA.

4.3.8.1.3 National Historic Preservation Act of 1966

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

Approval of the petition is not a decision that would directly or indirectly result in alteration of the character or use of historic properties protected under the NHPA, nor would it result in any loss or destruction of cultural or historical resources. Where MON 87429 corn was cultivated there may be the potential for increased noise during the operation of machinery and other equipment, as with all corn crop production, however, these activities would have only temporary effects on historic sites in proximity to MON 87429 corn fields, with no consistent long-term effects on the enjoyment of a historical or cultural resources.

4.3.8.2 Executive Orders

The following executive orders (EO) are relevant to this EIS, as to the potential impacts of federal actions on public health, cultural resources, wildlife, the environment, and equitable sharing of potential harmful effects on the environment shared among all communities.

- **EO 12898–Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations**

  This EO requires federal agencies to conduct their programs, policies, and activities that substantially affect human health or the environment in a manner so as not to exclude persons and populations from participation in or benefiting from such programs. It also enforces existing statutes to prevent minority and low-income communities from being subjected to disproportionately high and adverse human health or environmental effects.

- **EO 13045–Protection of Children from Environmental Health Risks and Safety Risks**

  Children may suffer disproportionately from environmental health and safety risks due to their developmental stage, higher metabolic rates, and behavior patterns, as compared to adults. This EO requires each federal agency to identify, assess, and address the potential environmental health and safety risks that may disproportionately affect children.

- **EO 13175–Consultation and Coordination with Indian Tribal Governments**

  Executive departments and agencies are charged with engaging in consultation and collaboration with tribal governments; strengthening the government-to-government relationship between the United States and Indian tribes; and reducing the imposition of unfunded mandates upon Indian tribes. The EO emphasizes and pledges that federal agencies will communicate and collaborate with tribal officials when proposed federal actions have potential tribal implications.

- **EO 13985–Executive Order on Advancing Racial Equity and Support for Underserved Communities Through the Federal Government**

  This EO requires federal agencies to advance equity for all, including people of color and others who have been historically underserved, marginalized, and adversely affected by persistent poverty and inequality. Because advancing equity requires a systematic approach to embedding fairness in decision-making processes, executive departments and agencies are required to recognize and work to redress inequities in their policies and programs that serve as barriers to equal opportunity. Consistent with these aims, each agency must assess whether, and to what extent, its programs and policies perpetuate systemic barriers to opportunities and benefits for people of color and other underserved groups. Such assessments will better equip agencies to develop policies and programs that deliver resources and benefits equitably to all.

- **EO 13990–Protecting Public Health and the Environment and Restoring Science to Tackle the Climate Crisis**

  This EO requires federal agencies to listen to the science; to improve public health and protect our environment; to ensure access to clean air and water; to limit exposure to dangerous chemicals and pesticides; to hold polluters accountable, including those who disproportionately harm communities of color and low-income communities; to reduce greenhouse gas emissions; to bolster resilience to the impacts of climate change; to restore and expand our national treasures and monuments; and to prioritize both environmental justice and the creation of the well-paying union jobs necessary to deliver on these goals.

- **EO 14091–Further Advancing Racial Equity and Support for Underserved Communities Through the Federal Government**

  This EO expands on EO 13895, and targets major barriers faced by underserved communities. It establishes mechanisms for advancing environmental justice and racial equity: A White House Steering Committee on Equity, Agency Equity Teams, and the requirement for an annual Equity Action Plan.

- **EO 14096–Revitalizing Our Nation's Commitment to Environmental Justice for All**

  This order builds upon ongoing efforts to advance environmental justice and equity consistent with EO 13985 (Advancing Racial Equity and Support for Underserved Communities Through the Federal Government), EO 13990 (Protecting Public Health and the Environment and Restoring Science To Tackle the Climate Crisis), EO 14008 (Tackling the Climate Crisis at Home and Abroad), EO 14052 (Implementation of the Infrastructure Investment and Jobs Act), EO 14057 (Catalyzing Clean Energy Industries and Jobs Through Federal Sustainability), EO 14082 (Implementation of the Energy and Infrastructure Provisions of the Inflation Reduction Act of 2022), and EO 14091 (Further Advancing Racial Equity and Support for Underserved Communities Through the Federal Government). This order also supplements the foundational efforts of EO 12898 to address environmental justice.

Neither alternative evaluated in this EIS would result in disproportionate adverse impacts on underserved or marginalized communities, minorities, low-income populations, or children, or adversely affect tribal entities. As reviewed in this EIS, there are no risks to human health, nor to food animal health and welfare, associated with the trait genes and gene products in MON 87429 corn. Tribal entities are recognized as independent governments and agricultural activities on tribal lands would only be conducted if approved by the tribe. Approval of the petition would have no effect on Indian tribal self-governance or sovereignty, tribal treaties, or other rights. APHIS engaged in outreach with tribal nations, seeking comment on the EIS NOI. APHIS received comments from two tribal nations, which are provided in Appendix 1.

- **EO 13751–Safeguarding the Nation from the Impacts of Invasive Species**

  Invasive species are a significant issue in the United States, causing both adverse economic and environmental impacts. This EO directs actions to continue coordinated federal prevention and control efforts related to invasive species. This order maintains the National Invasive Species Council (Council) and the Invasive Species Advisory Committee; expands the membership of the Council; clarifies the operations of the Council; incorporates considerations of human and environmental health, climate change, technological innovation, and other emerging priorities into federal efforts to address invasive species; and strengthens coordinated, cost-efficient federal action.

- **EO 13186–Responsibilities of Federal Agencies to Protect Migratory Birds**

  The United States has recognized the critical importance of migratory birds as a shared resource by ratifying international, bilateral conventions for the conservation of migratory birds. These conventions impose substantive obligations on the United States for the conservation of migratory birds and their habitats. Through the Migratory Bird Treaty Act (Act) the United States has implemented these conventions with respect to the United States. This Executive Order directs executive departments and agencies to take certain actions to further implement the Act.

Migratory birds may transit corn fields and forage on corn, namely residual corn cobs/kernels left in the field post-harvest (Sherfy et al. 2011). For example, during migration, about 90% of the sandhill crane diet consists of corn, when corn is available (NGP 2019). As reviewed in this EIS, it is unlikely the PAT, DMO, FT_T, and EPSPS proteins present any risks to the health of birds. Thus, it is unlikely that approval of the petition, and subsequent production of MON 87429 corn, would present any hazard to migratory bird populations. Rather, MON 87429 corn would provide a food source for some species of migratory birds.

Limited agricultural activity is authorized on some wildlife refuges by law, including cooperative agreements in which farmers are permitted to grow certain crops to produce more food or improve habitat for the wildlife. The National Wildlife Refuge System, the public lands network managed by the Service, employs a variety of wildlife management practices to deliver specific conservation objectives on each of the nation's 568 national wildlife refuges (USFWS 2020a). The use of crops by farmers on refuges in the Southeast Region can help refuge managers meet the purposes of the refuge and provide wildlife forage for birds and other wildlife. Supporting waterfowl populations is a priority purpose for many southeastern refuges (USFWS 2020b). Most refuges that use agriculture as a management tool do so in cooperation with local farmers (Cooperative Farming) in order to meet USFWS habitat and wildlife management objectives. In exchange for use of the land, growers leave a percentage of the crops in the field as forage for wildlife.

Many wildlife refuges situated along migratory bird flyways were established to provide food for a target number of waterfowl for a certain length of time, a metric known as "duck energy days" (Jarman 2018; USFWS 2020a). Some refuges meet these duck energy day goals by arranging cooperative agriculture agreements with local farmers. Farmers are able to plant and harvest crops on refuge lands in exchange for leaving a portion of their crop to supplement wildlife food or habitat on the refuge (Jarman 2018; USFWS 2020a). Cooperative agriculture is only used in situations when the USFWS cannot meet resource management goals in other ways. Even with careful planning, not every area can consistently meet the goals to make up for waterfowl habitat loss outside of federal lands.

4.3.8.3 State and Local Requirements

The PPA contains a preemption clause (7 U.S.C. § 7756) that prohibits state regulation of any, "plant, biological control organism, plant pest, noxious weed, or plant product" to protect against plant pests or noxious weeds if the Secretary (USDA) has issued regulations to prevent the dissemination of biological control organisms, plant pests, or noxious weeds within the United States. The PPA preemption clause does however allow states to impose additional prohibitions or restrictions based on special needs supported by sound scientific data or risk assessment. Consequently, while the PPA limits states' issuance of laws and regulations governing regulated organisms and bars conflicting state regulation, it does allow state oversight when there is a special need for additional prohibitions or restrictions.

States use a variety of mechanisms to regulate the movement or release of biotechnology-derived organisms within their jurisdiction. For example, South Dakota simply authorizes holders of a federal permit issued under 7 CFR part 340 to use it within the state (SD Stat § 38-12A-31 (2015)). Minnesota issues state permits for release of modified organisms only after federal applications or permits are on file (MN Stat § 18F.07 (2015)). Nebraska may rely on APHIS or other experts before they issue their permit (NE Code § 2-10,113 (2015)). These illustrative examples show the range of state approaches to regulating the movement and release of biotechnology-derived organisms within state boundaries.

Neither of the alternatives considered would affect APHIS partnerships with states in the oversight of biotechnology-derived organisms, to include the production of MON 87429 corn. Under both alternatives, APHIS would continue working with states. The range of state legislation addressing agricultural biotechnology, namely in the way of permitting, crop protection, seed regulation, and economic development, would be unaffected by denial or approval of the petition.

4.3.8.4 International Agreements

The United States is a member of the World Trade Organization (WTO), which facilitates harmonizing the global rules of trade between nations. The Agreement on the Application of Sanitary and Phytosanitary Measures (the "SPS Agreement") entered into force with the establishment of the WTO on January 1, 1995, sets out the basic rules for food safety and animal and plant health standards. The SPS agreement recognizes three international organizations/frameworks that have established standards and guidelines related to SPS measures (WTO 2020b), these are; the Codex Alimentarius Commission (Codex), the World Organization for Animal Health (OIE), and the International Plant Protection Convention (IPPC). Any international trade of MON 87429 or products derived from it following a determination of nonregulated status would be subject to national phytosanitary requirements and be in accordance with international SPS standards, inclusive of the Codex (food safety) and IPPC (plant pests and disease).

4.3.9 Potential Impacts on the Human Environment

As discussed in the Scope of Analysis for this EIS (Section 4.1), in considering whether the effects of the proposed action could be significant (40 CFR § 1500.1), APHIS analyzed the affected environment and degree of the potential effects identified (40 CFR § 1501.3). As part of this analysis APHIS considered those requirements outlined in sections 102(2)(C) of NEPA, 40 CFR § 1502.16–Environmental consequences, 40 CFR § 1501.3–Determine the appropriate level of NEPA review, 40 CFR § 1502.24–

Environmental review and consultation requirements, and 40 CFR § 1502.15–Affected environment, which are summarized below.

4.3.9.1 The environmental impacts of the proposed action and reasonable alternatives to the proposed action and the significance of those impacts

Comparison of the potential environmental impacts of APHIS' regulatory decision on the petition, and the significance of the potential impacts, have been discussed in Section 4.2–No Action Alternative, Deny the Petition, and Section 4.3–Preferred Alternative, Approve the Petition.

4.3.9.2 Any adverse environmental effects that cannot be avoided should the proposal be implemented

Commercial crop production, whether a conventional, organic, or biotechnology-based cropping system will always have some degree of environmental impact (Robertson and Swinton 2005; NRC-IM 2015; Ritchie 2017), as discussed in this EIS. The potential introduction of pesticides and fertilizers (organic or synthetic) to surface water or groundwater, soil erosion, emission of air pollutants, and loss of wildlife habitats are all potential impacts that can derive from commercial crop production. These are issues that all farmers work with, not just those growing biotech crops, in providing sufficient food, feed, biofuels, fiber, and industrial products to meet societal needs. The degree of environmental impact can be transient and minor or noticeably adverse, depending on a variety of factors that include the type and quantity of agronomic inputs and practices employed, geography and proximity of surface waters and groundwaters to crops, local biota, weather, prevalence and diversity of insect pests and weeds, and crop type being produced. With around 360,000 corn farms comprising some 90 million acres of the land in the United States (USDA-NASS 2023), the scale of potential impacts, namely in an aggregate sense, requires integration of crop production with sustainability and conservation practices—for both biotech and non-biotech crops. While implementing such practices can often result in significant mitigation of environmental impacts, not all impacts can be fully attenuated, and some degree environmental trade-offs (e.g., transient effects) in meeting the market demand for corn-based food, feed, fuel, and industrial products are inevitable (Robertson and Swinton 2005; NRC-IM 2015).

On approval of the petition, and subsequent grower adoption of MON 87429 corn, the agronomic practices and inputs that would be used in the cultivation of MON 87429 corn/hybrids, and any contribution of these practices and inputs to impacts on soils, water quality, or air quality, is expected to be similar to that of other corn crops currently cultivated. Dicamba, glufosinate, quizalofop-p-ethyl, 2,4-D, and glyphosate, are used on wide variety of other crops, these would not be novel uses on MON 8742 corn. It is expected that MON 87429 corn would be produced on lands already converted to cropland, replace other HR corn crops currently cultivated.

Potential increased herbicide use with this variety, discussed in this EIS, were it to occur, could increase risks to water and air quality, wild and cultivated non-crop plants via spray and vapor drift, and to aquatic plants via runoff. Herbicide spray and vapor drift, as well as runoff, could also present risks to terrestrial and aquatic wildlife, by affecting plants that wildlife depend on. All herbicide use with MON 87429 corn would need to be complaint with EPA label use requirements and restrictions (these are legal requirements), as well as any state restrictions that may be imposed in addition to that of the EPA herbicide label. It should be noted there are EPA label restrictions on the maximum quantity of an herbicide that can be applied on an annual basis, as well limits on use rates during application.

Based on the data reviewed in this EIS, in the event of dicamba spray or/and vapor drift, and to some extent 2,4-D, or dicamba misuse (use the product off-label requirements), there are potentially significant economic impacts on producers of crops (that are not resistant to dicamba or 2,4-D) proximate to those lands on which MON 87429 corn hybrids were produced, and dicamba and 2,4-D sprayed. Growers affected could include those producing vegetable, grain, fruit, and horticultural crops. Residential and commercial properties could also be affected by herbicide spray/vapor drift. Herbicide spray or/and vapor drift into areas proximate to crop fields and injury to trees and flowering of plants can result in decreased visitation by pollinators and other beneficial insects. Herbicide spray/vapor drift on such plants, particularly on a broad geographic scale, can impair bird habitat by interfering with insect plant-based food sources. It is estimated that around 96% of terrestrial birds rear their young on insects (Tangley 2015), caterpillars, which feed on plants, being one of the main sources of protein for young birds. These types of potential impacts, agronomic and ecological, would be relative to the scale the environments affected. For example, corn production utilizes around 90 million acres of land; there are no corn acres as yet planted to dicamba resistant corn. As of 2019, the number of dicamba-resistant soybeans planted in the U.S. was around 60% of soybean acres, approximately 60 million acres (Hettinger 2019b; Unglesbee 2019d). As of 2020, around 70% of cotton acres—approximately 8.5 million acres—were planted to dicamba-resistant varieties (US-EPA 2020aa). Hence, the amount and variety of off-target non-crop foliage affected, in a cumulative sense, could be substantial, relative the level of spray and vapor drift that occurs.

4.3.9.3 The relationship between short-term uses of man's environment and the maintenance and enhancement of long-term productivity

Long-term agricultural productivity depends on the sustainable use of natural resources—namely topsoils, groundwater, populations of beneficial insects such as pollinators and plant pest predators, and the plants that support such insects. The balance in producing societal needs for food, animal feed, fiber, bio-based fuel products, and industrial products, while conserving/preserving the natural resources necessary to do so and minimizing environmental impacts are well recognized; this balance is often discussed in peer review and lay literature as "sustainability".

MON 87429 corn is agronomically equivalent to other dent corn cultivars and utilizes the same types, and same/similar quantities of resources (e.g., groundwater, agronomic inputs), as all other conventional and biotechnology-derived dent corn varieties. The annual production of MON 87429 corn would face the same challenges in sustaining topsoils and soil quality, and air and water quality, as other corn crops. Any groundwater use is expected to be similar to that of other dent corn varieties—there is no indication this variety utilizes more or less water during development.

There could be increased herbicide use with this variety on a seasonal basis, during the early phases of crop production (spring, early summer). As reviewed in this EIS, none of the herbicides that would be used with this variety are particularly persistent in the environment. The field dissipation half-life for glufosinate ranges from around 3 to 20 days (avg. 13 days) (TOXNET 2019). Biodegradation half-life of glyphosate in soil is around 2 to 7 days under aerobic conditions. Dicamba has a field half-life ranging from 8 to 592 days, with a typical half-life being 1 to 4 weeks (TOXNET 2019). For 2,4-D, an average half-life of 4 days has been observed (NPIC 2020b). Reported half-lives for quizalofop-p-ethyl range from around half a day to 4 days, although under certain conditions a half-life of 60 days was observed (Mantzos et al. 2017; TOXNET 2019).

In terms of sustaining the productivity of U.S. croplands on which corn is grown, MON 87429 corn would not be expected to present any significant risks in the way of weed management, or development of HR weeds. As discussed in 4.3.1.2.3 – Pesticides, and 4.3.1.3 – Potential Effects on U.S. Corn Production, stacked-trait HR varieties have been developed for the purposes of facilitating weed management, and minimizing the development of HR weed populations. The efficacy of such stacked-trait HR varieties in the long-term management of weeds and HR weed development is dependent on how well these varieties are incorporated to IWM programs by individual growers.

4.3.9.4 Irreversible or irretrievable commitments of resources that would be involved in the proposal should it be implemented

An irreversible or irretrievable commitment of resources refers to impacts on or losses of resources that cannot be recovered or reversed. Irreversible commitments of resources involve those where the resources cannot be restored or returned to their original condition. Irreversible commitments entail the loss of future options and applies to the use of resources such as nonrenewable fossil fuels, and resources that are renewable only over long time spans. Irretrievable is a term that refers to those resources that, once used or consumed, would cause the resource to be unavailable for use by others and future generations (e.g., land use).

The production of corn and the food, feed, fuel, and industrial products derived from corn involves irreversible and irretrievable utilization of resources. Corn production involves the irreversible consumption of nonrenewable petroleum-based products (e.g., fuels necessary to operate equipment, cleaning agents, pesticide additives/adjuvants). Crude oil cannot be replaced once utilized for energy or other purposes. Some crop production systems may utilize wind or solar energy sources—renewable sources. Topsoil is considered nonrenewable, its erosional capacity can be affected by the types of tillage and irrigation systems employed on cropland. Over the long-term continued crop production on the same site can potentially contribute to wind and sheet rill erosion; cover cropping can help preserve and rebuild topsoils. Materials such as aluminum, steel, wood, and plastics would be utilized as part of the process of crop production. Most of these materials are non-renewable and would be irreversibly utilized if not recycled (plastics, metals). Crop production inherently entails the irretrievable removal of natural habitat and associated wildlife from the landscape.

Renewable and nonrenewable resources utilized for MON 87429 corn production would differ little from that of other corn varieties. It is expected that MON 87429 corn would be produced on lands already converted and utilized for commercial crop production. Subtle variations in fossil fuel and energy use would occur relative to the frequency and duration of pesticide and fertilizer applications with this crop, and harvesting and facilities efficiencies, relative to other HR and conventional corn crops. Because MON 87429 corn would likely replace other HR dent corn varieties currently cultivated, impacts of an irreversible or irretrievable nature would be negligible, unchanged from that which currently occurs in U.S. corn production.

4.3.9.5 Whether the action would violate or conflict with a federal or state laws or local requirements governing protection of the environment

As reviewed in Section 4.3.8, approval of the petition would not lead to circumstances that resulted in non-compliance with any federal, state, or local laws and regulations providing protections for environmental and human health. The EPA will regulate the use of pesticides on MON 87429 corn under

FIFRA, FFDCA, and the Endangered Species Act. Bayer completed a Biotechnology Consultation on Food from GE Plant Varieties with the FDA, evaluating the safety of MON 87429 corn, in July 2022 (BNF No. 000173; (US-FDA 2022)).

4.3.9.6 Possible conflicts between the proposed action and the objectives of Federal, regional, State, Tribal, and local land use plans, policies and controls for the area concerned

There are no conflicts with the decision to approve the petition, and subsequent commercial production of MON 87429 corn, with federal, state, tribal, or local land use plans or policies.

Federal Lands

There are four major federal land management agencies that administer 606.5 million acres (as of September 30, 2018). These are the Bureau of Land Management (BLM), Fish and Wildlife Service (FWS), National Park Service (NPS) in the Department of the Interior (DOI), and the Forest Service (FS) in the USDA (CRS 2020). A fifth agency, the Department of Defense (DoD), administers 8.8 million acres in the United States (as of September 30, 2017). Together, the five agencies manage about 615.3 million acres, or 27% of the U.S. land base (CRS 2020). Many other agencies administer the remaining federal acreage. The lands administered by the four major agencies are managed primarily for purposes related to preservation, recreation, and development of natural resources (CRS 2020).

APHIS approval of the petition would have no effect on lands governed by federal land management agencies. Any cultivation of MON 87429 corn on federal lands would require approval by a federal land management agency.

Tribal Nations, State and Local Land Use Plans and Policies

As discussed in Section 4.3.8–Compliance with Federal and State Laws and Regulations, Executive Orders, Policies, and Treaties*,* approval nor denial of the petition would have any effect on Indian tribal self-governance or sovereignty, tribal treaties, or other rights, nor affect state or local authority in the oversight of organisms developed using genetic engineering, to include the production of MON 87429 corn on state or county lands. States most often delegate local land use and development oversight to cities and counties. Local planning decisions usually require approval of city or county boards/commissions governing land uses and reflect the desires and interests of the community. Federal law does not pre-empt state or local governments from banning biotech crops that have been deregulated by USDA. At the local level, counties may prohibit the cultivation of a biotech crop if it conflicts with local interests (LOC 2020).

4.3.9.7 Energy requirements and conservation potential of various alternatives and mitigation measures

The energy requirements involved with the full life cycle of MON 87429 corn production and marketing would differ little from that of other commercial corn crops. USDA-NRCS provides guidance on energy management in crop production via practices such as integrated pest management, precision agriculture, irrigation water and nutrient management, and crop residue management (USDA-NRCS 2020e). Energy conservation estimation tools are also provided to help growers estimate costs and saving associated with irrigation, nitrogen use, and tillage.

4.3.9.8 Natural or depletable resource requirements and conservation potential of various alternatives and mitigation measures

There are no depletable resource requirements unique to the production and marketing of MON 87429 corn. Use of natural resources (e.g., irrigation water, soils, production or herbicides and fertilizers) would be no different than that utilized with other corn varieties. Natural resource conservation opportunities, whether USDA funded or otherwise implemented by growers or/and state agencies would not differ from that of other conventional and biotechnology-derived corn crops. Available resource to help mitigate potential environmental impacts, such as those summarized below in 4.3.9.10, would likewise not differ.

4.3.9.9 Urban quality, historic and cultural resources, and the design of the built environment, including the reuse and conservation potential of various alternatives and mitigation measures

MON 87429 corn would be cultivated on lands allocated or zoned for agricultural uses, which may occur in proximity to historic or cultural resources. As discussed in 4.3.8 – Compliance with Federal and State Laws and Regulations, Executive Orders, Policies, and Treaties, cultivation of this corn variety would not be expected to directly or indirectly result in alteration of the character or use of historic properties protected under the NHPA, nor result in any loss or destruction of cultural or historical resources. There are no weediness/invasiveness characteristics associated with MON 87429 corn. MON 87429 corn, as other corn production, would occur on lands allocated or zoned for agricultural uses. Considering the areas in which corn is grown in the United States, it is unlikely that urban environments would be affected by MON 87429 corn production. The design of the built environment in relation to crop production activities would be resolved at the local and state levels of governance (e.g., city, county, and/or state authorities governing land use).

4.3.9.10 Mitigation of adverse environmental impacts

There are a number of federal, state, and private sector collaborative initiatives to help farmers alleviate the collective impacts of crop production on the physical environment, as well as biological resources. Some of the USDA and partner programs supporting agricultural sustainability and natural resources conservation are summarized below. Practices will vary from region to region and farm to farm, however, some common sets of practices have emerged, which include integrated insect pest and weed management strategies and programs, soil conservation, water resources conservation and protection, protection of cropland biodiversity, and nutrient management. Each contribute in some way to environmental stewardship and long-term agricultural sustainability. For a more detailed description of USDA sustainability and conservation initiatives, see the USDA websites provided in the references below.

Soils

All growers producing crops on highly erodible land are required to maintain and implement a soil conservation plan that substantially reduces soil loss, and is approved by the USDA NRCS (USDA-NRCS 2020d). The 2014 and 2018 Farm Bills have continued the requirement that producers adhere to conservation compliance guidelines to be eligible for conservation programs administered by USDA-FSA and USDA-NRCS. State agencies likewise provide assistance in development and implementation of soil conservation plans.

Water

There are various national and regional efforts to reduce NPS contaminants in agricultural runoff, and runoff itself, such as the EPA's Mississippi River/Gulf of Mexico Hypoxia Task Force and USDA-NRCS National Water Quality Initiative (NWQI) (US-EPA 2020v; USDA-NRCS 2020f). Through the NWQI, the NRCS and partners (e.g., local and state agencies, nongovernmental organizations) work with producers and landowners to implement voluntary conservation practices that improve water quality (USDA-NRCS 2019a). The NWQI program is in its 9th year and extended through 2023. It provides funding for financial and technical assistance for conservation practices. For example, in 2018 the NRCS invested $30 million in targeted assistance to help farmers and ranchers improve water quality in high priority streams and rivers. State water quality agencies and other partners contribute additional resources for watershed planning, program implementation, and for monitoring efforts to track water quality improvements over time.

Several other legislative drivers also influence how Federal agencies work to sustain water quality, including the Clean Water Act; the Food, Conservation, and Energy Act ("Farm Bill"); the Energy Independence and Security Act of 2007; the Coastal Zone Management Act; and The Harmful Algal Bloom and Hypoxia Research and Control Act. Responsibility for resolving hypoxia spans several Federal agencies (U.S. Department of Agriculture, U.S. Geological Survey, U.S. Environmental Protection Agency, and National Oceanic and Atmospheric Administration), which oversee research and management/control programs. States play a critical role in monitoring and managing eutrophication (CENR 2010).

Air

While the EPA establishes NAAQS to protect air quality, the standards do not set emission control requirements for any particular industry, including agriculture.[52] The USDA and EPA provide guidance for regional, state, and local regulatory agencies, and farmers, on how to best manage agricultural emissions sources (USDA-EPA 2012). These measures allow stakeholders the flexibility in choosing which measures are best suited for their specific situations/conditions and desired purposes. The EPA has also developed USDA-approved measures to help manage air emissions from cropping systems to help satisfy SIPs. The EPA recommends that in areas where agricultural activities have been identified as a contributor to a violation of NAAQS, USDA-approved conservation systems and activities be implemented to limit emissions. The USDA Environmental Quality Incentives Program Air Quality Initiative provides financial and technical assistance to help farmers and ranchers limit air pollution (USDA-NRCS 2019b). Conservation practices, as required by USDA to qualify for crop insurance, and federal loans and programs, can also effectively reduce crop production impacts on air quality through the use of windbreaks, shelterbelts, reduced tillage, and cover crops that promote soil protection on highly erodible lands.

Created by the 1996 Farm Bill, the USDA Task Force on Agricultural Air Quality Research promotes USDA research efforts and identifies cost-effective ways the agriculture industry can improve air quality.

[52] Many types of stationary engines exist and are found on farms, including diesel engines, spark ignited engines, and reciprocating internal combustion engines. Air quality requirements vary for stationary engines, depending on whether the engine is new or existing, where the engine is located, and what type of ignition system is used. The National Emission Standards for Hazardous Air Pollutants (NESHAP) for Reciprocating Internal Combustion Engines (RICE) are outlined in the Code of Federal Regulations under 40 CFR 63 Subpart ZZZZ.

The Task Force membership consists of leaders in farming, industry, health, and science for two-year terms (USDA-NRCS 2020g). Primary areas of research and development are:

- Air Filtration and Scrubbing
- Combustion System Improvement
- Dust Control on Unpaved Roads and Surfaces
- Dust Control from Animal Activity on Open Lot Surfaces
- Field Operations Emissions Reduction

Climate Change

The USDA Climate Change Program Office (CCPO) operates within the Office of Energy and Environmental Policy (OEEP) to coordinate agricultural, rural, and forestry-related climate change program and policy issues across USDA. The CCPO works across USDA to help ensure that the effects of climate change on working lands and rural communities are understood across the Department and that adaptation is integrated into USDA programs, policies and operations based on the most up-to-date science. OCE also provides data, tools and information to assist land managers, stakeholders and USDA agencies and mission areas with adaptation assessments, planning and implementation (USDA 2020b).

Biodiversity

While biodiversity will be inherently limited in commercial corn crops due to frequent disturbance, tillage, mechanized planting, planting of a monoculture crop, and application of fertilizers and pesticides, growers, as well as federal and state agencies, well recognize the need for maintenance of some degree of cropland biodiversity. A variety of federally supported programs, such as the USDA funded Sustainable Agriculture Research and Education Program (SARE), and partnership programs among the EPA and the agricultural community support sustainable agricultural practices that are intended to protect the environment, conserve natural resources, and promote cropland biodiversity (i.e., (US-EPA 2020ab; USDA-NIFA 2020)). The USDA NRCS, through its Conservation Stewardship Program, Landscape Initiatives, Environmental Quality Incentives Program, Landscape Planning, and other services provides technical and financial support to growers to assist in managing the complex interaction of cropping systems and the natural environment (USDA-NRCS 2020d). Tools are also developed by the industry. For example, *Field to Market: The Alliance for Sustainable Agriculture* supports various programs that helps farmers and the food supply chain benchmark sustainability performance, to included cropland biodiversity (Field-to-Market 2019).

USDA Funded Sustainability and Conservation Initiatives

Various USDA NRCS programs help people reduce soil erosion, enhance water supplies, improve water quality, increase wildlife habitat, and reduce damages caused by floods and other natural disasters (USDA-NRCS 2019c).

The USDA funded Sustainable Agriculture Research and Education Program (SARE) supports sustainable agricultural practices that are intended to protect the environment, conserve natural resources, and promote cropland biodiversity (USDA-NIFA 2020).

The USDA-NRCS Environmental Quality Incentives Program (EQIP) provides financial and technical assistance to agricultural producers to address natural resource concerns and deliver environmental benefits such as improved water and air quality, conserved ground and surface water, increased soil health and reduced soil erosion and sedimentation, improved or created wildlife habitat, and mitigation against increasing weather volatility (USDA-NRCS 2020a).

The USDA–NRCS Regional Conservation Partnership Program (RCPP) specifically promotes coordination of NRCS conservation activities with partners that offer value-added contributions to expand USDA's collective ability to address on-farm, watershed, and regional natural resource concerns (USDA-NRCS 2020c). The 2018 Farm Bill made a number of substantial changes to RCPP: It is now a standalone program with its own funding of $300 million annually.

The USDA National Institute of Food and Agriculture (NIFA) promotes sustainable agriculture through national program leadership and funding for research and extension. It offers competitive grants programs and a professional development program, and collaborates with other federal agencies through the USDA Sustainable Development Council (USDA-NIFA 2020).

The USDA Conservation Programs (CRP) is a voluntary land retirement program that helps farmers remove environmentally sensitive land from agricultural production and planting species that will improve environmental quality (USDA-NRCS 2020d). CRP is the largest federally administered private-land retirement program, with annual outlays approaching $2 billion per fiscal year. CRP enrollment is capped each year, and under the 2014 farm bill, enrollment was limited to no more than 24 million acres during fiscal years 2017 and 2018. The 2018 farm bill expanded CRP acreage to a maximum of 27 million acres by 2023. Nearly 24 million acres are enrolled in CRP as of 2019 (NSAC 2020). CRP has (USDA-NRCS 2022):

- Prevented more than 9 billion tons of soil from eroding, enough soil to fill 600 million dump trucks.

- Reduced nitrogen and phosphorous runoff relative to annually tilled cropland by 95 and 85 percent respectively.

- Sequestered an annual average of 49 million tons of greenhouse gases, equal to taking 9 million cars off the road.

- Created more than 3 million acres of restored wetlands while protecting more than 175,000 stream miles with riparian forest and grass buffers, enough to go around the world 7 times.

- Benefited bees and other pollinators and increased populations of ducks, pheasants, turkey, bobwhite quail, prairie chickens, grasshopper sparrows and many other birds.

4.3.9.11 Economic and technical considerations, including the economic benefits of the proposed action

Economic considerations have been evaluated in Section 4.3.6–Socioeconomics. The economic impacts associated with the utilization of MON 87429 corn for production of food, feed, fuel, and industrial commodities would be potentially beneficial, to both farmers and corn commodities markets. There are potential adverse economic impacts on producers of crops that are not dicamba resistant (e.g., vegetable, horticultural, orchard crops), as well as owners of residential and commercial properties, which could derive from herbicide spray and vapor drift, namely dicamba and to some extent 2,4-D. Spray or/and vapor drift can potentially affect crop-producers and non-crop residential and commercial sites through plant injury, and any associated claims (e.g., with the state) or litigation costs. Costs to crop producers can range up $50,000 and in rare instances a half million or more; costs to non-crop areas have not been well quantified, although can range in the thousands (see Section 4.3.6.2).

4.3.9.12 The degree to which the action may adversely affect endangered or threatened species protected under the Endangered Species Act

As discussed in Section 4.3.3.6 of this EIS, a determination of nonregulated status for MON 87429 corn, and subsequent commercial production of this corn variety, would have no effect on listed species or species proposed for listing, nor would it affect designated habitat or habitat proposed for designation.

4.3.9.13 The degree to which the proposed action affects public health or safety

As reviewed in Section 4.3.4, approval of the petition and subsequent availability of MON 87429 to commercial markets would not be expected to present any risks to public health, or worker safety, beyond those already associated with commercial crop production.

4.3.9.14 Whether the affected environment includes reasonably foreseeable environmental trends and planned actions in the affected areas

Approval of the petition would provide for the commercial production of MON 87429 corn, subject to any FDA consultation, and EPA and state requirements. As of September 2021, APHIS has issued 41 determinations of nonregulated status, in response to petitions, for biotechnology-derived corn varieties. APHIS maintains a publicly available list of petitions and determinations of nonregulated status on its website (USDA-APHIS 2020d). Biotechnology-derived corn varieties were first commercially produced in the United States in late 1990s, with adoption rates increasing rapidly in the years that followed. Currently, approximately 90% of U.S. corn is produced using biotechnology-derived varieties. Annual production of corn comprises around 90 million acres.

Farmers generally adopt a biotech crop based on the benefits they can derive from it, such as effective insect pest or weed control, increased crop yields per acre, increased farm net returns, and time savings (Fernandez-Cornejo et al. 2014b; Brookes and Barfoot 2020a). Potential net benefits are a function of the particular crop farmed; pest and weed pressures; agronomic input and market commodity prices; and existing on-farm crop production systems.

Advances in biotechnologies are expected to refine the precision with which crop varieties will be developed, and lead to a greater diversity of commercial crop varieties (NAS 2016). While it is difficult to predict the scope of improved crop varieties that will emerge in the coming decades, beneficial traits likely to be utilized include improved tolerance to abiotic stresses such as drought and temperature extremes; increased efficiency in plant physiological processes such as photosynthesis and nitrogen use; resistance to fungal, bacterial, and viral diseases; and new types of herbicide resistance (NAS 2016).

For those biotechnology-derived plants that APHIS has determined are not subject to 7 CFR part 340, which were evaluated for potential plant pest risks, and potential environmental impacts via NEPA analyses, as applicable: The available science provides little evidence that the cultivation of the presently commercialized biotechnology-derived corn plants have resulted in any adverse environmental impacts that are unique, or substantially differ from conventional crops and cropping systems (e.g., (Sanvido et al. 2007; Brookes and Barfoot 2013; Klümper and Qaim 2014; NAS 2016; Brookes and Barfoot 2020c) and others). Generally, to date, biotechnology-derived crops, which undergo evaluation by USDA, the EPA, and FDA under the Coordinated Framework (ETIPCC 2017; USDA-APHIS 2020b), have been found to have no more or fewer adverse effects on the environment than conventionally bred crops (NRC 2010; NAS 2016; Brookes and Barfoot 2020c).

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Appendix 1: Scoping and Public Comments on the Notice of Intent to Prepare an Environmental Impact Statement

Public Comments on Notification of Intent to Prepare and Environmental Impacts Statement for Bayer Petition (19-316-01p) for Determination of Nonregulated Status for Dicamba, Glufosinate, Quizalofop and 2,4-D Tolerant MON 87429 Maize with Tissue-Specific Glyphosate Tolerance Facilitating the Production of Hybrid Maize Seed

Overview

APHIS published a Notice of Intent (NOI) to prepare and Environmental Impact Statement (EIS) for Bayer (Monsanto) petition (19-316-01p) for MON 87429 corn in the Federal Register on April 28, 2021 ,Vol. 86, No. 80 / Wednesday, p. 22384: “Bayer; Notice of Intent To Prepare an Environmental Impact Statement for Determination of Nonregulated Status for Maize Developed Using Genetic Engineering for Dicamba, Glufosinate, Quizalofop, and 2,4–Dichlorophenoxyacetic Acid Resistance, with Tissue-Specific Glyphosate Resistance Facilitating the Production of Hybrid Maize Seed”. APHIS announced that it was seeking public comment on the NOI for the EIS to help identify potential alternatives, and relevant information, studies, and/or analyses that APHIS should consider in evaluating the potential impacts of the petition decision on the quality of the human environment. APHIS accepted written comments on the NOI for a period of 93 days, until midnight July 30, 2021.

Summary of Comments Received on NOI for the EIS

At the end of comment period there were over 3,000 comments in response to the NOI for the EIS. Comments received for the NOI, the issues raised and concerns expressed in the public comments, were incorporated into the EIS. A full record of each comment submitted online is available at www.regulations.gov [APHIS Docket No. APHIS-2020-0021-4127]. Comments submitted by letter or email, those not submitted online, are included in the summary below. Provided are the comments received that capture the subject matter and issues raised in all comments provided to APHIS, representative comments, and APHIS response to the comments.

1. Comment ID: APHIS-2020-0021-4656, Friends of the Earth (FOE)

“On behalf of Friends of the Earth [FOE] we are submitting over 23,500 public comments to USDA APHIS regarding Bayer-Bayer’s petition to deregulate maize MON 87429.The deregulation of this seed would lead problematic cross-breeding and continued introduction of new unregulated GE seeds leading to significant impacts for farmers including crop damage, reduced yields and economic losses. Applications of new mixtures could undermine plant health -- including food crops and plant pest health -- threaten both human and environmental health, and accelerate weed resistance. Farmers may find that herbicide residuals from persistent use over time could inhibit germination of those cover crops. Please see the attached comments for more detail.”

FOE Form Letter, submitted by over 23,500 signatories:

"Dear USDA:

I firmly oppose Bayer-Bayer's petition for the determination of nonregulated status for dicamba, glufosinate, quizalofop, 2,4-Dichlorophenoxyacetic acid, and tissue-specific glyphosate tolerant maize.

The implications of this dicamba, glufosinate, quizalofop, 2,4-Dichlorophenoxyacetic acid, and tissue-specific glyphosate tolerant maize on agroecosystems could be catastrophic for the health of people and the planet. Applications of new mixtures could undermine plant health -- including food crops and plant pest health -- threaten both human and environmental health, and accelerate weed resistance.

If deregulated, farmers may plant this genetically engineered seed "defensively" to avoid damage from chemical trespass, even if they do not intend to use one or more of these chemicals. A farmer who adds a small grain to a rotation may find that they inadvertently re-activate residual chemicals in the soil when they add phosphate fertilizer prior to planting. Farmers who would like to use cover crops as a part of a soil health program may find that herbicide residuals from persistent use over time could inhibit germination of those cover crops.

Now more than ever, farmers need more tools to build the biodiverse, climate-resilient food and agriculture systems we so urgently need. This new genetically engineered seed would reduce agroecosystem management options for farmers.

I urge you to reject Bayer Company's petition for the determination of nonregulated status for dicamba, glufosinate, quizalofop, 2,4-Dichlorophenoxyacetic acid, and tissue-specific glyphosate tolerant maize.

Thank you.

Sincerely,”

APHIS Response: *APHIS has considered all of the concerns expressed in the FOE comments. APHIS discusses potential impacts on human health in Section 4.3.4 –Human Health and Worker Safety;lant health in 4.3.3.2 – Plant Communities; weed and weed resistance management in 4.3.1.2 – Agronomic Practices and Input and 4.3.1.3 – Potential Effects on U.S. Corn Production.*

FOE commented that “If deregulated, farmers may plant this genetically engineered seed "defensively" to avoid damage from chemical trespass, even if they do not intend to use one or more of these chemicals. APHIS agrees, this could potentially occur, as it has occurred with dicamba resistant soybean, discussed in the EIS; see Section 4.3.1.3.4 –Herbicide Use with MON 87429 Corn.

FOE commented that “farmers who would like to use cover crops as a part of a soil health program may find that herbicide residuals from persistent use over time could inhibit germination of those cover crops.” This, the potential effect of residual herbicide activity on subsequent crops, to include cover crops, applies to any crop on which herbicides are applied, this would not be unique to MON 87429 corn. As APHIS discusses in the EIS, the herbicides that could be used with MON 87429 corn—dicamba, glufosinate, quizalofop–p–ethyl, 2,4–D, and glyphosate, have been and are used on a wide variety of U.S. crops, nationwide—these herbicides would not be exclusively used on MON 87429 corn. EPA herbicide labels provide guidance on the residual activity of the herbicide, as applicable, and crop rotation interval requirements when using the herbicide.

FOE commented that "This new genetically engineered seed would reduce agroecosystem management options for farmers." FOE provides no evidence to support this assertion; no peer reviewed literature, or other literature or data, on how MON 87429 corn would reduce agroecosystem management options. As reviewed in the EIS (see 4.3.1.2 – Agronomic Practices and Inputs, 4.3.1.3 – Potential Effects on U.S. Corn Production), MON 87429 corn hybrids, comprised of 4 transgenes controlling 5 herbicide resistant traits, could potentially expand grower options in weed and HR weed management, facilitate effective weed and HR weed management. This would be relative to the specific chemical and non-chemical integrated weed management practices implemented with MON 87429 corn. This considered, there is also the potential for increased herbicide use with MON 87429 corn, which is analyzed in the EIS in Section 4.3.1.2 – Agronomic Practices and Inputs, 4.3.1.3 – Potential Effects on U.S. Corn Production, 4.3.2 – Physical Environment, 4.3.3 – Biological Resources, 4.3.4 – Human Health and Worker Safety, and 4.3.9 –Potential Impacts on the Human Environment.

FOE commented that "Now more than ever, farmers need more tools to build the biodiverse, climate-resilient food and agriculture systems we so urgently need." As discussed in Section 4.3.7 – Climate Change, and 4.3.9.10 – Mitigation of adverse environmental impacts, there are a number of federal, state, and private sector collaborative initiatives to help farmers alleviate the collective impacts of crop production on the physical environment, as well as biological resources. Some of the USDA and partner programs supporting agricultural sustainability and natural resources conservation are reviewed in Section 4.3.9.10. Practices will vary from region to region and farm to farm, however, some common sets of practices have emerged, which include integrated insect pest and weed management, soil conservation tactics, water resources conservation and protection, protecting cropland biodiversity, and nutrient (fertilizer) management. Each contribute in some way to environmental stewardship, long-term farm sustainability, and improved quality of life. For a more detailed description of USDA sustainability and conservation initiatives, and climate change adaptation initiatives, see Section 4.3.7 and 4.3.9.10 of the EIS.

2. Comment ID: APHIS-2020-0021-7162

A. Alternatives

"The Notice of Intent states that the Animal and Plant Health Inspection Service will analyze the preferred alternative – approve Bayer's petition for a determination of nonregulated status for MON 87429 maize – and the no action alternative – deny the petition for nonregulated status. In the EIS, evaluate in detail all reasonable alternatives that fulfill the project's purpose and need (40 CFR Section 1502.14(a)). In the EIS, identify additional alternatives that avoid, minimize, and mitigate for significant pesticide impacts, such as those to human health, water, wildlife, and other resources. Quantify and present the environmental impacts of all alternatives in comparative form, thus sharply defining the issues so that reviewers may evaluate their comparative merits (40 CFR 1502.14(b)). In addition, provide a clear discussion of the reasons for eliminating alternatives."

APHIS Response: *APHIS evaluated two alternatives in the EIS, to either approve or deny the petition. This is because, if APHIS determines in its PPRA*[53] *that MON 87429 is unlikely to present a plant pest risk, APHIS has one, feasible, legally plausible option—to approve the petition, pursuant to the PPA and 7 CFR part 340 implementing regulations. APHIS is required to consider a "No Action" alternative, pursuant to CEQ NEPA implementing regulations at CFR 1500 – 1508. For APHIS, the No Action alternative would comprise denial of the petition. APHIS provides a summary of the outcome of denial of the petition request in the EIS (Section 4.2), so as to inform the public what would result if APHIS continued to regulate MON 87429 corn.*

B. Pesticides

"The EPA is responsible for regulating pesticides with public health uses under the Federal Insecticide, Fungicide and Rodenticide Act as well as ensuring that pesticide products do not pose unintended, unreasonable, or unacceptable risks to humans, animals, and the environment. The EPA also participates in the Coordinated Framework for Regulation of Biotechnology with APHIS and the Food and Drug Administration. These agencies work together through the Coordinated Framework to communicate and exchange information to ensure that any safety or regulatory issue regarding GE organisms are appropriately resolved. Due to these factors and EPA's subject matter expertise in pesticides, it is essential for APHIS to include the EPA as a formal cooperating agency for this EIS."

APHIS Response: *APHIS provides summary data on pesticide use in the EIS based on USDA-NASS, USGS, and EPA data. APHIS also provides summary information and references for EPA pesticide registrations for dicamba, glufosinate, quizalofop-p-ethyl, 2,4-D, and glyphosate, as well as summary information and references on EPA human health and ecological risk assessments for these herbicides*.

C. Increased Resistance

"Many pesticides gradually lose their effectiveness over time because pests develop resistance, resulting in reduced crop field performance of these pesticides. Whenever a pesticide is used, there is a potential for that use to contribute to the development of pesticide resistance, particularly if an insect or weed species or population is subjected to repeat sublethal doses of pesticide. This may occur in GE crops, conventional crops, or non-crop conditions.

MON 87429 would be resistant to dicamba, glufosinate, quizalofop, 2,4-dichlorophenoxyacetic (2,4-D), and glyphosate. As such, commercial use of MON 87429 may require increased application quantities of these herbicides, to be effective in treating of weeds. In the EIS, discuss the increased potential for pesticide use and resistance that may occur from deregulating MON 87429. Include how increased pesticide use caused by pesticide-resistance would affect the concentration of the pesticide in the environment and other fate and transport exposures (see below for more information). Also include

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[53] USDA-APHIS. 2020. *Plant Pest Risk Assessment: Monsanto Petition (19-316-01p) for Determination of Nonregulated Status for Dicamba, Glufosinate, Quizalofop and 2,4-D Tolerant MON 87429 Maize with Tissue-Specific Glyphosate Tolerance Facilitating the Production of Hybrid Maize Seed [OECD Unique Identifier: MON-87429-9]*. U.S. Department of Agriculture, Animal and Plant Health Inspection Service. Retrieved from https://www.aphis.usda.gov/aphis/ourfocus/biotechnology/permits-notifications-petitions/petitions/petition-status

scientific data to examine historical trends of increasing pesticide resistance to a range of pesticides, which may now encompass compounds like dicamba, glufosinate, quizalofop, 2,4-D, and glyphosate. This process should also address the potential expansion of acreage with pesticide resistant weeds. Therefore, APHIS should work with EPA's Office of Chemical Safety and Pollution Prevention to collaborate in the development of this analysis.

In the EIS, discuss the range of potential actions to monitor, manage, and mitigate the development of pesticide resistance in conjunction with alternative pest management strategies and Integrated Pest Management. In addition, discuss methods to monitor and mitigate for increased pesticide resistance, identifying who would be responsible for these actions, and detailing how APHIS would commit to these measures."

APHIS Response: *Weed and HR weed management, and HR weed monitoring and mitigation, are discussed throughout the EIS; in 4.3.1.2 – Agronomic Practices and Inputs, 4.3.1.3 – Agronomic Practices and Inputs, and 4.3.6 – Socioeconomics. HR weed resistance monitoring and mitigation are the responsibility of the registrant and the user of the registrant's product. The EPA's PRN 2017-2, Guidance for Herbicide Resistance Management Labeling, Education, Training, and Stewardship, requires monitoring and reporting of resistance. Section 6(a)(2) of FIFRA requires "if at any time after the registration of a pesticide the registrant has additional factual information regarding unreasonable adverse effects on the environment of the pesticide, the registrant shall submit such information to [EPA]." The development of herbicide-resistant weeds (either confirmed or suspected resistance) changes the benefits of an herbicide and must be reported. The agency has implemented the requirement to report resistance information under 6(a)(2) through regulations at 40 CFR Part 159. 40 CFR 159.188(c), states:*

(c) Development of pesticide resistance. Information must be submitted concerning substantiation of any incident of a pest having developed resistance to any pesticide (both public health and non-public health) that occurred under conditions of use, application rates and methods specified on the label if either of the following conditions is met:

(1) The survival of the suspected pesticide-resistant pest was significantly higher than that of a known susceptible pest when both the suspected resistant and susceptible pests were treated with the pesticide under controlled conditions.

(2) Biochemical tests or DNA sequencing indicate that the pest is resistant to the pesticide."

The EPA reiterates the requirements for reporting resistance in PRN 2017-2 (confirmed and suspected resistance as described above) in accordance with FIFRA 6(a)(2) and 40 CFR Part 159. The identification of any suspected resistant weed must be reported to the agency under 6(a)(2). The schedule for reporting resistance is, described in PRN 98-4 14 as follows:

Reports may be accumulated for three months and submitted to the agency by the end of the second month after the accumulation period. The first accumulation period will begin on 1 April of each year. All information submitted to the agency under 6(a)(2) is not entitled to confidential treatment, based on Class Determination 99-1, available at 64 FR 70019.

There are also EPA label requirements that address monitoring and mitigation.

Example Elements for EPA Use Labels:

Place the MOA, using the WSSA Groupings (as described in PRN 2017-1), on the label: This provides critical information to growers and crop advisors when developing herbicide programs and following best management practices for weed resistance. It allows the user to rotate between effective MOA's to reduce the buildup of resistant weeds.

Clearly express all currently required application parameters and product information on the label, including: maximum dose per application, maximum dose per crop cycle or per year, maximum number of applications per crop cycle or per year. This information is critical to allow the user to know how many applications and the amounts that can be applied in order to develop an effective Integrated Pest Management (IPM) plan for the season and the entire year.

Label statement defining suspected resistance: This element provides critical information for the user, and the registrant or their representative, to identify suspected resistant weeds.

Label statement that the user should report lack of pesticide performance to the registrant or their representative and proactively take action before escaped weeds become widespread in their fields: The EPA expects that the registrant or their representative will investigate to determine if the situation meets the criteria of suspected resistance. By reporting and investigating these incidents, cases resulting from suspected resistant weeds may be distinguished from lack of performance from other causes (e.g., equipment malfunction, weather events, etc…). This allows early action to be taken to control these weeds before resistance becomes widespread in their fields. The EPA states that prevention of the development of herbicide-resistant weeds should be the first priority of a weed resistance plan. When suspected resistant weeds are identified, the highest priority is to achieve control of these weeds over any sampling to confirm herbicide resistance.

Label statements describing best management practices for resistance management based on PRN 2017-1. Use of Best Management Practices from WSSA, and the Herbicide Resistance Action Committee (HRAC) guidance. Registrants should include statements that are appropriate to the labeled use sites.

Label statements on local resistant weeds: Knowing what herbicide-resistant weeds have been found in the local area allows the user to proactively address herbicide resistance based on the local circumstances. In general, the purpose of using multiple herbicides (MOAs) in a single product is to increase the spectrum of weeds controlled and not for herbicide-resistance management. Some products may contain one or more active ingredients at less than the optimal rate for control on a given weed species. Without clarification, the user may use a product with multiple herbicides and assume that multiple MOAs are being used for a specific herbicide-resistant weed species. This element will allow the user to make informed decisions about the need for additional control measures.

For Example, the XtendiMax® Herbicide label (dicamba) provides guidance—practices, and monitoring and mitigations measures—for delaying/preventing development of herbicide resistance, and management of dicamba-resistant biotypes. These include tillage practices, herbicide rotations, tank *mixtures, implementing recommended integrated weed management practices, scouting for HR weeds, monitoring control of HR weeds, and guidance for assistance to control escaped/problematic weeds.*[54]

Mandatory Training: Prior to applying dicamba, applicators must complete dicamba-specific training. Only certified applicators may apply the product; it cannot be used by uncertified persons working under the supervision of a certified applicator, except that uncertified persons may transport containers. Prior to using the product, users must complete dicamba-specific training to obtain certification on an annual basis. If state-specific training is required by the state where the applicator intends to apply the product, the applicator must complete training from the state or state-authorized provider.

Record Keeping: Records must be created within 72 hours of every application. Records must be kept for a period of two years. The certified applicator must keep these records for a period of two years. Records must be made available to State Pesticide Control Official(s), USDA, and EPA upon request. See www.xtendimaxapplicationrequirements.com for an example form summarizing record keeping requirements.

D. Fate and Transport

"It is likely that use of MON 87429 could result in increased resistance, as discussed above, which may require increased application of pesticides. Increased pesticide use is frequently associated with increased spray drift. Spray drift is the movement of pesticide dust or droplets through the air at the time of application or soon after, to any site other than the area.[5] In the EIS, address the range of potential health and environmental risks when sprays, dusts, and/or vapors are carried by the wind and deposited on proximate areas.

In the EIS, include pesticide fate and transport analysis for dicamba, glufosinate, quizalofop, 2,4-D, and glyphosate using the most recent scientific data and methods. This level of analysis should ensure that the fate and transport characteristics encompass the potentially increased pesticide use due to resistance (as discussed above). Section 3(c)(5) of FIFRA has authorized the end use of three dicamba products for use on dicamba tolerant cotton and soybeans, not maize. The labeling requirements and restrictions associated with these registration actions include a suite of mandatory control measures that address the potential for spray drift, volatile emissions and runoff. Each of the pesticides discussed above have specific requirements and restrictions that need to be presented in comparable method so that the interdependencies may be fully understood. In the EIS, elaborate on how these controls would or would not be effective for maize crops.

Place specific focus on potential impacts to nearby homes, schools, and playgrounds; farm workers in adjacent fields; wildlife, plants, streams and other water bodies; and other sensitive land uses. Please see following subsections for more information.

In the EIS, address the economic impacts associated with pesticide drift. For example, the NOI recognizes that use of dicamba-based pesticides have resulted in instances of significant economic impact on

[54] US-EPA. 2020. *Xtendimax with VaporGrip Technology*. U.S. Environmental Protection Agency. Retrieved from https://www3.epa.gov/pesticides/chem_search/ppls/000264-01210-20201105.pdf

neighboring crop and orchard fields because of unintended drift and volatilization of the pesticide. Include analysis on injury and impacts to proximate crops and nearby land uses. More specifically, conduct direct analysis at potential locations where crops may become unsellable if the drifting pesticide is not registered for use on the crop. In addition, include information on the resources that state and local agencies spend annually to investigate pesticide drift complaints."

APHIS Response: *APHIS addresses herbicide fate and transport, and herbicide labeling requirements and use restrictions associated with the herbicide registrations, control measures that address the potential for spray drift, volatile emissions, and runoff, in Section 4.3.1.2 – Agronomic Practices and Inputs, 4.3.1.3 – Potential Effects on U.S. Corn Production.*

APHIS addresses potential impacts to nearby homes, schools, and playgrounds, and farm workers in adjacent fields in Section 4.3.4 – Human Health and Worker Safety. APHIS addresses potential impacts to wildlife, plants, streams, and other water bodies, and other sensitive land uses in 4.3.3.2 – Plant Communities, 4.3.3.3 – Animal Communities, 4.3.2 – Physical Environment, 4.3.3 – Biological Resources, 4.3.8 – Compliance with Federal and State Laws and Regulations, Executive Orders, Policies, and Treaties. APHIS addresses the potential economic impacts associated with pesticide spray and vapor drift in Section 4.3.6 –Socioeconomics.

E. Human Health

"The risk of adverse health impacts from pesticide use depends on exposure and toxicity. The EPA has developed human health benchmarks for pesticides that are currently registered for use on food crops and uses these benchmarks to better determine whether the presence of a pesticide may increase the likelihood of adverse health impacts and to help prioritize monitoring efforts. Therefore, ensure the EIS includes numerical human health benchmarks (i.e., cancer and non-cancer benchmarks) for dicamba, glufosinate, quizalofop, 2,4-D, and glyphosate. Describe each benchmark with a clarity intended for the general public. Do not categorize an impact as de minimis or negligible if the impact only minorly exceeds the human health benchmarks as this could still have an impact to human health. APHIS should work with the EPA's pesticides subject matter experts in obtaining this information.

The EIS should include a brief, screening-level quantitative analysis of pesticide-specific human health-risks using EPA default exposure information and toxicity criteria. This data should be used to develop health-based risk management pesticide-specific levels of concern in air, water or soils. It may be helpful to reference the restrictions and limitations of these pesticides on other crops for comparative analysis. The EIS should include indirect and cumulative impacts, including increased pesticide use and drift. Please note that while the updated NEPA regulations remove the definitions of indirect and cumulative impacts, it does not remove the need to discuss them.

Identify the persistence of the existing pesticides in an average or existing representative maize cropland, the potential impacts that MON 87429 could contribute to that cropland, and the cumulative, iterative impacts that could occur through cultivation of MON 87429. Include future effects from increased pesticide applications in this discussion. Analyze each pesticide's persistence separately and work with the EPA to develop this section of the EIS."

<u>Sensitive Populations</u>

"Sensitive populations are more susceptible to health effects from pesticides. In the EIS, address the potential impacts to the elderly, children (including consideration of prenatal exposures), and immunocompromised.

Environmental justice concerns may arise from the potential human health, ecological, social, cultural, and economic impacts associated with MON 87429's resistance to dicamba, glufosinate, quizalofop, 2,4-D, and glyphosate and its wide range of potential use. Address adverse environmental effects, including individual or cumulative actions, of the proposed project on minority and low-income communities."

<u>Farmworkers</u>

"Farmworkers are exposed to pesticides in a variety of ways. Workers who perform hand labor tasks in treated areas are vulnerable to exposure from direct spray, aerial drift, or contact with pesticide residues on the crop or soil. Workers who mix, load, or apply pesticides can be exposed to pesticides due to spills, splashes, and defective, missing, or inadequate protective equipment. This is not a full account of the ways that farmworkers and their families are exposed to these chemicals. Important considerations include:

- The frequency of pesticide safety training in a manner that workers will understand.
- The mechanisms by which workers receive information about the specific pesticides used in their work.
- The established medical monitoring protocols and requirements of workers who handle neurotoxic pesticides.
- Documented safety precautions that limit farmworkers' contact with pesticides.
- The use of Spanish translations of pesticide labels.
- The implementation of buffer zones around.
- Schools and residential areas to protect from aerial drift.
- Farmworker families from exposure to pesticides through aerial drift.
- The protocol for national reporting of pesticide use and pesticide poisonings to the EPA."

APHIS Response: *APHIS addresses the potential health impacts associated with pesticide use in Section 4.3.4 – Human Health and Worker Safety, and 4.3.8 – Compliance with Federal and State Laws and Regulations, Executive Orders, Policies, and Treaties. Potential effects of herbicides on air, water, or soils are discussed in the respective sections addressing these topics (4.3.2.1 – Soil Quality, 4.3.2.2 – Water Resources, 4.3.2.3 – Air Quality). Potential increased herbicide use and spray and vapor drift is addressed in Section 4.3.1.2 – Agronomic Practices and Inputs, 4.3.1.3 – Potential Effects on U.S. Corn Production, and 4.3.4 – Human Health and Worker Safety.*

F. Drinking Water Quality

“Pesticides applied to farmlands can make their way into ground water or surface water systems that feed drinking water supplies, which could and adversely affect public health and safety. According to the National Pesticide Information Center, ‘inland fresh water is the source for 70% of U.S. drinking water supply, so protecting that supply from unnecessary contamination is important. Whether pesticides pose a health risk in drinking water depends on how toxic the pesticides are, how much is in the water, and how much exposure occurs on a daily basis.

The 1996 amendments to the Safe Drinking Water Act require federal agencies to protect sources of drinking water for communities. State agencies have been delegated responsibility to delineate and map each federally regulated public water system, and to conduct source water assessments and provide a database of information about the watersheds and aquifers that supply public water systems.

APHIS should work with states where MON 87429 use is expected to help identify source water protection areas. Identify all source water protection areas statewide and discuss all activities and potential contaminants caused by management activities that could potentially affect these areas. Disclose all measures that would be taken to protect the source water protection areas. Dicamba, glufosinate, quizalofop, 2,4-D are not currently regulated.

In addition, it is estimated that more than 13 million households rely on private wells for drinking water in the U.S. As such, the EIS should also address potential drinking water impacts to private wells, in which private well owners are responsible for the safety of their water.”

APHIS Response: *APHIS addresses water quality relative to the herbicides that could be used with MON 87429 corn in Section 4.3.4 – Human Health and Worker Safety, and 4.3.2.2 – Water Resources.*

G. Environmental Justice

“Executive Order 12898, ‘Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations’ (February 16, 1994), directs federal agencies to identify and address, as appropriate, disproportionately high and adverse human health or environmental effects of their actions on minority and low-income populations. It further directs agencies to develop a strategy for implementing environmental justice and providing minority and low-income communities access to public information and public participation.

Environmental justice concerns may arise from the potential human health, ecological, social, cultural, and economic impacts associated with MON 87429’s resistance to dicamba, glufosinate, quizalofop, 2,4-D, and glyphosate and its wide range of potential use. Address adverse environmental effects, including individual or cumulative actions, of the proposed project on minority and low-income communities.

The EIS should describe measures taken by APHIS to fully analyze the environmental effects of the action on minority communities and low-income populations and identify potential mitigation measures. Address any disproportionate adverse impacts, such as higher exposure to toxins; changes in existing ecological, cultural, economic, or social resources or access; cumulative or multiple adverse exposures from environmental hazards; or community disruption. In addition, specify whether the EIS meets requirements of the USDA’s current Environmental Justice Strategic Plan.

Clearly identify mitigation measures for environmental justice impacts and include a monitoring and adaptive management plan to ensure that mitigation is effective and successful."

APHIS Response: *APHIS addresses potential environmental justice concerns, such as potential impacts on minority and low-income populations, in Section 4.3.8 – Compliance with Federal and State Laws and Regulations, Executive Orders, Policies, and Treaties.*

H. Biological Resources

Threatened and Endangered Species

"Work closely with the U.S. Fish and Wildlife Service to determine potential impacts of the project on plant and wildlife species, especially species classified as rare, threatened, or endangered on either state or federal lists and critical habitat. In the EIS, identify and quantify which species and/or critical habitat might be directly, indirectly, or cumulatively affected by each alternative. Emphasis should be placed on the protection and recovery of species due to their status or potential status under the federal or state Endangered Species Act. Summarize, or include as an appendix in the EIS, the USFWS's biological opinion and clearly demonstrate that the preferred alternative is consistent with the biological opinion. Discuss mitigation measures to minimize impacts to special status species, describe the effectiveness of such measures to protect wildlife, and indicate how they would be implemented and enforced."

APHIS Response: *APHIS addresses ESA requirements and provides a Threatened and Endangered Species (TES) Analysis in Section 4.3.3.6 – Threatened and Endangered Species. APHIS found no potential effects on TES that would necessitate consultation with the U.S. Fish and Wildlife Service.*

Other Wildlife Species

"Discuss impacts to other species of wildlife and their habitat that may be impacted, including migratory birds, pollinators, such as bees and monarch butterflies, and aquatic organisms. In the EIS, identify and quantify which species may be directly, indirectly, or cumulatively affected by each alternative. This EIS should also discuss potential offsite pesticide movement and transport of residues to surface or ground water that may impact aquatic organisms and stream ecology. Discuss mitigation measures to minimize impacts to wildlife species, describe the effectiveness of such measures to protect wildlife, and indicate how they would be implemented and enforced."

APHIS Response: *APHIS addresses potential impacts on wildlife (flora and fauna), including habitat that may be impacted, migratory birds, pollinators, such as bees and monarch butterflies, and aquatic organisms in 4.3.3 – Biological Resources, and 4.3.8 – Compliance with Federal and State Laws and Regulations, Executive Orders, Policies, and Treaties.*

Ecosystem Impacts

"The sustainable use of natural ecosystems, including activities affecting wildlife populations, have an important role in the conservation of biodiversity and ecosystem services. In the EIS, consider the full range of ecological effects from pesticides, including, but not limited to local, regional, and state-wide biological diversity; trophic food web effects (i.e., trophic cascades); connections to ecological structure and function; interference of migratory wildlife movement; species outside the borders of the U.S.

(migratory, and normal home range movements of species that move across national boundaries); riparian habitat or sensitive natural community; and ecosystem services that humans depend on and need from public lands. Discuss how ecosystem impacts will be considered in management decision-making."

APHIS Response: *APHIS addresses potential ecosystem level impacts in the analyses presented in 4.3.2 – Physical Environment and 4.3.3 – Biological Resources*.

I. Ecological Agriculture

"The NOI recognizes that MON 87429 may require increased application quantities of pesticides to be effective in treating weeds, which may impact soil function because many GE crops aim for homogeneity to increase the productive yield of a crop. Heterogeneity of crops may not be useful in increasing yield, but diversity does maintain the health and ecological function of the soil biome. In a mono-culture context, many soil microorganisms face nutritive stress, which determines their distribution and functioning. To ensure ecosystem function is maintained, it may be important to investigate how changes in key base cations (through tilling and fertilization) could impact the taxonomic and functional structures of the bacterial communities.

Analyze how soil fertility could be maintained through organic measures and reducing dependence on synthesized materials such as fertilizers, pesticides and other agricultural chemicals. Control measures, or mitigation measures, may be useful to establish protocols that allow for better long-term yields of future hybrids. The EIS should also include an analysis of how the impacts of climate change affect these soil communities and structures."

APHIS Response: *APHIS addresses soils, soil fertility, and soil microorganisms, to include the potential effects of herbicides on soils and the soil biome, in 4.3.2.1 – Soil Quality, and 4.3.3.1 – Soil Biota. Climate change is discussed in 4.3.7 – Climate Change and Greenhouse Gas Emissions.*

J. Consultation with Tribal Governments

"It is important that formal government-to-government consultation take place early in the scoping phase of the project to ensure that all tribal concerns are adequately addressed in the EIS. The principles for interactions with tribal governments are outlined in the presidential "Memorandum on Government-to Government Relations with Native American Tribal Governments" (April 29, 1994) and Executive Order 13175, 'Consultation and Coordination with Indian Tribal Governments' (November 6, 2000).

In the EIS, discuss how tribes were consulted, summarize the results of tribal consultation and identify the main concerns expressed by tribes (if any), and how those concerns were addressed. If tribes did not respond to consultation (based on sending an email or letter approach), please describe additional efforts to consult with tribes. As a resource, refer to *Tribal Consultation: Best Practices in Historic Preservation,* published by the National Association of Tribal Historic Preservation Officers."

APHIS Response: *APHIS addresses tribal consultation requirements and APHIS outreach in 4.3.8 – Compliance with Federal and State Laws and Regulations, Executive Orders, Policies, and Treaties. APHIS provided outreach to tribes via an APHIS letter of notification on May 3, 2021. APHIS received comments from two tribes, which are addressed in comments 4 and 5, below.*

K. Monitoring

"Include a monitoring program designed to assess impacts from the project, and the implementation and effectiveness of measures taken to mitigate impacts. The EIS should describe the monitoring program, how it would be used in present and future resources management, and the likely extent to which it would be adequately implemented/funded".

APHIS Response: *If APHIS deregulates MON 87429 corn, it will have no statutory or other authority to directly monitor production of the crop plant for potential environmental impacts. That said, as summarized in the EIS, there are various USDA programs, and other federal programs, that support sustainable crop production through financial and other assistance to crop producers, and applicable to MON 87429 corn. These are summarized in Section 4.3.9 – Potential Impacts on the Human Environment, and other reference provided as to EPA and USGS programs.*

3. Comment ID: APHIS-2020-0021-XXXX (multiple entries),[55] form letter that comprised over 3,000 of the comments submitted

"Reject Bayer-Bayer's petition for MON-87429 corn. MON-87429 corn is designed as a pesticide delivery system. I understand that USDA does not regulate pesticides, but due to herbicide-tolerant GMO crops' reliance on their associated herbicides, it is illogical to separate the GMO crops from the herbicides. No GMO farmer would buy the seeds without buying and using the herbicides. Therefore, the GMO crops and herbicides need to be considered as an inseparable system. Since the introduction of Bayer's glyphosate-tolerant GMOs in the 1990s, we have seen the use of this genotoxic carcinogen increase by hundreds of millions of pounds across the U.S. Since 2016, we have seen that the use of Bayer's dicamba-tolerant GMOs has caused untold destruction across America. Dicamba drift has decimated millions of acres of non-dicamba-tolerant crops, including non-GMO and organic crops, orchards and vineyards, and has killed off pollinator-important plants, private gardens and valuable trees across the country. There have been hundreds of lawsuits launched against Bayer for damage caused by dicamba drift from GMO crops. The San Francisco Ninth Circuit Court of Appeals even ordered the EPA to vacate their unlawful approval of dicamba-based herbicides manufactured by Bayer and BASF. Additionally, 2,4-D is also known to be drift-prone and will likely cause further damage as its usage increases with adoption of MON-87429 corn. A recent study found that glyphosate, dicamba and glufosinate, three of the herbicides that will be sprayed on MON-87429 corn, change the genetic composition of soil microbiomes, potentially contributing to the global antimicrobial resistance problem in agricultural environments. The EPA approval process is flawed. There is no assessment of the combined toxicity of pesticide mixtures on the soil microbiome, on pollinators, wildlife, birds, biodiversity, or endangered species. A recent study found that pesticide mixtures are more toxic than the individual pesticides. This study of laboratory animals exposed to low concentrations of pesticides revealed metabolic effects on the gut-liver axis, which can potentially be used as biomarkers for the prediction of future negative health outcomes. The study found adverse impacts of the mixture on the host-gut microbiome. The risks of pesticide mixtures must be investigated before considering the approval of MON-8429 GMO corn. It would be unconscionable for USDA to allow Bayer-Bayer's MON-

[55] See https://www.regulations.gov/document/APHIS-2020-0021-4127 [Docket No. APHIS-2020-0021-4127 at www.regulations.gov]

87429 corn to be grown in the U.S. given everything we know about GMO contamination of non-GMO and organic crops, the damage that herbicide drift causes, and the toll of pesticides on human and environmental health. Growing crops genetically engineered to tolerate five different toxic herbicides is madness and USDA must put a stop to this now."

APHIS Response: *Herbicide use with MON 87429 corn, and herbicide spray and vapor drift is addressed in Section 4.3.1.2 – Agronomic Practices and Inputs, and 4.3.1.3 – Potential Effects on U.S. Corn Production. Soil biota are addressed in Section 4.3.3.1 – Soil Biota. Pollinators, wildlife, birds, biodiversity, and endangered species are addressed in Section 4.3.3 – Biological Resources. Potential contamination of non-biotech and organic crops is addressed in Section 4.3.6 – Socioeconomics. The potential effects of pesticides on human health is addressed in Section 4.3.4 – Human Health and Worker Safety.*

4. Oneida Nation's comments USDA Notice of Intent (NOI) to prepare an Environmental Impact Statement (EIS) to examine the potential environmental impacts that may result from approving a petition from Bayer CropScience U.S for Deregulation of Hybrid Corn

May 27, 2021

Cultural Significance of Our Corn

"The Oneida people have always highly regarded our traditional white corn as sacred; a living and spiritual being. Our creation story recognizes the importance of our Three Sisters; corn beans and squash. In our teachings Sky Woman descended from the skies above to a body of water that eventually land, animal life and life sustenance would form upon. Since that time our ancestors have deeply valued life sustenance as not only a necessity for survival but also for spiritual and personal wellbeing. In our traditional Thanksgiving address, which is our daily recital of giving thanks to all of creation, we recognize and thank the Three Sisters for the sustenance they provide for our people.

As People of the Longhouse who have lived on these lands for time immemorial, we assume responsibility for our foods, water, air, land, and people. Through the instructions that our people received by the Creator, we feel it our obligation to voice our concerns when threats to our health, safety and welfare are approaching. Our responsibility to ensure that our future generations have sustainable, healthy and traditional foods is taken very seriously.

Give the natural relationship between the Three Sisters, our traditional white corn is grown as a unit with beans and squash which provides a strong nucleus for food sustenance for our community. Our staff works hard to protect our white corn crops from cross pollination. Thus, our white corn crops are grown separately from the Nation's other farming operations and has a dedicated staff with specialized knowledge of how to grow, produce, harvest and process our white corn.

On an annual basis, the Nation produces 10,000 pounds of white corn for the Oneida community and at times the demand is much greater than what can be produced. Our community understands the value of our white corn, and the health benefits that come with consumption of the white corn."

Nation's Opposition to the Deregulation of Hybrid Corn

“As indigenous communities throughout the world practice indigenous agriculture, our concerns with deregulation of hybrid and/or genetically modified organism (GMO) corn seed is how this affects neighboring growers and producers that are making concentrated efforts to resist the use of GMO seeds. We know that pollen drift is real, with corn pollen having the ability to travel up to seven miles from the source. What happens when these community’s and individuals’ seeds are tainted with GMO seeds? Does Bayer then “own” the seed? As indigenous growers, this is a concern that has historically shown to resurface. While we do not believe that our natural resources can be owned, we do believe we carry a responsibility to care for those resources that were given to us to sustain our people in accordance with our original instructions from the Creator.

Deregulation of hybrid and GMO crops hinders our responsibilities and efforts, while taking away the choice in how producers choose to grow. While we realize that this impact statement is specific to the environment, we believe that our food systems need to be assessed comprehensively, from soil to table. This all starts with the seed. We know that there is systematic overflow of the imbalance of the inputs into the environment caused from conventional farming. Deregulation of these hybrid and/or GMO crops is a continual injustice to indigenous communities in our food sovereignty efforts as tainted seeds and environmental inputs that is required from the use of GMOs, continue to take away our control of owning and pursuing our own way of agriculture and life.

Relating to the question of data or research derived from this deregulation, the Nation would be cautious of any movement with lack of data or evidence. Lack of data is not positive, or neutral for that matter. We would hope that any lack of data on long term effects does not cause policy change to move forward too quickly. Some of our questions include; What are the long-term impacts on our food systems with the increase in the use of GMOs? How does this deregulation impact our food systems’ resiliency to climate change?

Our traditional corn is an invaluable resource to our community, and the risks for potential cross pollination are concerning. The Nation expresses its strong opposition of the deregulation of hybrid corn as we believe this could be detrimental to not only our crops, but to indigenous crops across Indian Country, limit access to healthy traditional foods and impact our food sovereignty initiatives to improve the health of our people.

If you should have any questions or require additional information, please feel free to contact me at thill7@oneidanation.org

With a Good Mind, a Good Heart and Strong Fire,

Tehassi tasi Hill, Chairman”

APHIS Response: *APHIS understands and appreciates the cultural and food value of indigenous maize varieties to Tribal Nations. APHIS also understands the need for maintaining genetic purity and diversity among indigenous maize varieties, sustaining Tribal agricultural practices, food sovereignty, and integrity of traditional foods. The ability of each tribal nation and its citizens to feed its people, and the recognition that native traditional foods are important to the health and well-being of native people, is a* *primary USDA focus.*[56] *APHIS is aware that one of the Oneida Nation's major focuses the past several years has been in its production of white corn, one of the principal Three Sisters crops. The USDA supports Tribal Nations' agriculture, food sovereignty, and traditional foods through various programs.*[57] *These include loan programs for beginning farmers and ranchers, farm operating loans, the plant pest and disease management and disaster prevention program, specialty crop block grants, and national organic certification cost share program, among others.*

The Oneida Reservation is located in Brown and Outagamie Counties, adjacent to downtown Green Bay, Wisconsin—shares the western border with Green Bay, and totals 65,400 acres. Approximately 23,122 acres are tribally owned, 12,208 acres are considered fee land, and 10,904 acres are considered tribal trust land. In 2020, in Brown County Wisconsin, the area planted to corn for grain was 67,300 acres, 22,000 acres were harvested. In Outagamie County, 84,200 acres were planted for grain, 34,500 harvested. The Oneida Nation produces around 1,900 acres of corn, and 30 acres of white corn.[58] *Organic certification was obtained in 2001 for white corn, hay, pasture, pumpkins, and other fruits and vegetables. Thus, commercial corn production occurs in the area were the Oneida Nation also produces crops.*

The movement of transgenic DNA sequences from a biotechnology derived crop to other crop plants has attracted attention because of its potential economic and cultural impacts. As reviewed in Section 4.3.3.4 – Gene Flow and Potential Weediness of Corn, sweet corn and field corn are potentially susceptible to pollen-mediated gene flow—between the male tassel and female silk—typically by wind (cross pollination can also be performed through hand pollination). Two neighboring farms in close proximity may potentially observe crop-to-crop gene flow if one farm has biotechnology derived corn and the other has non-biotech corn.

As reviewed in Section 4.3.3.4 – Gene Flow and Potential Weediness of Corn, MON 87429 corn, if grown for commercial purposes, would present the same potential risk for gene flow, specifically the propensity for and frequency of gene flow, as current corn varieties. While corn pollen can travel as far as 1/2 mile (800 m) in a wind of 15 miles per hour (27 km/h), most pollen is deposited within a short distance of the corn plant. Numerous studies show the majority (84%-92%) of pollen grains travel less than 16 feet (5 meters). At a distance of 200 feet (60 m) from the corn plant, the pollen concentration averages only about 1%, compared with pollen samples collected about 3 feet (0.9 m) from the pollen source. The number of outcrosses is reduced to one-half at a distance of 12 feet (3.6 m) from the pollen source, and at a distance of 40 to 50 feet (12 to 15 m), the number of outcrosses is reduced by 99%. Studies have shown that cross-pollination between cornfields could be limited to 1% or less by a separation distance of 660 feet (200 m), and to 0.5% or less by a separation distance of 984 feet (300 m). However, cross-pollination frequencies could not be reduced to 0.1% consistently, even with isolation distances of 1,640 feet (500 m)—see Section 4.3.3.4 of this EIS.

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[56] USDA Office of Tribal Relations [https://www.usda.gov/tribalrelations]

[57] 2022 USDA Resource Guide for American Indians & Alaska Natives, United States Department of Agriculture Office of Tribal Relations [https://www.usda.gov/sites/default/files/documents/usda-resource-guide-american-indians-alaska-natives.pdf]

[58] Chapter 5 – Farmlands that Provide [https://oneida-nsn.gov/wp-content/uploads/2018/01/Chapter-5-Farmlands-that-Provide.pdf]

The utilization of best management practices by growers of biotech and non-biotech crops to minimize or prevent cross-pollination is fundamental to reducing the potential for gene flow. The potential for gene flow can be managed through a combination of containment strategies, buffer zones, and cooperation and communication among neighboring growers. For example, when corn fields are physically separated by sufficient distances (e.g., around 1,500 feet, or 1/3 mile) they are less likely to have pollen drift and gene flow. Gene flow can also be reduced by staggering planting times—when adjacent corn fields flower and release pollen at different times in the summer.

APHIS understands the Oneida Nation's comment and opposition to the deregulation of MON 87429 corn as the Nation believes this could be "detrimental to not only the Nation's crops, but to indigenous crops across Indian Country, limit access to healthy traditional foods and impact our food sovereignty initiatives to improve the health of our people." While APHIS acknowledges there exists, under certain circumstances, the potential for gene flow—cross-pollination between biotechnology derived corn grown in Brown and Outagamie Counties—utilization of best management practices, coordination and cooperation with neighboring growers adjacent to the Nation's land, and adherence to USDA National Organic Program requirements for organic crops, can preclude the occurrence of cross-pollination. APHIS disagrees that deregulation of MON 87429 corn would limit access to healthy traditional foods, or impact Oneida Nation's food sovereignty initiatives to improve the health of the Oneida people. Tribal entities are recognized as independent governments and any agricultural activities on tribal lands, as all other activities, would only be conducted if approved by the tribe. Tribes have control over any potential conflict with cultural resources on tribal properties.

Bayer upholds voluntary commitments along their product chain consistent the Food and Agriculture Organization of the United Nations (FAO) Code of Conduct on Pesticide Management, the CropLife International Plant Biotechnology Code of Conduct, the Excellence Through Stewardship (ETS) and Responsible Care programs, and the Universal Declaration of Human Rights.[59]

5. Upper Sioux Community (Tribe)

May 24, 2021
Bill Doley
Biotechnology Regulatory Services Tribal Liaison
USDAAPHIS
4700 River Road, Unit 98,
Riverdale, MD 20737

"Dear Mr. Doley,

Please accept these comments on the behalf of the Upper Sioux Community regarding the petition from Bayer CropScience U.S. Bayer in seeking the deregulation of a corn variety developed using genetic

[59] Product Stewardship in the Agricultural Business, https://www.bayer.com/en/sustainability/product-stewardship-agriculture-farming

tolerance to the herbicides dicamba, glufosinate, quizalofop, and 2,4D, and for tissue-specific tolerance to the herbicide glyphosate to facilitate the production of hybrid seed.

The Upper Sioux Community has a mission to ensure the health, welfare, and safety of Tribal members and to protect and conserve the natural resources of the earth for todays and future generations. Bayer's proposal to deregulate a genetically engineered corn variety does not correlate with the Upper Sioux Community's short- or long-term goals or ethics. The Upper Sioux Community believes that any potential harm to human health, damage to the environment, the lack of research and unforeseen results therein do not outweigh the possible benefits that commercial farmers may see from this deregulation. Therefore, the Upper Sioux Community does not support the deregulation of the corn variety that was using genetic tolerance to the herbicides dicamba, glufosinate, quizalofop, and 2,4D, and for tissue-specific tolerance to the herbicide glyphosate to facilitate the production of hybrid seed.

Respectfully,

Kevin Jensvold
Upper Sioux Community, Chairman"

APHIS Response: *The Upper Sioux Community states they believe that "any potential harm to human health, damage to the environment, the lack of research and unforeseen results therein do not outweigh the possible benefits that commercial farmers may see from this deregulation." The Upper Sioux Community does not support the deregulation of MON 87429 corn.*

As discussed in the EIS, there are no human health risks associated with MON 87429 corn, the plant itself (4.3.4 – Human Health and Worker Safety). Commercial crop production—whether a conventional, organic, or biotechnology derived cropping system—always has some degree of environmental impact, as discussed throughout Chapter 4 of the EIS. The potential introduction of pesticides and fertilizers (organic or synthetic) to surface water or groundwater, soil erosion, emission of air pollutants, and loss of wildlife habitats and biodiversity and are all impacts that can derive from commercial crop production. These are issues that all farmers, not just those growing biotech crops, work with in providing food, feed, fuel, fiber, and industrial products to meet societal needs. The degree of environmental impacts can be minor or noticeably adverse, depending on a variety of factors that include the type and quantity of agronomic inputs and practices employed, geography and proximity of surface waters to crops, local biota, weather, prevalence and diversity of insect pests and weeds, and crop type being produced. With around 360,000 corn farms comprising some 90 million acres of the land in the United States, the scale of potential impacts, namely in an aggregate sense, requires integration of crop production with sustainability and conservation practices—for both biotech and non-biotech crops. While implementing such practices can often result in significant mitigation of environmental impacts, not all impacts can be fully attenuated, and some degree environmental trade-offs in meeting the market demand for corn-based food, feed, fuel, and industrial products are inevitable.

On approval of the petition, and subsequent grower adoption of MON 87429 corn, the agronomic practices and inputs that would be used in the cultivation of MON 87429 corn, and any contribution of these practices and inputs to impacts on soils, water quality, or air quality, is expected to be similar to that of other corn crops currently cultivated. Dicamba, glufosinate, quizalofop-p-ethyl, 2,4-D, and *glyphosate, are used on wide variety of other crops. It is expected that MON 87429 corn would be produced on lands already converted to cropland—replace other HR corn crops currently cultivated. Hence, impacts on wildlife habitats and biodiversity would be negligible.*

Increased herbicide use with this variety, were it to occur, could increase risks to water and air quality, wild and cultivated non-crop plants via spray and vapor drift, and to aquatic environments via runoff. Spray and vapor drift, as well as runoff, could also present risks to terrestrial and aquatic wildlife. All herbicide use would need to adhere to EPA label use requirements and restrictions (these are legal requirements), as well as any state restrictions that may be imposed, in addition to that of the EPA label.

There are various federal, state, and private sector collaborative initiatives to support sustainable agricultural practices and help alleviate the collective impacts of crop production on the physical environment, as well as biological resources—these are also described in this EIS (e.g., see Section 4.3.8 and 4.3.9).

Appendix 2: Public Comments on the Draft Environmental Impact Statement

[Placehodler]

To be completed after public comment period closes on draft EIS and APHIS review of public comments.