Appendix 1.

USDA Notifications and States Approved for Environmental Releases of MON 88701 Dicamba- and Glufosinate-Resistant Cotton and MON 87708 Dicamba-Resistant Soybean

Table 1-1. USDA Notifications, Permits and States Approved for MON 88701 Cotton

USDA No.	Date	State/Territory-Number of Releases
07-241-107n	9/28/2007	PR-2
08-042-109n	3/12/2008	TX-2, TN-1, NC-2, MS-3, GA-4
08-056-112n	3/26/2008	NM-2
08-056-117n	3/26/2008	TX-3, SC-2, NC-2, MS-2, LA-1, GA-4, AR-1
08-266-130n	10/19/2008	PR-3
09-058-104n	3/29/2009	CA-1
09-065-111n	4/5/2009	AZ-5, GA-1, MS-3, SC-2, TX-4
09-068-108n	4/8/2009	AL-1, AR-2, AZ-1, GA-1, IL-1, LA-1, MS-1, NC-4, NM-2, TX-1
09-072-103n	4/8/2009	AR-1, MS-2, SC-5, TN-2, TX-5
09-224-101n	9/21/2009	PR-2
10-054-134n	3/20/2010	TX-4
10-059-109n	3/28/2010	GA-2, NC-9, SC-3
10-061-102n	7/10/2010	MS-1, PR-7
10-064-101n	4/3/2010	CA-2, GA-1, LA-1, MO-1, OK-3, SC-1, AR-1
10-067-104n	4/7/2010	AZ-5, IL-1, MS-4, NM-2, PR-2, TX-10
10-071-101n	4/9/2010	AR-4, AZ-2, GA-2, KS-1, LA-1, NC-2, NM-1, SC-1, TX-2
10-071-102n	4/10/2010	AR-1, GA-1, LA-1, MS-1, NC-1, SC-1, TN-1, TX-2
10-242-102n	9/29/2010	PR-2
10-285-105n	11/11/2010	AR-1, GA-1, LA-1, NM-1
11-045-101n	3/16/2011	MS-1, PR-2
11-052-105n	3/23/2011	AL-1, FL-2, GA-9, MS-1, NC-6, SC-4
11-053-105n	3/25/2011	AR-3, LA-2, MO-2, MS-8, TN-5, TX-4
11-075-107n	4/15/2011	AL-1, AR-1, AZ-4, IL-1, LA-1, MO-1, MS-4, NC-1, SC-1, TX-9
11-068-103n	4/8/2011	AL-2, AR-2, AZ-1, CA-2. GA-2, LA-1, NC-1, NM-1, SC-1, TX-5
11-083-104n	4/23/2011	AL-1, MS-1
11-084-107n	4/24/2011	NC-1
11-091-102n	5/1/2011	TX-1

Table 1-1 (Continued). USDA Notifications, Permits and States Approved for MON 88701 Cotton

USDA No.	Date	State/Territory-Number of Releases
11-094-101n	5/4/2011	AZ-1
11-111-104n	5/21/2011	FL-1
11-133-103n	6/12/2011	IL-1
11-153-101n	7/2/2011	MS-1, PR-2
11-152-101n	7/1/2011	GA-1
11-199-102n	8/17/2011	PR-1
11-290-101n	11/16/2011	MS-1, PR-3
12-018-101n	2/17/2012	AL-1, TX-2
12-053-110n	3/23/2012	AR-3, CA-1, GA-2, LA-2, MS-11, NC- 1, TN-1, TX-2
12-046-104n	3/16/2012	AL-1, AR-4, FL-1, GA-2, LA-1, NC-3, SC-1, TN-4, TX-2
12-051-106n	3/21/2012	AL-3, AR-3, FL-1, GA-3, MS-7, SC-1, TN-1, TX-5
12-051-105n	3/21/2012	GA-5, MS-4, NC-6, SC-2, TN-1, TX-5
12-046-109n	3/16/2012	AR-1, MO-5, TN-13,TX-2
12-055-101n	3/25/2012	AR-1, CA-1, SC-1, TX-1
12-068-101n	4/7/2012	CA-4
12-053-109n	3/23/2012	AL-1, NC-1, SC-1, TX-4
12-069-101n	4/8/2012	GA-9, TX-2
12-075-102n	4/14/2012	AL-1, AR-2, MS-1, NC-1, SC-1, TX-4
12-074-107n	4/13/2012	TX-1
12-081-101n	4/20/2012	AL-1, TX-2

Abbreviations:
AL = Alabama; AR = Arkansas; AZ = Arizona; CA = California; FL = Florida; GA = Georgia; LA = Louisiana; IL = Illinois; MO = Missouri; MS = Mississippi; NC = North Carolina; PR = Puerto Rico; SC = South Carolina; TN = Tennessee; TX = Texas

Table 1-2. USDA Notifications, Permits and States Approved for MON 87708 Soybean

USDA No.	Date	State/Territory-Number of Releases
05-269-02n	11/16/2005	PR-1
06-045-15n	5/18/2006	HI-5
06-045-17n	5/18/2006	PR-3
06-052-01n	3/20/2006	IL-7, KS-5
06-052-02n	4/24/2006	IA-7, IL-5, IN-2
06-052-09n	4/24/2006	IA-2, IL-6, IN-2
06-067-05n	4/24/2006	IL-2
06-090-03n	5/5/2006	IL-2
06-275-102n	11/14/2006	PR-1
06-345-101n	1/10/2007	PR-3
07-018-103n	2/17/2007	IL-10, IN-3, MO-1, PR-1
07-018-106n	2/17/2007	IA-7, KS-6
07-018-109n	2/17/2007	IA-1, IL-10, IN-3, MO-1
07-024-101n	3/18/2007	IA-7, KS-6
07-039-101n	3/18/2007	IA-4, IL-5, IN-3, KS-3
07-043-102n	4/10/2007	IA-1, IL-2, KS-1 MD-1, WI-1
07-050-107n	4/9/2007	IA-1, IL-2, IN-1, KS-1 KY-1, MN-1, NE-1, SD-1
07-057-109n	4/6/2007	AL-1, IA-3, IL-1 IN-1, LA-1, MN-1
07-094-104n	5/4/2007	MO-2, MS-1, NE-1 SD-1, TN, IA-1
07-094-116n	5/4/2007	MN-1
07-113-103n	6/4/2007	PR-2
07-241-103n	9/28/2007	PR-1
07-250-102n	10/7/2007	PR-2
07-261-101n	10/18/2007	PR-2
07-271-101n	10/28/2007	PR-2
07-312-101n	12/5/2007	PR-1

Table 1-2 (Continued). USDA Notifications, Permits and States for MON 87708 Soybean

USDA No.	Date	State/Territory-Number of Releases
07-352-101rm	3/26/2008	IA-8, IL-16, IN-4, KS-7, MO-1
08-030-103n	2/29/2008	PR-2
08-031-105n	3/13/2008	IA-5, IL-4, KS-5
08-031-106n	3/1/2008	IA-2, IL-5, IN-3
08-039-107n	3/9/2008	IA-5, IL-1, IN-3, KS-5, MO-1
08-043-107n	3/13/2008	IA-3, IL-10, IN-1, OH-1
08-049-101n	3/19/2008	IL-1, MD-1, WI-1
08-058-101n	3/28/2008	IA-3, IL-2, IN-1, MO-1, PA-1, WI-2
08-059-109n	3/29/2008	IA-1
08-059-110n	3/29/2008	IL-1
08-059-112n	3/29/2008	IN-1
08-060-103n	4/2/2008	MN-1
08-063-112n	4/2/2008	IA-4, IL-2, IN-1, MI-1 MO-1, NE-2
08-063-113n	4/4/2008	MN-2, ND-1, SD-5, WI-5
08-065-101n	4/4/2008	IL-2, IN-1
08-064-102n	4/3/2008	PA-1
08-064-103n	4/3/2008	IL-1
08-064-104n	4/3/2008	AR-1, GA-1, KS-5 LA-1, MO-1 SC-1
08-064-105n	4/3/2008	AR-1, IL-2, IN-1, KS-3, MD-1 MN-3, NC-1, SD-1, WI-1, ND-1
08-072-110n	4/25/2008	AR-1, IA-1, IN-3 KS-1, MI-1, MO-2
08-079-101n	4/17/2008	NE-1, IA-3
08-084-102n	4/24/2008	IA-1, NE-1
08-182-101n	8/1/2008	PR-2
08-219-101n	9/5/2008	PR-1
08-263-101n	10/19/2008	AR-1, IA-1, IL-1, MO-1
08-266-105n	10/22/2008	PR-1
08-323-101n	12/18/2008	PR-1
08-352-108n	1/26/2009	PR-1
08-357-101rm	3/17/2009	IA-8, IL-7, IN-3, KS-5, NE-1

Table 1-2 (Continued). USDA Notifications, Permits and States for MON 87708 Soybean

USDA No.	Date	State-Number of Releases
09-007-106n	2/25/2009	PR-1
09-036-103n	3/7/2009	IA-2, IL-2, IN-1, NE-1
09-042-103n	3/19/2009	MS-1
09-049-110n	3/20/2009	IA-1
09-050-136n	4/3/2009	IA-2, IL-2, IN-2,MD-1, MN-1, OH-1, PR-1
09-061-108n	4/1/2009	AR-1, IA-1, IL-3, KS-1, SD-1
09-061-117n	4/1/2009	IL-1, MO-2
09-068-111n	4/8/2009	IL-2, IN-2, MS-1 NE-2, OH-1
09-071-102n	4/11/2009	NE-1, SD-1, TN-2
09-082-103n	4/22/2009	IN-1
09-091-103n	5/1/2009	AR-1
09-093-120n	5/3/2009	AR-1
09-124-102n	6/3/2009	PR-1
09-124-105n	5/13/2009	IA-1
09-135-104n	6/14/2009	IL-1
09-162-105n	7/11/2009	PR-1
09-162-106n	7/11/2009	PR-1
09-222-101n	9/9/2009	PR-2
09-237-104n	9/24/2009	PR-1
09-247-101rm	11/17/2009	PR-1

Abbreviations:

AR = Arkansas; GA = Georgia; HI = Hawai'i; KS = Kansas; KY = Kentucky; LA = Louisiana; IA = Iowa; IL = Illinois; IN = Indiana; MD = Maryland; MI = Michigan; MN = Minnesota; MO = Missouri; MS = Mississippi; NC = North Carolina; ND = North Dakota; NE = Nebraska; OH = Ohio; PA = Pennsylvania; PR = Puerto Rico; SC = South Carolina; SD = South Dakota; TN = Tennessee; WI =Wisconsin

Appendix 2. Summary of Public Comments

Public Scoping Comments

Members of the public were invited to participate in the scoping process for this draft EIS through an announcement of a notice of intent (NOI) to prepare an environmental impact statement (EIS) in connection with making a determination on the status of Monsanto petitions 10-188-01p (designated as event MON 87708 soybean) and 12-185-01p (designated as event MON 88701 cotton). APHIS published an NOI to prepare an EIS for the two petitions and requested public comments for scoping the EIS in the Federal Register on May 16, 2013. The 60-day public comment period closed on July 17, 2013. The docket file was published at http://www.regulations.gov/#!docketDetail;D=APHIS-2013-0043.

In this NOI, APHIS asked for comments, data, and information regarding 18 broad, overlapping issues. APHIS also requested the public to provide suggestions for other issues to be discussed or alternatives to be analyzed in the draft EIS. During this comment period, APHIS received 64 comments (see summary in Table 2-1) with an additional 16 comments from the virtual public meetings (see summary in Table 2-2). Comments were made by interest groups, industry representatives, industry trade organizations, growers, private individuals, scientists, agronomists and crop specialists, and a Federal agency. Full text of the comments received during the open comment period is available online at www.regulations.gov.

In addition to posting written comments directly to the docket, members of the public were given opportunities to provide their comments directly to APHIS during public meetings held on June 26 and 27, 2013. Transcripts of the public meetings are available as follows:

For the June 26, 2013, virtual meeting:

http://www.aphis.usda.gov/biotechnology/downloads/VPM/062613/VPM_062613_transcript.pdf

For June 27, 2013, virtual meeting:

http://www.aphis.usda.gov/biotechnology/downloads/VPM/062713/VPM_062713_transcript.pdf

In all, a total of 80 public comments were received with 64 public comments submitted to the docket folder on the NOI for the preparation of an EIS on dicamba-resistant soybean and cotton and an additional 16 comments were given on the NOI during the virtual meetings.

APHIS used the public comments to identify issues to be considered in development of the Draft EIS. A number of commenters indicated they object to APHIS Notice of Intention to prepare an EIS, finding the level of analysis performed in the EAs scientifically sufficient. These commenters felt preparing an EIS unnecessarily keeps valuable traits and tools currently needed by growers battling herbicide-resistant weeds.

Commenters who were opposed to the deregulation of MON 87708 soybean and MON 88701 cotton generally were concerned about the potential increased use of dicamba by growers with adoption of the deregulated events. While APHIS recognizes these concerns, APHIS does not regulate pesticide use. EPA is reviewing and analyzing the information Monsanto has submitted in support of the registration of their dicamba formulation. This includes assessing the physical and chemical properties of, fate and transport of, and impacts to the environment and human health from the new formulation. APHIS has no input into the decision of permitting the use of the new dicamba uses; therefore, those issues are not analyzed in this EIS.

Table 2-1. EIS Public Scoping Comments Submitted Online

Comment #	Comment ID	Commenter	Comment Excerpt
1	APHIS-2013-0043-0002	Anna Fox	• Opposed to Monsanto receiving unregulated status for herbicide resistant soybeans and cotton. • These crops may be resistant to the herbicides glufosinate but what about all the other organisms in the ecosystem?
2	APHIS-2013-0043-0003	Darryl Figueroa	• We need to stop using pesticides that are banned in Europe and killing our bees. • Stop using genetically engineered food without long term study RE the impact on our health. GE crops and seeds are creating super weeds and changing the bacteria in our stomachs and changing how we digest food. • We want and need labelling of all genetically engineered food and products using GE seeds and crops.
3	APHIS-2013-0043-0004	Arthur Tesla	• Opposed to Monsanto receiving unregulated status for herbicide resistant soybeans and cotton. • Spraying these crops with dangerous herbicides makes these crops plant pests!.
4	APHIS-2013-0043-0006	Caitlyn Batche	• Opposed to Monsanto receiving unregulated status for herbicide resistant soybeans and cotton. • Monsanto's "Roundup Ready" crops require about 4 times more water, and the application of several pesticides. Clean water is a diminishing resource because of exploitation and pollution. In Environmental Protection Agency's Numeric Nutrient Criteria, pesticides were a major problem in water systems. • GMO products should be labelled.
5	APHIS-2013-0043-0005	Philip Nelson, Illinois Farm Bureau (IFB)	• These traits have already gone through USDA's rigorous regulatory review protocol and there have been no scientific, findings to warrant additional EIS. On behalf of nearly 83,000 Illinois farmers, I write today to request-that, APHIS move expeditiously when completing this seemingly superfluous regulatory review.
			• Biotechnology has produced vast improvements in farm production practices, permitting farmers to do more with less. Herbicide-tolerant seeds are simply another tool for our producers to utilize towards helping feed the world's ever increasing population. These technologies will have a positive impact on farming and the food that we produce.
6	APHIS-2013-0043-0008	U.S. Department of Interior, National Park Service – Elaine Leslie	• The National Park Service supports the objective identified or development of science that addresses the Environmental Issues for Consideration identified on pages 28799 [of the Federal Register notice]. The NPS is

Comment #	Comment ID	Commenter	Comment Excerpt
			concerned about the indirect effects on the soil and water quality in NPS areas as a result of increased herbicide use. We believe the indirect effects on soil and water quality as a result of increased herbicide use of the products proposed to be de-regulated, be evaluated.
7	APHIS-2013-0043-0009	Jean Public	• Opposed to Monsanto receiving unregulated status for herbicide resistant soybeans and cotton. • I do not believe the tests on these products are adequate. This is new stuff. It has not had rigorous long term testing.
8	APHIS-2013-0043-0010	None None	• No content
9	APHIS-2013-0043-0011	Sergio Benitez	• Wants labeling of GMOs
10	APHIS-2013-0043-0012	Kelli Lord	• Opposed to Monsanto receiving unregulated status for herbicide resistant soybeans and cotton.
11	APHIS-2013-0043-0013	Omar Flores	• Two documents, one in English and the other in Spanish (by European Union and Greenpeace Mexico), show the negative health, economical and ecological consequences of having allowed Monsanto's GMO soybean RoundUp(tm) resistant in the Yucatan Peninsula and in Argentina. • An economical study by the Autonomous University of Yucatan shows that the economical costs of using GMO soybean, not even counting the environmental costs is 55 higher than the total benefit.
12	APHIS-2013-0043-0016	Carl Bausch	• Opposed to preparation on an EIS. • The statement of purpose and need is missing from the notices. To what need and for what purposes are *petitioners* responding in developing and commercializing their products? The answer to this question largely determines the range of reasonable alternatives the agency must consider in the NEPA process. • Granting (with or without conditions) or denying petitions does not constitute “alternatives” to be considered in NEPA’s environmental impact statement process; rather, they are decision options for the agency (see my earlier comment for explanation). Alternatives that must be considered under NEPA relate directly to the purposes of and need for proposed actions. • APHIS NEPA documents are not written in plain language, as required by the NEPA implementing procedures (40 C.F.R. § 1502.8). • Monitoring, which is an essential component of the NEPA process (40 C.F.R. § 1505.3), should be employed in biotechnology permitting to confirm assumptions made in NEPA documents and respond to many

Comment #	Comment ID	Commenter	Comment Excerpt
			unanswered, but oft-repeated questions. • APHIS has often claimed that, although individual farmers may be affected by releasing genetically engineered organisms in the area, when examined in total, none of the potential business losses is expected to be so severe as to amount to a significant impact. This determination fails to recognize that environmental "significance" exists at all levels—"society as a whole (human, national), the affected region, the affected interests, and the locality." 40 C.F.R. § 1508.27(a). • APHIS tends to rely on the United States Environmental Protection Agency's (EPA) consideration of environmental effects in the context of the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) registration process, as well as FDA's determinations under its enabling legislation. The regulatory and review processes of EPA and FDA cannot be relied upon to relieve APHIS from considering in the context of the National Environmental Policy Act (NEPA) process any and all effects associated with release into the environmental of petitioners' products. • In the past, APHIS appears to have placed a great deal of reliance on petitioners in complying with NEPA. Agencies have a responsibility under NEPA to independently investigate and assess the environmental impacts of proposals under consideration (40 C.F.R. § 1506.5(a) and (b)). • There is considerable uncertainty regarding potential environmental effects of releasing genetically engineered organisms. Although an agency is not precluded from approving a particular proposal involving substantial uncertainty, it must disclose all areas of uncertainty. *Save Our Ecosystems v. Clark*, 747 F.2d 1240, 1246 (9th Cir. 1984). • The taxpayer and the agricultural biotechnology industry would be better served if APHIS announced it would no longer "regulate" agricultural biotechnology because there has not been a proven plant-pest risk associated with the technology in decades, perhaps ever.
13	APHIS-2013-0043-0014	Sally Smith-Weymouth	• Opposed to Monsanto receiving unregulated status for herbicide resistant soybeans and cotton. • Please do not grant Monsanto's request for nonregulated status of herbicide resistant soybeans and cotton. Such herbicides are already wreaking havoc all over the world causing crop failures and super weeds, soil depletion, and a plethora of ailments afflicting humans the world over. • Wants labeling of GMOs
14	APHIS-2013-0043-0015	Sarah Stolar	• The raise in acceptable levels of glyphosphate on our foods are ridiculous and criminal. Round up is toxic to the environment, soil organisms, and

Comment #	Comment ID	Commenter	Comment Excerpt
			people.
15	APHIS-2013-0043-0017	Jessica Padgett	• Opposed to Monsanto receiving unregulated status for herbicide resistant soybeans and cotton. • One theory for the cause of the decrease in the bee population is because of the bacterial toxin, Bacill Thuringiensis (Bt), which was created by Monsanto for the GM corn seeds. According to the Health Wyze Report, "Bbacterial toxin Bacill Thuringiensis is known to provoke an immune response in humans and bees. An immune response in a bee prevents proper memory formation, and causes confusion. One of the symptoms of Colony Collapse Disorder is bees' decreased navigational ability [1]." The bees are unable to go back to their hives and end up dying. • According to the American Academy of Environmental Medicine (AAEM), "Several animal studies indicate serious health risks associated with GM food, including infertility, immune problems, accelerated aging, faulty insulin regulation, and changes in major organs and the gastrointestinal system [2]." • According to the Institute for Responsible Technology, "the only published human feeding experiment revealed that the genetic material inserted into GM soy transfers into bacteria living inside our intestines and continues to function. This means that long after we stop eating GM foods, we may still have their GM proteins produced continuously inside us [5]."
16	APHIS-2013-0043-0018	Gregg Langer	• This technology will be very valuable to our growers as a herbicide option of choice. It will broaden and increase our control options while limiting impact on environment. It will be an essential technology to prevent and control resistance in weed control.
17	APHIS-2013-0043-0019	Reid J. Smeda, Professor of Weed Science, University of Missouri	• Development of dicamba-tolerant soybean represents a novel solution to the postemergence control of glyphosate-resistant weeds. I would urge you to not limit a potentially significant management tool (dicamba) because of fears that past mistakes will be repeated. The path forward should be an integrated approach to weed management in soybean. • I believe that adoption of dicamba-tolerant soybean technology will be different than adoptive practices of glyphosate-resistant soybean, and the potential for selection for dicamba-resistant weeds will be lower than for glyphosate. Below are my reasons to support the previous statement: 1) In-crop, growers know that weed size is important for using dicamba. I believe this same mentality can be transferred to postemergence use of dicamba on tolerant soybean.

Comment #	Comment ID	Commenter	Comment Excerpt
			2) I believe that the current mind-set of soybean growers, especially in Missouri, is to apply labeled rates of residual herbicides in soybean, and clean up escape weeds with a timely postemergence herbicide. This is the pattern that was practiced before glyphosate-resistant soybeans were introduced, and I believe sets the stage for proper use of the dicamba-tolerant technology. 3) Current options for postemergence control of glyphosate-resistant weeds in soybean are limited. We have observed a dramatic increase in the use of PPO herbicides (lactofen, fomesafen, etc.). However, prior to the introduction of glyphosate-resistant soybean, a number of biotypes of waterhemp were found resistant to lactofen and fomesafen. Re-release of Liberty Link® soybean has resulted in effective control of glyphosate-resistant weeds in soybean. However, growers have few other options and my fear is that glufosinate-resistant weeds in soybean will occur. Now is the time to adopt the use of dicamba-tolerant soybean to preclude selection for weed resistance to glufosinate. 4) Dicamba use will be limited in amount (total applied per cropping year) and to specific weed sizes, which should reduce selection pressure for resistance. 5) I believe increased grower knowledge about Amaranthus species will improve decision-making with dicamba-tolerant soybean, which will lower the risk for selection of resistant Amaranthus species. 6) In my field trials, we have shown over time that dicamba can provide from 3-7 days of residual weed control. This can provide some short-term benefit to growers, but is not a substitute for adoption of preemergence herbicides. Therefore, dicamba is not a stand alone product. 7) Although reduction of production costs remains important, the higher commodity price for soybean has resulted in openness of the grower to adopt use of residual herbicides to protect soybean yield. Use of residual herbicides will be important for protecting the integrity of the dicamba-tolerant crop technology. 8) ….herbicide use cannot be reversed or abandoned for the majority of our soybean acres. Continued education on proper herbicide use is, in my opinion, the only path forward. Dicamba-tolerant soybeans provide crop producers with a highly effective tool, and integration of dicamba should be in the context of proper use of residual herbicides.
18	APHIS-2013-0043-0020	J. Christopher Hall, Professor, University of Guelp	Emphasize the following points in regards to de-regulation of dicamba-tolerant crops; specifically in terms of evolution of resistance to auxinic herbicides (e.g., dicamba and others) in weed species: • …the risk of evolution of week resistance to herbicides can be

Comment #	Comment ID	Commenter	Comment Excerpt
		Mithila Jugulam, Assistant Professor, Kansas State University	significantly mitigated through implementation of diversified weed management programs by farmers, that include: use of multiple herbicides with overlapping activity on target weeds and/or the inclusion of mechanical and/or cultural weed control practices. • Compared with other herbicides families, the incidence of resistance to auxinic herbicides is relatively low… • Information about fitness cost associated with auxin herbicides has been documented in a few species indicating that resistant plants are less fit in the absence of herbicide application. This could be a major reason for the limited occurrence of auxinic herbicide-resistant weeds. Additionally, this could explain why farmers continue to use and derive benefits from these products after resistant populations have been identified. • The recessive trait spreads much slower in a population than a dominant trait. Since the resistance to auxinic herbicides in some weeds is determined by recessive genes…, this may be one of the reasons for low occurrence of auxinic herbicide resistant weeds. • In many cases the use and, thus, selection pressure of these auxinic herbicides has exceeded that of other herbicides groups to which resistance is more common. • Definitive mechanisms of resistance to auxinic herbicides have yet to be defined….This suggests a relatively low probability for cross resistance to other herbicide groups and classes that could occur because of common metabolic resistance pathways. • The low probability in combination with stringent implementation with integrated weed management practices should reduce risks of evolution of resistance to there herbicides. Overall, the key is, educating the farmer of the negative consequences of continuous use of herbicides with the same mode of action and the positive consequences of implementing efficient weed-management practices such as herbicide rotations, use of multiple herbicides in mixtures and sequences, inclusion of tillage where necessary and other non-chemical-based weed management practices, which will help reduce the chances of evolution of herbicide-resistant weed populations. See attached review article: Mithila, J., J.C. Hall, W.G. Johnson, K.B. Kelley, and D.E. Riechers. 2011. Evolution of resistance to auxinic herbicides: Historical perspectives,

Comment #	Comment ID	Commenter	Comment Excerpt
			mechanisms of resistance, and implications for broadleaf weed management in agronomic crops. Weed Sci. 59: 445-457.
19	APHIS-2013-0043-0020	Fred Yoder, grower, Ohio Corn and Wheat Growers Association, and former president of the National Corn Growers Association	• Farmers should have the choice to use safe and valuable new agricultural technologies to help manage weeds, using multiple modes of action. • It is important to ensure the USDA regulatory review of new biotech traits does not fall further behind those of other major crop producing countries such as Brazil or Argentina, who are rapidly gaining a larger share of the global market. • Farmers have many years of experience using products like dicamba, and are very capable of preventing off-site movement through proper stewardship including application techniques, equipment settings, nozzle selection, and consideration of environmental conditions during application, such as wind speed.
20	APHIS-2013-0043-0032	Charles Hall, North Carolina Soybean Producers Association	• I support the full deregulation of event MON 87708 - dicamba-tolerant soybeans- so that soybean farmers will have full access to this technology which, combined with other currently available technologies, will expand options for weed management practices on the farm. Timely access to a safe, sustainable new technology will increase farmer options for cost-effective weed management. The beneficiaries will be the downstream users of soybean products, including human and livestock nutrition products. As demand increases worldwide for human and livestock nutrition, effective weed management will be vital to sustaining the soybean yield increases that will be demanded of U.S. soybean farmers. • The dicamba- tolerant soybeans and the same tolerance being developed in cotton expands the dicamba weed control window from the current preplant burndown use to allow in-crop applications of dicamba herbicide for the control of broadleaf weeds pre-emergence and post-emergence. When combined with Roundup Ready, it will allow a new mode of action for improved weed control and weed resistance management. Use of dicamba at planting in this system eliminates having to wait the three weeks required in non-dicamba tolerant crops. This translates into a three week gain on weed control. Additionally, dicamba provides potential residual benefit, depending on soil type and rainfall. • The dicamba product has a decades-long record of safety and effectiveness, and is highly effective at combating the major weed pests of soybeans. North Carolina soybean farmers have the knowledge and training to incorporate

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			dicamba-tolerant soybeans into on-farm stewardship practices. • I oppose USDA's proposal to conduct an Environmental Impact Statement (EIS), which is not necessary and would only serve to delay farmers' access and ability to use this new tool.
21	APHIS-2013-0043-0023	Steve Austin	• Wishes to join the concerns expressed by the Save Our Crops Coalition in its comment to this docket. • Non-target plant damage associated with herbicide spray drift and volatilization is a major concern for specialty crop growers and processors. Credible estimates project significant increases in the amount of dicamba that will be applied upon the introduction of dicamba tolerant crops. Dicamba, because of its potential to drift and volatilize, has proven to be one of America's most dangerous herbicides for non-target plant damage. • We do not oppose advances in plant technology, however, we will not accept a range of alternatives that includes only wholesale deregulation or wholesale prohibition of these crops. We request that USDA expand the scope of its inquiry to consider uses of its authority to address a range of issues our membership faces. • We request that USDA strictly analyze changes to agronomic practices, including herbicide use, that will result from deregulation of these crops, and consider where USDA and EPA may be able to jointly develop effective measures to protect against the threat of non-target plant damage these crops pose.
22	APHIS-2013-0043-0024	Victor Miller	• Herbicide use, possible selection for and the spread of weeds resistant to the herbicide and drift from applications of dicamba onto dicamba intolerant crops and other areas, seems to be the responsibility of EPA not USDA. All of these questions are under review at EPA, which is responsible for issues related to herbicides and their use. • This is a safe, widely used herbicide. Over the past 10 years it has been used very successfully on over 250 million acres, including corn, wheat, pasture and range land, as well as other crop land. • The equipment, the knowledge, and the desire to use the products in a responsible manner by the Agricultural Community already exists! • Glyphosate tolerant weeds are becoming a problem and we as producers need more modes of action to limit this problem. Dicamba is one of those additional modes of action and it becomes criminal to deny that tool to us as we then have less produce to serve to a hungry world.
23	APHIS-2013-	Kenneth Martin,	• We are a medium sized food processor and our business was built and

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	0043-0025	Director Ag Operations, Furmano Foods, Inc.	continues on specialty crops who are highly suspectable to Dicamba drift. Non-target plant damage associated with herbicide spray drift and volatilization is a major concern for specialty crop growers and processors like us. Credible estimates project significant increases in the amount of dicamba that will be applied upon the introduction of dicamba tolerant crops. Dicamba, because of its potential to drift and volatilize, has proven to be one of America's most dangerous herbicides for non-target plant damage. Because of these drift issues a large portion of row crop growers have discontinued the use of this product. • I do not oppose advances in plant technology, however, the answer is not in accepting a range of alternatives that includes only wholesale deregulation or wholesale prohibition of these crops. I think that USDA should expand the scope of its inquiry to consider uses of its authority to help look for better ways to combat the resistant weed issue from the over use of certain chemicals. • Approving Dicamba tolerant crops seems very short sighted given the potential of drift damage that we know has happened in the past. There has to be better alternatives to work at this problem, lets find them.
24	APHIS-2013-0043-0026	Mark Jackson, president Iowa Soybean Association	• I write to reaffirm our strong support for full deregulation of dicamba-tolerant soybeans and cotton. Full deregulation of dicamba-tolerant soybeans will help Iowa growers increase yields in an environmentally-friendly manner and is consistent with the ISA's mission. • ISA understands USDA APHIS' reasons for conducting an Environmental Impact Statement (EIS) on dicamba-tolerant technologies, and how they appear to relate to potential impacts associated with herbicide use and resistance. However, matters relating to herbicide use are regulated under the authority of the Environmental Protection Agency (EPA). • growers need access to weed management technologies with proven efficacy over a broad spectrum of weeds - like dicamba tolerant soybeans (MON87708) and dicamba tolerant cotton (MON88701). As herbicide resistance becomes more prevalent, the arsenal of tools at our disposal to effectively control and manage resistance is limited. Weed scientists tell us that the best way to address herbicide resistance is to implement diversity in weed management practices, including the use of multiple herbicide modes of action. The dicamba-tolerant system will provide an additional mode of action, while expanding the dicamba weed control window, eliminating planting restrictions and permitting in-crop applications. • Access to a broad range of technologies will help us maintain healthy yields and ensure a stable supply of quality soybeans to the food and

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			feed processing industries. USDA's decision on dicamba-tolerant technologies will have broad implications for the entire soybean value chain in the U.S. and globally. • we believe that dicamba-tolerant technologies will enable growers to continue to be good stewards of the land. Compared to some weed control programs, this system may result in fewer herbicide applications. Glyphosate-tolerant crops enabled widespread adoption of conservation tillage practices. This has been a tremendous advance in sustainable farming practices thanks to the preservation of the topsoil, reduced fuel emissions and better water conservation. The use of dicamba as part of the Roundup Ready Xtend Crop system will help us preserve the value of existing pre- and post-emergent herbicides, which continue to bring significant value. • With regard to concerns about dicamba off-site movement, growers have experience with various cropping systems and are experienced and capable of applying dicamba in a manner that will minimize drift. With the use of an appropriate formulation, following label directions, training and communicating with neighbors, we are confident these concerns will be addressed. Newer dicamba formulations, along with best management practices make it possible for all types of growers to co-exist and prosper.
25	APHIS-2013-0043-0027	Wayne Keeling, Professor, Texas A&M University Darrin Dodds, Associate Extension Professor, Mississippi State University Dr. Stanley Culpepper, Professor, University of Georgia	• We believe that the ability to selectively use dicamba in cotton will provide a much needed tool for management of broadleaf weeds and in particular *Amaranthus spp.*, currently the most troublesome weed species in cotton. In particular additional postemergence options in cotton are needed for control of broadleaf weeds and dicamba will be such an option. However with the launch of any new herbicide in a cropping system we must understand how to use it in a sustainable way so to minimize the risk of resistance. • It is widely recognized that the way to mitigate resistance to herbicides is to use herbicides in diversified weed management systems. The WSSA has define this as using more than one herbicide mode of action that is effective on the targeted specie(s) in mixtures, sequences or in rotation and/or using herbicides in combination mechanical and/or cultural practices. Weed management is ultimately the responsibility of farmers and requires that the weed science community, including industry, academics, crop commodity groups and others reach out to farmers and communicate information on practices to best manage resistance as well as the benefits of implementing these practices. By so doing resistance to our

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			existing herbicide resources, as well as new options such as dicamba, will be minimized. • We believe that farmers will integrate dicamba into diversified management programs because they will see better overall weed control. • The risk of resistance for an herbicide is a function of the probability for resistance based upon genetic and biological factors and the probability that farmers will implement recommended best management practices. In the case of dicamba's use in dicamba and glufosinate tolerant cotton we believe that the risk of evolution of resistance is relatively low. If one balances risk of resistance with benefits of use, the benefits greatly outweigh the risk in this case.
26	APHIS-2013-0043-0028	Dale Moore Executive Director Public Policy, American Farm Bureau Federation	• Farm Bureau respectfully asks APHIS to abide by the Ninth Circuit's interpretation of its legal obligations under the PPA and NEPA and reconsider its decision to prepare EISs for the herbicide tolerant crops identified in the Notices. Farm Bureau asks APHIS to act expeditiously to finalize the deregulation process for these crops in keeping with the Ninth Circuit's recent RRA decision and the APHIS regulations governing deregulation petitions.
27	APHIS-2013-0043-0029	Dennis M. Dixon, Hartung Brothers, Incorporated	• Non-target plant damage associated with herbicide spray drift and volatilization is a major concern for specialty crop growers and processors. Credible estimates project significant increases in the amount of dicamba that will be applied upon the introduction of dicamba tolerant crops. Dicamba, because of its potential to drift and volatilize, has proven to be one of America's most dangerous herbicides for non-target plant damage. • We do not oppose advances in plant technology, however, we will not accept a range of alternatives that includes only wholesale deregulation or wholesale prohibition of these crops. We request that USDA expand the scope of its inquiry to consider uses of its authority to address a range of issues our membership faces. • We request that USDA strictly analyze changes to agronomic practices, including herbicide use, that will result from deregulation of these crops, and consider where USDA and EPA may be able to jointly develop effective measures to protect against the threat of non-target plant damage these crops pose.
28	APHIS-2013-0043-0030	Kimberly Iott, Iott Ranch & Orchard	• Iott Ranch & Orchard, Inc wishes to join the concerns expressed by the Save Our Crops Coalition in its comment to this docket. • Non-target plant damage associated with herbicide spray drift and volatilization is a major concern for specialty crop growers and processors.

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			Credible estimates project significant increases in the amount of dicamba that will be applied upon the introduction of dicamba tolerant crops. Dicamba, because of its potential to drift and volatilize, has proven to be one of America's most dangerous herbicides for non-target plant damage. • We do not oppose advances in plant technology, however, we will not accept a range of alternatives that includes only wholesale deregulation or wholesale prohibition of these crops. We request that USDA expand the scope of its inquiry to consider uses of its authority to address a range of issues our membership faces. • We request that USDA strictly analyze changes to agronomic practices, including herbicide use, that will result from deregulation of these crops, and consider where USDA and EPA may be able to jointly develop effective measures to protect against the threat of non-target plant damage these crops pose.
29	APHIS-2013-0043-0031	Kevin Wilson	• I'm a tomato grower from Indiana,and also a corn and soybean producer as well. What I am asking for is a reasonable ruling that will let me protect my crop as well as use these products as well. The agreement that was worked between DOW agriscience and the SOCC accomplishes this. Monsanto has chosen to ignore the SOCC's request to work out an agreement similar to DOW. The current label that Monsanto is trying to get approval does not address several issues that I feel have potential events that can cause losses of my crops.
30	APHIS-2013-0043-0032	Thomas Parker, H & T Parker Farms	• H & T Parker Farms wishes to join the concerns expressed by the Save Our Crops Coalition in its comment to this docket. • Non-target plant damage associated with herbicide spray drift and volatilization is a major concern for specialty crop growers and processors. Credible estimates project significant increases in the amount of dicamba that will be applied upon the introduction of dicamba tolerant crops. Dicamba, because of its potential to drift and volatilize, has proven to be one of America's most dangerous herbicides for non-target plant damage. • We do not oppose advances in plant technology, however, we will not accept a range of alternatives that includes only wholesale deregulation or wholesale prohibition of these crops. We request that USDA expand the scope of its inquiry to consider uses of its authority to address a range of issues our membership faces. • We request that USDA strictly analyze changes to agronomic practices, including herbicide use, that will result from deregulation of these crops, and consider where USDA and EPA may be able to jointly develop effective measures to protect against the threat of non-target plant

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			damage these crops pose.
31	APHIS-2013-0043-0033	A. Stanley Culpepper - University of Georgia, Weed Scientist, and grower	• Cotton weed management programs in Georgia have undergone, and are continuing to undergo, significant changes. Currently recommended programs are complex, costly, and challenging to implement in a timely fashion. Growers are desperately in need of new technologies to improve control of Palmer amaranth, reduce the potential for further herbicide resistance development to currently used tools, and to reduce the economic burden that Palmer amaranth is placing on the agricultural industry. • We admire and respect the desire of USDA and EPA to be certain that no agriculture technology will negatively impact the consumer, the user, or the environment in which we and our children live. Our request is simple, if deemed safe please assist in the movement of all new technologies to our growers as rapidly as feasible. • Herbicide-resistance has significantly changed agriculture forever in the Southeast; especially for cotton growers. To combat this pest, growers have relied heavily on herbicides, tillage, and hand weeding. Herbicide use in cotton has increased sharply with 2.5-times more herbicide active ingredient applied to cotton following the confirmation of glyphosate resistance in Palmer amaranth as compared to before documented resistance. Although grower herbicide input costs have more than doubled following the evolution and spread of glyphosate resistance, Palmer amaranth control is still not adequate. Thus, 92% of Georgia cotton growers hand-weed 52% of the crop with an average cost of $23 per hand-weeded acre, which is an increase of at least 475% as compared to hand weeding costs prior to resistance. In addition to increased herbicide use and hand weeding, growers in Georgia have indicated that they are using mechanical, in-crop cultivation (44% of acres), tillage for the incorporation of preplant herbicides (20% of the acres), and deep turning (19% of the acres every three years) to aid in Palmer amaranth control. Current weed management systems are extremely diverse, complex, less environmentally friendly, and costly when compared to those systems employed only a decade ago. Growers are in desperate need of new technologies that will aid in the management of glyphosate-resistant Palmer amaranth, and other problematic weeds, for long term sustainability.
31	APHIS-2013-0043-0033	A. Stanley Culpepper - University of Georgia, Weed Scientist, and grower	**Benefits of 2,4-D or Dicamba Technologies For the Georgia Cotton Grower:** ***1.*** ***Improved Weed Control:*** Neither dicamba nor 2,4-D are consistently effective in controlling Palmer amaranth larger than 4 inches when applied alone (Culpepper et al. 2010; Culpepper et al. 2011; Merchant et al. 2011);

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			however, weed management systems including these herbicides are more consistently effective than current standards (Braxton et al. 2010; Beckie 2011; Merchant et al. 2013; Richburg et al. 2012; Shaw and Arnold 2012). Weed management programs including 2,4-D or dicamba would improve a grower's ability to manage this problematic weed in the following ways: 1) improved consistency in weed control especially on dryland production acres where residual herbicides often are not activated with rainfall at planting time, 2) more flexibility with herbicide application timings because glufosinate plus dicamba or 2,4-D will consistently control Palmer amaranth up to 6 inches in height (at least 2 inches larger than todays standards), 3) less herbicide carryover to subsequent crops because growers would be less dependent on long lasting residual herbicides, and 4) less yield loss from Palmer amaranth crop competition for light, nutrients, and water (Coetzer et al. 2002; Culpepper et al. 2010; Merchant et. al 2013; MacRae et al. 2013). ***2. Prevention of Additional Herbicide Resistance Development:*** USDA has voiced concerns that growers may adopt 2,4-D or dicamba technologies and rely too heavily on these herbicides thereby developing an even greater weed resistance scenario. Science has clearly shown that there is risk of resistance development to all herbicides; dicamba and 2,4-D are no exception. In fact, weeds have developed resistance to nearly all forms of weed management including herbicides, tillage, mowing and even hand weeding. Our data and surveys contrast the assumption that rapid development of resistance to 2,4-D or dicamba would occur in Georgia cotton. First, our data notes that since these auxin herbicides control only very small Palmer amaranth then they must be applied in tank mixtures with other herbicides such as glufosinate. Second, even mixtures of glufosinate plus 2,4-D or dicamba will only control Palmer amaranth less than six inches in height and since Palmer amaranth can grow as much as two inches per day selective residual herbicides must be used throughout the season. Simply put, data throughout the belt supports the fact that over-use and/or over-dependence of 2,4-D or dicamba in cotton would equal poor weed control and eventual crop failure which is a practice no grower would follow. Dicamba and 2,4-D would be an additional tool to include in the weed management program. The greatest risk for developing herbicide resistance is actually occurring at this moment with the PPO herbicides and glufosinate. These products are being over used as growers have no other effective herbicidal options. New technologies such as dicamba or 2,4-D could be used to delay resistance

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			development to the PPO herbicides and glufosinate and, in turn, systems could be developed using the PPO herbicides, glufosinate, 2,4-D, and dicamba extending the life of each of these chemistries. It is also critical to stress that, at least in Georgia, no weed management program relies exclusively on herbicides. The University of Georgia Weed Science Extension Team stresses to growers at more than 50 meetings each year that herbicides are only one part of the weed management program. Sustainability is only possible with the adoption and implementation of diverse management programs and Georgia growers have accepted this message as fact (Sosnoskie and Culpepper 2013). Growers are using programs that are complex and diverse integrating herbicides, hand weeding, and tillage or cover crops. Neither dicamba nor 2,4-D would change this approach but would simply be an additional tool to add into these management systems. ***3. Reduction in Herbicide Use:*** Glyphosate-resistant Palmer amaranth has increased herbicide pounds of active ingredient applied in Georgia cotton by a factor of 2.5 when compared to herbicide use prior to resistance (Sonoskie and Culpepper 2013). Programs developed by the University of Georgia for 2,4-D or dicamba technologies suggest the pounds of herbicide active ingredient may be able to be reduced by at least 30% while actually providing better weed control; similar results are also noted in other areas across the cotton belt (Edwards et al. 2013; Merchant et al. 2013; Smith and Hagood 2013; Steckel et al. 2013). ***4. Reduction in Tillage, Wind Erosion, and Soil Erosion:*** As the spread of glyphosate-resistant Palmer amaranth occurred, the adoption of tillage including deep turning of the land with moldboard plows has become common (Sosnoskie and Culpepper 2013). The return of conventional tillage has led to increased wind and water erosion. Neither 2,4-D nor dicamba technologies would eliminate tillage, but they would greatly reduce the need for deep tillage allowing many growers to return to more reduced tillage production systems. This opportunity to return to reduced tillage systems would be in response to a more consistently effective management program.
31	APHIS-2013-0043-0033	A. Stanley Culpepper - University of Georgia, Weed Scientist, and grower	**Concerns With 2,4-D- or Dicamba-Resistant Technologies:** *1. **Off-Target Movement:*** Off target movement of 2,4-D and dicamba pose the greatest limitation to the adoption of either auxin technology. Although it is currently unknown what restrictions will be in place to minimize off-target movement by herbicide labels, an enormous amount of research by the registrants

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			and other scientists across the world is being conducted to develop methods to minimize the potential for off-target movement. These efforts include 1) improving herbicide formulations, thereby reducing volatility and/or drift, 2) improving application equipment techniques and application methods, thereby reducing drift, and 3) developing educational materials to assist growers in reducing off target movement when making pesticide applications (Bagley 2013, Huff et al. 2013; Kendig et al. 2013; Magidow et al. 2013; Newsom et al. 2013; Reynolds et al. 2013, Sandbrink et al. 2013). Benefits from these efforts will be monumental in minimizing off-target movement of ALL pesticides, not just 2,4-D and dicamba, and will greatly improve the ability of a grower to apply pesticides that stay in the targeted area. In Georgia, the University of Georgia and the Georgia Department of Agriculture are currently developing additional methods to further minimize off-target movement of auxin herbicides and other pesticides. Also, a cooperative effort between The University of Georgia, Georgia Department of Ag, Agronomic Industry leaders, and Horticultural Industry leaders is underway to further define methods to minimize off-target movement.
32	APHIS-2013-0043-0034	Richard Minor, Past President and current Board Member of The Georgia Fruit and Vegetable Growers Association.	• I support full and timely deregulation of dicamba- and glufosinate- tolerant cotton and dicamba tolerant soybeans, an essential weed management tool that is badly needed by growers. Over the past several years, the pressure from glyphosate resistant weeds has become stronger and harder to manage, despite diligent stewardship. Our growers need multiple-mode-of-action options at their disposal to manage and prevent weed resistance. Farmers in this part of the country have no choice but to manage multiple chemistries to fight and control weeds. The dicamba tolerant traits will provide farmers with a cotton and soybean product that have increased yield opportunity and tolerance to multiple herbicides with different modes of action for weed control making dicamba tolerant cotton and soybeans an important weed management tool. • I believe Monsanto has convinced a majority of these growers that proper training and support will be available to combat any problems which might have concerned our growers concerning off target applications. In addition, Monsanto has demonstrated new spray technology which has further convinced our specialty crop growers that we will be able to adapt these new technologies. We recognize the complexity that can exist from off-site movement of certain herbicides and impact on vegetable crops. We would point out, however, that through proper application requirements and stewardship, much of the off-site movement and, thus, potential damage may be managed and allow fruit and vegetable crops to be grown in proximity to

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			traditional row crops. This crop diversity is well know to Georgia growers and on behalf of my members, wanted to express our organization's view that dicamba applications can and have successfully been made, provided care is taken in the type of equipment that is used, applications are not made in strong winds toward a sensitive crop and tank clean out is properly addressed. • Dicamba has been a safe and reliable resource in modern agriculture, used by growers in over 25 countries including the USA and Canada. In the U.S., dicamba has been used on more than 237 million acres over the past 10 years. Growers have experience and a long track record of using dicamba according to label specifications. • Dicamba has the potential to protect and may also increase the current acres under conservation tillage. Once approved, dicamba tolerance will allow growers to use dicamba in burn down without plant-back restrictions while providing effective control of hard to control and glyphosate resistant weeds including pigweed and marestail. More complete burn down has the ability to further enhance conservation tillage. • This system may lead to fewer herbicide applications, which may result is better soil and water conservation and a reduction in greenhouse gas emissions because of fewer trips across the field. Maintaining reduced tillage practices will enable our growers to preserve the value of their land. • In addition to helping growers maintain productivity thanks to improved weed management, dicamba tolerant traits will offer efficiencies and convenience to growers and improve their quality of life.
33	APHIS-2013-0043-0035	Mike Schulte	• As a vegetable farmer, I am quite concerned about the drift possibility of dicamba. Please reconsider the regulations on these types of chemicals as they could well cause hundreds of thousands of dollars of damage to a vegetable crop.
34	APHIS-2013-0043-0036	Scott Bretthauer, Extension Specialist in Pesticide Application Technology, University of Illinois	• I have conducted research investigating the use of drift reduction technologies for making applications of glyphosate and dicamba. These technologies have included drift reduction nozzles, drift reduction adjuvants, and combinations of the two. The results of this research, and research I've seen conducted by colleagues, indicates that applications of dicamba can be made both effectively and safely. • Applications of dicamba can be made safely by understanding two key components of drift reduction: droplet size and weather. • I believe the major drift risk for dicamba applications is particle drift, not vapor drift. This is positive because it means that application technology and understanding weather impacts can be used to reduce the

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			risk of drift…. research on the new formulation of dicamba, which shows volatility is virtually a non-issue…many off-target incidents blamed on volatility and vapor drift were in fact caused by particle drift of very small spray droplets that moved off target during an inversion….I have seen many reports from insurance companies, and in many cases the cause of drift was because applications were made during an inversion. Symptoms can be similar to vapor drift because the exposure is very minimal, damage will not show up for sometime after the application, and the pattern does not look like normal particle drift. • The label for a Monsanto registered pre-mix of glyphosate and dicamba has specific requirements that extend beyond current requirements for dicamba applications and will help ensure the risk of particle drift is minimized. Proper selection of nozzles and adjuvants has shown that the driftable fraction of the spray volume can be reduced to less than 1 percent in many cases, and one combination of nozzle and adjuvant completely eliminated all droplets of the size considered to be at risk of drift. • I believe that applicators can safely and effectively apply dicamba through the use of a combination of drift reduction technologies, including nozzles and adjuvants, operating those correctly through the use of other technologies such as pulse width modulation and auto boom height controllers, and making applications in suitable weather conditions with appropriate downwind buffers zones. • it is important to consider successful applications are both possible and being made today. U.S. farmers need access to new technologies to help control weeds and provide options in their operations. Spray applications can and will be managed to maximize both efficacy and safety.
35	APHIS-2013-0043-0037	Jerry Bambauer, Ohio Soybean Association	• OSA urges USDA to reconsider the need for the EIS since USDA's basis for conducting the EIS all relate to herbicide uses. The dicamba uses in question are currently being reviewed by the EPA, and as such EPA will review and mandate the conditions in which it may be used. Conducting a time-consuming analysis already within the responsibilities of other federal agencies will cause a significant delay in bringing needed technologies to growers. • Soybean farmers need new technologies such as dicamba-tolerant soybeans to increase yields, manage weed resistance and keep their farming operations profitable. • Soybean farmers need new technologies such as dicamba-tolerant soybeans to increase yields, manage weed resistance and keep their farming operations profitable. In light of the recent ruling by the Ninth Circuit Court

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			of Appeals on the Roundup Ready alfalfa case -- which confirmed that issues relating to the use of herbicides are the responsibility of the Environmental Protection Agency (EPA), not USDA – OSA urges USDA to reconsider the need for the EIS since USDA's basis for conducting the EIS all relate to herbicide uses. The dicamba uses in question are currently being reviewed by the EPA, and as such EPA will review and mandate the conditions in which it may be used. Conducting a time-consuming analysis already within the responsibilities of other federal agencies will cause a significant delay in bringing needed technologies to growers. • U.S. growers should have the choice to use safe and valuable new agricultural technologies to increase yields and keep their farms profitable. Farmers today need multiple mode-of-action weed management tools. Dicamba tolerance would be a valuable addition to the existing soybean weed control options to maximize yield potential. Dicamba has been used in crops for many decades in the U.S. and continues to be effective on major broad leaf weeds. Farmers have proven they are able to use different application techniques and equipment for different types of pesticides to ensure proper performance of the product as well as on-target application. OSA understands that newer dicamba formulations have been developed to substantially reduce volatility compared to first-generation dicamba products. The petitioner has also addressed the potential for off-site movement by prohibiting aerial applications and implementing specific environmental and equipment application requirements on the dicamba label, including a wind-directional buffer when sensitive areas are present, and use of low volatility dicamba formulations. • The U.S. soybean processing and feed industries, along with the growing U.S. soybean export markets, are very healthy segments of our economy. The availability of these new effective soybean production tools is vital to maintaining that health. Weed resistance pressures underscore the need for timely regulatory approval of multiple mode-of-action technologies that can help manage resistant weeds and keep U.S. agriculture productive, sustainable and globally competitive. It is important that USDA follow through on its commitment to U.S. farmers by expediting the science-based regulatory review process and put a stop analyses that are duplicative and outside the scope of its authority.
36	APHIS-2013-0043-0038	Bill Wykes, Chair, Illinois Soybean Association	• ISA requests USDA to not conduct an EIS on dicamba tolerant soybean and cotton and move quickly to approve these new weed fighting tools so our farmers may have access to them and incorporate them as they see a fit in

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			their operations and remain able to control weeds for the future. • The proposed EIS is seen as an inherent conflict. Given that the proposed subject of the EIS is to assess impacts on weed resistance and off-site movement of dicamba which can be attributed to the herbicide application, the subject of the EIS would appear to fall under the EPA jurisdiction and not that of USDA. • We urge the USDA to move quickly to approve new weed management tools, such as dicamba tolerant soybeans and dicamba tolerant cotton, referred to as MON87708 and MON88701, respectively. When both the trait and chemistry are used together, farmers will be able to realize several benefits from utilizing the proposed dicamba weed management systems. These benefits include: – Effective and sustainable management of glyphosate-resistant weed species including Palmer amaranth, waterhemp, giant ragweed, and marestail – Provides an additional mode of action and reduces the dependence on ALS and PPO herbicides helping to preserve these herbicide tools – Improved and more consistent control of hard-to-control broadleaf weed species – Crop safety to dicamba and glyphosate herbicides to maximize yield potential – Application flexibility in the event of challenging weather conditions especially in the spring – Proactive program for weed resistance management – Preservation of conservation tillage benefits • U.S. farmers are capable and experienced at making herbicide applications and effectively managing off-site movement. Just as with other herbicides, off-site movement of dicamba can be prevented through proper stewardship including application techniques, equipment settings, nozzle selection, and consideration of environmental conditions during application. Equipment and hand held applications facilitate access to weather data, field plot maps and other on board information. The technology and capability exists and is at work on the farm fields across America today. Additionally, newer dicamba formulations have been developed to substantially reduce volatility compared to first-generation dicamba products to which much of the folklore is attributed.
37	APHIS-2013-0043-0039	Andrew LaVigne - American Seed Trade Association	The Notices of Intent published on May 16 identify two issues that led APHIS to conclude that EISs were required by NEPA – the development of herbicide-resistant weeds (i.e., weed resistance) and increased herbicide use. Both of these issues relate

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			solely to the herbicides, such as 2,4-D and Dicamba, that would be available for use in conjunction with the crops modified to tolerate their application. As such, these issues are subject to the exclusive jurisdiction of the U.S. Environmental Protection Agency ("EPA") under the Federal Insecticide, Fungicide, and Rodenticide Act ("FIFRA") and are decidedly *not* subject to APHIS's jurisdiction under the Plant Protection Act ("PPA").
38	APHIS-2013-0043-0040	Steve Verett, Executive Vice President, Plains Cotton Growers, Inc.	• Urge APHIS to make a recommendation to fully deregulate dicamba-tolerant technologies for cotton and soybeans. • An EIS on dicamba and glufosinate-tolerant cotton is not warranted from a legal standpoint. • The competitiveness of the U.S. cotton industry depends on the ability of growers to access new, cost-effective and sustainable technologies to manage production pressures, such as weed control. Weeds reduce cotton yields by an average of 30 percent. Herbicide resistant weeds are becoming a persistent problem that could affect the productivity of cotton production across the cotton belt. Texas growers currently experience fewer issues with resistant weeds, but they recognize the need to proactively manage weeds with multiple modes-of-action to prevent or delay future resistance issues. The dicamba and glufosinate-tolerant trait will be stacked with the Genuity® Roundup Ready Flex providing farmers with a cotton product that has increased yield opportunity and tolerance to three herbicides with three different modes-of-action for weed control, making dicamba and glufosinate-tolerant cotton an important weed management tool. The impact of dicamba and glufosinate-tolerant cotton is that it will provide growers with two additional herbicide modes-of-action for the control of broadleaf weeds in cotton, including hard-to-control and herbicide-resistant broadleaf weeds. Weed resistance pressures underscore the need for timely regulatory approval of multiple mode of-action technologies that can help manage resistant weeds.
39	APHIS-2013-0043-0041	Josh Carey, Carey Farms	The widespread use of the dicamba chemistry will endanger many non-resistant crops through the volatility of the chemical. Specialty crop growers like myself will have significant crop damage and loss due the use of this chemical.
40	APHIS-2013-0043-0042	Michael Forche, M Forche Farms Inc.	• Michael A. Forche wishes to join the concerns expressed by the Save Our Crops Coalition in its comment to this docket. • Non-target plant damage associated with herbicide spray drift and volatilization is a major concern for specialty crop growers and processors. Credible estimates project significant increases in the amount of dicamba that will be applied upon the introduction of dicamba tolerant crops. Dicamba, because of its potential to drift and volatilize, has proven to be one of America's most dangerous herbicides for non-target plant damage.

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			• We do not oppose advances in plant technology, however, we will not accept a range of alternatives that includes only wholesale deregulation or wholesale prohibition of these crops. We request that USDA expand the scope of its inquiry to consider uses of its authority to address a range of issues our membership faces. • We request that USDA strictly analyze changes to agronomic practices, including herbicide use, that will result from deregulation of these crops, and consider where USDA and EPA may be able to jointly develop effective measures to protect against the threat of non-target plant damage these crops pose.
41	APHIS-2013-0043-0043	Robert Wolf, Wolf Consulting & Research LLC, Retired Professor Emeritus and Extension Specialist in Application Technology in the Biological and Agricultural Engineering Department, Kansas State University	• Particle drift is controllable through equipment selection and conditions of use, such as formulation, spray tips and other technologies, wind speed and direction at application, sprayer speed and boom height. In some of my most recent research, selecting the proper nozzle type alone can be shown to reduce spray drift from 13.5% down to 0.5% and in some cases the inclusion of drift control additives can reduce that drift amount even more. • Newer dicamba formulations have been developed to substantially reduce volatility compared to first-generation dicamba products. The research is supporting this and through further research, education and training this point will be stressed. • Tank contamination will be of concern when switching between tolerant and non-tolerant crops. This will be addressed through proper tank clean out procedures that adequately clean out herbicide residues from the lining of the tank, boom and inner workings of the sprayer, including all hoses and filters, crevices and drain lines. Newer spray systems are being engineered to improve cleanout. • Monsanto has addressed one concern of the potential for offsite movement by prohibiting aerial applications and other concerns by implementing specific environmental and equipment application requirements on the draft dicamba label, including a wind-directional buffer when sensitive areas are present, and the use of low volatility dicamba formulations. • It is my opinion that US farmers and commercial applicators are capable and experienced at preventing off-site movement. Like any other herbicides, off-site movement of dicamba can be prevented through proper stewardship including application techniques, equipment settings, nozzle selection, and consideration of environmental conditions during application. • Equipment and hand held tools such as smart phone apps that support applications to facilitate access to weather data, field plot maps, nozzle details, and other on board information now exists. This technology and capability is at

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			work on the farm fields across America today. • When recommended label practices are followed, growers of various crops can co-exist and prosper. I believe that in combination with approved best management practices, including the use of the proper nozzle type(s), applications using dicamba will have potential to reduce the amount of off-target drift.
42	APHIS-2013-0043-0044	Bruce Rohwer, President, Iowa Corn Growers Association	• New technologies are needed to ensure agricultural productivity meets growing demand for food. We believe US farmers should have the choice to use safe and valuable agricultural technologies, such as herbicide tolerant soybeans, to help manage weeds. With the growing glyphosate resistance threat to soil conservation and the limited postemergence options for control of Palmer pigweed, waterhemp, and marestail, farmers need new technology solutions. Without effective weed management practices, herbicide resistance can decrease farm productivity and increase the complexity of crop production. Tillage may increase in order to control weeds, which increases the risk of erosion. • Farmers need new tools to manage weed resistance in order to preserve the value of their land. Dicamba tolerant technology is a sustainable solution that gives farmers additional choice and helps them to be good stewards of the land. Compared to some weed control programs, this system can equate to fewer herbicide applications, resulting in fewer trips across the field, reduced greenhouse gas emissions, reduced soil erosion, reduced soil compaction and enhanced water conservation. • The deregulation of MON 87708 helps sustain the long-term agronomic, environmental, and economic benefits of glyphosate as a weed control tool in soybeans. Growers should be able to access new agricultural technologies to keep agricultural productivity on pace to meet demands for food. In order for farmers to remain competitive, it is critical that the USDA regulatory review of new biotech traits does not fall further behind those of other major crop producing countries such as Brazil or Argentina.
43	APHIS-2013-0043-0045	Steve Smith, Save Our Crops Coalition	• Requests APHIS consider a range of possible alternatives beyond out-right denial or approval of these crops, and requests that APHIS specifically address the problem of non-target drift damage caused by the increased use of dicamba on dicamba tolerant crops. • SOCC requests that APHIS expand the scope of its EIS inquiry to address non-target drift damage impacts cause by the use of dicamba on dicamba tolerant crops, especially in sensitive areas. Dicamba tolerant crops heighten the drift and volatilization concerns associated with dicamba. The introduction of

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			dicamba tolerant crops is anticipated to increase the use of dicamba in cotton-producing regions. These regions also produce substantial acreages of broadleaf crops that are sensitive to dicamba. Thus, any drift or volatilization from dicamba could be expected to have significant impacts on non-target crops grown in proximity. • If APHIS considers spray drift and volatilization impacts but determines on balance that the environmental effect is positive, and therefore does not anticipate adverse effects within its conclusion, this level of consideration is insufficient. If spray drift and volatility impacts are significant effects, the regulations require APHIS consider and explain them within an EIS. Upon consideration of the "context" factor, APHIS would find the proposed action to be "significant" in multiple contexts. Upon consideration of the "intensity" factor, APHIS would find the proposed action to have "severe" impacts. Thus, upon consideration of the "context" and "intensity" factors, APHIS would find the proposed action raises substantial questions about whether it may have a significant effect on the environment. Therefore, APHIS should prepare an EIS addressing dicamba spray drift and volatilization impacts associated with Dicamba Tolerant Soybeans and Cotton. • The use of dicamba has declined precipitously from its peak 1994 level. Monsanto's petitions do not indicate the rate of change in dicamba use from current use levels. This omission was particularly glaring given the intensity of the rate of change. The latest figures place the amount of dicamba applied at about 2.7 million pounds annually. Monsanto's projected use pattern would represent an approximately 925% increase in pounds applied over current levels, an almost 250% increase in the total acreage treated, and a 5660% increase in soybean acreage treated. Such an increase would represent a dramatic shift in the utilization of an herbicide both in terms of total pounds applied and areas in which the herbicide would be used. Even the increase in the use of glyphosate upon the introduction glyphosate tolerant crops, an increase of almost 600% in pounds applied, would be eclipsed by this shift in use. • Dicamba has substantial harmful effects on unmodified broadleaf crops even at very low applications rates, and because dicamba tolerant crops will be grown in such close proximity to unmodified broadleaf crops like soybeans and tomatoes, the potential for non-target plant damage caused by drift and volatilization is great. • We suggest that APHIS and EPA work together to find solutions that protect against non- target drift damage caused by the increased use of dicamba on dicamba tolerant crops. Because SOCC cannot be certain that EPA will

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			adequately evaluate the potential for environmental harms, at this time, SOCC requests that APHIS withhold a grant of the petition until such time as effective measures are in place to protect against non-target plant damage, whether imposed by it, or in conjunction with other agencies.
44	APHIS-2013-0043-0046	Wenonah Hauter – Food & Water Watch	Food & Water Watch urges the USDA to consider the following risks in its upcoming Environmental Impact Statement for dicamba-tolerant soybeans and cotton: • Dicamba-resistant cotton and soybeans will lead to an increase in dicamba use, which will spur the evolution of dicamba resistant weeds and the abandonment of conservation tillage practices; • Higher volumes of dicamba will lead to pollution of surface water, which will impact non-target plants and animals, including endangered species; • The volatility of dicamba will result in more occurrences of pesticide drift into neighboring fields, affecting plant health and the livelihoods of nearby farmers; • Dicamba-tolerant crops will cost farmers more through higher seed prices, the loss of export markets due to contamination of non-genetically engineered (GE) or organic seed and through the presence of dicamba---resistant weeds; and • Dicamba is dangerous to human health and its continued use will endanger agricultural workers and the general public. The USDA's Environmental Impact Statement must include, at a minimum: • An analysis on how dicamba-tolerant soybeans and cotton will facilitate increased use of dicamba, leading to the evolution of dicamba-resistant weeds and the abandonment of conservation tillage practices; • Data on the potential carcinogenicity and long-term risks to human health that dicamba would pose at new application levels and the cumulative effects of its interaction with other herbicides on human health and the environment; • Studies on the effects of increased application of dicamba on surface water quality and impacts on non-target plants and animals, including endangered species; • A detailed evaluation of the volatility of dicamba, including a map of potentially affected specialty crop growing regions that would be in the proximity of dicamba-tolerant cotton and soybean growing areas. The USDA must look at the impacts of pesticide drift onto neighboring conventional specialty crop and organic fields, including its effects on plant health and farmer costs; • Research on how the ingestion of foods manufactured from this crop would affect human health and how the continued use of the herbicide in agriculture could

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			endanger agricultural workers and the public; and • A detailed examination of the cumulative effects of stacking dicamba-tolerant corn with other herbicide tolerances, including the costs of contamination to non-GE farmers and the costs that dicamba and glyphosate resistant weeds would impose on these growers.
45	APHIS-2013-0043-0047	Cory Rosenbaum, Rosenbaum Farms	• Rosenbaum Farms wishes to join the concerns expressed by the Save Our Crops Coalition in its comment to this docket. • Non-target plant damage associated with herbicide and volatilization is a major concern for specialty crop growers and processors. Credible estimates project significant increases in the amount of dicamba that will be applied upon the introduction of dicamba tolerant crops. Dicamba, because of its potential to drift and volatilize, has proven to be one of America's most dangerous herbicides for non-target plant damage • We do not oppose advances in plant technology, however, we will not accept a range of alternatives that includes only wholesale deregulation or wholesale prohibition of these crops. We request the USDA expand the scope of its inquiry to consider uses of its authority to address a range of issues our membership faces. • We request that USDA strictly analyze changes to agronomic practices, including herbicide use, that will result from deregulation of these crops, and consider where USDA and EPA may be able to jointly develop effective measures to protect against the threat of non-target plant damage these crops pose.
46	APHIS-2013-0043-0048	Curt Utterback, Secretary, Utterback Farms, Inc.	Utterback Farms, Inc. wishes to join the concerns expressed by the Save Our Crops Coalition in its comment to this docket. • Non-target plant damage associated with herbicide spray drift and volatilization is a major concern for specialty crop growers and processors. Credible estimates project significant increases in the amount of dicamba that will be applied upon the introduction of dicamba tolerant crops. Dicamba, because of its potential to drift and volatilize, has proven to be one of America’s most dangerous herbicides for non-target plant damage. • We do not oppose advances in plant technology, however, we will not accept a range of alternatives that includes only wholesale deregulation or wholesale prohibition of these crops. We request that USDA expand the scope of its inquiry to consider uses of its authority to address a range of issues our membership faces. • We request that USDA strictly analyze changes to agronomic practices, including herbicide use, that will result from deregulation of these crops, and consider where USDA and EPA may be able to jointly develop effective

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			measures to protect against the threat of non-target plant damage these crops pose.
47	APHIS-2013-0043-0049	E. Keith Menchey, Manager, Science & Environmental Issues, National Cotton Council	• With regard to the proposed EIS on dicamba-tolerant cotton, the NCC believes this activity is not warranted from a legal standpoint and will unnecessarily delay a needed technology for cotton farmers. • The competitiveness of the U.S. cotton industry depends on the ability of growers to access new, cost-effective, and sustainable technologies to manage production pressures such as weed control. • The availability of dicamba- and glufosinate-tolerant cotton will help the sustainability of related industries (including gins, cottonseed processors, livestock operations, food processors, and textile mills) who could potentially face higher input costs if cotton supplies decrease due to weed resistance pressures. The loss of cotton acreage could result in the inability to reach “critical mass” of production to support gins and other related infrastructure. • The use of dicamba- and glufosinate-tolerant cotton provides a new weed control system that should provide for fewer herbicide applications resulting in less trips across the field, reduced greenhouse gas emissions, reduced soil erosion, reduced soil compaction, and enhanced water conservation. In fact, the use of dicamba- and glufosinate-tolerant cotton has the potential to protect and may also increase the current acres under conservation tillage. Once approved, dicamba tolerance will allow growers to use dicamba in burn down without planting restrictions, while providing effective control of herbicide resistant weeds. More complete burn down should further enhance conservation tillage. Most importantly, dicamba and glufosinate tolerance will offer a robust weed management program, incorporating multiple herbicide modes of action, to combat weed resistance. • Cotton farmers are good stewards of the land and have extensive experience in preventing off-site movement. Like any other herbicides, off-site movement of dicamba can be prevented through proper stewardship including application techniques, equipment settings, nozzle selection, and consideration of environmental conditions during application, such as wind speed. Moreover, newer dicamba formulations have been developed to substantially reduce volatility compared to first-generation dicamba products. Today, growers of different crops have access to information, resources, equipment, and best management and application practices necessary to enable responsible usage of dicamba, with benefits to all parties.
48	APHIS-2013-	Adam Hartley, grower	Dicambia has a long history of volitization after it has been sprayed. You can

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	0043-0050		spray this active ingredient on days when the wind is calm and then a few days later it will get up and move onto adjacent crops that are not resistant to it. This will cause a huge liability on row crop producers that have speciality crops raised in the same area. Just this year I have had an issue where the railroad sprayed the track and the product got up and moved onto my soybeans on both sides of the railroad. This was caused by volitization and not drift since it was on both sides of the track. Please consider requiring similar limitations and restrictions on the use of dicamba similar to what Dow Agro Sciences supported with their agreement with the SOCC. Those were reasonable and proper and recognizes the need for weed control alternatives but works to protect sensitive crops.
49	APHIS-2013-0043-0051	Leon Corzine, LPC Farms, former President of Illinois Corn Growers Association and the National Corn Growers Association	• Opposes preparation of an EIS. • Supports full deregulation of dicamba-tolerant soybeans and dicamba- and glufosinate-tolerant cotton. • Technologies like these give farmers choices so we can continue to improve our farms and remain competitive in the global marketplace, pass on reasonable prices to processors and, ultimately, end consumers who buy high-protein soybean-containing products in the form of food and feed. • Soybeans resistant to both glyphosate and dicamba will add a new mode of action to the system, allowing for better weed control and harvested soybeans with less foreign material from weed seeds, a valuable characteristic for processors. • Dicamba-tolerant soy and cotton are not only likely to help us manage weed resistance, but will enable us to continue to be good stewards of • the land. Compared to some weed control programs, this system may result in fewer herbicide applications, less tillage, reduced greenhouse gas emissions, and soil conservation. Dicamba tolerance will allow growers to use dicamba in burn down without plant-back restrictions while providing effective control of hard to control and resistant weeds, further enhancing conservation tillage. • Growers follow label instructions closely, go through training and and invest heavily in equipment that prevents and minimizes drift. In addition, the new formulations of dicamba have lower volatility than previous generations of the product. Today, growers of different crops have access to information, resources, tools and best management and application practices necessary to enable responsible usage of dicamba, with benefits to all parties.
50	APHIS-2013-0043-0052	TJ Idlewin, grower	I am concerned and do not want to be held liable due to volatilization and drift from dicamba herbicide spray. I not only have specialty crops neighboring my commercial grain crops but will also have some neighbor's crops that are not dicamba tolerant. I have great concern with drift and volatilization when spraying next to homeowner's properties and grandmas backyard gardens.

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51	APHIS-2013-0043-0053	Pam Johnson - National Corn Growers Association	• Opposed to preparation of an EIS. USDA should immediately convey nonregulated status on these traits and make them available to U.S. growers. • Growers need new tools for weed management. Growers need new tools for weed management. With additional modes of action, growers will be able to more effectively manage glyphosate-resistant and conventional weeds.
52	APHIS-2013-0043-0054	Dallas Peterson, Professor and Extension Weed Specialist, Kansas State University	• Support the deregulation of dicamba tolerant soybeans, which could provide benefits for control of problematic weeds and provide a needed management tool for herbicide resistance management. New technologies such as dicamba tolerant soybeans would provide an additional tool that could be incorporated into an integrated weed management program to improve overall weed management, including glyphosate resistant weeds. • The introduction of dicamba tolerant soybean would likely increase the potential for developing dicamba resistant weeds, but I feel the potential benefits of helping to control existing herbicide resistant weeds far outweighs the risk of developing dicamba resistant weeds. I also believe the risk of developing dicamba resistant weeds if this technology is introduced is much lower than what has occurred with glyphosate in recent years. • Many problematic weeds, especially waterhemp and Palmer amaranth germinate over an extended period of time, so later flushes of weeds will not be controlled by short residual herbicides like glyphosate and dicamba. Consequently, weed management will be much more successful if glyphosate plus dicamba is used in conjunction with preemergence residual herbicides that can provide extended control. The use of preemergence herbicides as part of an integrated approach has increased in recent years due to the difficulties of controlling glyphosate resistant weeds and because of the improved commodity prices. Although growers were successful with multiple postemergence applications of glyphosate before the development of glyphosate resistant weeds, I think farmers now realize the many benefits of using a preemergence herbicide in conjunction with a postemergence treatment. This approach helps minimize potential for early season weed competition and provides more flexibility and better efficacy with the postemergence treatment. The other huge benefit is that by utilizing multiple herbicide modes of action, the risk of developing herbicide resistant weeds is greatly diminished. • Finally, I think farmers and crop advisers now realize that relying simply on a single technology such as glyphosate in Roundup Ready crops is not a sustainable practice and will eventually lead to the development of herbicide resistant weeds and the loss of an effective tool for weed management.
53	APHIS-2013-0043-0055	Cathleen Enright - Biotechnology Industry	• Opposes the preparation of an EIS. • BIO and its members are also concerned that the decision to prepare EISs for

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		Organization (BIO)	the crops identified by APHIS will unnecessarily delay Issuance of determinations of nonregulated status, causing significant harm to American farmers and the developers of the crops without any additional environmental benefit. • The delay that will result from preparation of the EISs will deny American farmers the new tools they need to prevent and combat herbicide-resistant weeds and maximize yields. BIO members have submitted applications to EPA that would authorize use of their herbicides on the associated herbicide tolerant crops identified In the APHIS Notices. These herbicides have differing modes of action, enhancing the ability of growers to address weed problems and supporting the continued use of environmentally sustainable practices such as no-till farming. • Delays inherent in the EIS process will also put U.S. corn, soybean and cotton growers at a particular disadvantage in relation to their counterparts in other nations that are now completing their review processes for GE crops on a far more timely basis than the United States. In addition, the developers of these crops will suffer further delay in commercializing and offering valuable new products for sale and other developers of Innovative products may reconsider whether to invest in the U.S. market. Because the APHIS Notices failed to provide a satisfactory legal or scientific justification for opting to prepare an EIS for the subject products, developers of future products also lack predictability as to whether APHIS will opt to prepare an EA or an EIS, which significantly affects the deregulation timeline and product development decisions.
54	APHIS-2013-0043-0056	Rachel Lattimore, Senior Vice President, General Counsel, Secretary - CropLife America	• Opposed the preparation of an EIS. • We strongly urge you to reconsider the need for EISs for these technologies. The proposed EISs would introduce unnecessary regulatory redundancy and potential regulatory confusion by analyzing the proposed use of herbicides that are under active review by EPA and outside the jurisdictional purview of APHIS.
55	APHIS-2013-0043-0057	- Agricultural Retailers Association - American Farm Bureau Federation - American Seed Trade Association - American Soybean Association	• Oppose the preparation of an EIS. • Our members, who produce the vast majority of commodity crops in America, must be able to utilize the very best available methods to combat weed resistance problems. Weed resistance is a well understood scientific phenomenon that is not unique to biotechnology or any other form of agriculture. Different herbicides attack weeds by different methods or “modes of action.” • The delay that will result from preparation of the EISs as proposed by APHIS will deny growers the tools they need to prevent and combat weed

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		- American Sugarbeet Growers Association - Biotechnology Industry Organization - National Association of Wheat Growers - National Corn Growers Association - National Cotton Council	resistance and maximize yields through the use of herbicides that have been shown to operate with differing modes of action. The proposed use of these herbicides in conjunction with the associated herbicide tolerant plants also supports the continued use of environmentally sustainable practices such as no-till and low-till farming. • The delays inherent in the EIS process proposed by APHIS will put American growers at a further disadvantage to corn, soybean and cotton growers in other nations that are now completing their review processes for biotechnology-derived crops on a far more timely basis than the United States.
56	APHIS-2013-0043-0058	Michael Owen, Extension Weed Scientist, Iowa State University	• I support the deregulation of the new technologies as they will be helpful in managing weeds with evolved resistance to glyphosate and other herbicides and giving farmers a choice to use tools to maximize yield potential and meet growing global demand for their product. • I believe that if growers use these technologies in compliance with the stewardship programs developed by the companies, the potential issues will be minimal.
57	APHIS-2013-0043-0059	David Cleavinger, grower, past president of the National Association of Wheat Growers	• American farmers count on USDA to be timely and scientific in the review of beneficial new biotech crop technologies. Growing delays in this process have a real cost to farmers who need these tools. In the case of dicamba-tolerant crops, we are in dire need of new weed management tools that allow us to diversify weed management and thereby address weeds developing resistance to other herbicides. Several already have, and more will if USDA continues to delay such an important technology. • USDA's delays have already resulted in the US falling behind other countries that have more reliable, science-based regulatory processes. Canada, for example has already approved the dicamba-tolerant soybean trait and South American governments are poised to approve it.
58	APHIS-2013-0043-0060	Robert Savage, Director of Risk Management, Red Gold, Inc.	Wishes to join the concerns expressed by the Save Our Crops Coalition in its comment to this docket. • Non-target plant damage associated with herbicide spray drift and volatilization is a major concern for specialty crop growers and processors. Credible estimates project significant increases in the amount of dicamba that

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			will be applied upon the introduction of dicamba tolerant crops. Dicamba, because of its potential to drift and volatilize, has proven to be one of America's most dangerous herbicides for non-target plant damage. • We do not oppose advances in plant technology, however, we will not accept a range of alternatives that includes only wholesale deregulation or wholesale prohibition of these crops. We request that USDA expand the scope of its inquiry to consider uses of its authority to address a range of issues our membership faces. • We request that USDA strictly analyze changes to agronomic practices, including herbicide use, that will result from deregulation of these crops, and consider where USDA and EPA may be able to jointly develop effective measures to protect against the threat of non-target plant damage these crops pose.
59	APHIS-2013-0043-0061	Phillip Miller, Vice President, Global Regulatory Sciences & Affairs, Monsanto Company	• Opposed to the preparation of an EIS. • Because EPA, not USDA, regulates herbicides under FIFRA and according to the Coordinated Framework, and because herbicide resistance is not a proper factor for USDA to consider in making its plant pest risk determination under the PPA, herbicide resistance alone (or any other alleged herbicide impacts) cannot justify the preparation of a full EIS in this instance. • The vitality of the agricultural economy in the United States depends upon the development of new technologies like those GE crops under review. These products will provide important benefits to farmers, and growers should not be required to wait for USDA to perform duplicative and time consuming analyses already within the regulatory responsibilities of another federal agency. As numerous growers, grower groups and agronomy professors have previously commented in 2012 for DT soybean and 2013 for DT cotton, such products are needed *now* and should be approved promptly.
60	APHIS-2013-0043-0062	Danny Murphy - American Soybean Association	• Soybean farmers need new technologies such as dicamba-tolerant soybeans to increase yields, manage weed resistance and maintain profitability. As stated in ASA's comment on MON87708, we strongly support biotechnology and believe the development of biotechnology-enhanced soybean varieties and products can benefit farmers, consumers, and the environment. • ASA strongly urges USDA to reconsider the need for the EIS. The delay that will result from preparation of the EISs as proposed by APHIS will deny growers the tools they need to prevent and combat weed resistance and maximize yields through the use of herbicides that have been shown to operate with differing modes of action. • The proposed use of these herbicides in conjunction with the associated

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			herbicide tolerant plants also supports the continued use of environmentally sustainable practices such as no-till and low-till farming. • The introduction of soybeans tolerant to both glyphosate and dicamba will allow an additional mode of action to be used in the system, allowing for better weed control and harvested soybeans with less foreign material from weed seeds, a valuable characteristic for processors. • To meet growing global demand and maintain the United States as the largest producer of soybeans globally, growers need access to new and effective technologies such as MON 87708 to increase yield potential and keep soybean prices stable. U.S. soybeans rely on exports and the EIS would need to take into consideration any implications for international trade. • While ASA appreciates concerns about off-target movement of dicamba, we are confident that farmers have a long history of successfully using proper equipment and application procedures to avoid and minimize off-target movement of herbicides. Similarly to other herbicide products, off-site movement of dicamba can be prevented through proper stewardship, application techniques, equipment settings and consideration of environmental conditions during application, such as wind speed. ASA is pleased that newer dicamba formulations have been developed to substantially reduce volatility compared to first-generation dicamba products. We are also pleased that the petitioner has addressed the potential for off-site movement by prohibiting aerial applications and implementing specific environmental and equipment application requirements on the dicamba label, including a wind-directional buffer when sensitive areas are present, and the use of low volatility dicamba formulations. ASA believes that when recommended label practices are followed, farmers of various crops can co-exist and prosper.
61	APHIS-2013-0043-0063	Joyce Dillard	We request that more thorough studies occur on bees and colony collapse, birds and the watershed ecosystems as well as viruses that spread through migration related to watershed ecosystem connectivity. Water contamination is a problem in a watershed not necessarily in the vicinity of the crops, so all avenues need to be studied. The liabilities of the Clean Water Act should not be placed on other watershed systems.
62	APHIS-2013-0043-0064	Lee Van Wychen, Director Science Policy - WSSA	Science has clearly shown that there is a risk of resistance development to all herbicides, and 2,4-D and dicamba are no exception. In fact weeds have evolved resistance to nearly all forms of weed control including herbicides, tillage, mowing and hand weeding. Some of our members have voiced concerns that growers may adopt 2,4-D and dicamba technologies and rely too heavily on these herbicides thereby developing an even greater weed resistance situation. However, the majority

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			of our member scientists view 2,4-D and dicamba resistant crops as an additional weed management tool to include in an integrated weed management program. The greatest risk for developing herbicide resistance is actually occurring right now with the PPO herbicides and glufosinate. These products are being over-used in certain cropping systems as farmers have no other effective herbicide options. The 2,4-D and dicamba resistant crops could be used to delay resistance development to the PPO herbicides and glufosinate and, in turn, weed management systems could be developed using the PPO herbicides, glufosinate, 2,4-D and dicamba, extending the life of each of these chemistries.
			Weed management is ultimately the responsibility of farmers and farm advisors. However, the weed science community, including industry, academics, crop commodity groups and others who reach out to farmers, must recommend robust and effective stewardship programs espousing the basic principles of good weed management and encourage adoption of these practices. By doing so, evolution of resistance to our herbicide resources and new options such as 2,4-D and dicamba resistant crops will be minimized.
			Research indicates that 2,4-D and dicamba will fit best in a fully diversified program and such a program is particularly important when glyphosate resistant palmer pigweed and waterhemp are the targets.
			Resistance to 2,4-D and dicamba represents no more a threat to agricultural production than resistance to other critical herbicides and the likelihood that it will be used in a manner consistent with best management practices is good.
			Stacking 2,4-D and dicamba tolerance with that of glyphosate, glufosinate, and other herbicide tolerant traits will further facilitate the use of these herbicides in a diversified program. Stacking herbicide traits does not in itself promote the evolution of resistance to more than one herbicide since, just as for individual herbicides, the evolution of resistance is a function of how the herbicides are used rather than a function of the selectivity of the crop to multiple herbicides.
			The ability of farmers to use 2,4-D and dicamba in diversified weed management programs in soybeans, corn, and cotton is not expected to significantly change current farming practices. These herbicide tolerant crops will, however, provide valuable new postemergence options that will allow farmers to most effectively manage their weeds when practicing conservation tillage even in the presence of glyphosate resistant populations. Farmers have clearly shown a preference for postemergence weed control in conservation tillage systems and 2,4-D and dicamba can be an important part of this system. As the spread of glyphosate-resistant weeds occurred, the adoption of tillage, including deep tillage with a moldboard plow has once again become more common.

Comment #	Comment ID	Commenter	Comment Excerpt
			The return of conventional tillage has led to increased wind and water erosion. Neither 2,4-D nor dicamba technologies would eliminate tillage, but they would greatly reduce the need for deep tillage allowing many farmers to return to more reduced tillage production systems.
			New and expanded uses of existing herbicides are needed for integrated weed management programs in order to mitigate weed resistance and meet our current and future crop production needs.
			Off target movement of 2,4-D and dicamba pose the greatest limitation to the adoption of either auxin technology. An enormous amount of research by the registrants and other weed scientists around the world has been conducted to develop methods to minimize the potential for off-target movement. These efforts include 1) improving herbicide formulations, thereby reducing volatility and/or drift, 2) improving application equipment techniques and application methods, thereby reducing drift, and 3) developing educational materials to assist growers in reducing off target movement when making pesticide applications. There is no question these research efforts will greatly minimize off-target movement of all pesticides, not just 2,4-D and dicamba, and will greatly improve the ability of a grower to apply pesticides that stay in the targeted area.
63	APHIS-2013-0043-0065	Center for Food Safety	**2,4-D-resistant crops must be viewed as weed control systems** APHIS must assess dicamba-resistant soybeans and cotton as crop systems comprising the herbicide-resistant crop itself and associated use of dicamba. Monsanto describes its Roundup Ready (RR) crops as RR crop systems, and will also treat its dicamba-resistant crops in the same manner.
			Impacts of dicamba-resistant crop systems on herbicide use APHIS must assess the shift in dicamba use patterns to be expected in various DR crop adoption scenarios. APHIS should assess both the change in amount applied, per acre per crop, and the shift in use pattern (i.e. amount used pre-emergence vs. post-emergence). APHIS should also assess the impact of DR crops on overall herbicide use, keeping in mind that dicamba would likely displace little if any glyphosate, which has a broader spectrum of activity, including (unlike 2,4-D) activity on grass family weeds. We refer APHIS to our comments, where CFS makes such projections.
			Features of HR crop systems that promote HR weeds As discussed in our comments, HR crop systems promote not only (near-) exclusive reliance on the associated herbicide(s), but also more frequent use over a broader application window that extends much further into the crop season than would otherwise be possible. Resistant weeds with Roundup Ready crops are too often treated superficially as simply the result of excessive glyphosate use, but as Paul Neve has pointed out, the post-emergence use pattern of glyphosate with RR crops is

Comment #	Comment ID	Commenter	Comment Excerpt
			another, independent factor promoting weed resistance, beyond exclusivity and frequency of glyphosate use. In other words, the timing as well as the exclusivity and frequency of herbicide use is a factor in promoting weed resistance. In practice, applications are often made late post-emergence to larger weeds, increasing resistance risks still more. Additional evidence comes from weed resistance to ALS inhibitor herbicides, many of which were and are used post-emergence. ALS inhibitor-resistant weeds arose in 1987 just five years after the first ALS inhibitor herbicide was introduced, and became extremely prevalent in less than a decade; in fact, by undermining the efficacy of widely used ALS inhibitors (especially in soybeans), resistant weeds provided much of the impetus for adoption of RR crops (as a means to kill ALS inhibitor-resistant weeds), just as glyphosate-resistant weeds have become the rationale for 2,4-D-resistant crop systems. We emphasize that while a post-emergence herbicide use pattern is certainly not a necessary condition for weed resistance to evolve (e.g. atrazine used primarily pre-emergence and early post-emergence in corn led to substantial weed resistance), it does appear to be a facilitating factor where present. APHIS must assess the post-emergence weed control paradigm that is a central feature of HR crop systems for its resistance-promoting potential in the case of 2,4-D-resistant crops and weeds, in addition to the more obvious factors of exclusivity and frequency of use.
			Socioeconomic factors associated with HR crops and HR weeds As discussed in our comments, pricing strategies influence farmer weed management decisions in such a way as to contribute to evolution of weed resistance. Companies charge fees for HR traits that are substantial enough to create a strong incentive for the farmer to make full use of the trait(s) through total reliance on the associated herbicide(s). APHIS should find or develop studies that explore the extent to which pricing strategies for HR crop systems (e.g. high-priced seed, low-cost herbicide) reinforce herbicide use patterns that foster resistance in the case of 2,4-D-resistant corn and soybeans. RR crops' major and closely intertwined "benefits" are reduced labor needs for weed management (at least until resistant weeds emerge) and the simplicity of glyphosate-only weed control. In addition, glyphosate's superior ability to control large weeds relative to other herbicides broadens the application window for acceptable weed control. These factors together facilitate increased farm size, since more land can be managed for weeds with the same labor, and labor needs for weed control are a major limiting factor on farm size. One can expect 2,4-D- resistant crops to have similar impacts. APHIS should assess the socioeconomic consequences of 2,4-D-resistant corn and soybeans, in terms of increased land and rental prices from increased competition for land, increased average size of farms, and accelerated exit of small- to medium-size farmers from agriculture.

Comment #	Comment ID	Commenter	Comment Excerpt
			HR crops and drift damage HR crop systems entail a pronounced shift in herbicide use to much later in the season when neighboring crops have leafed out and are more vulnerable to drift damage (from early season herbicide use when drift poses much less risk). Glyphosate has become a leading cause of drift damage in the era of Roundup Ready crops, despite the fact that it is not a volatile or drift-prone herbicide. This is not merely because its use has increased so dramatically, but also because its use has shifted heavily to later in the season. 2,4-D is much more volatile than glyphosate, and is particularly prone to vapor drift. APHIS must comprehensively assess the increased drift damage that would occur with various 2,4-D-resistant corn and soybean adoption scenarios, both in terms of lost yield and income, broken down by major crop (e.g. soybeans, cotton) or crop category (e.g. vegetables). APHIS should further assess the extent to which 2,4-D-resistant crop adoption would reduce plantings of susceptible crops (e.g. vegetables, grapes) and/or shift acreage to 2,4-D-tolerant crops that could withstand drift level doses (e.g. corn). In conducting this assessment, APHIS must account for the inevitable use of more drift-prone 2,4-D formulations (e.g. because likely to be cheaper than the choline salt), and not presume an ideal world scenario where only potentially less drift-prone formulations are used.
			Crop volunteers resistant to 2,4-D, ACCase inhibitors, glyphosate, glufosinate, etc. as weeds RR crop volunteers have been repeatedly noted as problematic weeds, particularly corn, but also cotton and soybeans; and particularly where RR crops are rotated (see comments). SmartStax corn is even more problematic, since glufosinate as well as glyphosate are eliminated as control options. APHIS must assess the increased weediness of volunteers of corn and soybeans resistant to 2,4-D, ACCase inhibitors, glyphosate, and/or glufosinate. Further, since cross-pollination with other prospective herbicide-resistant cultivars will be possible (e.g. dicamba-resistant corn), APHIS should consider scenarios with volunteers that have stacked resistance. The assessment should include increased costs of control, increased use of herbicides, increased weed resistance risks from a narrowing of herbicidal control options and increased reliance on those (few) herbicides still effective.
			Interplay between HR traits and Bt resistant pests 2,4-D-resistant corn will be offered mainly in stacks with Bt traits. Research described in the 2,4-D comments shows that HR corn volunteers produce lower levels of Bt toxin and thereby promote Bt resistance in corn rootworm; the more HR traits in the corn volunteers, the less likely they will be managed adequately, and hence the more likely they will contribute to Bt resistance. See discussion in 2,4-D-comments.

Comment #	Comment ID	Commenter	Comment Excerpt
			Cross-resistance between 2,4-D, dicamba and other synthetic auxin herbicides In our comments, we discuss evidence that certain weeds resistant to 2,4-D (e.g. waterhemp) also exhibit increased tolerance to dicamba; and that dicamba-resistant crops have increased tolerance to chlorophenoxy herbicides like 2,4-D. In view of their common mechanism of action, these findings strongly suggest the potential for evolution of cross-resistance in weeds to dicamba and phenoxy herbicides. Most weed biotypes resistant to either dicamba or 2,4-D have not been tested for resistance to the other. APHIS must assess the potential for 2,4-D crop systems to foster resistance, not only to 2,4-D, but also to dicamba, and the impacts such cross-resistant weeds (against a background of resistance to glyphosate, ALS inhibitors and/or other herbicides), would have on weed control in soybeans, corn and other crops. Known weed biotypes with resistance to either 2,4-D or dicamba should be tested for tolerance to the other, to help establish the potential for such cross-resistance.
			Non-target effects of 2,4-D-resistant crops Roundup Ready crop systems have dramatically increased use of one of the most effective plant-killing compounds ever developed. Glyphosate is particularly noted for its efficacy against perennial weeds, which most other herbicides have difficulty controlling. Glyphosate use with Roundup Ready crops is a major factor in the dramatic decline in Monarch butterfly populations over the past two decades (see 2,4-D-resistant soybean comments to USDA). Glyphosate has decimated milkweed populations in Midwest corn and soybean fields; and milkweed in such fields is the major breeding ground for migratory Monarchs that overwinter in Mexico. APHIS must project the impact of 2,4-D-resistant corn and soybean systems (with additional resistance to glyphosate and/or glufosinate) in further reducing populations of milkweed in agricultural fields and thus exacerbating the decline in Monarch populations.
			Many glyphosate formulations are extremely toxic to various species of frogs. Massive glyphosate use accompanying Roundup Ready crops has been posited as a likely factor in the global decline of amphibian populations. APHIS must assess the impacts of 2,4-D-resistant corn and soybean systems (with additional resistance to glyphosate and/or glufosinate) on amphibian populations.
			Impact of HR crop systems on sustainable weed control Please assess the impact that Roundup Ready crop systems have had on efforts to advance adoption of sustainable weed management techniques (e.g. crop rotation, cover crops); and based on this analysis, similarly project the impacts that 2,4-D-resistant crops (with additional resistance to ACCase inhibitors, glyphosate and/or glufosinate) would have on the same.
			Health impacts of increased 2,4-D use with 2,4-D-resistant crop systems

Comment #	Comment ID	Commenter	Comment Excerpt
			Medical scientists have found 2,4-D use associated with increased risk of non-Hodgkin's lymphoma and other adverse human health impacts (for discussion see human health section of 2,4-D comments to EPA). Dioxins continue to contaminate 2,4-D, and EPA has failed to collect comprehensive, independent data on the dioxin content of the many 2,4-D formulation used by farmers. CFS projects a many-fold increase in use of 2,4-D with introduction of either or both 2,4-D crop systems, and thus a further increase in exposure to and disease from this toxic herbicide. APHIS and EPA must assess the increased incidence of disease to be expected with the substantial increase in 2,4-D use accompanying introduction of these crop systems.
			2,4-D-resistant crops and tillage Roundup Ready crops have not, as popularly imagined, fostered increased use of conservation tillage. The major gains in conservation tillage adoption came in the 1980s and early 1990s, in consequence of 1985 and 1990 Farm Bill provisions that tied subsidies to use of soil-conserving practices. In fact, adoption of conservation tillage actually stagnated in the decade of Roundup Ready crop adoption. Instead, the glyphosate-resistant weeds generated by RR crop systems have led to increased tillage for weed control and hence greater soil erosion. CFS has presented a detailed analysis to support these conclusions in the 2,4-D-resistant soybean comments. APHIS must assess the potential for 2,4-D crop systems to further increase soil erosion through increased use of tillage to control the 2,4-D-resistant weeds that will be generated by these crop systems.
			APHIS should also require the applicants to supply information necessary for meaningful risk assessments that is not in their petitions, or better yet undertake appropriate research to fill in the gaps. For example, the following information should be available for review by APHIS and the public: • Proposed herbicide application regime: how much herbicide, how often, window of application. • Degree of resistance conferred by the transgene in different plant parts and stages of development. • Expression of the transgene in pollen, nectar; levels of herbicide residues and metabolites in pollen, nectar. • Herbicide residues and metabolites in plant tissues from the time of application through post-harvest.
			APHIS needs to analyze the following areas: • Agricultural production impacts, including and not limited to burden on organic and non-transgenic agricultural production and potential harms to non---target crops from the adoption of the HR crop system. • Environmental impacts, including but not limited to: - Herbicide use and changes in herbicide use patterns;

Comment #	Comment ID	Commenter	Comment Excerpt
			- Gene flow from 2,4-D-resistant corn and soybeans to compatible varieties and the resulting increased weediness; - Agricultural practices, including herbicide use, effects on tillage; and - Weed resistance and volunteers. • Socioeconomic impacts, such as: - Transgenic contamination and their effects on both domestic and export markets, as well as, consumers and farmers' right of choice - Changes in seed industry market concentration and their impacts, - Effects on the methods and costs of weed control • Human health impacts, such as: - Herbicide use, including impacts on farm workers; and - Safety of food products • Livestock health, such as: - Herbicide use; and - Safety of animal feed. • Threatened and endangered species, such as: - Herbicide use; and - Quality of crop tissues as food sources. • Disease and pest impacts stemming from 2,4-D-resistant soybeans and corn and the associated herbicide use.
63	APHIS-2013-0043-0065	Center for Food Safety	Comments to USDA APHIS on Environmental Assessment for the Determination of Nonregulated Status of Herbicide-Tolerant DAS-40278-9 Corn, *Zea mays*, Event DAS-40278-9 - Center for Food Safety, Science Comments II See Comment Summary for DEA for DAS-40278-9 Corn
64	APHIS-2013-0043-0066	Center for Food Safety	Comments to USDA APHIS on Draft Environmental Assessment and Draft Plant Pest Risk Assessment for Dupont-Pioneer's Petition (11-244-01p) for Determination of Nonregulated Status of Insect-Resistant and Herbicide-Resistant Pioneer 4414 Maize: Event DP-004114-3

Table 2-2. Public Scoping Comments Submitted During Virtual Public Meeting

Commenter	Affiliation	Concern/Issue
June 26, 2013		
Victor Miller	grower and past chairman U.S. Grains Council	As USDA surveys the topics to be considered in the development of the draft EIS, I would first offer that USDA should take a hard look at the question is an EIS even warranted. USDA's and APHIS' reasons for conducting the EIS all appear to relate to potential impacts associated with herbicide use, possible selection for, and spread of weed resistance to herbicides…from applications of dicamba on the dicamba intolerant crop and other areas.
		Use of dicamba is nothing new. According to industry estimates, dicamba has been used successfully on more than 250 million acres over the past 10 years. In 2012, it was the fifth most widely used herbicide in the U.S. in terms of acres treated, used on over 32 million acres of farmland across the range of crops, including 12 million acres of corn, 6 million acres of wheat, 4 million acres of other crops, and 10 million acres of fallow for (indiscernible). Additionally, any homeowner who has gone to their local Weed-B-Gon herbicide product has used dicamba without certification or licensing. The equipment, the know-how, and the ability to successfully apply dicamba as part of the new dicamba tolerant soybean and cotton weed control system under review exists today. I have purchased upgrades through my current system to accommodate the new requirements, and I'm confident that I and other producers will do this successfully.
		The ability to choose dicamba within my soybean acres will allow me to have a badly needed additional mode of action to control weeds such as waterhemp and lambsquarters that are a problem on my farm. Without it, I am left with few viable alternatives to control weeds in my field, resulting in poor yields, which means I produce less on these acres. This means I get paid less for my crop, I deliver fewer beans to my local elevator, and this cascade of impact carries on down the line, as the elevator adds (indiscernible) fewer beans and more weed seed to foreign material that end up at the local crushing plants. The crush plant profitability is hurt, and so is bean quality that is made into animal feed, soybean oil, biodiesel, food ingredients, and ultimately either used domestically in many applications or sold to foreign buyers

Commenter	Affiliation	Concern/Issue
		for their use in international markets. Now, not only has my income been impacted, but very possibly, hungry people in foreign markets have less to eat.
		Looking on the bright side, incorporating dicamba tolerant soybeans into my weed management program allows me to reduce dependence on ALS and PPO herbicides and would offer a proactive program for weed resistance management and preserve the value of glyphosate, an herbicide that still controls most of the weeds on my farm.
		Lastly, I adopted no till, also called conservation tillage, because of the great environmental benefits that it creates: reduced soil erosion, increased moisture and benefit to top soil. Here, I use Roundup to remove the weeds in my field before I plant instead of tilling them under. With dicamba tolerant soybeans, I have another tool to assist me in my conservation tillage efforts and potentially help me and other farmers to expand this practice. Without dicamba tolerant beans, I may be forced to till my fields if and when weed pressure dictates, which could lead to soil erosion, impaction, and unsatisfactory weed control.
		In closing, restricting the use or denying access to these new technologies would have a negative effect on U.S. farmers' operations, reduced weed control capability, increasing costs, reducing farm returns, and impacting the producer's ability to meet foreign market demand. And also, it stands a very great chance of reducing conservation tillage options. Ultimately, this has a very negative impact on the food supply of not only the U.S. but the world as well. I urge you to complete your report and remove promptly so that other farmers may have access to this knowledge.
Ray Gaesser	grower and First Vice President of the American Soybean Association	Those traits (indiscernible) are much needed. They will allow us, on our farm at least, to continue to no till. If we don't have those products, we may have to go back to tillage to deal with some of the weeds that we have. So I would really urge you to move forward with the approval of both the dicamba and the 2,4-D for our soybeans and our corn…
		We use them [2,4-D and dicamba] on our farms. I've been farming 25 years now, and I've had experience using both of those products in a different formulation for all that time. And, really, I've never had any problems with it, (static - call interference) response to our own crop or our neighbor's. As the previous

Commenter	Affiliation	Concern/Issue
		speaker said, we are tested in Iowa. As is required of all of our applicators that come from the co-ops and from the industry, are tested, and understand the need and the right way to apply herbicides.
		We used to use a lot of those products, and now with glyphosate, we use less in order to address the issues of weed resistance in particular, and the real need for multiple modes of actions. All of our universities are saying that we need multiple modes (indiscernible) of action to avoid weed resistance. So I would urge you to move forward with both of these applications.
David Shaw	Past President, Weed Science Society of America (WSSA)	Biotechnology has allowed us to maximize yields in economics, to be able to mitigate the potential development of herbicide resistance, and to be able to effectively gain tremendously with the development of conservation tillage practices in the United States.
		Herbicide resistance has developed substantially over the last few years, but is not a new phenomenon. In fact, it has been recorded and noted for over 40 years now.
		One of the primary practices that we scientists recommend in managing proactively herbicide resistance is the ability to use a wide diversity of mechanisms of actions with different herbicides that affect plants in different ways. We need more herbicide options to be able to manage these and to be able to preserve the utility of those that we already have. The ability to effectively use dicamba and 2,4-D in soybean and cotton will help fill this critical need. We have seen the development of herbicide resistant plants most notably in the last few years with glyphosate resistance in (indiscernible) crops. This problem has become widespread, in several of our major commodities. And dicamba and 2,4-D, also the ability to use a different mechanism of action than what is currently available in these crops to be able to more effectively and proactively mitigate and delay the evolution of herbicide resistance.
		There are a number of factors that come into play in the evolution of herbicide resistant weeds and crops. However, we scientists understand that this is a function of managing the practices and the herbicides that are available for weed management. It is as such not a plant biotechnology issue. It is a use of the technology and

Commenter	Affiliation	Concern/Issue
		the rotation and a development of an overall plan using various management practices that have been identified. Weed management is ultimately the responsibility of farmers and farm advisors that requires the entire community of weed scientists, industry, academia, crop commodity, and others to be able to effectively steward herbicide resistance management. By using the development of resisted crops that have the tolerance to dicamba and 2,4-D, this represents no greater threat than the development of any herbicide technology that has hurt in the past.
		Dicamba best fits in a fully diversified program that utilizes many different mechanisms of action of herbicides, and is therefore a tool that can be used either in stacked (indiscernible) or as stand alone to be able to offer the growers options that 16 they currently do not have. It is also noted that one of the major challenges that we have with the development of herbicide resistance is the losses that we are now experiencing in conservation tillage acres. Dicamba and 2,4-D tolerance will certainly allow us to help preserve these valuable gains and the preservation of our soils in the United States.
		We urge the USDA to expedite the necessary review process that will lead to final approval of dicamba and 2,4-D tolerant crops, and we appreciate the opportunity to provide this comment.
Victor Miller	grower and past chairman U.S. Grains Council	I would like to make an additional comment on the fact or the idea that we as private applicators applying herbicides to our crops, the amount of time that we spend in reading and understanding and following the label is of paramount importance to us. And as we look at this, there are many reasons for doing it, but the two that stick out the most are the fact that if we do not follow those label requirements, we risk unsatisfactory control. And worse yet, we risk crop injury, which is at the ultimate end a reduction in our incomes. And so, I think it's very important for USDA to understand that we spend a great deal of time doing exactly what is on that label.
Ray Gaesser	grower and First Vice President of the American Soybean Association	I'd like to talk from my heart, and I really don't understand the fear of these products, because on our farms -- and I have 25 years in this experience -- we've been using these products for all that time, for a decade now, and we haven't had a problem. And they've been used all over the world for a decade. And you have all the data and

Commenter	Affiliation	Concern/Issue
		the experience that I would think you need. I can't understand why there is a need for an environmental impact assessment. I just really struggle with that. It's going to delay my ability and my fellow farmers here in the United States to use these products in a new way that allows us to (indiscernible) of this issue; that let's us use multiple modes of action to avoid these resistances in the first place and let's us farm the way we really need to run our land so that we can continue, and not have to use facilities to incorporate some of the other herbicides that can work okay, but it's not very good for my part of the country where we're having (indiscernible). So I would really encourage you to move forward to deregulate these products, to not do the EIS. You have all the data in the world. You have all the data you need to move forward with these two products, and I would encourage you to do that.
Michael McCarty	grower	We've been fighting this [resistant weeds] for probably the last five or six years. We have glyphosate tolerant cotton, soybeans, all that was great. We followed the stewardship requirements, followed everything that was presented to us, all that by the book. And now we've come upon a resistant, amaranth, pigweed. And it is totally destroying the infrastructure on our cotton industry. We've gone from a 2800-acre cotton farm down to 1500 acres. And trying to maintain, it's a battle we just can't fight. We don't have enough tools in our arsenal. There aren't enough -- it's enough technology for us to overcome this problem, so we're just totally out of the cotton industry now. We have zero acres of cotton. And I've got a $600,000 cotton picker that's sitting under the shed -- it's decreased in value, probably now cut in half because there's nobody interested in buying it so they can plant cotton. My problem is, I know that there's technology out there, and why haven't we been able to use it? It's out there for us. I've been to two fields, test spots, looked at different things, read different articles about it. And my main concern is we're getting ready to totally lose it. And I'm just voicing a concern from the field standpoint. I read all these -- these people in Austin and California and all these different places that are trying to tell us what we need to be doing and how we need to do it. I'm telling you from the field level, we need the technology, and we need it quick. These other countries

Commenter	Affiliation	Concern/Issue
		are already using it, and we're at a disadvantage to them. I know some of the problems are worried about drift management, whether or not we can control it. We've got the John Deere, the green release, all technologies, everything in our arsenal to keep drift down, (indiscernible), GPS equipment, stuff that doesn't have any overlap. We've got sprayers that will cut off to keep from overlapping. It's an amazing amount of technology that's out there to keep out drift control down. I know that was one of the problems that I read about. It was a concern. Farmers are some of the most responsible people because we get back from the earth whatever we put in it. If we destroy our ground, we overlay chemicals, then we don't get anything back. That's how we make a living. We're not going to do that. We're not going to abuse anything, nothing like that. No farmer that's still in business has ever abused a chemical because simply there's EPA regulations; there's everything that can toss us out. And it's just not going to happen. My deal is -- my main concern is let's get this technology. You've been going over this for three years, and steady having meetings, talking about them. Come back with another set of meetings. You can only meet so long. You can only have so many (indiscernible) to do this for, so let's open it up. Let's give us the technology we need so we can start using them.
June 27, 2013		
Genna Reed	Food and Water Watch	Our previously submitted comments outline issues that must be considered carefully in (indiscernible). Environmental Impact Statement. The Food and Water Watch analysis of USDA data revealed that for every 1 million acres of dicamba tolerant soybean plant, there could be an additional 2 millions of dicamba applied to crop. Even if just a million dicamba tolerant soybean acres are planted, that would be 17 times the current dicamba volume used on soybeans. If 2,4-D corn were adopted as quickly a Roundup Ready corn, about 1 million acres a year between 1997 and 2001, 2,4-D application on corn is easily increased by nearly three

Commenter	Affiliation	Concern/Issue
		(indiscernible), from 3.5 million pounds to 5.5 million pounds in two years 21 of 2,4-D tolerant corn introduction. USDA must look at the economic cost to development of 2,4-D and dicamba tolerant weeds could have on (indiscernible). Farmers face significant costs from (indiscernible).and increased production costs. These costs can range from $12 to $50 an acre, or as much as $12,000 for an average bag of corn or soybean farm, or $28,000 for an average cotton farm. Since U.S. farmers have found herbicide-resistant weeds in their fields, they've changed farming methods to control them, resulting in higher weed control costs and even tillage and hand tilling. Additionally, USDA must also look at the impacts that these resistant and multiple herbicides could have on farmers and agriculture. Second, increased applications of 2,4-D and dicamba will lead to elevated surface water pollution, which will not only affect the quality of water near agriculture, but will impact plants and animals, including endangered species. USDA must consider the biological opinion of the National Marine Fishery Service regarding 2,4-D registration and specific (indiscernible), and look carefully at the individual and synergistic effects of increased volumes that of these chemicals on non-target organisms, threatened and endangered species.
Robert Wolf	retired professor emeritus, application technology in the biological and agricultural engineering department, and extension specialist, Kansas State University	My main responsibility while at Kansas State was to conduct an extension and research program in our chemical pesticide application with a particular emphasis on novel technology. My research focus was and continues to evaluating novel types for improved pest control efficacy while minimizing the straight drift. In retirement, I have formed a consulting company, Wolf Consulting and Research and continued working with the application industry as a researcher and a trainer. As a part of my consulting work, I have had the opportunity to work with Monsanto's dicamba tolerant soybean train team and trained Monsanto employees and others on the topic of spray technology basics, including the focus on selecting and using

Commenter	Affiliation	Concern/Issue
		proper novels for the application with dicamba as a part of a prescribed weed control system as it relates to the introduction of these dicamba tolerant crops. For the past four years, the focus of this reach has involved conducting commercial size sprayer oriented research trials involving spray nozzles and drip- producing (indiscernible) to support this training, with the most recent efforts used in resistant weed plots (ph). As the USDA considers areas of study for the plant environmental impact statement, I would like to offer some thoughts and consideration, as well as my perspective on the new weed control tool. Current spray technologies for residual off-site movement and the application practices available to make herbicide applications accessible. Some forces of concern include off-site movement caused by particle drift, volatility, contamination due to improper clean out and making applications in unfavorable environmental conditions. Here are some of my key points. Particle drift is controllable through equipment selection and conditions of use, such as formulation, spray tips, and other technologies, wind speed and direction of application considerations and sprayers feed and (indiscernible). In some of my most recent research, selecting a proper nozzle type alone was shown to reduce (indiscernible) as much as 13 and a half percent, down to as low as half a percent. And in some cases, with the inclusion of drip control additives reducing drip even more. Newer dicamba formulations have been developed to substantially reduce volatility compared to earlier generations of dicamba products. The research is supporting this and to further research, education and training at this point will be stress, and contamination will be a major concern when switching between tolerant and non-tolerant crops. This will be addressed through proper cleanout procedures that adequately clean out herbicide residues from the lining tank and inner workings of the sprayer,

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		including all (indiscernible) 45 builders, crevices, drain lines, et cetera. Newer spray systems are being engineered to improve this cleanout process. Monsanto has addressed one concern of the potential for off-site movement by prohibiting aerial applications and other concerns by implementing specific environmental and equipment applications comments on the draft dicamba label, including wind directional buffer when sensitive areas are present and the use of low volatility dicamba formulations. In my opinion, the U.S. farmers and applicators are capable and experienced after many on-site movement. Like any other herbicides off-site movement of dicamba can be prevented through proper stewardship, including application techniques, equipment settings, nozzle selection, and consideration of the environmental conditions during the application. Equipment and other hand-held tools, such as Smartphone apps that support applications to facilitate access to weather data, field crop mass, nozzle details and other information now exist in this technology, and its capabilities are being used in fields across America today. Correct label practices are followed and growers of various crops will co-exist and prosper. I believe that in combination with approved best management practices, including the use of proper novel type, or types, applications using dicamba will have the potential to reduce the amount of off-target drift. In closing, the use of dicamba does not (indiscernible) at 2012 pictures indicating its use in over 32 million acres of farmland in the U.S. The equipment know-how and ability to successfully apply dicamba as a part of the new dicamba tolerant soybean and cotton weed control systems exist today. Putting these application details on a label is an effective means of communicating and requiring these strategies to be followed. Restricting the use or denying access to these new technologies, based on concerns for off-site movement because it may not be controlled or labeled formulations may not be successfully applied (indiscernible)

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		exaggeration are a huge disservice to the farmers who I understand the USDA is representing.
Jim Broten	Grower and past chairman, U.S. Grains Council	I just want to comment that in spite of the, problems with weeds (indiscernible), including (indiscernible). These weeds compete with our crops for (indiscernible), water, and (indiscernible), and they hurt our fields. If left without effective control, these weeds can decrease our (indiscernible).
Bill Bridgeforth	Grower and chairman, National Black Growers Council	…we produce cotton and soybeans on our farm. And the pigweed problem has become a very serious issue for us. This year, pigweed threatens our profitability. It could take the whole farm, just that one weed alone. We do have -- each year, we'll have some areas of our farm where the technologies that we're using now and the chemicals we're using, they just do not work. And we'll have to abandon those crops. It's not a large percentage of the acres, but we do have it. It does happen. Without another mode of action on the pigweed, we're going to see more and more of this -- we're just going to have to start -- we're going to start seeing more acres that will have to be amended because the pigweed is just taking over. And so I believe that the dicamba technology in cotton and soybeans on our farm is going to be very important. We're already using all the technology and precision. All the tools out there that can help us be better farmers, we're using them. And we just think that the approval of dicamba cotton and soybeans will keep us on track to being good farmers with a high level of productivity.
Michael Owen	extension weed scientist and professor (weed management), Iowa State University	I would like to suggest a couple of things. First of all, that as the previous speaker indicated, growers not just in the south or the Delta, or in the Midwest, need as many tools to manage weeds as possible. Weeds represent the most important, most prolific and most consistent pest complex that causes reductions in yields and profitability throughout the world. And having new tools to help manage those pests are incredibly important. A comment was made earlier that the de-registration or deregulation of these traits -- and I am speaking both to Docket 42 and to Docket 43. The statement was made that there will be an

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		increased use of these two herbicides, dicamba and 2,4-D. I would look back not that far in history where 2,4-D/dicamba was the most prevalent herbicide treatment used in corn production across the United States. And thus, I do not see that this change in the technology is going to dramatically change how over the history these two herbicides have been used. Importantly, I would also point out that the concern for the EIS reflects the concern for evolved resistance to these herbicides. The fact is that these herbicides represent no more greater risk than any other herbicide in whether or not they will select for herbicide resistant weed biotype. It is the decision on how those herbicides are used and the management practices that dictate the level of selection pressure and the likelihood of herbicide resistant weeds. The truth is that there are already some leaves that evolve resistance to dicamba and some leaves that evolve resistant to 2,4D. The manner by which the companies are prescribing the use of these new technologies and the concomitant use of these herbicides to such that selection pressure by their rules will be reduced significantly; and thus in my opinion, reduce the probability that new leaves will indeed be selected and have the training for resistance to either 2,4-D or dicamba. The other point is that we talk about these concerns about volatilization. And again, the new formulations of the 2,4-D and of the dicamba are such that volatization potential is minimized. It's not eliminated but if you significantly minimize – and once again, it is the decision as to how these herbicides are applied, as Dr. Wolf explained, will determine the risk of all target movement, based on the stewardship programs that the companies are placing in effect in anticipation of deregulation. My sense is that the potential for off- target movement of these herbicides has been managed very effectively. he other comment that was made is that if these trades were deregulated, that we will lose opportunities for conservation tillage. The fact remains that these products specifically do support the success of conservation tillage in all row crops that

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		form the soybean and the cotton, where these new genetically-engineered traits will be sold and these herbicides will be used. The final point that I want to make is that it was suggested that. But the final point that I want to make is that it was suggested that herbicides are now a major problem with regard to how widely they are used and how other alternative strategies have been compromised as a result of the ubiquitous use of herbicides. This is not new. This has been an agricultural fact over 40 years. And so, I do not see where the deregulation of the corn, cotton and soybeans, with traits for either 2,4-D or dicamba is dramatically going to change. The amount of herbicides or the acres of herbicides treated crops, will occur. I think that in fact, the industry has learned from their historical efforts with developing products and having them cause selection pressure resulting in herbicide resistance. There's historical knowledge, and they're putting this into practice with the stewardship programs that they now are beginning to up into place. I think this will change grower behavior. And by changing grower behavior the potential negative consequences of these new genetically engineered crops or the use of either 2,4-D or dicamba will be minimized.
Kip Tom	grower, Tom Farms	This is nothing new to us. We've experienced a lot of -- in Argentina as well, so we're not surprised we're seeing some of it here. And when I say that, I'm talking about the (indiscernible). Well, I've got to tell you that on May 10th of this year, USDA took an action-oriented step by delaying the regulatory approval of the dicamba tolerant technologies for corn and soybeans and the 2,4-D tolerant technologies for soybeans and corn from Dow, requiring an environmental impact statement. This move threaten, though, severe delays to the Farmers Act, that's multiple weed control technology across three major U.S. crops: corn, cotton, and soybeans. These technologies have been under USDA for approximately three years, a timeline that is already much longer than expected. And now the USDA is initiating a process that's taken as long as four years, when I think

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		about Roundup Ready alfalfa in the past. Unacceptable. USDA's stated purposes for the EIS revolves around stewardship of chemistry herbicide-resistant weed and (indiscernible), which is EPA's goal as determined by Congress decades ago and upheld in federal courts as recent as last month, the Ninth Circuit Court of Appeals ruling on Roundup Ready alfalfa. USDA has no legal authority to regulate these matters, and it's hurting farmers with delays, while it takes this overreaching step. These traits already have been approved by the Canadian government for the Canadian soybean farmer. This is bad enough, but further delays may result in Argentina and South American governments also close to approving these technologies. If it delays another three years, it's going to put the U.S. way behind most other countries and access to these technologies to address an issue that we have today. Continued delays and lack of predictability in USDA's process hinders innovation and creates insurmountable barriers to entry for a variety of new tools and competitive product choices that would benefit all of us in U.S. agriculture and our consumers globally. The impact of U.S. delays are potentially not deregulating these technologies on our farm and our communities, and the U.S. farmer's ability to compete for supplies and growing global markets. We all know the numbers. Today we're feeding 7 billion people, and we're on the pathway to feed 9 billion people by the year 2050, a big job to do, especially when we have to face some of the challenges we do in these regulatory processes. This technology is critical to allow successful over-the-top control broadleaf weeds, crops and soybeans, cotton and corn. Several broadleaf weed species, such as palmer amaranth, waterhemp, and (indiscernible) must be controlled with a limited set of tools, including tillage and other less effective chemistries that also face the same resistant issues, and (indiscernible), and farmers are forced to (indiscernible).

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		The weeds are only on USA (indiscernible), but will continue to get worse as a great cost to farmers and consumers who benefit from the productivity. Failure to deploy multiple tools for the sake of diversifying management by farmers result in the development of resistance to one herbicides at a time, which can lead to multiple herbicide resistance evolving. When a new tool finally gets approved, all the pressure's on it. If major global competitors have access to this technology and U.S. farmers do not, it will hurt global competitors, exports, and economic value. This is very important in all American agriculture to see if this gets moved forward. If U.S. gives up leadership in these important technologies, it will be a major setback in reaching the critical goal of growing production to meet the demand of a growing and hungry population on planet earth. U.S. farmers already manage these tools and many others responsibly. Although it is EPA's job to regulate matters related to chemistry, USDA should know that farmers use herbicides responsibly and understand the risk of careless misuse. Farmers and applicators who use these tools are highly sophisticated. These have to be in order to stay in business. Awareness and compliance with labels is higher than ever as the applicator training and experience. The sophistication of application equipment, safety features, and GIS systems is far beyond what most of the public, including regulators, ever experienced in their vehicles, offices, or Smartphone apps. As it relates to herbicide resistance, farmers have rapidly adopted diverse weed management programs that put more weight on multiple herbicides, tillage and cultural practices and one herbicide. This has been the (indiscernible) neglect of safe resistance. These new tools are critical of broadleaf control that do not provide the full strength and control of (indiscernible) or even the same timing flexibility, not effective in all tall weeds. It is impossible for a farmer to rely exclusively on them the way glyphosate (indiscernible) was often used for many years, which leads to resistant weeds. After decades of use on hundreds of

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		millions of acres over time, there are very few weed resistance to these chemistries. As it relates to drip and off-site movement, these chemistries are very familiar to farmers who have used them over the last several decades. In 2012, over 30 million acres of U.S. crop (indiscernible) was treated with dicamba. A large crop market was done. Farmers and applicators are eager to use the new formulation and technologies to reduce any drip on off-site movement. This is motivated by a good neighbor stewardship, inherent to agriculture as well as financial motives that (indiscernible) costly damage. In conclusion, many farmers who grow sensitive crops and specialty crops also grow row crops, and benefit from the use of herbicide tolerant technologies. This is more mutual need to understanding and stewardship than (indiscernible) between different crop types, as most farmers produce a variety of crops for economic and agronomic reasons. This is not about a soybean farmer and a vegetable farmer, or a cotton farmer and a soybean farmer. It's about farmers and farmers. I hope that my comments paint a clear picture for our needs here in rural agriculture. But we need this technology today because the problem is becoming more evident each and every year we wait.
Danny Murphy	Current president, American Soybean Association	As I've traveled around the country speaking to the soybean farmers this year, I continually hear the story of farmers having to deal with resistance to mainly palmer amaranth, and their frustration and desire for these new chemicals to be able to help combat that resistance. Many of those farmers have adopted no-till practices. They're comfortable with those, but their only alternative at this point is for many years to go back to tillage, which results in soil erosion and more expensive reduction costs. So it was really disappointing to see the additional delay in both the dicamba and 2,4-D products. I really feel like the farmers really need these tools to be able to combat this resistance. I think it's critical for us -- for USDA and APHIS to move these products

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		alone and give farmers the opportunity to use them. Both of these products have been used, probably 2,4-D over 50 years and dicamba over 40 years, that they've used. So farmers are familiar with those products, and I think they understand how to use them. They understand the labels that we operate under today, and they're used to dealing with off-target movement and drift and understand what they need to do to correct that. I also would like to respond as a farmer in Mississippi that grows cotton and corn and soybeans. I'm fortunate in this area that I do not have resistant palmer amaranth today. My field's more isolated, but I'm really concerned that the next time I spray, that it may show up. So these tools, both dicamba and 2,4-D, would really provide me an alternative to an alternate chemistry to make sure that I don't develop resistant palmer, or glyphosate resistant palmer. And it would really be a great benefit to me if I was able to insert one of those products in my application and be able to make sure that I don't develop that resistance in the future. I've begun to adopt no-till (indiscernible) farming just as those farmers across the nation have, and super savings in soil erosion and reduced reduction cost, reduced inputs for diesel and labor and equipment. We really need to be able to continue to use these practices. I can say that we really need the availability of the best technology. And to delay the vote for 2,4-D and the dicamba -- and there are a number of products that are coming down the line as that will also be available and help to combat this resistance. So I think it's critical for U.S. agriculture and U.S. farmers that we have these products available.
Barron Brown	Grower	This technology is really made for the (indiscernible). I am fortunate enough that I was in the -- been a part of the Roundup Ready (indiscernible). And I had several acres of the dicamba resistant soybeans. (Comments are indiscernible.) Soybeans are not always important. From my logic, they're also important to crop in the United States. They're found on over more than 55 million acres. We've got to have this technology. That's

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		basically all I really have to say.
Bryan Young	Professor of wheat science, Southern Illinois University	Ultimately, the responsibility that I have with the university is to develop solid recommendations for growers to implement in their field, primary corn and soybeans, as well as some wheat, to be successful and profitable in managing weeds and productivity. So in terms of experience with herbicide-resistant crops, obviously, I've been involved with the use of herbicide-resistant crops with both corn and soybean to date, and I have been involved with testing both the dicamba tolerant soybean system, as well as the 2,4-D tolerant soybean system, the Roundup Ready, and then corn and beans (indiscernible). I think I first want to comment on what brought you to this point. So there's a need for the technology because we have seen a rapid decline in recent years in the robust weed control that we can achieve with glyphosate in some geographies because of resistance. But it's not just resistance to glyphosate, it's resistance to the other herbicides that we have used in the past, such as the inhibiting herbicides, the triazine herbicides, the PTO-inhibiting herbicides. And so, it's been a culmination that's been building for years were you selected for herbicides as to weed biotypes that have been extremely problematic, and now it's represented within the (indiscernible) complex, as well as amaranth and pigweed family, both waterhemp and palmer amaranth. And so, there's a definite need. I'll just share that on Friday, I had a phone call from somebody who is involved with the industry giving recommendations to growers. And they wanted me to provide them, what criteria do I give to the grower to determine if they just dig up the entire soybean field and try again because they applied all available herbicides to date this year, and they still have waterhemp that they were not able to control. And so they obviously need additional tools. So we've gotten to this point where the previous herbicides that

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		we've utilized are not working out, (indiscernible) herbicides resistance, and we need additional tools, and in some cases more herbicides, which sounds like more fuel on the fire, but I would contend that is probably the best solution we have to date until another alternative presents itself. But none have as of yet. So we've gotten to this point in some ways because of our efforts to be more sustainable in crop productivity and crop production. I was part of an analysis looking at the sustainability of U.S. soybean production. That was a publication by CAS (ph), Council for Cultural Science and Technology (ph), and I was the author for the part of weed management side. And that publication spoke towards the greatest component, at least towards sustainability, of soybean production in the U.S., its conservation tillage practices. And because we are reducing the amount of tillage that we use pre-plant or in the fall, or even row cultivation, that means we rely more heavily on herbicides today that we ever have. And so, it would be logical to expect that an outcome of that would be greater selection pressure for herbicide-resistant weeds. So it's not a surprise that in our efforts to be more sustainable in soil conservation practices, that we have greater challenges in how we utilize our herbicides. Now, how do these two technologies fit, the 2,4-D and dicamba technology? Well, actually we've used these herbicides for decades. That has been mentioned by some of the growers as well as Mike Owen and Bob Wolf, who participated thus far. So we're really expanding their use window, so it allows greater flexibility utilizing the herbicides to provide a greater benefit in overall weed management, and I would say the sustainability or stability, if you will, of our weed management practices. So I think they're a key component, and right now they're the only component that we have available because the discovery of new herbicides active ingredients, like that have come in the past 50 years, that pipeline of new active ingredients has dried up temporarily possibly. But we don't have any alternatives, so we're going back to the older herbicides that growers have decided that didn't provide as much benefit. And so these two technologies,

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		2,4-D and dicamba, provide another -- some other options that I would suggest might be favored than some of the other alternatives that we might be considering, especially when it comes to conservation practices and some of the deep tillage that might be occurring in some areas because of these resisting weeds. So the other thing I want to comment about is I have tested both the technologies that have been listed on ready to extend, and in the program, if you will, the herbicide program concept. Now, how we achieve weed control with these technologies in the future, as stated before, it's not just a 2,4-D or a dicamba, and that's all you need like we did with squat (indiscernible), and soon won't develop resistance. I think in most cases I've seen residual herbicides, which represent different herbicide modes of action that are utilized prior to planting and then after planting. And then other herbicides, that all provide solar (ph) activity. It might be glufosinate or glyphosates, around the liberty involved in the mixtures as well. So what I have tested in my research on glyphosate-resistant waterhemp (indiscernible) and glyphosate-resistant marestail, with these technologies has been multiple herbicide modes of action to develop a more sustainable weed management program. So it's not just based on a single herbicide active ingredient. It's more robust, so I think that it is a more sustainable approach to achieving a well-rounded IPM approach for how we manage our weeds. And those are the things I think are important because, as stated before, 2,4-D or dicamba will not control all of our weeds. It's going to be required to involve other herbicides. And I think that is the part that's different than where we went through with the Roundup Ready system back in 1996 when it was released. So moving forward over the next ten years, obviously weed management is going to get a lot more difficult because if we don't have other alternatives to glyphosate that are viable or another older herbicide like the PPO-inhibiting herbicides, we're going to continue to use those herbicides, and we're going to continue to

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		get more resistance to those herbicides and create an even larger problems than what we have today. So it's going to be a challenge to manage these until we get these tools that tell us as scientists be more -- that are able to develop these solutions. And as growers or crop consultants to devise a program on a field-by-field basis to be sustainable as much as possible, as well as being effective and profitable in wheat management and crop production.
Jim Broten	Grower and past chairman, U.S. Grains Council	As you can see, the farmers across the nation all emphasize the importance of our needed to use both 2,4-D and dicamba. And to use it with glyphosate tolerance would just be fantastic. We are in a world market. We need it to feed the world, but we also need to be competitive. And we need all the advantages that we can have, and we need to encourage USDA to pass this quickly as they can.

Appendix 3. Weed Management and Herbicide Use

Weed Management and Herbicide Use

Weed control programs are important aspects of soybean and cotton production intended to prevent the establishment of plants other than the intended crop. In crop production systems, these plants, identified as weeds, are controlled using a number of tactics to maximize the production of food, fiber, and fuel (Green and Martin, 1996). The goal of weed management is to reduce weed populations, allowing for more efficient use of herbicides and other cultural practices to control weeds.

Each field has a finite amount of resources, i.e., light, nutrients, and moisture, available for the growth and development of crops. Weeds allowed to compete with crops can ultimately result in crop yield loss. Once the critical period of weed control (CPWC) has been reached, if weed control is delayed, the yield loss can increase fairly rapidly. Knezevic concluded that delaying the time of weed removal after the starting point of CPWC will cost soybean producers an average of 2% in yield loss per every leaf stage of delay (Knezevic *et al.*, 2003). According to Iowa State University research, uncontrolled weeds of 3-4 inches in corn at the V-3 to V-4 growth stage have been shown to decrease yields by about 3 bushels per acre per day (Rosenberg, 2013). For cotton, if weed control is implemented later than 30 days after crop emergence, it will result in a crop loss yield of greater than 1 % (Schutte *et al.*, 2010).

Weeds species present varying degrees of competitiveness. Table 3-1 shows the potential yield losses associated with specific weed species present at two different densities. The impacts to yield are based on normal weather conditions and adequate soil moisture and assume that the weeds emerged with the crop. Crops under drought conditions or other stresses may have higher yield losses. According to the data, at higher densities annual broadleaf weeds impact yields more than annual grasses (Ontario Ministry of Agriculture and Food, 2009).

The degree of yield loss for a crop can be related to:

- Environmental conditions (e.g., temperature, moisture, etc.),
- The distribution of weed species within a given field;
- Weed density; and
- The timing of weed emergence (i.e., weed height) relative to the crop growth stage (Knezevic, 2007).

Therefore, weed management programs should not only focus on minimizing weed density and yield reductions, they should also include approaches to minimize weed seed banks. Eliminating weeds before seed production diminishes contributions to the weed seed bank and provides the best assurance for improving future weed management.

Weed control programs vary by crop, weed problem, geography, and cropping system (e.g., no-till, conventional-till, etc.). Many growers use a combination of weed control techniques, including cultural, mechanical, and chemical. Practices that establish a dense, vigorous crop canopy quickly (e.g., higher seeding rates, optimum soil fertility, proper seedbed preparation, seeding depth) provide competition to smother weeds.

The keys components to successful weed management are:

- Knowing the exact identity of all weeds in the field;
- Treating (if necessary) while the weeds are small;
- Tailoring control measures to the type of weed and its size (Linker *et al.*).

Although weed control typically involves an integrated approach that includes herbicide use, crop rotation, weed surveillance, and weed monitoring (Farnham, 2001; IPM, 2004; 2007; Hartzler, 2008; University of California, 2009), currently, herbicides are the most common and efficient tactic to manage weeds within agroecosystems (Gianessi and Reigner, 2007). Various strategies utilized for weed management are discussed in the following sections.

<u>Chemical Control - Herbicides</u>

Herbicides are chemicals that move into a plant and disrupt vital biological process. Herbicides have been the primary tactic used to manage weed communities in cotton and soybean since the mid-1960s and will continue to be an important feature of row crop weed management for the foreseeable future. One study, which examined aggregated data on crop yield losses and herbicide use, estimated that even if additional tillage and hand weeding labor replaced the use of herbicides, U.S. crop production would decline by 20 percent with a $16 billion loss in value if herbicides were not used (Gianessi and Reigner, 2007). Herbicide use is not regulated by APHIS but rather by EPA under FIFRA and its amendments.

Before selecting a herbicide program, growers should know what weeds are present or expected to appear, the soil texture and organic matter content, capabilities and limitations of the various herbicides, and how to best apply the herbicides (York and Culpepper, 2000). Additionally, when selecting an herbicide, a grower must consider, among other factors, whether an herbicide can be used on the crop (herbicides are registered by EPA for specific uses and crops), potential adverse effects on the crop, residual effects that can limit crops that can be grown in rotation, effectiveness on expected weeds, and cost.

To be effective, herbicides must (1) adequately contact plants, (2) be absorbed by plants, (3) move within the plants to the site of action without being deactivated, and (4) reach toxic levels at the site of action (Penn State Extention, 2013).

Herbicides are classified according to their effects on plants as either selective or nonselective. Selective herbicides will kill weeds without significant damage to desirable plants. Nonselective herbicides kill or injure all when applied at an adequate rate (Penn State Extention, 2013). Herbicide action is either contact or systemic. Contact herbicides kill only plant tissue contacted by the chemical. Systemic herbicides are absorbed from the point of application, either the roots or foliage, and move within the plant to other plant parts. Systemic herbicides may be effective against both annual and perennial weeds, but are particularly effective for control of established perennial weeds. However, systemic movement of an herbicide in perennial weeds can vary seasonally (NC State University, 1998).

Applications of herbicides to a crop or weed are described according to when they are applied:

- Pre-plant (i.e., burndown): applied to soil before the crop is planted. In burndown situations, there is no crop present requiring post-emergence selectivity if soil-residual herbicide is a component of the burndown application. Burndown applications in both cotton and soybean often incorporate glyphosate, dicamba, and 2,4-D and may include paraquat or glufosinate to control weeds prior to planting the crop.

- Pre-plant incorporated (PPI): for PPI, herbicides are applied to soil and mechanically incorporated into the top 2 to 3 inches of soil before the crop is planted.
- Pre-emergence: applied after the crop is planted, but prior to emergence of the crop. Pre-emergent herbicides are generally not effective after weeds have established.
- Post-emergence: applied after the weeds and crop emerges. Early post emergence application occurs when the crop has just emerged and the weeds are small. Post-emergent herbicides selectively target weeds relative to the crop. The post materials have activity when applied to leaves and can be used over the top of crops if the crop is resistant to the active ingredient.

Most herbicides used as pre-plant and pre-emergent applications are residuals, herbicides that remain active for several weeks and theoretically work continuously after application. These types of herbicides are finding increasing use in the management of glyphosate-resistant weeds. (See Appendix 4, Herbicide Use Trends, for more details). Examples include acetochlor, trifluralin, metolachlor, metolachlor-S, pendimethalin, atrazine and alachlor. These herbicides work by controlling weeds before they germinate or emerge. Usually residual herbicides need to be activated by water (Hager and McGlamery, 1997). In rainfed crops, residual herbicides may fail to become activated during drought. The foliar product controls emerged weeds while the residual material controls weeds prior to germination or emergence.

When herbicides are applied, biochemical pathways that control the growth and development of plants are interrupted and plant death and injury occurs (Sosnoskie and Hanson). These biochemical pathways control the growth and development of plants; when herbicides are applied, these processes are constrained and plant injury and death will occur. Most herbicides bind to, and thereby block the action of, a specific enzyme. Herbicides are classified according to their mode of action, which is the overall manner in which the herbicide affects a plant at the tissue or cellular level. The Weed Science Society of America (WSSA) has classified herbicides by group number, based on their mode of action. Brief descriptions of these groups are provided (Sosnoskie and Hanson) :

Group 1: herbicides inhibit the action of acetyl CoA carboxylase (ACCase) needed for the synthesis of lipids. Grasses, but not broadleaf weeds, are affected.

Group 2: herbicides inhibit the action of acetolactate synthase (ALS) needed for the synthesis of three amino acids (isoleucine, leucine, and valine).

Group 3: herbicides inhibit cell division (mitosis inhibitors).

Group 4: herbicides are growth regulators. At low concentrations, they mimic the plant growth hormone auxin and are referred to as synthetic auxins. At high concentration they produce distinctive symptoms on broadleaf weeds; twisted and curled stems, malformed flowers, thickened or stunted roots, and cupped, strapped or otherwise deformed leaves. Grasses are usually resistant.

Group 5, 6, and 7: herbicides inhibit photosynthesis leading to a buildup of highly reactive free radicals that damage chlorophyll and cell membranes.

Group 8: herbicides inhibit fatty acid and lipid biosynthesis but not ACCase (Group 1).

Group 9: herbicides inhibit the action of the enzyme enolpyruvyl shikimate-3-phosphate synthase (EPSPS) needed for the synthesis of three aromatic amino acids (tryptophan, phenylalanine, and tyrosine) that are produced through the shikimate pathway.

Group 10: herbicides inhibit glutamine synthetase. These herbicides stop the conversion of glutamate and ammonia to glutamine which causes ammonia to accumulate in the plant, inhibiting photosynthesis and destroying plant cells.

Group 12: herbicides inhibit carotenoid biosynthesis. Lack of carotenoids results in destruction of chlorophyll, which is needed for plant photosynthesis.

Group 14: herbicides inhibit protopophyrinogen oxidase (PPO). PPO inhibitors block the production of chlorophyll and cause reactive molecules to form in the cell, resulting in the destruction of existing chlorophyll molecules, carotenoids and cell membranes.

Group 15: herbicides block mitosis by inhibiting the synthesis of very long chain fatty acids.

Group 20, 21, 29: herbicides inhibit the synthesis of cellulose needed for the synthesis of cell walls.

Group 22: herbicides inhibit photosystem I (PSI) forming reactive molecules that destroy lipids, eventually breaking down plant cell membranes.

Group 27: herbicides inhibit 4-hydroxyphenyl-pyruvate-dioxygenase needed for the synthesis of carotenoids.

Herbicides with a common chemistry are grouped into “families.” Also, two or more families may have the same site of action, and thus can be grouped into “classes.” Table 3-1 provides WSSA herbicide groups with information on modes of action, chemical families, and example active ingredients and herbicides.

Table 3-1. Herbicide Groups with Example Active Ingredients and Herbicides.

	Site of Action Group (WSSA Group)	Site of Action	Number of Resistant Weed Species in U.S.	Chemical Family	Active Ingredient	Herbicide
Lipid Synthesis Inhibitors	1	ACCase Inhibitors (acetyl CoA carboxylase)	15	Aryloxyphenoxy propionate (“FOPs”)	fenoxaprop	Puma
					diclofop	Hoelon
					fluazifop	Fusilade
					quizalofop	Assure II

	Site of Action Group (WSSA Group)	Site of Action	Number of Resistant Weed Species in U.S.	Chemical Family	Active Ingredient	Herbicide
				Cyclohexanedione (“DIMs”)	clethodim	Select
					sethoxydim	Poast
				Phenylpyrazoline (“DENs”)	pinoxaden	Axial XL
Amino Acid Synthesis Inhibitors	2	ALS Inhibitors (acetolactate synthase)	44	Sulfonylurea (“SUs”)	chlorimuron	Classic
					foramsulfuron	Option
					halosulfuron	Permit
					iodosulfuron	Autumn
					nicosulfuron	Accent
					primisulfuron	Beacon
					prosulfuron	Peak
					rimsulfuron	Resolve
					thifensulfuron	Harmony
					tribenuron	Express
					metsulfuron	Ally
					triasulfuron	Amber
					chlorsulfuron	Glean
					sulfofsulfuron	Maverick
					mesosulfuron	Osprey
				Imidazolinone (“IMIs”)	imazamox	Beyond
					imazaquin	Scepter
					imazapic	Cadre
					imazethapyr	Pursuit
				Triazoloyrmidine	flumetsulam	Python
					chloransulam-methyl	FirstRate
					pyroxysulfam	PowerFlex
					diclosulam	Strongarm
				Triazolinones	thiencarbazone	Component of Caperno
				Pyrimidinyl(thio) benzoate	pyrithiobac	Staple
				Sulfonylaminocarbonyl-triazilonones	flucarbazone	Everest
					propoxycarbazone	Olympus
	9	EPSP Synthase Inhibitor	13		glyphosate	RoundUp
Growth Regulators (Synthetic Auxins)	4	Specific Site Unknown	10	Phenoxy	2,4-D	
					2,4-DB	Butyrac
					MCPA	
				Benzoic acid	dicamba	Banvel
				Carboxylic acid	chlopyralid	Stinger
					fluroxypr	Starane
					picloram	Tordon
	19	Auxin Transport	0	Semicarbazone	diflufenzopyr	Component of Status
Photosynthesis	5	Photosynthesis	24	Triazine	prometryn	Caparol

	Site of Action Group (WSSA Group)	Site of Action	Number of Resistant Weed Species in U.S.	Chemical Family	Active Ingredient	Herbicide
Inhibitors		II Inhibitors (binding sites other than 6 and 7)			atrazine	Aatrex
					simazine	Princep
				Triazinone	hexazinone	Velpar
					metribuzin	Sencor
	6	Photosynthesis II Inhibitors (binding sites other than 5 and 7)	1	Nitrile	bromoxynil	Buctril
				Benzodiazole	bentazon	Basagran
	7	Photosynthesis II Inhibitors (binding sites other than 5 and 6)	7	Ureas		Lorox
Nitrogen Metabolism	10	Glutamine Synthesis Inhibitor		Phosphonic Acid	glufosinate	Liberty
Pigment Inhibitors	13	Diterpene Synthesis Inhibitors	1	Isoxazolidinone	clomazone	Command
	27	HPPD Inhibitors	1	Isoxazole	isoxaflutole	Balance
				Pyrazolone	topramezone	Impact
				Triketone	mesotrione	Callisto
					tembotrione	Laudis
Cell Membrane Disruptors	14	PPO Inhibitors	2	Diphenylether	acifluoron	Blazer
					fomasefen	Reflex
					lactofen	Cobra
					oxyfluorfen	Goal
				N-Phenylphthalamide	flumiclorac	Resource
					flumioxazin	Valor
				Aryl triazinone	sulfentrazone	Spartan
					carfentrazone	Aim
					fluthiacet-ethyl	Cadet
	27	Photosystem I Electron Diverter	5	Bipyridium	paraquat	Gramoxone Inteon
					diquat	Reglone
Seedling Root Growth Inhibitors	3	Microtubule Inhibitors	6	Dinitroaniline	ethalfluralin	Sonalan
					pendamethalin	Prowl
					trifluralin	Treflan
Seedling Shoot Growth	8	Lipid Synthesis	8	Thiocarbamate	butylate	Sutan +
					EPTC	Eradicane

	Site of Action Group (WSSA Group)	Site of Action	Number of Resistant Weed Species in U.S.	Chemical Family	Active Ingredient	Herbicide
Inhibitors		Inhibitors				
	15	Long-chain Fatty Acid Inhibitors	1	Chloroacetamide	acetochlor	Harness
					alachlor	Intrro
					metalochlor	Dual
					dimethanamid	Outlook
				Oxyacetamide	flufanacet	Define
				Pyrazole	pyroxasulfone	Zidua

Sources: (Armstrong, 2009; Glyphosate Stewardship Working Group, 2012).

Mechanical Weed Control – Tillage

Prior to planting, the soil must be stripped of weeds that would otherwise compete with the crop for space, water, and nutrients. Tillage is used to prepare a seedbed, address soil compaction, incorporate fertilizers and herbicides, manage water movement both within and out of a production field, and control weeds (Heatherly *et al.*, 2009). Soil cultivation or tillage can be very valuable in many situations and should be considered as an alternate weed control practice where appropriate:

- Tillage serves as another way to control weeds and break certain weed patterns
- Tillage reduces complete reliance on herbicides
- Periodic tillage is a reliable cultural practice that also provides the benefits of removing trash build-up on the soil surface and levels ruts or rough spots in fields.

Some form of conservation tillage is utilized by the majority of cotton and soybean growers. Tillage can supplement chemical control (i.e., herbicides) and, in the case of light weed infestations, could provide sufficient control if used alone. Cultivation should be shallow to reduce crop root damage and to avoid breaking through any residual herbicide layer and bringing up untreated soil and weed seed. Use of tillage is optimized when weeds are small and should not be practiced for a week prior or after post-emergence herbicide application (York and Culpepper, 2000).

Tillage can be a useful weed control method in some situations but may not be appropriate for all producers or areas. For example, tillage is not a good practice where soils are susceptible to erosion. Also, no-till soybean production is less successful in heavier, cooler soils more typical of northern latitudes (Kok *et al.*, 1997; NRC, 2010).

Although tillage may control weeds, fuel costs and machine maintenance may represent substantial farm expenditures (NRC, 2010). This fact and the availability of herbicide technology have driven producers to increasingly adopt chemical management strategies. For example, in 2012, 98 percent of soybean acreage was treated with synthetic herbicides (USDA-NASS, 2013).

Cultural Weed Control

The successive planting of different crops on the same land is known as crop rotation. In contrast, the planting of the same crop on the same field in successive years is known as continuous crop production. Crop rotations are used to optimize soil nutrition and fertility, reduce pathogen loads, control volunteers (carry over in successive years), and limit the potential for weeds to develop resistance to herbicides (IPM, 2004; 2007; USDA-ERS, 2010).

Crop rotation is also a key element of successful weed control as it often reduces the populations of weeds that closely mimic the appearance of the young crop or are tolerant to herbicides often used in these crops. Crop rotation should be an integral component of a weed management program. Crop rotation generally leads to healthier crops that are more competitive with weeds. Moreover, certain weeds are more easily or more economically managed in one crop than in another. Additionally, crop rotation allows use of different herbicide chemistries on the same field in different years. This can prevent weed population shifts (changes in the species composition), avoid selection of herbicide resistant weeds, and help to keep the overall weed population at lower levels.

Weed control in cotton is essential to maximize both yield and quality of cotton fiber. The slow early growth of cotton does not permit the crop to aggressively compete against weed species that often grow more rapidly and utilize the available water, nutrients, light, and other resources for growth (Smith and Cothren, 1999). Cotton yields can be reduced substantially if weeds are uncontrolled. Palmer amaranth has been reported to cause yield losses as high as 54 percent (Morgan *et al.*, 2001) and johnsongrass and barnyardgrass have been reported to reduce yields by 90 percent and 98 percent, respectively (Vargas *et al.*, 1996). Based on 2005 data, not using herbicides in cotton would result in an increased production cost of approximately $2.3 billion annually and an estimated yield loss of 27 percent (Gianessi and Reigner, 2006).

Weed-crop competition studies have demonstrated that the control of weeds during the first four to eight weeks after cotton planting is critical as weeds compete against the crop for water, nutrients, light and other resources necessary for growth (Smith and Cothren, 1999). The primary weed competition factors affecting yield loss potential are the weed species, weed density, and the timing/duration of weed competition. Cotton emergence and above ground growth is relatively slow during the first few weeks after planting, and does not permit the crop to aggressively compete against often more rapidly developing weed species (Smith and Cothren, 1999). In addition, cotton is primarily planted using wide row spacing which delays crop canopy closure until layby stage of cotton and extends the window of weed-crop competition.

Crop rotation is a common practice on U.S. soybean fields, with approximately 95 percent of the soybean acreage planted in some form of a crop rotation system since 1991 (USDA-ERS, 2013). A variety of crops may be rotated with soybean. In terms of acreage however, corn is the most commonly rotated crop. In a survey of major corn/soybean production states, corn and soybean were alternated on 72 to 80 percent of acreage, other rotations were grown on 16 to 20 percent of acreage, and soybean was grown continuously on 5 to 12 percent of acreage between 1996-2002 (Sandretto and Payne, 2006). Other crops that may be rotated with soybean include wheat, cotton, rice, sorghum, barley, oats, and dry beans.

The mitigation of pest cycles on an agricultural field is one of the primary benefits of crop rotation. The rotation of other crops following soybean production may disrupt pest life cycles that are more adapted to soybean field cultivation than other crops (Poole, 2004) through the creation of a relatively unstable agroecosystem (Weller *et al.*, 2010). For example, crop rotation may encourage the use of alternative herbicides to further control broadleaf weeds in the same field in successive years that would not otherwise be used if continuous soybean was grown (Gunsolus, 2012).

Planting high-quality, weed-free crop seed is another cultural practice that keeps weed infestations low and easier to manage. One of the most effective means of reducing weed competition is to establish a highly competitive crop. This is best accomplished by planting good quality seed into a well-prepared seedbed with good fertility and soil moisture. Higher seeding rates can help establish a competitive crop and for some weed species delaying planting will allow for destruction of early flushes of weeds via tillage or non-selective herbicide application.

Integrated Weed Management

To reduce or mitigate against the selective pressures associated with the use of a single weed management practice, agronomists have recommended that growers adopt a diverse weed management strategy, also known as integrated weed management (IWM) (Norsworthy, 2012; HRAC, 2013). Effective IWM in crops usually involves a combination of cultural, mechanical, and chemical methods. Thus, IWM does not exclude any one management technique. IWM integrates practices such as crop rotation, cover crops, competitive crop cultivars, the judicious use of tillage, and targeted herbicide application to reduce weed populations and selection pressures toward the development of herbicide resistant weeds (Mortensen *et al.*, 2012).

Resistance management begins with good agronomic practices, including the implementation of IWM to incorporate diverse weed control practices to reduce the frequency of herbicide applications and decrease selection pressure for herbicide resistant weed populations (Norsworthy, 2012). IWM programs that use herbicides from different groups, vary cropping systems, rotate crops, and use mechanical as well as chemical weed control methods will prevent the selection of herbicide-resistant weed populations (Powles, 2008; Green and Owen, 2011; Sellers *et al.*, 2011; Gunsolus, 2012; HRAC, 2013).

The Herbicide Resistance Action Committee, an industry-based group, has developed the following general principles of weed resistance management:

- Apply integrated weed management practices. Use multiple herbicide sites-of-action with overlapping weed spectrums in rotation, sequences, or mixtures;
- Use the full recommended herbicide rate and proper application timing for the hardest to control weed species present in the field;
- Scout fields after herbicide application to ensure control has been achieved. Avoid allowing weeds to reproduce by seed or to proliferate vegetatively; and
- Monitor site and clean equipment between sites.

For annual cropping situations, the following recommendations of the Herbicide Resistance Action Committee (HRAC, 2013) are provided:

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

References

Armstrong, J. "Herbicide How-to: Understanding Herbicide Mode of Action." Oklahoma Cooperative Extension Service, 2009. Vol. PSS-2778. http://pods.dasnr.okstate.edu/docushare/dsweb/Get/Version-11370/Pss2778web.pdf.

Farnham, D (2001) "Corn Planting." Cooperative Extension Service, Iowa State University of Science and Technology. Last Accessed: April 6, 2011 http://www.extension.iastate.edu/publications/pm1885.pdf.

Gianessi, L and Reigner, N (2007) "The value of herbicides in U.S. crop production." *Weed Technology*. (21): p 559-66.

Gianessi, LP and Reigner, NP (2006) "The Value of Herbicides in U.S. Crop Production 2005 Update." CropLife America. http://croplifefoundation.files.wordpress.com/2012/07/2005-update-report-and-data.pdf.

Glyphosate Stewardship Working Group. "GWC-3, Corn and Soybean Herbicide Chart." *Glyphosate, Weeds, and Crop Series*2012. http://www.glyphosateweedscrops.org/Info/MOA_060807.pdf.

Green, DJ and Martin, RJ (1996) "Dealing with Perennial Broadleaf Weeds in Conservation Tillage Systems."

Green, JM and Owen, MD (2011) "Herbicide-resistant crops: Utilities and limitations for herbicide-resistant weed management." *Journal of Agricultural and Food Chemistry*. 59 p 5819-29.

Gunsolus, J (2012) "Weed Control in Soybean." Last Accessed: January, 2013 http://appliedweeds.cfans.umn.edu/weedbull/Soybeans.pdf.

Hager, A and McGlamery, M. "Principles of Postemergence Herbicides." Champaign, IL: University of Illinois, Cooperative Extension Service, 1997. 3. http://bulletin.ipm.illinois.edu/pastpest/articles/v977h.html.

Hartzler, B (2008) "Timeliness Critical to Protect Corn Yields." Iowa State University Extension. http://www.extension.iastate.edu/CropNews/2008/0523BobHartzler.htm.

Heatherly, L; Dorrance, A; Hoeft, R; Onstad, D; Orf, J; Porter, P; Spurlock, S; and Young, B (2009) "Sustainability of U.S. Soybean Production: Conventional, Transgenic, and Organic Production Systems." Council for Agricultural Science and Technology. http://www.cast-science.org/publications/index.cfm/.

HRAC (2013) "Herbicide Resistance Action Committee (HRAC): Resistance Management Strategies." http://www.hracglobal.com/.

IPM (2004) "Crop Profile for Field Corn in Pennsylvania." Department of Agronomy, Penn State University.

IPM (2007) "Crop Profile for Corn in the Northern and Central Plains (KS, NE, ND, and SD),."

Knezevic, S (2007) "Timing Weed Control in Corn to Get the Most Effect." http://cropwatch.unl.edu/archive/-/asset_publisher/VHeSpfv0Agju/content/891332.

Knezevic, SZ; Evans, SP; and Mainz, M (2003) "Yield Penalty Due to Delayed Weed Control in Corn and Soybean." *Crop Managment.* http://www.plantmanagementnetwork.org/pub/cm/research/2003/delay/.

Kok, H; Fjell, D; and Kilgore, G (1997) "Seedbed Preparation and Planting Practices-Soybean Production Handbook." Kansas State University. http://www.ksre.ksu.edu/library/crpsl2/c449.pdf.

Linker, H; Coble, H; Van Duyn, J; Dunphy, E; Bacheler, J; and Schmitt, D (unknown) "Chapter 3 - Scouting for Weeds." http://ipm.ncsu.edu/soybeans/Scouting_Soybeans/scouting_for_weeds.html.

Morgan, GD; Baumann, PA; and Chandler, JM (2001) "Competitive impact of Palmer amaranth (Amaranthus palmeri) on cotton (Gossypium hirsutum) development and yield. ." *Weed Technology.* 15 (3): p 408-13. http://www.bioone.org/doi/pdf/10.1614/0890-037X(2001)015%5B0408:CIOPAA%5D2.0.CO%3B2.

Mortensen, DA; Egan, JF; Maxwell, BD; Ryan, MR; and Smith, RG (2012) "Navigating a Critical Juncture for Sustainable Weed Management." *Bioscience.* 62 p 75-84. http://bioscience.oxfordjournals.org/content/62/1/75.

NC State University (1998) "Postemergence, Non-Selective Herbicides for Landscapes and Nurseries " http://www.ces.ncsu.edu/depts/hort/hil/hil-648.html.

Norsworthy, JK, Ward, S. M., Shaw, D. R., Llewellyn, R. S., Nichols, R. L., Webster, T. M., Bradley, K. W., Frisvold, G., Powles, S. B., Burgos, N. R., Witt, W. W., and Barrett, M. (2012) "Reducing the Risks of Herbicide Resistance: Best Management Practices and Recommendations." *Weed Science.* (Special issue): p 31-62. http://www.bioone.org/doi/abs/10.1614/WS-D-11-00155.1.

NRC (2010) *The Impact of Genetically Engineered Crops on Farm Sustainability in the United States*. Washington, DC: National Academies Press. http://www.nap.edu/catalog.php?record_id=12804.

Ontario Ministry of Agriculture and Food (2009) "Chapter 12: Weed Control: Crop Yield Losses Due to Weeds." http://www.omafra.gov.on.ca/english/crops/pub811/12crop.htm.

Penn State Extention (2013) "Herbicides " http://extension.psu.edu/pests/weeds/control/introduction-to-weeds-and-herbicides/herbicides.

Poole, T (2004) "Crop Rotation." University of Maryland - Maryland Cooperative Extension. Last Accessed: December, 2012 http://extension.umd.edu/publications/pdfs/fs784.pdf.

Powles, SB (2008) "Evolution in action: Glyphosate-resistant weeds threaten world crops." *Outlooks on Pest Management.* 12 p 256-59.

Rosenberg, M (2013) "Effect Of Weed Competition On Corn " http://igrow.org/agronomy/corn/effect-of-weed-competition-on-corn/.

Sandretto, C and Payne, J (2006) "Soil Management and Conservation." United States Department of Agriculture - Economic Research Service. http://www.ers.usda.gov/publications/arei/eib16/eib16_4-2.pdf.

Schutte, BJ; Hager, AG; and Davis , AS (2010) "Respray Requests on Custom-Applied, Glyphosate-Resistant Soybeans in Illinois: How Many and Why." *Weed Technology.* 24 (4): p 590-98. http://naldc.nal.usda.gov/download/47592/PDF.

Sellers, BA; Ferrell, JA; and MacDonald, GE (2011) "Herbicide Resistant Weeds." http://edis.ifas.ufl.edu/ag239.
Smith, CW and Cothren, JT (1999) *Cotton: Origin, history, technology, and production*. New York, New York: John Wiley and Sons, Inc.
Sosnoskie, LM and Hanson, B (2013) "Understanding herbicide mechanisms (modes) of action and how they apply to resistance management in orchards and vineyards." http://ceventura.ucdavis.edu/?blogtag=mode%20of%20action&blogasset=19305#.
University of California (2009) "UC IPM Pest Management Guidelines: Corn." University of California Agriculture and Natural Resources, UC Statewide Integrated Pest Management Program. http://www.ipm.ucdavis.edu.
USDA-ERS (2010) "Adoption of Genetically Engineered Crops in the U.S.: Corn Varieties." http://www.ers.usda.gov/Data/BiotechCrops/ExtentofAdoptionTable1.htm.
USDA-ERS (2013) "Crop & Livestock Practices: Soil Tillage and Crop Rotation." USDA-Economic Research Service. http://www.ers.usda.gov/topics/farm-practices-management/crop-livestock-practices/soil-tillage-and-crop-rotation.aspx.
USDA-NASS (2013) "2012 Agricultural Chemical Use Survey Soybeans." USDA-National Agricultural Statistics Service. http://www.nass.usda.gov/Surveys/Guide_to_NASS_Surveys/Chemical_Use/2012_Soybeans_Highlights/ChemUseHighlights-Soybeans-2012.pdf.
Vargas, RN; Fischer, WB; Kempen, HM; and Wright, SD (1996) "Cotton weed management." *Cotton Production Manual*. Davis, California: University of California Division of Agricultrue and Natural Resources. p 187-88.
Weller, S; Owen, M; and Johnson, W (2010) "Managing Glyphosate-resistant Weeds and Populations Shifts in Midwestern U.S. Cropping Systems." *Glyphosate Resistance in Crops and Weeds*. Hoboken, NJ: John Wiley & Sons, Inc. p 213-33.
York, AC and Culpepper, AS (2000) "Weed Management." http://www.ces.ncsu.edu/plymouth/cropsci/cornguide/Chapter8.html.

Appendix 4. Herbicide Use Trends and Predicted Xtend™ Use on Dicamba-Resistant Soybean and Cotton

Herbicide Use Trends

The following information was presented in Monsanto's *Petitioner's Environmental Report for Dicamba-Tolerant Soybean MON 87708 and Dicamba- and Glufosinate-Tolerant Cotton MON 88701* (ER) (citation). Additional information can be obtained in the ER, which will be posted by USDA as supplementary information to the Federal Register docket for this EIS:

http://www.regulations.gov/#!docketDetail;D=APHIS-2013-0043

Herbicide Use – Soybean

The use of herbicides has become an important part of managing weeds in soybean. Approximately 98 percent of the soybean acreage received an herbicide application in 2012 (USDA-NASS, 2012b). The availability of herbicide-tolerant soybean products is an important aspect of weed management in U.S. soybean production. Herbicide-tolerant soybean was introduced to provide growers with additional options by improving crop safety (no herbicide damage to the crop) and improving weed control. In 2013, 93% of the U.S. soybean crop was herbicide-tolerant (USDA-ERS, 2013); almost all is glyphosate-tolerant. As a result and as shown by the 2012 use data shown in Table 4-1 (ER Appendix A, Table A-8 (Monsanto, 2013)), glyphosate is the most widely used herbicide, being applied on 98 percent of the soybean acreage in 2012, including for pre-plant burndown and post-emergence in crop applications (USDA-NASS, 2012b). In 2012, dicamba-treated acres in soybean accounted for only 87 thousand acres, or 0.07% of the total pre-emergent treated acres (USDA-NASS, 2012b). This is primarily because dicamba is phytotoxic to current soybean varieties and is therefore currently only labeled for application at timings that avoid contact with the growing plant, such as pre-plant treatments prior to planting, depending on rate and rainfall.

Over 35 different herbicide active ingredients are registered and available for use by soybean growers to control weeds. The ten most widely used alternative herbicides in soybean are listed in Table 4-2 (ER Table II.B-6 (Monsanto, 2013)). Alternative soybean herbicide use has almost doubled between 2009 and 2012. Integration of DT soybean into the glyphosate-tolerant soybean system and the subsequent use of dicamba will result in the displacement of some currently used, or foreseeable future use, non-glyphosate herbicides. Some non-glyphosate alternative herbicides have less benign human health and environmental characteristics as compared to dicamba, and reduced agronomic flexibility due to soybean planting restrictions, rotational crop planting restrictions, the need for adequate soil moisture for activation, or the need to apply prior to planting to minimize crop injury.[1] The properties of these alternative herbicides are summarized in Appendices A and C (see ER (Monsanto, 2013)) to provide a baseline for comparison to dicamba use on DT soybean.

Herbicide weed control programs in conventional soybean consist of pre-emergence herbicides used alone or in mixtures. Mixtures of two pre-emergence herbicides are used to broaden the

[1] In order to approve a new use of a herbicide EPA must conclude that the herbicide, when used according to the label, does not pose an unreasonable adverse effect to humans or the environment, and, in order to establish a tolerance for the use of a herbicide on a food or feed crop, find there is a reasonable certainty of no harm to human health from non-occupational (food, water and residential/recreational) exposures to the herbicide. Therefore, all alternative herbicides used in soybean production can be used safely, and do not pose an unreasonable risk to humans or the environment.

Table 4-1. Herbicide Applications Registered for Use in Soybean in 2012[1]

Herbicide	Chemical Family	Mode-of-Action (MOA)	Percent-Treated Acres	Total Area Applied (Percent/MOA)	Quantity Applied (1000 lb)	Total Quantity Applied (1000 lb/MOA)
Glyphosate	glycine	EPSPS inhibitor	98	100	109,336	110,589
Sulfosate	glycine		3		1,253	
Pendimethalin	dinitroanaline	Tubulin inhibitor	2	4	1,559	2,865
Trifluralin	dinitroanaline		2		1,306	
Metribuzin	triazinone	PSII inhibitor	3	11	675	1,753
Sulfentrazone	triazolinone		8		1,078	
Chlorimuron-ethyl	sulfonylurea	ALS inhibitor	11	26	187	590
Cloransulam-methyl	triazolopyrimidine		4		83	
Flumetsulam	triazolopyrimidine		*		14	
Imazamox	imidazolinone		*		6	
Imazaquin	imidazolinone		*		34	
Imazethapyr	imidazolinone		5		221	
Rimsulfuron	Imidazolinone		*		4	
Thifensulfuron	sulfonylurea		5		31	
Tribenuron-methyl	sulfonylurea		1		10	
Acetochlor	chloroacetamide	Cell division inhibitor	1	9	635	6,553
Metolachlor	chloroacetamide		7		5,683	
Dimethenamid	chloroacetamide		1		235	
Paraquat	bipyridilium	PSI disruption	3	3	813	813

Table 4-1 (continued). Herbicide Use in Soybean in the U.S. in 2012[1]

Herbicide	Chemical Family	Mode-of-Action (MOA)	Percent-Treated Acres	Total Area Applied (Percent/MOA)	Quantity Applied (1000 lb)	Total Quantity Applied (1000 lb/MOA)
Clethodim	cyclohexenone	ACCase inhibitor	9	14	524	907
Fenoxaprop	aryloxyphenoxy propionate		*		7	
Fluazifop-P-butyl	aryloxyphenoxy propionate		3		195	
Quizalofop-P-ethyl	aryloxyphenoxy propionate		2		118	
Sethoxydim	cyclohexenone		*		63	
Acifluorfen	diphenylether	PPO inhibitor	1	29	210	2,477
Carfentrazone-ethyl	triazolinones		*		1	
Fluthiacet	thiadiazole		2		10	
Flumiclorac-pentyl	N-phenylphthalimide		1		35	
Flumioxazin	N-phenylphthalimide		11		602	
Fomesafen	diphenylether		8		1,347	
Lactofen	diphenylether		2		192	
Saflufenacil	pyrimidinedione		4		80	
2,4-D	phenoxy	Synthetic auxin	15	15	6,021	6,108
Dicamba	benzoic acid		*		87	
					Total	**132,979**

* Area receiving application is less than 0.5 percent.

[1] Data derived from (USDA-NASS, 2013). Planted acreage for the nineteen primary soybean production states was 72.9 million acres, which represented 96.5% of total planted acres.

Source: Appendix A, Table A-8 (Monsanto, 2013), spectrum of control to both grasses and broadleaf weed species. Preemergence herbicides are followed by postemergence applications to control weeds that emerge later in the crop. Total postemergence weed control programs were seldom used in conventional soybean prior to 1995 when glyphosate-tolerant soybean was first introduced. Prior to glyphosate-tolerant soybean, soybean planted in a no-till system would receive a preplant burndown herbicide application for broad-spectrum control of existing weeds at time of planting, followed by different soil residual herbicides at planting and possibly still other herbicides applied postemergence to the crop and the weeds. In conventional soybeans, the typical herbicide program consisted of multiple soil residual herbicides applied preemergence to the crop and weeds and, possibly, other herbicides applied postemergence to the crop and weeds. Therefore, multiple herbicides and/or multiple applications were generally used in conventional and no-till non-glyphosate-tolerant soybean. The average number of herbicide applications per acre in soybean rose from 1.5 in 1990 to 1.7 applications in 1995, reflecting the use of at-plant and postemergence applications or two postemergence applications (Gianessi *et al.*, 2002).

Table 4-2. Ten Most Widely Used Alternative Herbicides in U.S. Soybean Production in 2012

Herbicide	Treated Acres (millions)[1]	Pounds Applied (millions)[1]
2,4-D (acid, salts, and esters,	11.58	6.02
Flumioxazin	8.49	1.56
Imazethapyr	3.86	1.35
cloransulam-methyl	3.09	0.60
chlorimuron-ethyl	8.49	0.52
Fomesafen	6.18	0.22
Clethodim	6.95	0.19
pendimethalin	1.54	0.08
Tribenuron	0.77	0.04
flumiclorac-pentyl	0.77	0.01

[1] (USDA-NASS, 2012b)
Source: Table II.B-6 (Monsanto, 2013)

Selective herbicides are designed to kill specific types of plants, usually grasses or broadleaf weeds, and have proven effective to reduce in-crop tillage or cultivation to control weeds in soybean production. The development of selective herbicides has progressed since the introduction of the first herbicide (2,4-D) for weed control in corn in early 1940s. Although the primary purpose of tillage is for seedbed preparation, tillage still is used to supplement weed control with selective herbicides in soybean production. Refer to Appendix A (see (Monsanto, 2013)) for details on alternative herbicides used in soybean production.

In glyphosate-tolerant soybean, a total of 53 different non-glyphosate herbicides had been used in the preemergence (PRE) timing, while 37 different non-glyphosate herbicides had been used in the postemergence (POST) timing Table 4-3 (ER Table A-9 (Monsanto, 2013)).

Table 4-3. Non-Glyphosate Herbicides Used in Glyphosate-Tolerant Soybeans from 2002 to 2011[a]

Preemergence (PRE) Active Ingredients			Postemergence (POST) Active Ingredients	
2,4-D	Iodosulfuron		2,4-D	Paraquat
2,4-DB	Lactofen		2,4-DB	Pelargonic acid
Acifluorfen	Linuron		Acetochlor	Pendimethalin
Alachlor	MCPA		Acifluorfen	Pyraflufen ethyl
Bentazone	Metolachlor		Alachlor	Quizalofop
Carfentrazone-ethyl	Metolachlor-S		Bentazone	Sethoxydim
Chlorimuron	Metribuzin		Carfentrazone-ethyl	Sulfosate
Chlorsulfuron	Metsulfuron		Chlorimuron	Thifensulfuron
Clethodim	MSMA		Clethodim	Tribenuron methyl
Clomazone	Nicosulfuron		Cloransulam-methyl	
Cloransulam-methyl	Norflurazon		Dicamba	
Dicamba	Paraquat		Dimethenamid	
Diflufenzopyr	Pelargonic acid		Dimethenamid-P	
Dimethenamid	Pendimethalin		Fenoxaprop	
Dimethenamid-P	Pyraflufen ethyl		Fluazifop	
Ethalfluralin	Quizalofop		Flumetsulam	
Fenoxaprop	Rimsulfuron		Flumiclorac	
Fluazifop	Saflufenacil		Flumioxazin	
Flufenacet	Sethoxydim		Fluthiacet-methyl	
Flumetsulam	Simazine		Fomesafen	
Flumiclorac	Sulfentrazone		Imazamox	
Flumioxazin	Sulfosate		Imazaquin	
Fluthiacet-methyl	Thifensulfuron		Imazethapyr	
Fomesafen	Tribenuron methyl		Lactofen	
Glufosinate	Trifluralin		Linuron	
Imazamox			Metolachlor	
Imazaquin			Metolachlor-S	
Imazethapyr			Naptalam	

[a] Unpublished market research data (Monsanto, 2012b)
Source: Table A-9 (Monsanto, 2013).

<u>Herbicide Use – Cotton</u>

Herbicides are used on essentially all (>99%) cotton acres, and in 2011 approximately 39 million pounds of herbicides were applied pre- or postemergence in cotton production (Brookes and Barfoot, 2012; Monsanto, 2012b). According to 2010 market data[2], there were approximately 46.3 million herbicide-treated cotton acres. Herbicides were applied to 21.8 million acres prior to the planting or emergence of cotton (preemergent) and to 24.5 million acres after the emergence of cotton (postemergent). For clarification, the market survey data counts one treated acre as the application of one active ingredient (a.i.) one time to an acre. If the same a.i. is applied a second time to that same acre or if two a.i.s are applied, it counts as two treated acres. USDA reports that 11.0 million acres of cotton were planted in 2010,[3] so that the 46.3 million herbicide-treated cotton acres means that on average each planted

[2] Monsanto Company. 2011. Farmer Survey Data. St. Louis, MO.

[3] USDA Statistics for crops and geographic regions are available at http://www.nass.usda.gov/index.asp.

acre received at least 4 herbicide treatments. Cotton acres also received on average four treatments with herbicides during the 2011 growing season (USDA-ERS, 2012).

Herbicide-tolerant cotton is planted on the majority of U.S. cotton acres (73% in 2011), which allows for the postemergence in-crop use of glyphosate for control a broad spectrum of weeds. Glyphosate is the most widely-used herbicide in cotton, applied on 91% of cotton acres with an average of 2.4 applications per growing season (Monsanto, 2012b). In 2010, between 49 and 76% of the growers who plant glyphosate-tolerant (GT) cotton applied non-glyphosate herbicides prior to planting, at planting, or postemergence. Percentages varied among cropping systems, with 76% of GT cotton in a rotation system with GT soybean receiving non-glyphosate herbicide applications, whereas non-glyphosate herbicides were only applied 49% of the time in continuous cotton cropping systems (Prince *et al.*, 2011a).

Over 30 different herbicide active ingredients are registered and available for use by cotton growers to control weeds. Table 4-4 (ER Table A-33 (Monsanto, 2013)) provides a summary of the herbicide applications registered for use in cotton in 2011, demonstrating that herbicides are used on essentially all (>99%) cotton acres in the U.S (Brookes and Barfoot, 2012; Monsanto, 2012b). Approximately 39 million pounds of herbicide active ingredient were applied to cotton in 2011.

Of these treatments, 50% (23.3 million acres) were made with glyphosate herbicides, and the remaining 50% of treatments were made with more than 25 other active ingredients. The number of glyphosate applications on an average cotton acre was between 2 and 3 applications per year at an average rate of 2.0 pounds acid equivalent (a.e.) of glyphosate active ingredient per acre per crop year.

Approximately 53% to 64% of growers used a non-glyphosate herbicide in addition to glyphosate in the glyphosate-tolerant cotton systems in 2005 (Givens *et al.*, 2009a). In 2007, approximately 39% of the growers often or always used herbicides with different modes-of-action in the glyphosate-tolerant cotton systems (Frisvold et al., 2009).

Non-glyphosate herbicides with different modes-of-action are also frequently used to provide residual weed control, improve control on certain weed species, and extend weed control or control resistant weed species (Prince *et al.*, 2011a). The non-glyphosate herbicides applied on cotton in 2011, included ALS inhibitors (trifloxysulfuron, pyrithiobac), longchain fatty acid inhibitors (acetochlor, metolachlor), microtubule inhibitors (pendimethalin, trifluralin), PSII inhibitors (prometryn, fluometuron, diuron), PPO inhibitors (flumioxazin, fomesafen), synthetic auxins (2,4-D, dicamba), glufosinate, MSMA and paraquat (Monsanto, 2012b).

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Table 4-4. Herbicide Applications Registered for Use in Cotton in 2011[1]

Herbicide	Herbicide Family	Mode-of-Action (MOA)	Cotton Acres Treated (%)	Cotton Acres Treated per MOA	Quantity Applied (1000 lb a.i. [2])	Total Quantity Applied/MOA (1000 lb a.i.[2])
Glyphosate	Glycine	EPSPS inhibitor	73	73	20,015	20,015
Pendimethalin	Dinitroanaline	Microtubule inhibitor	16	40	1,964	5,043
Trifluralin	Dinitroanaline		24		3,079	
Diuron	Urea	PSII inhibitor	15	34	1,727	3,737
Prometyrn	Triazine		10		1,102	
Fluometuron	Urea		8		870	
Linuron	Urea		<1		38	
Acifluorfen	Diphenylether	PPO inhibitor	<1	38	1	856
Carfentrazone	Triazolinone		<1		<1	
Flumiclorac	N-phenylphthalimide		<1		<1	
Flumioxazin	N-phenylphthalimide		19		192	
Fomesafen	Diphenylether		17		626	
Oxyfluorfen	Diphenylether		1		36	
Pyraflufen	Phenylpyrazole		<1		<1	
2,4-D	Phenoxy	Synthetic Auxin	17	27	1,659	2,023
Dicamba	Benzoic acid		10		364	
Pyrithiobac	Benzoate	ALS inhibitor	14	21	113	120

Table 4-4. (continued). Herbicide Applications Registered for Use in Cotton in 2011[1]

Herbicide	Herbicide Family	Mode-of-Action (MOA)	Cotton Acres Treated (%)	Cotton Acres Treated per MOA (%)	Quantity Applied (1000 lb a.i.[2])	Total Quantity Applied/MOA (1000 lb a.i.[2])
Thifensulfuron	Sulfonylurea		<1		<1	
Thibenuron	Sulfonylurea		<1		<1	
Trifloxysulfuron	Sulfonylurea		6		6	
Acetochlor	Chloroacetamide	Long-chain fatty acid inhibitor	8	25	1,502	4,587
Metolachlor	Chloroacetamide		17		3,085	
Norflurazon	Pyridazinone	Inhibition of carotenoid	<1	<1	2	2
Paraquat	Bipyridylium	Photosystem-I-electron	10	10	735	735
Glufosinate-ammonium	Phosphinic acid	Glutamine synthesis	10	10	800	800
MSMA	Organoarsenical	Cell membrane	6	6	1,066	1,066
Clethodim	Cyclohexanedione	ACCase inhibitor	<1	<1	3	3
Fluazifop	Aryloxphenoxy propionate		<1		<1	
Diflufenzopyr	Semicarbazone	Auxin transport	<1	<1	3	3
Clomazone	Isoxazolidinone	Diterpene synthesis	<1	<1	<1	<1
Total				99.4		38,992

[1] Updated version of Table VIII-9 of petition 12-185-01p_a1 (Monsanto, 2012a) with 2011 data (Monsanto, 2012b).
[2]lb a.i.= pounds active ingredient.

Source: Table A-33 (Monsanto, 2013).

Dicamba is currently labeled for use in cotton although its use is limited to preplant applications due to cotton's susceptibility to dicamba. Consequently, the average application rate preplant in cotton is 0.26 pounds of dicamba per acre with one application per season. Dicamba preplant use in cotton has been on the rise in recent years, increasing from 140,000 acres in 2004, to 590,000 acres in 2008, and 1.4 million acres, or 9.6% of U.S. cotton acres, in 2011 (Monsanto, 2012b). This is primarily because it is a leading recommended herbicide for control of glyphosate-resistant marestail and Palmer amaranth in the Southeast and Midsouth region (McClelland *et al.*, 2006; AgWatch, 2011; University of Georgia, 2012)

The ten most widely used alternative herbicides in cotton in 2010 are listed in Table 4-5 (ER Table B-18 (Monsanto, 2013)), compared to 2007 use.

Table 4-5. Ten Most Widely Used Alternative Herbicides in U.S. Cotton Production

Herbicide	2007 Applications (million lb)[1]	2010 Applications (million lb)[1]
Trifluralin	2.8	3.1
Diuron	1.3	1.3
Pendimenthalin	1.3	1.2
S-metolachlor	0.6	1.1
Prometryn	0.6	0.4
2,4-D, dimethylamine salt	0.3	0.4
Fluormeturon	0.3	0.4
MSMA	0.4	0.3
Fomesafen	0.05	0.2
2,4-D, ethylhexyl ester	0.1	0.1

1 (USDA-NASS, 2014)
Source: Table B-18 (Monsanto, 2013)

Soil residual herbicides play an important role in cotton weed management by providing control of a number of weeds species that continuously germinate in cotton prior to canopy closure (Wilcut *et al.*, 2003). Soil residual herbicides, such as pendimethalin, trifluralin, diuron, fluometuron, acetochlor, and metolachlor, are applied to more than 40% of the current cotton acres (Monsanto, 2012b). In addition, many of the soil residual herbicides are limited by application restrictions, plant-back restrictions, the need for adequate soil moisture for activation, and the need to apply prior to planting or with hooded sprayers in-crop to minimize crop injury. Approximately 20% of growers applied a fall residual herbicide to control weeds prior to planting the following spring, and 60% (continuous cotton system) to 75% (GR cotton/GR soybean rotation) applied a mixture of glyphosate and a synthetic auxin herbicide (2,4-D or dicamba) as a spring burndown application (Prince *et al.*, 2011a). Post emergent residual herbicides, such as metolachlor and acetochlor, were applied on over 25% of cotton acres in 2010 (Monsanto, 2012b).

In glyphosate-tolerant cotton, a total of 38 different non-glyphosate herbicides had been used in the PRE timing while 40 non-glyphosate herbicides had been used at the POST timing (Table 4-6) (ER Table A-34 (Monsanto, 2013)).

Table 4-6. Non-Glyphosate Herbicides Used in Cotton from 2002-2011

Preplant/preemergence Active Ingredients	Postemergence Active Ingredients
2,4-D	2,4-D
2,4-DB	Acetochlor
Alachlor	Acifluorfen
Bromoxynil	Alachlor
Carfentrazone-Ethyl	Bromoxynil
Clethodim	Carfentrazone-Ethyl
Clomazone	Clethodim
Cyanazine	Cyanazine
Dicamba	Dicamba
Diflufenzopyr	Dimethipin
Diuron	Diuron
Fluazifop	DSMA
Flumiclorac	Fenoxaprop
Flumioxazin	Fluazifop
Fluometuron	Flumiclorac
Fomesafen	Flumioxazin
Glufosinate	Fluometuron
Lactofen	Fomesafen
Linuron	Glufosinate
Metolachlor	Hexazinone
Metolachlor-S	Lactofen
MSMA	Linuron
Norflurazon	Metolachlor
Oxyfluorfen	Metolachlor-S
Paraquat	Metsulfuron
Pendimethalin	MSMA
Prometryn	Oxyfluorfen
Pyraflufen Ethyl	Paraquat
Pyrithiobac-Sodium	Pelargonic Acid
Quizalofop	Pendimethalin
Rimsulfuron	Prometryn
Saflufenacil	Pyraflufen Ethyl
Sethoxydim	Pyrithiobac-Sodium
Sulfosate	Quizalofop
Thifensulfuron	Rimsulfuron
Tribenuron Methyl	Sethoxydim
Trifloxysulfuron	Sulfosate
Trifluralin	Trifloxysulfuron
	Trifluralin
Total 38	**40**

Source: Table A-34 (Monsanto, 2013).

Further details on the use of non-glyphosate herbicides in cotton producing states can be found in Prince et al. (2011a; 2011b), where it is reported that approximately 50% of surveyed growers who did not have glyphosate-resistant weeds on their farm used a non-glyphosate residual and/or postemergence herbicide in the 2009 growing season. For growers who have on-farm herbicide-resistant weed populations, the percentage of growers was higher, with 72% to 75% reporting the use of non-glyphosate herbicides. Older studies report that approximately 40 to 50% of the growers utilizing glyphosate-tolerant crops indicate that applying herbicides with different modes-of-action in sequence, rotating herbicides with different modes-of-action across the season, or tank mixing glyphosate with other herbicide modes-of-action are effective management practices to minimize the evolution and/or development of glyphosate resistance (Powles *et al.*, 1996; Diggle *et al.*, 2003; Beckie, 2006; Beckie and Reboud, 2009). The use of non-glyphosate herbicides in cotton production is expected to continue to increase as more growers adopt more diversified weed management strategies. Refer to Appendix A (see ER (Monsanto, 2013)) for details on alternative herbicides used in cotton production.

Volume Projections for Proposed New Uses of Dicamba

The following sections of Appendix 4 present Monsanto's projections of the increases in dicamba usage volumes based on the proposed new dicamba application rates for DT soybean and cotton. Monsanto has submitted an application to EPA to amend current registrations of DGA salt formulation for new uses of dicamba on dicamba-resistant soybean and cotton. The application is currently being evaluated by the U.S. Environmental Protection Agency (EPA).

Details on and supporting information for Monsanto's calculations can be found in the Environmental Report prepared by Monsanto (Monsanto, 2013) and posted by USDA as supplementary information to the Federal Register docket for this EIS:

http://www.regulations.gov/#!docketDetail;D=APHIS-2013-0043

Impact of DT Soybean Deregulation on Dicamba Usage

Use of Low-Volatility DGA Salt of Dicamba – Proposed Changes in Dicamba Registration: Monsanto has submitted to EPA an application to amend EPA Reg. No. 524-582 to register a new use pattern for dicamba on DT soybean. The current and proposed uses are summarized in Table 4-7 (ER Table IV.A-1 (Monsanto, 2013)).

Table 4-7. Summary of Dicamba Uses on Soybean

Application Timing	Current Approved Uses: Maximum Single Application Rate (lb a.e./acre)	Current Approved Uses: Maximum Annual Application Rate (lb a.e./acre)	Proposed Uses on DT soybean: Maximum Single Application Rate (lb a.e./acre)	Proposed Uses on DT soybean: Maximum Annual Application Rate (lb a.e./acre)
Pre-emergence	0.50[1]	2.0	1.0[2]	2.0
Post-emergence	Not labeled		**0.50** (V3) + **0.50** (R1/R2)[3]	
Pre-harvest (7 days prior to harvest)	1.0		Not labeled	

[1] 14-28 day planting interval based on product application rate
[2] No planting interval
[3] In-crop application through V3 with a sequential application through R1/R2 growth stage as needed. Total of all in-crop applications from emergence up to R1/R2 is 1.0 lb a.e./acre.
Source: Table IV.A-1 (Monsanto, 2013).

In the pending application to EPA, Monsanto requested approval only for the low volatility DGA salt formulation of dicamba (U.S. EPA Reg. No. 524-582) for use on DT soybean, and has proposed that dicamba applications be limited to ground applications only (*i.e*., no aerial spraying), as well as proposing additional enforceable directions for use. Monsanto has also requested the establishment of a tolerance for soybean forage and hay; no other revisions to the dicamba residue tolerances are necessary, including animal products such as meat and milk.

Combination with Glyphosate-Tolerant Soybean. DT soybean is intended to be combined with glyphosate-tolerant soybean utilizing traditional breeding techniques. Soybean containing both DT soybean and glyphosate tolerance will allow the use of glyphosate and dicamba herbicides in a diversified weed management program, which includes the use of residual herbicides or other cultural practices, to control a broad spectrum of grasses and broadleaf weed species, and to sustain and complement the benefits and value of the glyphosate use in the glyphosate-tolerant systems. The combined system will support long-term sustainability of weed management in soybean and, in turn, support sustained, economic soybean production.

Inclusion of Potential Impacts from Herbicide Use: As discussed above, it is EPA's regulatory authority under FIFRA to register pesticide products for their intended uses. EPA has sole authority to regulate the use of any herbicide. Nonetheless, for the reasons discussed above, this environmental report evaluates potential impacts of dicamba use associated with DT soybean on the human environment.

Anticipated Weed Management Recommendations for DT Soybean: Monsanto's weed management system recommendations are shown in Table 4-8 (ER Table IV.A-2 (Monsanto, 2013)). The recommended use patterns for dicamba on DT soybean will vary across U.S. soybean growing regions based on differences in growth habits and competitiveness of certain glyphosate-resistant weed species. Option 1 would be recommended for more aggressive glyphosate-resistant weed species, such as Palmer amaranth (*Amaranthus palmeri*) and waterhemp (*Amaranthus rudis*). These weed species are very fast growing, highly competitive with crops, high seed producers, very densely populated, and germinate and emerge throughout the growing season (Keeley *et al.*, 1987; Nordby *et al.*, 2007; Fast *et al.*, 2009; Sprague, 2012). Two sequential postemergence applications will generally be required to control late-season emergence of these weed species. However, low rainfall conditions and/or early crop canopy closure that can be associated with narrow row spacing of soybean can reduce late-season weed emergence and potentially reduce the number of dicamba postemergence applications. Option 2 would be used for less aggressive glyphosate resistant weed species, such as horseweed (*Conyza canadensis*), common ragweed (*Ambrosia artemisiifolia*) and giant ragweed (*Ambrosia trifida*).

These weed management system recommendations represent a high-end proposal for dicamba use associated with DT soybean when combined with glyphosate-tolerant soybean. The actual number of applications and timing of applications of dicamba or glyphosate that the grower will make will vary depending on the specific weed spectrum, weed infestation levels, and the agronomic situation of the individual soybean field. Applying a residual herbicide preemergence in sequence with glyphosate plus dicamba postemergence, or tank mixing a residual herbicide with glyphosate plus dicamba postemergence could be considered as an alternative to two postemergence applications of glyphosate plus dicamba for season long weed control.

Table 4-8. Proposed Weed Management System Recommendations for DT Soybean Combined with Glyphosate-Tolerant Soybean.

Application Timing	Conventional Tillage[1]			Conservation Tillage (No-till or reduced till)[1]		
	No GR Weeds	GR Weeds or Suspected GR Weeds[2]		No GR Weeds	GR Weeds or Suspected GR Weeds[2]	
		Option 1[4]	Option 2[5]		Option 1[4]	Option 2[5]
Pre-emergence/ Pre-plant Burndown[3]	Residual	Residual	Residual	Residual plus Glyphosate plus Dicamba	Residual plus Glyphosate plus Dicamba	Residual plus Glyphosate plus Dicamba
Post-emergence 1 (V1-V3)	Glyphosate plus Dicamba	Glyphosate plus Dicamba	Glyphosate plus Dicamba	Glyphosate plus Dicamba	Glyphosate plus Dicamba	Glyphosate plus Dicamba
Post-emergence 2 (V4-R1)	---	Glyphosate plus Dicamba	---	---	Glyphosate plus Dicamba	---

[1] Anticipated average rate for dicamba is 0.38 pound a.e. per acre except for fields with glyphosate resistant (GR) species where a 0.5 pound a.e. per acre postemergence application rate will be recommended in most situations. See Appendix A (Monsanto ER (Monsanto, 2013)).
[2] GR indicates glyphosate-resistant
[3] Monsanto and academics recommend the use of soil residuals as part of a comprehensive weed resistance management program to ensure that at least two effective herbicide modes-of-action are used in soybean and to provide protection against additional resistance development to existing herbicides used in soybean production. When a residual plus glyphosate plus dicamba is recommended the residual may be applied separately or in tank mixture with glyphosate plus dicamba.
[4] Option 1 would be used for more aggressive glyphosate resistant weed species, such as *Amaranthus spp*.
[5] Option 2 would be used for less aggressive glyphosate resistant weed species, such as horseweed.
Source: Table IV.A-2 (Monsanto, 2013).

Potential Additional Dicamba Use. It is impossible to determine the exact amount of acreage on which DT soybean may be grown if deregulated. Projections on the annual application of dicamba used on DT soybean are based on market adoption rates and the dicamba use pattern on DT soybean. The maximum possible annual application of dicamba on DT soybean, based on 100% adoption of across all U.S. soybean acreage (75 million acres) and applications of dicamba at the maximum labeled rates (proposed at 2.0 lbs a.e. per acre per year), would be 150 million pounds dicamba (as acid equivalent or a.e.). However, as discussed below, the actual total anticipated application will be much lower.

For the purposes of this assessment, it is assumed that DT soybean will occupy 40% of the U.S. soybean acreage at peak penetration. This estimate is based on a number of factors: 1) the percentage of non-glyphosate herbicides currently used in glyphosate-tolerant soybean, 2) current and historical use of dicamba in corn, 3) the development of glyphosate-resistant weeds in soybean cultivation areas, 4) the effectiveness of other non-glyphosate herbicides used in glyphosate-tolerant soybean, s; and 5) the foreseeable future introduction of new competitive biotechnology-derived traits in soybean.

Similarly the anticipated use patterns for dicamba on DT soybean will vary across U.S. soybean growing regions. This variability is dictated by growth habits and competitiveness of certain glyphosate-resistant weed species. As discussed above in *Anticipated Weed Management Recommendations for DT Soybean*, weed management recommendations will vary based on cultivation practices (i.e., tillage) and spectrum of glyphosate-resistant weeds present in the field. Based on weed management trials conducted across regions and weed spectrum a single early season in-crop application per year of dicamba at 0.38 lb a.e. per acre is expected on the majority of DT soybean acres. However, in no-till or conservation tillage soybean systems, an additional preplant application at 0.50 lb a.e. per acre could also be common practice, and in areas where glyphosate resistant weeds, especially *Ambrosia and Amaranthus* species, are present two in-crop applications at 0.5 lb a.e. each may be needed in some situations. See Appendix A (of Monsanto's ER: (Monsanto, 2013)) for additional information supporting these anticipated use patterns.

Based on the anticipate dicamba application and use rate analysis summarized above, use of DT soybean on 40% of U.S. soybean acres would result in approximately 20.5 million lbs a.e. of dicamba applied to DT soybean annually (including preplant, preemergence and in-crop applications), see Table 4-9 (ER Table IV.A-3 (Monsanto, 2013)). Currently 233,000 lbs a.e. of dicamba are applied preplant to commercially available soybean (Monsanto, 2012b).

The potential increase in dicamba usage associated with DT soybean production is expected to displace, in part, some of the current herbicides used in soybean today. Dicamba offers a relative reduction of risk potential in comparison to some of the alternative non-glyphosate herbicides currently available to soybean growers (see Appendices E and F (Monsanto, 2013)). Dicamba could be expected to conservatively replace approximately 21% of the projected total acres treated (TAT)[4] for all non-glyphosate herbicides used in preplant/preemergence application timing and 56% of the projected TAT for all non-glyphosate herbicides used in postemergence application timing at peak dicamba use based on a projection that 40% of total planted soybean acres may be treated with dicamba following the introduction of DT soybean. At projected peak penetration of dicamba use in DT soybean, an increase in both total soybean acres treated and total pounds of non-glyphosate herbicides applied to soybean is projected, however estimated increases are 12% or less of the total herbicide use projections if DT soybean is not commercialized.

4 The use of TAT provides a way to look at herbicide use that is independent of the various use rates of herbicides. If a herbicide is used more than once on an acre the TAT will reflect this multiple use, and consequently the TAT may exceed the number of crop acres planted. This provides a more complete view of herbicide use.

Table 4-9. Projected Dicamba Use on DT Soybean

Use Scenario	Dicamba Treated DT Soybean Acres (x1,000,000)	# PRE applications	PRE application rate (lb/acre a.e.)	# POST applications (V3 or V3 & R1)	POST application rate (lb/acre a.e.)	Total lb of Dicamba (000,000)[a]	Total Annual lb of Dicamba
Maximum labeled use pattern, 100% adoption							
	75	1	1.0	2	0.50	150	**150**
Anticipated use pattern, 100% adoption							
no-till acres [b]	30	1	0.5	1	0.38	26.4	
conventional tillage acres[c]	45			1	0.38	17.1	
Total							**44**
Anticipated use pattern, anticipated peak adoption of dicamba-treated DT soybean acres							
no-till acres [b]	12[d]	1	0.5	1	0.38	10.6	
conventional tillage acres[c]	18[d]			1	0.38	6.8	
Resistant *Amaranthus spp.* acres [e]	5			2	0.31[f]	3.1	
Total							**20.5**[g]

[a] Total lbs dicamba is calculated combining the lbs of dicamba PRE and POST, where the lbs dicamba used either PRE or POST is calculated by multiplying the number of applications by the application rate for the respective application timing.

[b] No-tillage is practiced on 40% of the U.S. soybean acres (CTIC, 2007).

[c] Conventional tillage acres also includes acres where reduced or minimum tillage is practiced and where it is assumed that a preemergent application of dicamba will be needed for weed control.

[d] Monsanto projects dicamba to be used on 40% of U.S. soybean acres (i.e., 30 million acres).

[e] These acres are a subset of the no-till and conventional tillage acres.

[f] Monsanto anticipates that two POST applications at 0.5 lb/acre a.e. each will be needed on acres resistant with A*maranthus spp*. Since these acres are a subset of the no-till and conventional tillage acres where a single POST application at 0.38 lb/acre dicamba a.e. has already been accounted for, the POST application rate is adjusted to avoid double counting of dicamba use on this subset of acres (i.e., adjusted POST application rate = 0.5 lb/acre – (0.38÷2) lb/acre).

[g] This figure is slightly less than the estimate of 22 million pounds described in Section VIII.H of the petition because it subtracts out the single 0.38 lb/acre a.e. application already accounted for in the no-till and conventional tillage calculations.

Impact of DGT Cotton Deregulation on Dicamba Usage

The deregulation and commercialization of DGT cotton will expand dicamba use to in-crop postemergence applications to address hard-to-control and herbicide-resistant broadleaf weeds found in U.S. cotton production. The impact that DGT cotton will have on overall dicamba use will depend on the level of DGT cotton adoption by growers. Therefore, the extent of DGT cotton acreage following the deregulation of DGT cotton is difficult to forecast. Monsanto estimates that dicamba-treated acres could ultimately reach 50% of the total U.S. cotton acres. This estimate is based on a number of factors, including: (1) the percentage of non-glyphosate herbicides currently used in glyphosate-tolerant cotton; (2) the development of glyphosate-resistant weeds; (3) the effectiveness of other non-glyphosate herbicides used in the glyphosate-tolerant cotton weed control systems; (4) the perceived risk of offsite movement onto dicamba-sensitive crops; and (5) the foreseeable future introduction of new competitive GE-derived traits in cotton.

Approximately 53% to 64% of growers used a non-glyphosate herbicide in addition to glyphosate in the glyphosate-tolerant cotton systems in 2005 (Givens *et al.*, 2009a). In 2007, approximately 39% of the growers often or always used herbicides with different modes-of-action in the glyphosate-tolerant cotton systems (Frisvold *et al.*, 2009). Regardless of the availability of DGT cotton, the future use of non-glyphosate herbicides is expected to increase in order to support the management of glyphosate-resistant weeds. Additionally, grower educational programs on weed resistance management conducted by industry and universities encourage the use of non-glyphosate herbicides with alternative modes-of-action in glyphosate-tolerant cropping systems as a proactive measure to minimize the potential for development of glyphosate-resistant weeds (Powles, 2008; Beckie *et al.*, 2011). These programs will likely drive a further increase in non-glyphosate herbicides applied in cotton production.

A second factor impacting dicamba-treated cotton acreage is the current and future need for control of glyphosate-resistant weeds. Glyphosate-resistant weeds have been identified in multiple states (Heap, 2014). When a glyphosate-resistant weed biotype has been confirmed to be present in a geographical area, growers in that area are advised proactively to implement glyphosate-resistant weed management programs to ensure effective control of the resistant weed biotype regardless of whether the weed species has been confirmed to be resistant on a grower's farm. Therefore, the acreage in an area where responsive weed resistance management practices are implemented is potentially greater than the actual acres known to be impacted by glyphosate-resistant weeds. University weed scientists recommend that growers implement best management practices, including a non-glyphosate herbicide with a second mode-of-action, in their cropping systems to minimize the development and potential spread of glyphosate-resistant weeds in the future (Hurley *et al.*, 2009; Owen *et al.*, 2011; Norsworthy, 2012; University of Georgia, 2012; Culpepper *et al.*, 2013).

It is anticipated that even in locations where glyphosate-resistant weeds are present, glyphosate will continue to be the base herbicide applied to DGT cotton as a combined trait product with glyphosate-tolerant cotton. Table 4-4 (ER Table A-33 (Monsanto, 2013)) provides a summary of the herbicide applications registered for use in cotton in 2011, demonstrating that herbicides are used on essentially all (>99%) cotton acres in the U.S (Brookes and Barfoot, 2012; Monsanto, 2012b). Approximately 39 million pounds of herbicide active ingredient were applied to cotton in 2011. These alternative herbicides will compete with dicamba and are expected to reduce the potential dicamba use on DGT cotton integrated into the glyphosate-tolerant cotton systems and in future combined trait products containing DGT cotton.

Another factor influencing the number of dicamba-treated cotton acres in the future will be the introduction of competing herbicide-tolerant traits in cotton. Currently, there are numerous herbicide-tolerant cotton products that are under regulatory review or have recently been authorized. This includes several products that have tolerance to multiple herbicides with different modes-of-action. These new GE-derived herbicide-tolerant cotton products are anticipated to be introduced in future years and will compete with Monsanto's DGT cotton and glyphosate-tolerant cotton products, thereby further reducing the potential dicamba use in cotton.

Taking into consideration the above assessment, the potential acreage of DGT cotton treated with dicamba is estimated to be 50% of the U.S. cotton acres, and would result in approximately 5.2 million pounds a.e. of dicamba applied to DGT cotton annually (including preplant, preemergence, and in-crop applications). Currently, 364,000 pounds of dicamba are applied preplant to commercially available cotton (see Table 4-4) (ER Table A-33 (Monsanto, 2013)). It is anticipated that dicamba applications will continue for all other currently labeled crops at the current annual level of approximately 3.8 million pounds (see Table 4-4) (ER Table A-33 (Monsanto, 2013)). Therefore, the addition of the estimated 5.2 million pounds of dicamba that would be applied to DGT cotton would result in a total U.S. dicamba use of approximately 9 million pounds annually.

Use of Low-Volatility DGA Salt of Dicamba – Proposed Changes in Dicamba Registration: Monsanto has requested a registration from U.S. EPA for the expanded use of a low volatility diglycolamine (DGA) salt of dicamba on DGT cotton, limited dicamba application to ground application equipment, as well as proposing additional stewardship measures. Monsanto plans to further address the use of dicamba on DGT cotton with U.S. EPA to evaluate whether any additional measures may be appropriate to further address potential drift and offsite movement. Monsanto has also requested an increase in the dicamba residue tolerance for cottonseed, the establishment of a tolerance for cotton gin by-products, and the inclusion of DCSA in the residue definitions for both cottonseed and gin by-products.

Monsanto submitted an application to EPA to amend Registration number 524-582, a low-volatility DGA salt formulation, to remove all existing preemergence planting restrictions (application intervals, rainfall, and geographic) and to allow in-crop postemergence dicamba applications to DGT cotton containing varieties[5]. Before any application of dicamba can be made onto commercially cultivated DGT cotton, the EPA must first approve a label describing the conditions of use of the herbicide on DGT cotton – including the appropriate application rates and timing, and other measures necessary to address potential impacts of dicamba drift and offsite movement. Dicamba can currently be applied to cotton in the U.S. as a preplant application, at least 21 days prior to planting. Following EPA approval of the dicamba label amendment, growers would be authorized to apply dicamba alone or in mixtures with glyphosate, glufosinate, or other registered herbicides for preplant or postemergence in-crop applications on DGT cotton. If the proposed label is approved by EPA, dicamba would be authorized to be applied up to 1.0 lb a.e.

[5] The current dicamba label approved by EPA prohibits dicamba preplant application on cotton west of the Rockies due to the potential for direct crop injury caused by dicamba in conjuction with the environmental conditions in this area. This restriction will not be included on the amended label for application of dicamba on DGT cotton since DGT cotton is tolerant to dicamba.

per acre any time prior to cotton emergence, and postemergence in-crop up to 0.5 lbs a.e. per acre per application up through seven days prior to harvest. Maximum application amounts for dicamba would be 1.0 lb a.e. per acre for preplant/preemergence applications and 0.5 lb a.e. per acre per in-crop application with the combined total not to exceed 2.0 lbs a.e. dicamba per year for all applications. The proposed application rates on DGT cotton would be less than or equivalent to rates for dicamba established for other uses in the dicamba RED including the 2.0 lbs a.e. dicamba per year for all applications (U.S. EPA, 2009). Based on Monsanto's proposed dicamba label, aerial applications of dicamba will not be allowed on DGT cotton, thereby reducing spray drift potential (BASF, 2008). Monsanto has requested a registration from U.S. EPA for the expanded use of dicamba on DGT cotton, an increase in the dicamba residue tolerance from 0.2 ppm to 3 ppm for cottonseed, the establishment of a tolerance of 70 ppm for cotton gin by-products, and the inclusion of DCSA in the residue definitions for cottonseed and gin by-products. No other revisions to the dicamba residue tolerances are necessary, including animal products such as meat and milk. Furthermore, the use of dicamba on DGT cotton does not present any new environmental exposure scenarios not previously evaluated in the RED and deemed acceptable by EPA.

Use of Glufosinate – No Changes in Registration: The PAT(*bar*) protein acetylates the free amino group of glufosinate to produce non-herbicidal N-acetyl glufosinate, a known metabolite in glufosinate-tolerant plants (OECD, 2002). The use pattern and rate of glufosinate application on DGT cotton will follow the existing glufosinate-tolerant cotton uses outlined on the existing glufosinate herbicide label (Bayer Crop Science, 2007) and Monsanto has confirmed that glufosinate residues on DGT cotton treated with commercial glufosinate rates are below the established pesticide residue tolerances established by U.S. EPA for both cottonseed and gin by-products (40 CFR 180.473). Consequently, Monsanto has not and will not pursue any changes in the glufosinate label or the established tolerances for its use on DGT cotton. Because there will be no changes in the use pattern and rate of glufosinate on DGT cotton from the current baseline, these aspects related to the associated use of glufosinate on DGT cotton are not discussed in detail in this analysis.

Combination with Glyphosate-Tolerant Cotton. DGT cotton is intended to be combined with glyphosate-tolerant cotton utilizing traditional breeding techniques. Cotton containing both DGT cotton and glyphosate tolerance will allow the use of glyphosate, dicamba, and glufosinate herbicides in a diversified weed management program, which includes the use of residual herbicides or other cultural practices, to control a broad spectrum of grasses and broadleaf weed species, and to sustain and complement the benefits and value of the glyphosate use in the glyphosate-tolerant systems. The combined system will support long term sustainability of weed management in cotton and, in turn, support sustained, economic cotton production.

Use of Multiple Herbicide-Tolerant Traits. In recent years, the development, in certain areas of the U.S., of glyphosate-resistant weeds, as well as shifts in broadleaf weed populations to species that are inherently more tolerant to glyphosate, have increased the use of non-glyphosate herbicides that work through different modes-of-action to achieve an acceptable level of weed control. As a result, multiple herbicide-tolerant traits are and have been developed to provide cotton growers with additional weed control options that will compete with DGT cotton. These herbicides and traits will be available at the time DGT cotton is introduced to the marketplace; thus, DGT cotton will compete for market share with approved herbicide tolerance traits, including

LibertyLink®, GlyTol®, and TwinLink® combined-trait products, and new herbicide-tolerance traits that will be available in the foreseeable future. Growers will ultimately select weed control systems that fit the needs for their individual farming operation, such that some proportion of growers will choose to use DGT cotton-containing varieties integrated into glyphosate-tolerant cotton systems.

Anticipated Weed Management Recommendations for DGT Cotton: The expected use patterns for dicamba and glufosinate on DGT cotton will vary across U.S. cotton growing regions. This variability is dictated by the environment and weed spectrum variations across these regions. Monsanto's recommendations for the Midsouth and Southeast regions are shown in Table 4-10 (ER Table IV.A-4 (Monsanto, 2013)). In these regions, conventional tillage planted acres are expected to receive a single in-crop application per season of dicamba at 0.5 lbs a.e. per acre and conservation tillage or no-tillage acres are expected to receive two applications (one preplant application at 0.375 lbs a.e. per acre and one in-crop application at 0.50 lbs a.e. per acre). All acres in this region where glyphosate-resistant weeds are present, regardless of tillage, are expected to receive a single in-crop application of glufosinate as 0.53 lbs a.i. per acre. For the remaining acres where glyphosate-resistant weeds are not present, glyphosate will likely be used for control of late-emerging weeds. Dicamba and glufosinate use in eastern Texas and California is expected to be similar to that described for the Midsouth and Southeast regions.

In western Texas, New Mexico, Kansas, Oklahoma, and Arizona, dicamba is expected to be utilized more extensively than glufosinate for management of hard-to-control and/or glyphosate-resistant weeds in DGT cotton. Glufosinate is considered less effective on the weed spectrum under the high temperature and low humidity environmental conditions in these regions (Bayer CropScience, 2011). The recommendations for these cotton growing areas are shown in Table 4-11 (ER Table IV.A-5 (Monsanto, 2013)). All acres are expected to receive one preplant application of dicamba (0.375 lbs a.e. per acre). Areas with glyphosate-resistant weeds are also expected to receive two in-crop applications of dicamba (0.50 lbs a.e./acre) per season, whereas areas without glyphosate-resistant weeds will only receive one in-crop application of dicamba (0.50 lbs a.e./acre).

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Table 4-10. Anticipated Weed Management Recommendations for DGT Cotton Combined with Glyphosate-Tolerant Cotton Systems for MO, AR, TN, AL, FL, GA, NC, SC, VA, LA, MS, eastern TX and CA.[1,2]

Application Timing	Conventional Tillage	Conservation Tillage (No-till or reduced till)
Preplant burndown and/or Preemergence	Residual	Dicamba + Glyphosate + Residual
Postemergence 1	Dicamba + Glyphosate + Residual[3]	Dicamba + Glyphosate + Residual
Postemergence 2	Glyphosate OR Glufosinate[4,5]	Glyphosate OR Glufosinate + Residual[5,6]

[1] Recommendations modified from those presented in Petition 12-185-01p_a1.
[2] Monsanto and academics recommend the use of soil residuals as part of a comprehensive weed resistance management program to ensure that two effective herbicide modes-of-action are used in cotton and to provide protections against additional resistance development to existing herbicides used in cotton production.
[3] Residual recommended if GR weeds present.
[4] Glyphosate recommended if no GR weeds present, glufosinate recommended in the presence of GR weeds.
[5] Tank mixes of glyphosate and glufosinate will not be recommended, because reduced weed control has been observed with the glyphosate and glufosinate tank mix as compared to each individual herbicide (Dotray *et al.*, 2011; Reed *et al.*, 2011; Reed *et al.*, 2012).
[6] Glyphosate only if no GR weeds present, glufosinate and residual recommended in the presence of GR weeds.
Source: Table IV.A-4 (Monsanto, 2013).

Table 4-11. Anticipated Weed Management Recommendations for DGT Cotton Combined with Glyphosate-Tolerant Cotton Systems for Western TX, NM, KS, OK, and AZ [1,2]

Application Timing	Conventional Tillage	Conservation Tillage (No-till or reduced till)
Pre-plant burndown and/or Pre-emergence	Dicamba + Glyphosate + Residual	Dicamba + Glyphosate + Residual
Post-emergence 1	Dicamba + Glyphosate	Dicamba + Glyphosate
Post-emergence 2	Glyphosate ± Dicamba[3]	Glyphosate ± Dicamba[3]

[1] Recommendations modified from those presented in Petition 12-185-01p_a1.
[2] Monsanto and academics recommend the use of soil residuals as part of a comprehensive weed resistance management program to ensure that two effective herbicide modes-of-action are used in cotton and to provide protections against additional resistance development to existing herbicides used in cotton production.
[3] Dicamba recommended when GR weeds present.
Source: Table IV.A-5 (Monsanto, 2013).

Inclusion of Potential Impacts from Herbicide Use: As discussed above, it is EPA's regulatory authority under FIFRA to register pesticide products for their intended uses. EPA has sole authority to regulate the use of any herbicide. Nonetheless, for the reasons discussed above, this environmental report evaluates potential impacts of dicamba use associated with DGT cotton on the human environment. Glufosinate will not be discussed in detail because glufosinate use on DGT cotton is equivalent to currently deregulated glufosinate-tolerant cotton and will be considered baseline.

Potential Additional Dicamba Use: The maximum possible annual application of dicamba on cotton, with 100% adoption of DGT cotton across all U.S. upland cotton acreage (14.8 million acres)[6] and applications of dicamba at the maximum labeled rates (proposed at 2.0 lbs a.e. per acre per year), would be 29.6 million pounds a.e. However, as discussed below, the actual total anticipated application will be much lower and will not likely be additive with the current application of herbicides currently used on cotton, as dicamba will displace some of the current herbicide usage in cotton.

As discussed above, in the Midsouth, and Southeast regions, conventional tillage-planted acres are expected to receive a single in-crop application per season of dicamba at 0.5 lbs a.e. per acre and conservation tillage or no-tillage acres are expected to receive two applications (one preplant application at 0.375 lbs a.e. per acre and one in-crop application at 0.50 lbs a.e. per acre). Dicamba use in East Texas and California is expected to be similar to that described for the Midsouth and Southeast regions. In West Texas, Kansas, Oklahoma, New Mexico, and Arizona dicamba is expected to be utilized more extensively than glufosinate for management of troublesome and/or glyphosate-resistant weeds. Glufosinate is considered less effective on the weed spectrum under the high temperature and low humidity environmental conditions in these regions (Bayer CropScience, 2011). In West Texas, Kansas, Oklahoma, New Mexico, and Arizona conventional tillage acres are expected to receive two in-crop applications of dicamba per season at 0.50 lbs a.e. per acre. No-till or conservation tillage cotton acres will realistically receive three applications per season (one preplant application at 0.375 lbs a.e. per acre and two in-crop applications at 0.50 lbs a.e. per acre. Assuming these anticipated applications and use rates of dicamba, and using the assumption that DGT cotton has 100% adoption across all U.S. cotton acres and conservation tillage systems are used on approximately 21% of the U.S. cotton acres (CTIC, 2008), dicamba use on DGT cotton would total approximately 10.5 million pounds.

It is impossible to determine the exact amount of acreage on which DGT cotton may be grown if deregulated. A 100% adoption rate of DGT cotton among cotton growers is unrealistic. Monsanto estimates dicamba-treated acres could eventually reach 50% of the total U.S. cotton acres. Growers will ultimately select weed control systems that fit the needs for their individual farming operations such that some proportion of growers will choose to use DGT cotton integrated into the glyphosate-tolerant cotton systems. As discussed in ER Section II.B.2.d (See ER (Monsanto, 2013)), growers produced herbicide-tolerant cotton on approximately 73% of U.S. cotton acres in 2011, with almost all of this cotton being glyphosate-tolerant and approximately 3% being glufosinate tolerant. Growers currently producing herbicide-tolerant cotton are the growers most likely to adopt DGT cotton. Some of these growers may continue to grow the currently-available

6 Based on approximately 14.8 million acres planted to cotton in 2011, see ER Table II.B-12 Monsanto (2013).

types of herbicide-tolerant cotton, and use other herbicides for hard-to-control weeds. For example, approximately 53 to 64% of growers of glyphosate-tolerant cotton used a non-glyphosate herbicide in addition to glyphosate in their cotton crops in 2005 (Givens *et al.*, 2009b). An additional factor influencing the number of dicamba-treated cotton acres in the future will be the introduction of competing herbicide-tolerant traits in cotton.

Based on the dicamba application and use rate analysis summarized above, use of DGT cotton on 50% of U.S. cotton acres would result in approximately 5.2 million lbs a.e. of dicamba applied to DGT cotton annually (including preplant, preemergence and in-crop applications). Currently 364,000 lbs a.e. of dicamba are applied preplant to commercially available cotton (Monsanto, 2012b).

It is anticipated that dicamba applications will continue for all other currently labeled crops at the current annual level of approximately 3.8 million pounds (Monsanto, 2012b). Therefore, the addition of the estimated 5.2 million pounds of dicamba that would be applied to DGT cotton would result in a total estimated U.S. dicamba use of approximately 9.0 million pounds annually. This does not include the additional amount from DT soybean (ER Section IV.A.1 (Monsanto, 2013)).

The potential increase in dicamba usage associated with DGT cotton production is expected to displace a number of the current herbicides used in cotton today, particularly applications of fluometuron, fomesafen, MSMA, and paraquat. Dicamba offers a relative reduction of risk potential in comparison to some of the alternative non-glyphosate herbicides currently available to cotton growers (see Appendices E and F. Dicamba could be expected to conservatively replace approximately 34% of the projected total acres treated (TAT)[7] for all non-glyphosate herbicides used in preplant/preemergence application timing and 37% of the projected TAT for all non-glyphosate herbicides used in postemergence application timing at peak dicamba use based on a projection that 50% of total planted cotton acres may be treated with dicamba following the introduction of DGT cotton. At projected peak penetration of dicamba use in DGT cotton an increase in both total cotton acres treated and total pounds of non-glyphosate herbicide active ingredient applied to cotton is projected, however estimated increases are 16% or less of the total herbicide use projections (16% for TAT and 12% of total pounds of active ingredient) if DGT cotton is not commercialized.

Projected Dicamba Use (Total Pounds) on DGT Cotton: Based upon anticipated use patterns for dicamba on DGT cotton, projections on the number of dicamba TAT and total pounds of dicamba used on DGT cotton were determined for the combined PRE and POST application timing. The anticipated use projections represent a high-end estimate of the incremental dicamba use. Projected dicamba use at peak penetration is 10.8 million TAT (see ER Table A-40) and 5.2 million pounds active ingredient Table 4-12 (Table A-41) (Monsanto, 2013).

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7 The use of TAT provides a way to look at herbicide use that is independent of the various use rates of herbicides. If a herbicide is used more than once on an acre the TAT will reflect this multiple use, and consequently the TAT may exceed the number of crop acres planted. This provides a more complete view of herbicide use.

Table 4-12. Estimated Dicamba Total lbs a.i. at Peak Dicamba Use on DGT Cotton

Cotton Growing Region	Tillage system	2011 planted acres (000) available for dicamba use[1]	Planted acres at Peak (*i.e.* 15% reduction)	Planted conventional till acres (000) at Peak	Planted no till acres (000) at Peak	Conventional Tillage: # dicamba in-crop applications	Conservation tillage: # dicamba apps in crop[2]	Conservation Tillage: # dicamba application preplant	Conventional Tillage: Dicamba rate in-crop	Conservation tillage: Dicamba Rate Preplant	Total lbs dicamba ai (000)
SE, Delta, E.TX	Conventional			2,310		1			0.5		1,155
	Conservation				614		1	1	0.5	0.375	537
	Total	**3,441**	**2,924**								**1,693**
CA	Conventional			214		1			0.5		107
	Conservation				57		1	1	0.5	0.375	50
	Total	**319**	**271**								**157**
W.TX, AZ, OK, NM, KS	Conventional			2,472		2			0.5		2,472
	Conservation				657		2	1	0.5	0.375	904
	Total	**3,682**	**3,129**								**3,376**
US Total											**5,225**

[1] Acres from (USDA-NASS, 2012a). Note: Total planted acres for 2011 varies between USDA-NASS and the grower survey data used in previous tables. USDA-NASS was used to calculate dicamba TAT in the different cotton growing areas because only USDA-NASS planted acres is broken out by state.

[2] Based on 21% of cotton acres being no till.

Source: ER Table A-41(Monsanto, 2013).

References:

AgWatch (2011) "Cotton growers look at late-season burndown options." AgWatch Network. http://www.agwatchnetwork.com/newsView.cfm/uuid/03358CBB-9B9F-47AC-B8172EF5AA0426F2.

BASF. "Clarity herbicide label." Research Triangle Park, North Carolina: BASF Corporation, 2008.

Bayer Crop Science. "Liberty® herbicide label." *Bayer CropScience*. Research Triangle Park, North Carolina: Bayer Crop Science, 2007.

Bayer CropScience. "Liberty Herbicide label." Research Triangle Park, North Carolina: Bayer CropScience LP, 2011.

Beckie, HJ (2006) "Herbicide-resistant weeds: Management tactics and practices." *Weed Technology*. 20 p 793-814.

Beckie, HJ; Harker, KN; Hall, LM; Holm, FA; and Gulden, RH (2011) "Risk assessment of glyphosate resistance in Western Canada." *Weed Technology*. 25 p 159-64.

Beckie, HJ and Reboud, X (2009) "Selecting for weed resistance: Herbicide rotation and mixture." *Weed Technology*. 23 (3): p 363-70.

Brookes, G and Barfoot, P (2012) "Global impact of biotech crops: Environmental effects, 1996–2010." *GM Crops and Food: Biotechnology in Agriculture and the Food Chain*. 3 (2): p 129-37. http://www.landesbioscience.com/journals/gmcrops/article/20061/.

CTIC (2007) "2007 amendment to the national crop residue management survey summary." Conservation Technology Information Center. Last Accessed: June, 14, 2010 http://www.conservationinformation.org/pdf/National_Summary_2007_Amendment.pdf.

CTIC. "2008 amendment to the national crop residue management survey summary." West Lafayette, Indiana: Conservation Technology Information Center, 2008.

Culpepper, AS; Kichler, J; and York, AC (2013) "University of Georgia programs for controlling Palmer amaranth in 2013 cotton." University of Georgia Cooperative Extension.

Diggle, AJ; Neve, PB; and Smith, FP (2003) "Herbicides used in combination can reduce the probability of herbicide resistance in finite weed populations." *Weed Research.* 43 (5): p 371-82.

Dotray, P; Keeling, W; and Johnson, J. "Synergistic/antagonistic effects of glyphosate and glufosinate in tank mixture in Glytol™ plus LibertyLink® cotton." College Station, Texas: Texas A&M University, AgriLIFE Research, 2011.

Fast, BJ; Murdock, SW; Farris, RL; Willis, JB; and Murray, DS (2009) "Critical timing of Palmer amaranth (*Amaranthus palmeri*) removal in second-generation glyphosate-resistant cotton." *Journal of Cotton Science.* 13 p 32-36.

Frisvold, GB; Hurley, TM; and Mitchell, PD (2009) "Adoption of best management practices to control weed resistance by corn, cotton, and soybean growers." *AgBioForum.* 12 p 370-81.

Gianessi, LP; Silvers, CS; Sankula, S; and Carpenter, JE (2002) *Plant biotechnology: Current and potential impact for improving pest management in U.S. agriculture. An analysis of 40 case studies*. Washington, D.C.: National Center for Food & Agricultural Policy.

Givens, WA; Shaw, DR; Johnson, WG; Weller, SC; Young, B; Wilson, R; Owen, MDK; and Jordan, DL (2009a) "A grower survey of herbicide use patterns in glyphosate-resistant cropping systems." *Weed Technology.* 23 p 156-61.

Givens, WA; Shaw, DR; Johnson, WG; Weller, SC; Young, BG; Wilson, RG; Owen, MDK; and Jordan, D (2009b) "A grower survey of herbicide use patterns in glyphosate-resistant cropping systems." *Weed Technology.* 23 p 156-61.

Heap, I "The International Survey of Herbicide Resistant Weeds." www.weedscience.com.

Hurley, TM; Mitchell, PD; and Frisvold, GB (2009) "Weed management costs, weed best management practices, and the Roundup Ready weed management program." *AgBioForum.* 12 p 281-90.

Keeley, PE; Carter, CH; and Thullen, RJ (1987) "Influence of planting date on growth of Palmer amaranth (*Amaranthus palmeri*)." *Weed Science.* 35 p 199-204.

McClelland, MR; Smith, KL; and Norsworthy, JK. "Managing glyphosate-resistant horseweed in conservation-tillage cotton production: Final summary and recommendations." Fayetteville, Arkansas: University of Arkansas Agricultural Experiment Station, 2006. Vol. AAES Research Series 552.

Monsanto (2012a) "Petition for the Determination of Nonregulated Status for Dicamba and Glufosinate-Tolerant Cotton MON 88701." Submitted by Marianne Malven, Registration Manager. Monsanto Company. St. Louis, MO. http://www.aphis.usda.gov/brs/aphisdocs/12_18501p.pdf.

Monsanto. "Unpublished grower survey data performed by a contracting agency." St. Louis, Missouri: Monsanto Company, 2012b.

Monsanto (2013) "Petitioner's Environmental Report for Dicamba-Tolerant Soybean MON 87708 and Dicamba and Glufosinate Tolerant Cotton MON 88701."

Nordby, D; Hartzler, B; and Bradley, K. "Biology and management of waterhemp. GWC-13." West Lafayette, Indiana: Purdue Extension, Purdue University, 2007.

Norsworthy, JK, Ward, S. M., Shaw, D. R., Llewellyn, R. S., Nichols, R. L., Webster, T. M., Bradley, K. W., Frisvold, G., Powles, S. B., Burgos, N. R., Witt, W. W., and Barrett, M. (2012) "Reducing the Risks of Herbicide Resistance: Best Management Practices and Recommendations." *Weed Science.* (Special issue): p 31-62. http://www.bioone.org/doi/abs/10.1614/WS-D-11-00155.1.

OECD (2002) "Module II: Herbicide biochemistry, herbicide metabolism and the residues in glufosinate-ammonium (Phosphinothricin)-tolentant transgenic plants."

Owen, MD; Young, BG; Shaw, DR; Wilson, RG; Jordan, DL; Dixon, PM; and Weller, SC (2011) "Benchmark study on glyphosate-resistant crop systems in the United States. Part 2: Perspectives." *Pest Management Science.* 67 (7): p 747-57. http://www.ncbi.nlm.nih.gov/pubmed/21452168.

Powles, SB (2008) "Evolution in action: Glyphosate-resistant weeds threaten world crops." *Outlooks on Pest Management.* 12 p 256-59.

Powles, SB; Preston, C; Bryan, IB; and Jutsum, AR (1996) "Herbicide resistance: Impact and management." *Advances in Agronomy*. San Diego, California: Academic Press. p 57-93.

Prince, JM; Shaw, DR; Givens, WA; Newman, ME; Owen, MDK; Weller, SC; Young, BG; Wilson, RG; and Jordan, DL. *Benchmark study: III. Survey on changing herbicide use patterns in glyphosate-resistant cropping systems*. Weed Technology, Champaign, Illinois.

Prince, JM; Shaw, DR; Givens, WA; Owen, MDK; Weller, SC; Young, BG; Wilson, RG; and Jordan, DL. *Benchmark study: I. Introduction, weed population and management trends from the benchmark survey 2010.* Weed Technology, Champaign, Illinois.

Reed, JD; Dotray, PA; and Keeling, JW (2011) "Palmer amaranth (*Amaranthus palmeri* S. Wats.) management in Glytol™ + LibertyLink® cotton." San Juan, Puerto Rico.

Reed, JD; Keeling, W; and Dotray, PA (2012) "Palmer amaranth and morningglory management in glyphosate/glufosinate-tolerant cotton." Charleston, South Carolina.

Sprague, C. "Palmer amaranth: A new invasive weed to watch for in Michigan." East Lansing, Michigan: Michigan State University, 2012.

U.S. EPA (2009) "Memorandum: Correction to the amendments to the dicamba RED."

University of Georgia (2012) "2012 Georgia cotton production guide." University of Georgia College of Agricultural and Environmental Sciences.

USDA-ERS (2012) "Crop production practices for cotton: National."

USDA-ERS (2013) "Genetically engineered (GE) soybean varieties by state and United States, 2000-2013."

USDA-NASS (2012a) "Census of Agricultrue-Preliminary Report." USDA-National Agricultural Statistics Service.

USDA-NASS (2012b) "Soybean herbicide use."

USDA-NASS (2013) "2012 Agricultural Chemical Use Survey Soybeans." USDA-National Agricultural Statistics Service. http://www.nass.usda.gov/Surveys/Guide_to_NASS_Surveys/Chemical_Use/2012_Soybeans_Highlights/ChemUseHighlights-Soybeans-2012.pdf.

USDA-NASS "Quick Stats." USDA. Last Accessed: 4-8-2014 http://www.nass.usda.gov/Quick_Stats/.

Wilcut, JW; Hayes, RM; Nichols, RL; Clewis, SB; Summerlin, J; Miller, DK; Kendig, A; Chandler, JM; Bridges, DC; Brecke, B; Snipes, CE; and Brown, SM (2003) *Weed management in transgenic cotton*. Raleigh, North Carolina: North Carolina State University Agricultural Research Service.

Appendix 5. Common Weeds in Cotton and Soybean

Common Weeds in Cotton and Soybean

Weeds are simply plants growing in areas where their presence is undesired by humans (Baucom and Holt, 2009). Plants that colonize frequently disturbed environments have evolved with characteristics or mechanisms that allow them to survive conditions in agricultural environments. Weedy plants typically exhibit early germination and rapid growth from seedling to sexual maturity, have the ability to reproduce sexually and asexually, and therefore are well adapted to agricultural fields (Baucom and Holt, 2009).

The presence of weeds in cotton and soybean fields is a primary detriment to productivity. Weeds are the most important pest complex in agriculture, impacting yields by competing with crops for light, nutrients, and moisture. In addition to taking valuable resources from crops, weeds can introduce weed seed or plant material to a crop, thereby reducing the market grade of the crop.

Additionally, weeds can harbor insects and diseases; weeds also can interfere with harvest, clogging and causing extra wear on harvest equipment (Loux *et al.*, 2008). For example, some winter annuals have been found to serve as alternative hosts for the soybean cyst nematode, a pest that affects soybean yields in the U.S.

Effective weed management involves an understanding of weed biology and of weed management strategies. This section provides an overview of weed types, the weed seed bank, and the timing and occurrence of weeds. Also described are the types of weeds that occur in corn and soybean. Weed management is discussed in Appendix 3.

Weed Classification

Weeds are classified according to their life cycle, as annuals, biennials or perennials. Weeds are also classified as broadleaf (dicots) or grass (monocots). Weeds can reproduce by seed, rhizome (underground creeping stems), or other underground part (e.g., buds, bulbs).

An annual is a plant that completes its lifecycle in one year or season and reproduces only by seed. Annuals can be further differentiated into summer or winter annuals. Summer annuals appear in the spring or early summer and die prior to or by the first frost, producing seeds within the same growing season. These weeds grow rapidly, strongly competing with crops for resources, and can outgrow and shade slower-growing crops.

Summer annuals can be further categorized into three groups: small-seeded summer annual broadleaf weeds, large-seeded summer annual broadleaf weeds, and summer annual grass weeds (Schonbeck, 2010). Some small-seeded summer annual broadleaf weeds include pigweeds, common lambsquarters, common purslane, galinsoga, and smartweeds. Commonly found large-seeded summer annual broadleaf weeds include velvetleaf, common cocklebur, and morningglory. Summer annual grass weeds have small to medium sized seeds and include foxtail, crabgrass, and goosegrass.

Winter annuals typically emerge in late summer or early fall, but can also germinate as late as early spring. Usually these weeds over-winter as small seedlings and set seed in the spring. These weeds have little effect on warm season crops. Common winter annuals include purple deadnettle, henbit, field pennycress, shepherd's-purse, and chickweed (Schonbeck, 2010; Mock *et al.*, 2011).

Biennials have a life cycle of two years or seasons. After persisting as low-growing vegetation during their first season, biennial weeds overwinter, then flower and produce seeds in their second growing season. Examples of biennial weeds are burdock, bull thistle, poison hemlock, and wild carrot.

Perennials are plants that live for more than two years and are typically categorized as simple or creeping or invasive perennials. Canada thistle, bermudagrass, common milkweed, common pokeweed, dandelion, Johnsongrass are examples of perennial weeds (Penn State University, 2009; Mock *et al.*, 2011).

<u>Weed Seed Bank</u>

An important concept in weed control is the seed bank which is the reservoir of seeds that are on the soil surface and scattered at different depths in the soil. The soil weed seedbank determines the size and species composition of the weed community within a growing season (Norsworthy, 2012). Under favorable conditions, these seeds have the potential to germinate and emerge, creating weed pressure (i.e., competition) in crops. The weed seed bank contains recently dropped seeds, older seeds mixed into the soil, tubers, bulbs, rhizomes, and other vegetative structures. Climate, soil characteristics, shifts in agricultural management practices, such as tillage, crop selection, and weed management practices, affect the density and species composition of the seed bank within a given field (Davis *et al.*, 2005; May and Wilson, 2006; Buhler *et al.*, 2008).

The majority of seeds in the weed seed bank come from the weeds that have grown and set seed in the field. Wind, water, animals, and birds can carry seeds, adding to the weed seeds already present. Also, manure or other material (e.g., mulch, feed, soil) transported by humans or farm equipment from other locations can be indirect sources of weed seed (Renner, 2000).

Agricultural soils can contain thousands of weed seeds and a dozen or more vegetative weed propagules per square foot (Menalled and Schonbeck, 2013). Annual weeds produce large numbers of seeds. For example, a pigweed plant can shed at least 100,000 mature seeds and one lambsquarters plant can produce more than 50,000 seeds (Renner, 2000). If left untended and without crop competition, giant ragweed can produce approximately 10,000 seeds, common waterhemp 70,000 seeds, and waterhemp 100,000 seeds, or more, per plant. Larger-seeded broadleaf weeds are not as prolific in comparison to small-seeded summer broadleaf weeds, but seed production is still high, with a few hundred to a few thousand per plant (Schonbeck, 2010). It has been observed that weeds in agricultural fields produce less seeds as a result of competition from the crop, damage from herbicides, and other factors, although these weed still produce high numbers of seeds that can affect production (Buhler *et al.*, 1997). Effective weed control is required to limit the number of weed seeds entering the soil seed bank that will contribute to sustained competition with the crops into subsequent growing seasons.

Although seedbanks are made up of numerous weed species, generally only a few species will comprise 70 to 90 percent of the total seed bank (Wilson, 1988; Buhler *et al.*, 1997; Renner, 2000). For example, common lambsquarters (*Chenopodium album*) is the dominant weed seed in many field soils in the north central region of the U.S. (Michigan) (Renner, 2000). A second smaller group of weed species may represent 10 to 20 percent of the seed bank (Buhler *et al.*, 1997).

Additionally, only a fraction of the seeds in a weed seed bank germinate and grow each year. Birds, rodents, insects, and other animals typically will consume available weed seeds found on the soil surface. Some seeds may decay or become unviable in the soil; other seeds may germinate but will die. Some seeds can remain dormant in the soil for long periods of time. When changes in the cropping system change, creating conditions that are suitable for germination and development of a particular weed species, that species can respond rapidly, becoming non-dormant and establish itself in the cropping system (Renner, 2000; Durgan and Gunsolus, 2003; May and Wilson, 2006; Steckel *et al.*, 2007). It is estimated that less than 10% of the weed seeds in the soil are non-dormant and able to germinate within a season. The remaining dormant seeds thereby serve to extend the longevity of the seed bank (Renner, 2000; PhysicalWeeding, 2009). For example, summer annuals can remain viable for years, even if buried deeper in the soil, while the larger broadleaf seeds can remain viable for decades (Schonbeck, 2010).

The majority of weeds grow from seeds in the top two inches of soil with the most significant numbers emerging from only the top one inch of soil (PhysicalWeeding, 2009). In general, most small-seeded weeds (e.g., foxtail, pigweed) germinate and emerge within the upper half inch of the soil surface. The large-seeded summer annual broadleaf weeds are usually found in soils below the surface layer (about 0.5 to 2 inches below the surface) and can germinate from soil depths of 1.5 inches or more. Summer annual grass weeds germinate predominantly from the top inch of soil. Generally, tillage brings these seeds to the surface, where they rapidly grow in response to light. The effects of different forms of tillage on the prevalence of weed species are discussed further, below.

Weed populations change in response to agricultural management decisions. Collectively, management decisions will impart selection pressures[1] on the present weed community, resulting in weed shifts on a local level (i.e., field level). These weed shifts occur regardless of what the selection pressure may be and may result in changes in weed density or weed diversity (Reddy and Norsworthy, 2010; Weller *et al.*, 2010). Weed shifts are generally most dramatic when a single or small group of weeds increases in abundance at the expense of other weed populations, potentially dictating the primary management efforts of the grower.

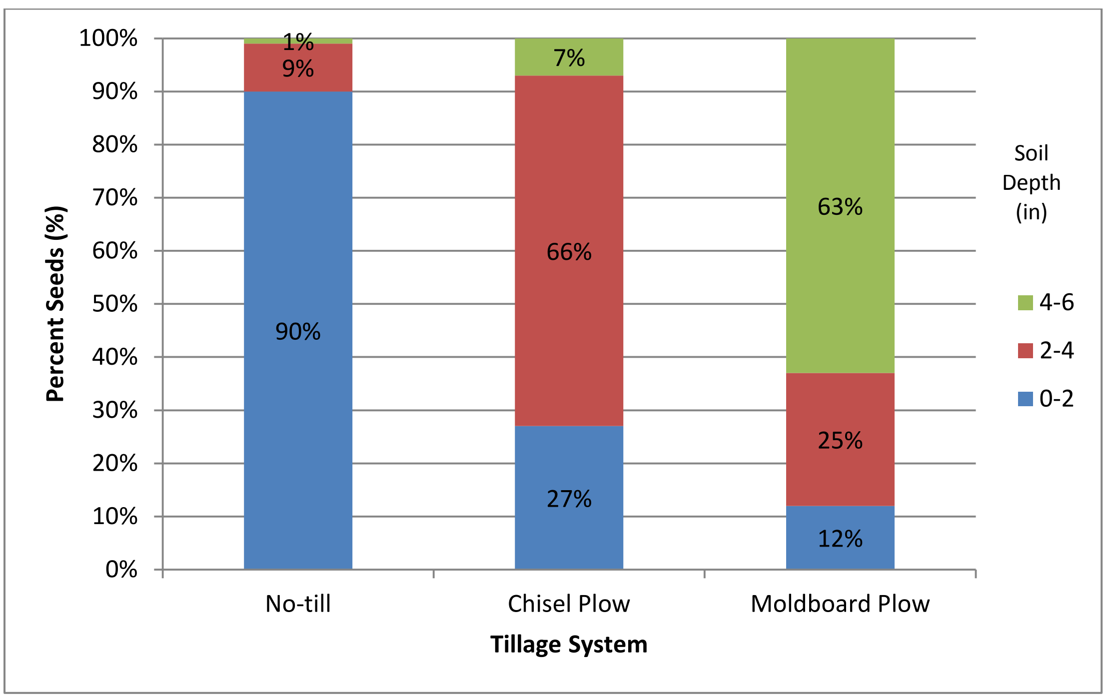
The vertical distribution of weed seeds in the soil is primarily influenced by the tillage system used.[2] These resulting changes in the distribution of the weed seeds in the weed seedbank will

[1] Selection pressure may be defined as any event or activity that reduces the reproductive likelihood of an individual in proportion to the rest of the population of that one individual. In agriculture, selection pressure may be imparted by any facet of management in the production of a crop, including the type of crop cultivated, strategy of pest management, or when and how a crop is planted or harvested.

[2] Tillage represents a mechanical means of weed control and is generally characterized by the amount of remaining in-field residue and may be classified as conservation ($\geq$30 percent), reduced (15-30 percent), or intensive (0-15 percent) CTIC (2008)

impact weed emergence and the resulting weed population in farm fields (Renner, 2000). As shown in Figure 5-1, the practice of no-till results in a majority of the weed seeds remaining at or near the soil surface where they have been deposited (Renner, 2000; Shrestha *et al.*, 2006; Menalled and Schonbeck, 2013). In no-till fields with more seeds at the surface, a greater diversity of annual and perennial weeds species may occur (Baucom and Holt, 2009). Winter annuals thrive in soil that is undisturbed from late summer or fall through early summer the following year which is best provided by no-till systems. Similarly, biennial weeds are prevalent in fields that have been no-till for several years, as they need undisturbed soil for two consecutive growing seasons.

Under reduced tillage systems (such as chisel plowing), approximately 80 to 90 percent of the weed seeds are distributed in the top four inches, with the majority found at depths ranging from two to four inches. Summer annual grass weeds germinate predominantly from the top inch of soil with prevalence in shallow and reduced tilled fields (Curran *et al.*, 2009). With recent increased rates of conservation tillage, there has been an observed decrease in large-seeded broadleaf weeds and an increase in perennial, biennial, and shallow-emerging annual grasses, small-seeded broadleaves, and winter annual weed species in those fields (Green and Martin, 1996; Durgan and Gunsolus, 2003; Norsworthy, 2012). The growth and spread of some perennial species that reproduce by spread of underground structures (e.g., rhizomes) may be encouraged by no-till or conservation tillage system which allows these structures to remain undisturbed (Buhler *et al.*, 2008; Baucom and Holt, 2009; Curran *et al.*, 2009).



Source: (Shrestha *et al.*, 2006)

Figure 5-1. Vertical Distribution of Weed Seeds in the Soil Profile at Depths of 0 to 2 inches, 2 to 4 inches, and 4 to 6 inches Affected by Different Tillage Regimes

Weed seeds become buried approximately four to six inches below the surface as a result of increasing tillage (Menalled and Schonbeck, 2013). As fewer weeds can germinate when buried, weed diversity tends to decline and annual large-seeded broadleaves are more prominent (Norsworthy, 2012).

These shifts in weed species necessitate changes in weed management strategies. Tillage practices must be regularly changed, in a manner similar to that of other agricultural production practices, to prevent buildup of any particular species or group of weeds in the soil seedbank.

Weed Emergence/Timing

In addition to weed density, the timing of weed emergence affects how they compete with the cotton or soybean crop and influences the level of crop yield loss. The critical period of weed control (CPWC) is the time during which weeds must be controlled to prevent yields losses. The key components defining CPWC are 1) knowing when weeds need to be removed and 2) when the crop becomes dominant (Boerboom, 2000). Weeds emerging before the CPWC may not impact crop yields if those weeds are controlled by the start of the CPWC. Weed competition occurring after the end of the CPWC will not affect yield (Boerboom, 2000; Knezevic, 2007). In particular, early in the growing season, the critical period of weed competition is most affected by: 1) how competitive the different weed species are, 2) the density of weeds, and 3) the relative time of weed emergence (Boerboom, 2000).

In contrast to other crops, including corn and soybean, cotton emergence and above ground growth is relatively slow during the first few weeks after planting. The slow early growth of cotton does not permit the crop to aggressively compete against weed species that often grow more rapidly (Smith and Cothren, 1999). Weeds in cotton are controlled through the diversified use of various cultural, mechanical, and chemical methods (Hake *et al.*, 1996). Historically, mechanical tillage and hand-weeding were the most important tools in cotton weed control due to the limited application window afforded to most chemical applications. Today with the advent of GE cotton, approximately 38% of the total cotton acres are post-plant cultivated. In fields classified as employing conventional tillage systems, over 50% cotton acres are cultivated for weed control (USDA-ERS, 2012).

Due to the biology and planting practices of cotton, in the U.S., whereby complete crop canopy closure is at times never achieved, herbicides are used at multiple intervals throughout the entire growing season on essentially all (>99%) the cotton acres in the U.S. (Brookes and Barfoot, 2012; Monsanto, 2012).

In soybean, the later that weeds emerge, the less impact they will have on yield, although weeds emerging later can have a negative influence on seed quality and harvest efficiency (Prostko, 2013). Soybean plants withstand early season weed competition longer than corn because the soybean canopy closes earlier (Boerboom, 2000). The extent of canopy closure restricts the light available for weeds and other plants growing below the soybean. In addition, canopy closure occurs more quickly when soybean is drilled or planted in narrow rows (Boerboom, 2000; Bradley, 2006); however, in some studies it has also been observed that, depending on factors such as weed species, environmental conditions (i.e., rainfall amounts) and soybean cultivar, soybeans are able to compete with weeds with no resulting yield reduction (Krausz *et al.*, 2001).

Place et al. have determined that larger soybean seeds produce a larger canopy more quickly and are, therefore, more successful at outcompeting weeds (Place *et al.*, 2011). Full-season soybean planting is preferable during the drier late spring conditions; however, summer annual weed emergence often occurs at this same time, resulting in a high level of weed interference with soybean emergence and establishment (DeVore *et al.*, 2013).

Common Weeds in Cotton and Soybean

Weed species emerge in a particular order throughout the year with each species having one or more periods of high emergence. The initial emergence date can vary from year to year, but the order stays relatively constant. Figure 5-2 shows the relative emergence of common weed species found in summer annual crops such as soybean and cotton. Weed emergence timing can dictate which weeds will be the most problematic for or be more easily controlled by a specific crop production or weed management practice (Buhler *et al.*, 2008). Weed management is discussed in Appendix 3.

Table 5-1. Summary of Problem Weeds Affecting Cotton and Soybean

Broadleaf Weeds			Grass Weeds		
Cotton + Soybean	Cotton	Soybean	Cotton + Soybean	Cotton	Soybean
Browntop millet	Bindweed	Wild buckwheat	Barnyard grass	Bermuda grass	Fall Panicum
Cutleaf primrose	Black nightshade	Burcucumber	Crabgrass	Crowfoot grass	Quackgrass
Florida beggerweed	Common cocklebur	Canada thistle	Cupgrass	Large crabgrass	
Florida pusley	Common lambsquarter	Chickweed	Johnsongrass		
Foxtail	Common purslane	Cockeburr	Goose grass		
Ground Cherry	Common ragweed	Copperleaf hophorn	Broadleaf signal grass		
Hemp sesbania	Devil's claw	Dandelion			
Henbit	Hairy Nightshade	Honeyvine milkweed			
Horseweed	Junglerice	Eastern black nightshade			
Jimson weed	Palmer amaranth	Hairy nightshade			
Kochia	Red Sprangletop	Wild oats			
Lambsquarter	Russian thistle	Common pokeweed			
Morning Glory	Shepardspurse	Wild proso millet			
Mustard	Smellmelon	Common ragweed			
Nutsedge	Sprangletop	Giant ragweed			
Palmer pigweed	Spurred anoda	Field sandbur			
Prickly sida	Texas blueweed	Shattercane			
Pigweed	Volunteer peanut	Venice mallow			
Sicklepod	Volunteer corn	Volunteer cereal			
Smart weed	Field bindweed	Waterhemp			
Spurge	Horse purslane	Tropic croton			
Sunflower	Woolyleaf bursage				
Texas millet	Silverleaf nightshade				
Velvet leaf					
Volunteer Corn					

Source: (Monsanto, 2013)
Notes:
Green: Weeds managed in both corn and soybean
Yellow: Weeds primarily managed in corn
Blue: Weeds primarily managed in soybean

References:

Baucom, R and Holt, J (2009) "Weeds of agricultural importance: Bridging the gap between evolutionary ecology and crop and weed science." *New Phytologist.* (184): p 741-43.

Boerboom, C (2000) "Timing Postemergence Herbicides in Corn and Soybeans." http://www.soils.wisc.edu/extension/wcmc/proceedings/3B.boerboom.pdf.

Bradley, KW (2006) "A Review of the Effects of Row Spacing on Weed Management in Corn and Soybean." http://www.plantmanagementnetwork.org/pub/cm/review/2006/weed/.

Brookes, G and Barfoot, P (2012) "Global impact of biotech crops: Environmental effects, 1996–2010." *GM Crops and Food: Biotechnology in Agriculture and the Food Chain.* 3 (2): p 129-37. http://www.landesbioscience.com/journals/gmcrops/article/20061/.

Buhler, DD; Hartzler, RG; and Forcella, F (1997) "Implications of Weed Seedbank Dynamics to Weed Management." *Weed Science.* 45 (3): p 329-36. http://www.jstor.org/stable/4046027.

Buhler, DD; Hartzler, RG; Forcella, F; and Gunsolus, JL (2008) "Relative emergence sequence for weeds of corn and soybeans." http://www.extension.iastate.edu/Publications/SA11.pdf.

CTIC (2008) "2008 Amendment to the National Crop Residue Management Survey Summary." Conservation Technology Information Center. http://www.ctic.purdue.edu/media/pdf/National%20Summary%202008%20(Amendment).pdf.

Curran, WS; Lingenfelter, DD; and Garling, L (2009) "An Introduction to Weed Management for Conservation Tillage Systems - Conservation Tillage Series Number Two." http://pubs.cas.psu.edu/freepubs/pdfs/uc126.pdf.

Davis, AS; Renner, KA; and Gross, KL (2005) "Weed seedbank and community shifts in a long-term cropping systems experiment." *Weed Science.* 53 (3): p 296-306. Last Accessed: 2013/12/04 http://wssajournals.org/doi/abs/10.1614/WS-04-182.

DeVore, JD; Norsworthy, JK; and Brye, KR (2013) "Influence of Deep Tillage, a Rye Cover Crop, and Various Soybean Production Systems on Palmer Amaranth Emergence in Soybean." *Weed Technology*. 27 (2): p 263-70. Last Accessed: 2013/12/04 http://dx.doi.org/10.1614/WT-D-12-00125.1.

Durgan, BR and Gunsolus, JL (2003) "Developing Weed Management Strategies that Address Weed Species Shifts and Herbicide Resistant Weeds." http://appliedweeds.cfans.umn.edu/pubs/03pub01.pdf.

Green, JD and Martin, JR (1996) "Dealing with Perennial Broadleaf Weeds in Conservation Tillage Systems." http://www.ag.auburn.edu/auxiliary/nsdl/scasc/Proceedings/1996/Green.pdf.

Hake, SJ; Kerby, TA; and Hake, KD (1996) "Preparation for the new crop season - Fall/winter." *Cotton Production Manual*. Davis, California: University of California Division of Agriculture and Natural Resources. p 6-14.

Knezevic, S (2007) "Timing Weed Control in Corn to Get the Most Effect." http://cropwatch.unl.edu/archive/-/asset_publisher/VHeSpfv0Agju/content/891332.

Krausz, RF; Young, BG; Kapusta, G; and Matthews, JL (2001) "Influence of weed competition and herbicides on glyphosate-resistant soybean (*Glycine max*)." *Weed Technology*. 15 p 530-34. http://www.bioone.org/doi/abs/10.1614/0890-037X(2001)015%5B0530:IOWCAH%5D2.0.CO%3B2.

Loux, M; Stachler, J; Johnson, W; Nice, G; and Bauman, T (2008) "Weed Control Guide for Ohio Field Crops " Ohio State University Extension. http://ohioline.osu.edu/b789/index.html.

May, M and Wilson, R. "Chapter 14: Weeds and Weed Control. Pgs. 359–386." *Sugar Beet*. Ed. Draycott, A.P. Oxford, United Kingdom: Blackwell Publishing Ltd., 2006. 474 pgs. Vol. World Agricultural Series.

Menalled, F and Schonbeck, M (2013) "Manage the Weed Seed Bank—Minimize "Deposits" and Maximize "Withdrawals"." http://www.extension.org/pages/18527/manage-the-weed-seed-bankminimize-deposits-and-maximize-withdrawals.

Mock, VA; Creech, EJ; Johnson, B; Faghihi, J; Ferris, VR; Westphal, A; and Bradley, K (2011) "Winter Annual Weeds and Soybean Cyst Nematode Management With a Guide for

Identifying Known Weed Hosts." http://www.extension.purdue.edu/extmedia/WS/WS-36.pdf.

Monsanto. "Unpublished grower survey data performed by a contracting agency." St. Louis, Missouri: Monsanto Company, 2012.

Monsanto (2013) "Petitioner's Environmental Report for Dicamba-Tolerant Soybean MON 87708 and Dicamba and Glufosinate Tolerant Cotton MON 88701."

Norsworthy, JK, Ward, S. M., Shaw, D. R., Llewellyn, R. S., Nichols, R. L., Webster, T. M., Bradley, K. W., Frisvold, G., Powles, S. B., Burgos, N. R., Witt, W. W., and Barrett, M. (2012) "Reducing the Risks of Herbicide Resistance: Best Management Practices and Recommendations." *Weed Science.* (Special issue): p 31-62. http://www.bioone.org/doi/abs/10.1614/WS-D-11-00155.1.

Penn State University (2009) "An Introduction to Weed Management for Conservation Tillage Systems." http://pubs.cas.psu.edu/freepubs/pdfs/uc126.pdf.

PhysicalWeeding (2009) "Information: Integrated Weed Management." http://physicalweeding.com/information/index.html.

Place, GT; Reberg-Horton, SC; Carter, TE; and Smith, AN (2011) "Effects of soybean seed size on weed competition." *Agronomy Journal.* 103 p 175-81. http://www.ars.usda.gov/research/publications/publications.htm?SEQ_NO_115=258170&pf.

Prostko, E (2013) "Soybeans Weed Control " http://www.caes.uga.edu/commodities/fieldcrops/soybeans/documents/2013GeorgiaSoybeanProductionGuide.pdf.

Reddy, K and Norsworthy, J (2010) "Glyphosate-Resistant Crop Production Systems: Impact on Weed Species Shifts." *Glyphosate Resistance in Crops and Weeds*. Hoboken, NJ: John Wiley & Sons, Inc. p 213-33.

Renner, KA (2000) "Weed Seedbank Dynamics." http://www.msuweeds.com/assets/ExtensionPubs/E2717.pdf.

Schonbeck, M. "Know the Weeds." eXtension.com, 2010. http://www.extension.org/pages/18540/know-the-weeds.

Shrestha, A; Lanini, T; Wright, S; Mitchell, J; and Vargas, R "Conservation Tillage and Weed Management."

Smith, CW and Cothren, JT (1999) *Cotton: Origin, history, technology, and production*. New York, New York: John Wiley and Sons, Inc.

Steckel, LE; Sprague, CL; Stoller, EW; Wax, LM; and Simmons, FW (2007) "Tillage, Cropping System, and Soil Depth Effects on Common Waterhemp (Amaranthus rudis) Seed-Bank Persistence." *Weed Science.* 55 (3): p 235-39. Last Accessed: 2013/12/04 http://wssajournals.org/doi/abs/10.1614/WS-06-198.

USDA-ERS (2012) "Crop production practices for cotton: National."

Weller, S; Owen, M; and Johnson, W (2010) "Managing Glyphosate-resistant Weeds and Populations Shifts in Midwestern U.S. Cropping Systems." *Glyphosate Resistance in Crops and Weeds*. Hoboken, NJ: John Wiley & Sons, Inc. p 213-33.

Wilson, R. (1988). ed.^eds. *Biology of weed seeds in the soil*. Boca Raton, FL: CRC Press. Print.

Appendix 6. Herbicide Resistance

Herbicide Resistance

Not unlike other agronomic practices, herbicide use may impart selection pressures on weed communities, resulting in shifts in the weed community that favor those weeds that do not respond to the herbicide used (Owen, 2008). Herbicide resistance is described by the Weed Science Society of America as the "inherited ability of a plant to survive and reproduce following exposure to a dose of herbicide normally lethal to the wild type" (WSSA, 2011b). The shift to herbicide resistance in plants is largely a function of the natural selection of herbicide-resistant traits and is strongly related to the repeated use of one or a limited number of herbicides (Durgan and Gunsolus, 2003; Duke, 2005).

Individual plants within a species can exhibit different responses to the same herbicide rate. Initially, herbicide rates are set to work effectively on the majority of the weed population under normal growing conditions. Genetic variability, including herbicide resistance, is exhibited naturally in normal weed populations, although at very low frequencies. When only one herbicide is used year after year as the primary means of weed control, the number of weeds resistant to that herbicide compared to those susceptible to the herbicide may change as the surviving resistant weeds reproduce. With no change in weed control strategies, in time, the weed population may be composed of more and more resistant weeds.

Both the increased selection pressure from the extensive use of glyphosate associated with glyphosate-tolerant crops along with the subsequent reduction in the use of other herbicides and changes in weed management practices (i.e., conservation tillage or no-till) have resulted in weed population shifts and increasing glyphosate resistance among some weed populations (Owen, 2008; Duke and Powles, 2009). Glyphosate-resistant crops themselves do not influence weeds any more than non-transgenic crops. It is the weed control tactics chosen by growers that create selection pressure that ultimately over time changes these weed communities and may result in the selection of herbicide-resistant weeds (Owen, 2008).

History of Weed Resistance to Herbicides and its Development

One of the earliest selective chemical herbicides to be used in agriculture was 2,4-D, a synthetic auxin, whose commercial use began in 1945 (Burnisde, 1996). Use of 2,4-D in corn was successful in controlling broadleaf weeds such that in the mid-1950s 2,4-D was applied to nearly one-half of all U.S. corn acres (Knake, 1996). Within 12 years, the first herbicide resistance to 2,4-D was reported in spreading dayflower in a Hawaiian sugarcane field (*Commelina diffusa*) in 1957 (see report in (Sellers *et al.*, 2011; Isaac *et al.*, 2013)).

Simazine was the first triazine to be used commercially in 1956. In 1958, the herbicide atrazine was first registered for weed control in corn in the U.S. Similar to what had occurred with 2,4-D, triazines were used extensively in the 1960s and common groundsel resistant to triazine herbicides was discovered in Washington in 1970 (Buhler, unknown). Regardless of the occurrence of resistant weeds, atrazine was, and still is, an extremely effective herbicide due to its broad spectrum, low cost, and flexible timing of applications (CropLife International, 2012).

ALS inhibitors or Group 2 herbicides were introduced in the mid-1980s and became extensively used in soybeans. With its broad-spectrum weed control, residual activity, and flexibility in application timing, the Group 2 herbicides became popular in the late 1980s and early 1990s. For example, by the early-1990s, Pursuit™, containing the ALS herbicide imazethapyr, was used on more than 75 percent of the soybeans in Iowa (Tranel and Wright, 2002). The widespread use of Group 2 herbicides resulted in the rapid selection of ALS-resistant waterhemp. By the mid-1990s, Group 2 resistant waterhemp was so widespread that the industry essentially stopped recommending Group 2 herbicides for this weed (Hartzler, 2013).

Sales of glyphosate began in 1974 and it became one of the most commercially successful and dominant herbicides in the U.S. (Duke and Powles, 2008). There are several reasons for the success of glyphosate in the market and the corresponding market sector penetration of glyphosate-tolerant crops since their introduction in the mid-late 1990s. Glyphosate: 1) works non-selectively on a wide range of plant species; 2) is a relatively low-cost herbicide; 3) enhances no-till farming practices; and 4) has minimal animal toxicological and environmental impact (Duke and Powles, 2008; Owen, 2008; Duke and Powles, 2009).

The widespread adoption of glyphosate-tolerant soybean, in combination with an increased reliance on glyphosate, has been related to the adoption of no-till cultivation which depends on controlling weeds without tillage. Glyphosate tolerant soybean also led to a simplification in weed control compared to past practices, reduced input and labor costs associated with the cultivar and glyphosate use, and increased flexibility in herbicide application timing (Lorenz *et al.*, 2006).

Most instructive are the events leading to the development of glyphosate resistance in weeds in the U.S. The previous history of glyphosate use for 20 years did not result the selection of herbicide-resistant weeds. As a result, industry promoted the view that widespread glyphosate use was unlikely to result in the selection of glyphosate resistant weeds (Bradshaw *et al.*, 1997), despite the fact that resistance to other herbicides, such as 2,4-D were being reported (see history in (Mithila *et al.*, 2011)). The first case reported, glyphosate resistant rigid ryegrass, was documented and confirmed in Australia in 1996 (Powles *et al.*, 1998), over twenty years after glyphosate first began to be used in agriculture.

Herbicide-resistant crops were introduced in 1996 with glyphosate-resistant soybean rapidly adopted by growers. As glyphosate went off patent in 2000, increased usage of glyphosate-resistant crops was facilitated by the low price of the herbicide. Tank mixes for separate activity against grasses and broad-leaf weeds were not needed when glyphosate could be used for weed control. In the mid-1990s, 51% of growers were using three, four or more herbicides for soybean weed control (cited in Gianessi et al. (2008)) or about three overall in 1995 (USDA-ERS, 1997). With the availability of glyphosate and glyphosate-resistant crops, herbicide applications could be reduced in many situations.

The efficacy of post-applications of glyphosate became clear, with weed control often not requiring a pre-application for good control (Reddy, 2001). If a grower needed additional weed control for effectiveness or flexibility, a pre-application of glyphosate and a post-glyphosate application were as effective and cost less than a pre-application with a non-glyphosate residual herbicide followed by post-application of glyphosate (Reddy, 2001). Increasing glyphosate applications resulted in a decline of the sales and use of most other herbicides. The earliest U.S. glyphosate resistance in a GE crop was found in horseweed, *Conyza canadensis*, in Delaware soybean in 2000 (Heap, 2013). Increasing exposure of weeds to glyphosate in other herbicide resistant crops such as corn and cotton soon began to expand the numbers and populations of resistant weeds in the U.S.

The intense use of glyphosate compared to sparing use of other herbicides on field crops is apparent in overall herbicide use trends over the last decade, and surveys of grower usage, such as that of Prince et al. (2012), provide specific details. These surveys give evidence of the prevalent practices employed by growers in which glyphosate was nearly the only herbicide used with the subsequent overexposure of crops and weeds to glyphosate.

It was reported by Young (Young, 2006) that there was a dramatic increase in the use of glyphosate in soybean and cotton production. In 2005, surveyed growers in multiple states rotating soybean and cotton indicated they chose glyphosate 51 % of the time for spring burndown, versus 21% for other herbicides (Table 6-1). For continuous soybean, growers chose glyphosate 46% of the time and 22% another herbicide (Table 6-1) (Prince *et al.*, 2012). Overall, 74% of the continuous soybean growers used glyphosate two or more times during a growing season (Table 6-2). When growers used non-glyphosate herbicides, continuous soybean growers used these herbicides in post-emergence applications 67% of the time, and cotton/soybean growers applied the herbicides on soybean post-emergence 76 % of the time (Table 6-2). Growers of GR cotton more frequently resorted applying glyphosate three or more times unless the GR cotton was rotated with GR corn (Prince *et al.*, 2012).

Table 6-1. Frequency of Spring Pre-plant Application of Glyphosate Among Surveyed Growers (2005)

	Herbicide Application	
Crop	**Glyphosate**	**Non-glyphosate**
Continuous soybean	46%	22%
Soybean in soybean/cotton rotation	51%	21%

Source: (Prince *et al.*, 2012)

Table 6-2. Frequency of Glyphosate Application to Crop by Surveyed Growers (2005).

	Herbicide Application					
	Glyphosate			Non-glyphosate		
Frequency	1X	2X	3X	1X	2X	3X
Crop						
Continuous soybean	23	62	12	27	7	67
Soybean in soybean/cotton rotation	26	53	13	24	---	76

Source: (Prince *et al.*, 2012)

It is clear that when herbicides are applied, selection for those weeds with adaptive mechanisms to escape elimination will survive. If the herbicide is repetitively used in crop production, the surviving weeds will be further selected, and dominant genes as well as multi-component resistance mechanisms will be selected. While many practices can be used to manage weeds, the recent history of glyphosate use shows that when the collective knowledge of resistance development is either neglected or practices not sufficiently integrated with mechanical and cultural controls, or with more robust herbicidal strategies, resistant weeds will arise. As noted earlier, it is not so much herbicide resistant crops that are a cause of herbicide resistant weeds, but from the failure to apply best management practices in the production of herbicide resistant crops.

Mechanisms of Herbicide Resistance in Weeds and Relationship to Selective Pressure

Two types of weed resistance may arise following inadvertent weed selection and both confer complex management concerns for growers. The first is target site-specific resistance (TSR), and the second, non-target site-specific resistance (NTSR). The first results in an alteration of the target site of the herbicide so the target is no longer inhibited. The second type of resistance is more general and may confer resistance to a wide range of chemistries. For example, NTSR resistance may provide protection by reduced penetration of the herbicide, altered translocation, overproduction of targets, target mutation, or neutralization of cytoplasmic toxins (Délye *et al.*, 2013). TSR confers resistance usually to a single herbicide, and NTSR may confer resistance to as many as nine different modes of action (e.g., *Lolium rigidum*) and 16 herbicides (Beckie, 2011). In the case of NTSR, the use of herbicides on weeds with unknown NTSRs may provide a substantial risk for development of weed resistance (Délye *et al.*, 2013).

The target site alterations leading to TSR are often produced by dominant or semidominant nuclear mutations and can be found in herbicide Groups 1, 2, 3, 23, 14, and 9, while triazine herbicides (Group 5) result from dominant cytoplasmic mutations (Délye *et al.*, 2013). This resistance arises following a single mutation, which because of its beneficial nature promotes immediate survival and is positively and rapidly selected within the agricultural environment. Glyphosate resistance that is TSR is a consequence of one amino acid change at position 106 of the chloroplast EPSPS protein. Worldwide, 14 of these populations have been identified (Beckie, 2011).

Natural Tolerance

Natural tolerance to certain herbicides may be apparent when weeds are first exposed to a herbicide, or with selection, existing genes may be selected and then accumulated to produce varying levels of tolerance (likely by NTSR). Field morning glory (*Convolvulus arvensis L.*) has such tolerance to glyphosate and has been assessed in detail (Westwood and Weller, 1997). Glyphosate tolerance in Convolvulus was also found in historical populations which predated glyphosate resistant crop introductions (Baucon and Mauricio, 2010). The pre exposure NTSR to glyphosate was at about the same level as that which is currently observed. Morning glory can also be shown to have pre-existing resistance (that is, by TSR) but which is not as high as that expressed by plants now collected (Baucon and Mauricio, 2010). Both types of resistance can exist in the species, but independently, with resource allocation costs apparent for the plant's tolerance mechanisms for the herbicide (Baucon and Mauricio, 2008). At least some populations of 16 species have been alleged as not controllable by recommended field rates of glyphosate, presumably by natural tolerance mechanisms (Duke and Powles, 2008).

Weeds Resistant to Multiple Herbicides

Direct resistance of a weed species to an herbicide is an unwelcome consequence of weed selection, but cross resistance to other herbicides in the same class or to other classes of herbicides provides an even greater consequence to those who manage weeds, since a grower's choice of herbicide site of action (SOA) will be restricted in the present season's crop and potentially also in the rotation crop. When resistance is based on non-target site mechanisms, which may include increased metabolism and reduced translocation to target sites, the weed may be capable of resistance to multiple herbicide modes of action (Beckie and Tardif, 2012). NTSR appears to arise from a weed's accretion of variants of several genes which may originally have been subsets of stress-tolerance genes (see review in Délye (2013)). Délye (2013) attributes much of the recently discovered weed resistance to this mechanism, and it is particularly important in Groups 9 (glyphosate) and 1 (acetyl-CoA carboxylase inhibitors), as well as grasses and probably broadleaf weeds (Group 2: acetohydroxyacid synthase inhibitors). In the case of glyphosate, Beckie (2011) lists 15 instances worldwide of glyphosate NTSR.

Weed Selection for Resistance to Herbicides by Overuse

The intense use of glyphosate on field crops compared to decreased use of other herbicides is a trend within the last decade, but how growers use glyphosate in field situations makes the situation clearer in grower surveys such as that of Prince (2012). These surveys give evidence of the prevalent practices employed by growers in which glyphosate is sometimes the only herbicide used, allowing the overexposure of crops and weeds to glyphosate. Growers were choosing glyphosate frequently for pre-plant burndown, but also post-planting with high frequency, so that repeated exposure of weeds to glyphosate during crop production was common within the same season. Because the most common rotation crop for corn is soybean, exposure of weeds to selecting doses of glyphosate occurs in consecutive seasons as well.

Because conservation tillage systems are inherently more dependent upon weed management using herbicides, selective pressure on weeds is greater than that on fields using conventional tillage with its greater options for pre-plant primary tillage and post plant secondary tillage (Vencill *et al.*, 2012). In a survey conducted in 2007, growers that planted 87% of their crops to glyphosate resistant corn, soy or cotton varied the SOA used on their crops 'always' or 'mostly' just 39% of the time, with the remaining 61% affirming they did so 'seldom' or 'never' (Frisvold *et al.*, 2009). Thus, when conservation tillage and HR crops define the production system, growers are likely to use the same herbicide (i.e., glyphosate) frequently. Some other options also may be foreclosed by conservation till (especially no-till), such as soil incorporation of residual herbicides, although some residuals can also be soil applied (Penn State Extention, 2013).

Considering the recommendations for success in reducing resistant weed development (Vencill *et al.*, 2012), unsuccessful herbicide strategies that have encouraged resistant weeds can include:

1. Herbicide use of mostly one or a few modes of action (Norsworthy, 2012) and infrequent use of herbicide tank mixes, sequences and diversity across seasons (WSSA, 2011a);

2. Incorrect timing of herbicide application (Norsworthy, 2012);

3. Failure to consider the likelihood that a weed already has non-target site resistance mechanisms (Délye *et al.,* 2013) against specific herbicides (including metabolic potential, ability to prevent translocation, or ability to sequester the herbicide);

4. Applying low doses of herbicide thereby allowing weeds to be exposed to low rates herbicide which encourages sequential escapes and accumulating resistance genes (WSSA, 2011b);

5. Not establishing fields devoid of active weeds at planting or good weed control at canopy closure (for soybean) because not all available tools and herbicides were used (Monsanto, 2013); resulting in poorer crop establishment and more weed initiation.

Weed Resistance from Undervaluing a Balance of Residual and Contact Herbicides

The decrease in use of soil applied residual herbicides and a focus instead on mainly foliar-applied contact herbicides may be another basic and strategic misapplication of technology by field crop producers and these resulted in resistant weed development. In the era before introduction of HR soybean and cotton, and afterwards, production changes by growers were noted in the use of herbicides in the transition to greater HR crop acreage. For soybeans, in 1996, 70% of growers used pre-emergent herbicides, but by 2002 they did so less than 20% of the time (Livingston and Osteen, 2012). Likewise, Prince (2012) concluded that soybean growers were less likely than corn or cotton growers to use a residual herbicide (often pre-emergent) in their multistate survey of herbicide use in 2005 and 2010. Growers thus lost value from an herbicide by not deploying a residual (soil applied residual in no-till production) herbicide that has a different SOA than glyphosate, and relying on post-emergence control using glyphosate or another foliar active herbicide. Perhaps as a consequence of awareness of weed herbicide resistance or in an effort to combat glyphosate resistant crops, use of residual herbicides has increased modestly between 2005 and 2009 from 15% to 27% of soybean acreage (Owen *et al.*, 2011).

Related to the issue of reductions in residual pesticide use is that of reductions in total numbers of herbicides used in soybean and cotton. An USDA Agricultural Resources and Environmental Indicators (AREI) survey showed that soybean growers reached a high point of rotating pesticides to slow resistance evolution in1998, but this declined steadily to low single digits in 2010 (USDA-ERS, 2010).

Herbicide-Resistant Weeds in Soybean and Cotton

It is important to distinguish herbicide resistance from herbicide tolerance. A herbicide-resistant weed is one in which there is an inherited ability of a plant to survive and reproduce following exposure to a dose of herbicide normally lethal to the wild type (WSSA, 2012). A herbicide-tolerant weed species is one that is naturally tolerant to a herbicide; for example, a grass species is not killed by the application of a broadleaf herbicide (WSSA, 2012). Furthermore, certain weed species, while neither resistant nor tolerant, are inherently difficult to control with a particular herbicide, requiring more careful herbicide use and weed management practices (Monsanto, 2013).

As of April 2014, 429 herbicide-resistant weed biotypes have been reported to be resistant to 22 different herbicide modes-of-action worldwide (Heap, 2014b). Glyphosate-resistant weeds, which occur in certain areas of the United States, account for approximately 7% of the herbicide-resistant biotypes while weeds resistant to herbicides that inhibit acetolactate synthase (ALS) account for 34% of the herbicide-resistant biotypes. Synthetic auxin-resistant and glufosinate-resistant weeds account for 7% and 0.5% of resistant biotypes, respectively (Heap, 2014b; Heap, 2014a).

There are currently 429 unique cases of herbicide-resistant weeds globally, with 234 species (138 dicots and 96 monocots). Weeds have evolved resistance to 22 of the 25 known herbicide sites of action (Heap, 2014b). The first herbicide-resistant biotypes were described in the 1950s, but the number of weeds resistant to herbicides increased dramatically in the 1980s and 1990s, and resistance to 22 of the 25 known herbicide sites of action has been identified throughout the world (Heap, 2014b) and to 154 different herbicides**.** Herbicide-resistant weeds have been reported in 81 crops in 65 countries (Heap, 2014b).

While there are hundreds of cases of herbicide-resistant weeds, most of these weeds are not actively managed in cotton and soybean.

Herbicide-resistant Weeds in Soybean Production

Glyphosate-resistant weed biotypes that can be found in soybean fields include Palmer amaranth (*Amaranthus palmeri*), spiny amaranth (*Amaranthus spinosus*), tall waterhemp (*Amaranthus tuberculatus*), common ragweed (*Ambrosia artemisiifolia*), giant ragweed (*Ambrosia trifida*), horseweed (*Conyza canadensis*), kochia (*Kochia scoparia*), goosegrass (*Eleusine indica*), Italian ryegrass (*Lolium multifloru*), and Johnsongrass (*Sorghum halepe*) (Heap, 2014c).

In certain areas of the United States, resistance to the ALS group of herbicides is present in most of the major broadleaf weed species commonly found in soybeans. For common ragweed and waterhemp, there is known resistance to at least one member for several of the major soybean herbicide chemistry classes. While there are effective options for managing common ragweed, waterhemp, Palmer amaranth and other key broadleaf weeds, the availability of additional herbicide modes-of-action will help combat future resistance in soybeans and manage existing herbicide-resistant weed populations in areas of the United States where such populations exist. Similarly, there has been an increase in the detection of weed populations with multiple resistance (i.e., resistance to multiple herbicide modes-of-action) in some weed species, for example, *Amaranthus* spp. (Tranel *et al.*, 2010). The emergence of these resistant biotypes in certain areas of the U.S. and continued need to utilize diversified weed management practices supports the need for additional herbicide modes-of-action in major crops such as soybean.

The relative occurrence of herbicide-resistant weeds varies between the different sub-groups of auxinic herbicides. Considering that auxin herbicides have been widely used in agriculture for more than 60 years, weed resistance to this class is relatively low (31 species, to date, worldwide) and its development has been slow, especially when compared to the speed of appearance of resistance to ALS inhibitors (144 species) or triazine-resistant populations (72 species) (Heap, 2014a). The relatively low incidence of auxinic herbicide resistance is believed to be attributable to the fact that there are multiple target sites for these herbicides (Gressel and Segel, 1982; Morrison and Devine, 1993; Monsanto, 2012).

Herbicide-resistant Weeds in Cotton Production

Glyphosate-resistant weed biotypes found in cotton fields in certain areas of the United States may include Palmer amaranth (*Amaranthus palmeri*), spiny amaranth (*Amaranthus spinosus*), tall waterhemp (*Amaranthus tuberculatus*), common ragweed (*Ambrosia artemisiifolia*), giant ragweed (*Ambrosia trifida*), horseweed (*Conyza canadensis*), junglerice (*Echinochloa colona*), kochia (*Kochia scoparia*), goosegrass (*Eleusine indica*), and Italian ryegrass (*Lolium multifloru*) (Heap, 2014c). The emergence and growth of herbicide-resistant weeds (including glyphosate-resistant weed biotypes) in certain areas of the United States over the past decade, has required growers to adapt and implement improved weed management strategies.

The occurrence of weed-resistant biotypes varies across the cotton-growing regions, with more resistance issues observed in certain areas of the Southeast and Midsouth cotton-growing regions. *Amaranthus* spp., in particular Palmer amaranth, are problematic weeds in the mid-south and southeastern U.S. Palmer amaranth is considered to be one of the most competitive and aggressive of the *Amaranthus* spp. because of its rapid growth and prolific seed production. In addition, it has developed resistance to multiple herbicide classes (glycines, ALS, and dinitroanilines) (Culpepper *et al.*, 2011; Heap, 2014b). Managing herbicide-resistant Palmer amaranth has proven to be challenging due to the biology of this particular weed, including its dioecious nature (the male and female flowers occur on separate plants), which leads to greater genetic diversity in the plant population and increases the potential for spreading herbicide resistance (Sosnoskie *et al.*, 2011).

Resistance to the ALS group of herbicides is present in most of the major broadleaf weed species commonly found in cotton. For *Amaranthus* spp. and *Ambrosia* spp., there is known resistance to at least one member for several of the major herbicide chemistry classes. In an effort to manage glyphosate-resistant Palmer amaranth in certain areas of the U.S., certain non-glyphosate cotton herbicides are being used in conditions and practices that can result in increased selection of resistant biotypes to those herbicides, and as a result some key agricultural herbicides in some major herbicide classes, such as glufosinate and PPO inhibitors, are at further risk (Nichols *et al.*, 2010; Prostko, 2011b; Prostko, 2011a). While there are effective options for managing *Ambrosia* spp., and *Amaranthus* spp., including Palmer amaranth and other key broadleaf weeds, the availability of additional herbicide modes-of-action will help combat potential future resistance of the key herbicides needed for weed management in cotton. In addition, there has been an increase in the detection of weed populations with multiple resistances (*i.e.*, resistance to multiple herbicide modes-of-action) in some weed species, for example, *Amaranthus* spp. (Tranel *et al.*, 2010). The emergence of these resistant biotypes in certain areas of the U.S. highlights the continuing need to utilize diversified weed management practices and the ongoing need for additional herbicide modes-of-action that are effective in major crops.

References:

Baucon, Regina S., and Rodeny Mauricio. 2008. "Constraints on the Evolution of Tolerance to Herbicide in the Common Morning Glory: Resistance and Tolerance are Mutually Exclusive."

Baucon, Regina S., and Rodney Mauricio. 2010. "Defence against the herbicide RoundUp®predates its widespread use." *Evolutionary Ecology Research* 2010.12: 131-41.

Beckie, Hugh. 2011. "Herbicide-resistant weed management: focus on glyphosate." *SCI*.

Beckie, Hugh, and Francois Tardif. 2012. "Herbicide cross resistance in weeds." *Crop Protection 35 (2012) 15e28*.

Bradshaw, Laura, Stephen Padgette, Steven Kimball, and Barbara Wells. 1997. "Perspectives on Glyphosate Reisitance." *Weed Technology* Review.

Buhler, Wayne. unknown. "Incidence and History of Herbicide Resistance." *Resistance* Pesticide Environmental Stewardship unknown. Web. December 5 2013 http://pesticidestewardship.org/resistance/Herbicide/Pages/Incidence-and-History-of-Herbicide-Resistance.aspx.

Burnisde, Orvin. 1996. "The History of 2,4-D and Its Impact on Development of the Discipline of Weed Science in the United States." *Phenoxy Herbicides Chapter 2*.

CropLife International.2012. "Implementing Integrated Weed Management for Herbicide Tolerant Crops." Belgium: CropLife International. 62. http://www.croplife.org/IntegratedWeedManagement.

Culpepper, A. S., A. C. York, and L. E. Steckel *Glyphosate-resistant Palmer amaranth management in cotton.* . 2011. http://www.swss.ws/wp-content/uploads/docs/2011%20Proceedings-SWSS.pdf.

Délye, Christophe, Marie Jasieniuk, and Valérlie Le-Corre. 2013. "Deciphering the evolution of herbicide resistance in weeds."

Duke, S. 2005. "Taking stock of herbicide-resistant crops ten years after introduction." *Pest Management Science* 61: 211-18. http://onlinelibrary.wiley.com/doi/10.1002/ps.1024/pdf.

Duke, S.O., and S.B. Powles. 2009. "Glyphosate-resistant crops and weeds: Now and in the future." *AgBioForum* 12.3&4: 346-57.

Duke, S.O., and S.B. Powles. 2008. "Glyphosate: A once-in-a-century herbicide." *Pest Management Science* 64.4: 319-25. http://www.ncbi.nlm.nih.gov/pubmed/18273882.

Durgan, B.R. , and J.L. Gunsolus. 2003."Developing Weed Management Strategies that Address Weed Species Shifts and Herbicide Resistant Weeds." 2011.August 14. Web. http://appliedweeds.cfans.umn.edu/pubs/03pub01.pdf.

Frisvold, George B., Terrance M. Hurley, and Paul D. Mitchell. 2009. "Adoption of best management practices to control weed resistance by corn, cotton, and soybean growers." *AgBioForum* 12: 370-81.

Gianessi, L.P. 2008. "Economic impacts of glyphosate-resistant crops." *Pest Management Science* 64.4: 346-52. http://www.ncbi.nlm.nih.gov/pubmed/18181242.

Gressel, J., and L. A. Segel.1982. "Interrelating factors controlling the rate of appearance of resistance: The outlook for the future." *Herbicide Resistance in Plants*. Eds. LeBaron, H. M. and J. Gressel. Hoboken, NJ: John Wiley and Sons. 325-47.

Hartzler, Bob. 2013."A History Lesson in Herbicide Resistance." *Integrated Crop Management News*. Web. http://www.extension.iastate.edu/CropNews/2013/0114hartzler.htm.

Heap, I. 2014a. "Herbicide-Resistant Weeds by Site of Action " WSSA 2014a. Web http://www.weedscience.com/summary/SOASummary.aspx.

Heap, I. 2013. "Herbicide Resistant Weeds in Soybean Globally: United States - State Specific." February 6, 2013 2013. Web. February 25 2013 http://www.weedscience.com/summary/Crop.aspx.

Heap, I. 2014b. "The International Survey of Herbicide Resistant Weeds." (2014b). Web. August, 2013 www.weedscience.com.

Heap, I. 2014c. "Weeds Resistant to EPSP synthase inhibitors (G/9)." WSSA 2014c. Web http://www.weedscience.org/Summary/MOA.aspx?MOAID=12.

Isaac, Wendy-Ann, Zongjun Gao, and Mei Li.2013 "Managing Commelina Species: Prospects and Limitations, Herbicides - Current Research and Case Studies in Use." *Herbicides - Current Research and Case Studies in Use.* Ed. Price, Dr. Andrew. Vol.: InTech, 2013. Web http://www.intechopen.com/books/herbicides-current-research-and-case-studies-in-use/managing-commelina-species-prospects-and-limitations.

Knake, Ellery. 1996. "Phenoxy Herbicide Use in Field Corn, Soybean, Sorghum, and Peanut Production in the United States." *Phenoxy Herbicides Chapter 6.*

Livingston, M., and C. Osteen. 2012. "Agricultural Production Management. Pest Management ": p.21-24.

Lorenz, Gus, Donald R. Johnson, Glenn Studebaker, Charles Allen, and Seth Young III. 2006. "Soybean Insect Management." University of Arkansas Division of Agriculture Cooperative Extension Service 2006. Web. September 9 2011 http://www.aragriculture.org/insects/soybean/default.htm.

Mithila, J., J. Christopher Hall, William G. Johnson, Kevin B. Kelley, and Dean E. Riechers. 2011. "Evolution of Resistance to Auxinic Herbicides: Historical Perspectives, Mechanisms of Resistance, and Implications for Broadleaf Weed Management in Agronomic Crops." *BioOne*.

Monsanto.2012. "Petition for the Determination of Nonregulated Status for Dicamba-Tolerant Soybean MON 87708." Ed. Mannion, Rhonda M.: Monsanto Company. http://www.aphis.usda.gov/brs/aphisdocs/10_18801p.pdf.

Monsanto. 2013."Weed Resistance Risk Assessment: U.S.". Web. http://weedtool.com/.

Morrison, I. N., and M. D. Devine. 1993. "Herbicide resistance in the Canadian prairie provinces: Five years after the fact." *Phytoprotection* 75.4: 5-16. http://nelson.cen.umontreal.ca/revue/phyto/1994/v75/n4/706067ar.pdf.

Nichols, R., K. Balkcom, S. Culpepper, M. Marshall, D. Monks, M. Patterson, A. Price, and L. Steckel.2010. "Meeting the challenge of glyphosate-resistant Palmer amaranth in conservation tillage." Cary, NC: Cotton, Inc. http://www.caes.uga.edu/topics/sustainag/contillage/conferences/2010/2010%20Bob%20Nichols%20Con%20Till.pdf.

Norsworthy, J.K., Ward, S. M., Shaw, D. R., Llewellyn, R. S., Nichols, R. L., Webster, T. M., Bradley, K. W., Frisvold, G., Powles, S. B., Burgos, N. R., Witt, W. W., and Barrett, M. 2012. "Reducing the Risks of Herbicide Resistance: Best Management Practices and Recommendations." *Weed Science*.Special issue: 31-62. http://www.bioone.org/doi/abs/10.1614/WS-D-11-00155.1.

Owen, M. D., B. G. Young, D. R. Shaw, R. G. Wilson, D. L. Jordan, P. M. Dixon, and S. C. Weller. 2011. "Benchmark study on glyphosate-resistant crop systems in the United States. Part 2: Perspectives." *Pest Management Science* 67.7: 747-57. http://www.ncbi.nlm.nih.gov/pubmed/21452168.

Owen, M.D.K. 2008. "Weed species shifts in glyphosate-resistant crops." *Pest Management Science* 64.4: 377-87. http://www.ncbi.nlm.nih.gov/pubmed/18232055.

Penn State Extention. 2013. "Herbicides " 2013. Web http://extension.psu.edu/pests/weeds/control/introduction-to-weeds-and-herbicides/herbicides.

Powles, Stephen, Debrah Lorraine-Colwill, James Dellow, and Christopher Preston. 1998. "Evolved resistance to glyphosate in rigid ryegrass (Lolium rigidum) in Australia."

Prince, Joby M., G. Shan, Wade Givens, M. D. Owen, S. C. Weller, B. Young, R. Wilson, and D. L. Jordan. 2012. "Benchmark Study: Survey of Grower Practices for Managing Glyphosate-Resistant Weed Populations." *A Journal of the Weed Science Society of America*.

Prostko, E. P.2011a. "Developing An Herbicide-Resistant Weed Management Plan." University of Georgia.

Prostko, E. P.*Developing an Herbicide Resistant Weed Management Plan*. 2011b.

Reddy, K.N.*Weed Control and Yield Comparisons of Glyphosate-Resistant and Glufosinate-Resistant Corn Grown Continuously and in Rotation [Poster Abstract]*. Southern Weed Science Society. 2001.

Sellers, B.A., J.A. Ferrell, and G.E. MacDonald. 2011."Herbicide Resistant Weeds." 2011.August 14. Web. http://edis.ifas.ufl.edu/ag239.

Sosnoskie, L.M., T.M. Webster, A.S. Culpepper, and J. Kichler. 2011. *The biology and ecology of Palmer amaranth: Implications for control.*: The University of Georgia Cooperative Extension. http://www.caes.uga.edu/applications/publications/files/pdf/C%201000_2.PDF.

Tranel, P. J., C. W. Riggins, M. S. Bell, and A. G. Hager. 2010. "Herbicide resistances in Amaranthus tuberculatus: A call for new options." *Journal of Agricultural and Food Chemistry* 59.11: 5808-12. http://pubs.acs.org/doi/pdf/10.1021/jf103797n.

Tranel, Patrick J., and Terry R. Wright. 2002. "Resistance of Weeds to ALS-Inhibiting Herbicides: What Have We Learned?" *Weed Science* 50.6: 700-12. http://www.jstor.org/stable/4046642.

USDA-ERS. 1997 "Crop Residue Management." *Agricultural Resources and Environmental Indicators 1996-1997*. Eds. Anderson, M. and R Magleby. Washington: U.S. Department of Agriculture–Economic Research Service. 356. http://www.ers.usda.gov/publications/arei/ah712/AH7124-2.PDF.

USDA-ERS. 2010. "Top 25 Agricultural Export Commodities, With Level of Processing, by Fiscal Year, Current Dollars." (2010). Web. August 13 http://www.ers.usda.gov/Data/FATUS/#monthly.

Vencill, William K., Robert L. Nichols, Theodore M. Webster, John K. Soteres, Carol Mallory-Smith, Nilda R. Burgos, William G. Johnson, and Marilyn R. McClelland. 2012. "Herbicide Resistance: Toward an Understanding of Resistance Development and the Impact of Herbicide-Resistant Crops." *Weed Science* 60.sp1: 2-30.

Westwood, J. H., and S. C. Weller. 1997. "Cellular Mechanisms Influence Differential Glyphosate Sensitivity in Field Bindweed(Convolvulus arvensis) Biotypes." *Weed Science* 45.1: 2-11.

WSSA.2011a "Lesson 5 - Principles of Managing Herbicide Resistance - " *WSSA Lesson Modules: Herbicide Resistant Weeds*. Vol.: Weed Science Society of America, 2011a. 24. Web http://wssa.net/wp-content/uploads/Lesson_5_HR-Turf.pptx.

WSSA. 2011b. "Weed Science Society of America." Weed Science Society of America April 18, 2011 2011b. Web. May 25 2011 http://wssa.net/wp-content/uploads/WSSA-Mechanism-of-Action.pdf.

WSSA. 2012. "WSSA lesson module: Herbicide resistant weeds." Weed Science Society of America, Champaign, Illinois 2012. Web http://wssa.net/2011/12/wssa-lesson-module-herbicide-resistant-weeds/.

Young, B. G. 2006. "Changes in herbicide use patterns and production practices resulting from glyphosate-resistant crops." *Weed Technology* 20: 301-07. http://www.bioone.org/doi/pdf/10.1614/WT-04-189.1.

Appendix 7. Off-Target Pesticide Movement

Off-Target Pesticide Movement

Once applied, pesticides (which include herbicides) remaining on the application site that are not taken up by targeted plants that have been harvested will persist, degrade, or move in the environment. The potential environmental fate of an herbicide is shown in Figure 7-1. Degradation occurs by hydrolysis, photolysis, or microbial dissipation resulting in the herbicide being broken down and eventually losing its herbicidal activity. Herbicides can be transported from their original application site by spray drift, runoff, leaching, volatility, wind erosion, or crop removal. Off-site movement of herbicides have the potential to impact non-target plant and animal communities living in proximity to fields in which herbicides are used, as well as human populations.

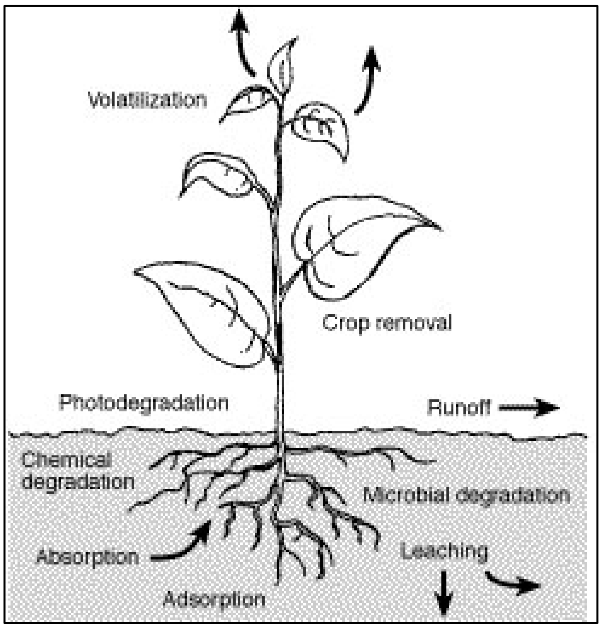


Figure 7-1. Environmental fate of herbicides in the environment.
Source: (Wright *et al.*, 1996).

The length of persistence of herbicides in the environment depends on the concentration and rate of degradation by biotic and abiotic processes (Carpenter *et al.*, 2002). Persistence is measured by the half-life or dissipation time (DT_{50}), which equates to the length of time needed for the herbicide to degrade to half of its original concentration.

Use of herbicides for field crop production may introduce these chemicals to water through spray drift, cleaning of pesticide application equipment, soil erosion, or filtration through soil to groundwater. Irrigation and rainfall occurring the first few days after herbicide application can influence herbicide loss through leaching and runoff. However, it has been estimated that even after heavy rains, herbicide losses to runoff generally do not exceed 5 to 10 percent of the total applied (USDA-NRCS, 2000; Tu *et al.*, 2001). Planted vegetation, such as grass buffer strips, or crop residues can effectively reduce runoff (Fishel, 1997; USDA-NRCS, 2000).

Pesticides applied to crops may volatilize, thereby introducing chemicals to the air. Volatilization typically occurs during application, but herbicide deposited on plants or soil can also volatilize.

Volatilization occurs when pesticide surface residues change from a solid or liquid to a gas or vapor after application. Volatilization refers to the transformation of a liquid or solid pesticide into a gas. The extent of volatilization is dependent on properties of the chemical and herbicide formulation, and environmental factors such as air temperature, wind speed, and relative humidity. Volatilized pesticides can be carried by air currents potentially leading to off-target exposure. Once airborne, volatilized pesticides may be carried long distances from the treatment location by air currents. The higher the vapor pressure of a chemical, the more volatility it exhibits. In addition, other physical and chemical pesticide properties, agricultural practices, meteorological conditions, persistence of a pesticide on plant surfaces, and soil properties influence the extent of volatilization (University of Missouri, 1997; US-EPA, 2012). It is also important to note that once volatilized, pesticides may undergo transformation in the atmosphere or physical removal in precipitation. Most of the herbicides considered highly volatile are no longer used (Tu *et al.*, 2001).

Drift is the physical movement of spray droplets moving off-site as a chemical application is made. Under certain conditions, the potential for physical drift from an application site to adjacent non-target environments is possible for all types of pesticide spray applications. This is an application-related phenomenon independent of the chemical pesticide, which may be influenced by the formulation ingredients and spray mix additives. Spray drift is a concern for non-target susceptible plants growing adjacent to fields when herbicides are used in the production of any crop. This potential impact relates to exposure of non-target susceptible plants to the off-target herbicide drift (Jordan *et al.*, 2009). Damage from spray drift typically occurs at field edges or at shelterbelts (i.e., windbreaks), but highly volatile herbicides may drift further into a field. The risk of off-target herbicide drift is recognized by EPA, which has incorporated both equipment and management restrictions to address drift on EPA-approved herbicide labels. These EPA label restrictions include requirements that the grower manage droplet size, control spray boom height above the crop canopy, restrict applications under certain wind speeds and environmental conditions, and use drift control agents (Jordan *et al.*, 2009).

The amount of drift varies widely and is influenced by a range of factors, including weather conditions, topography, the crop or area being sprayed, application equipment and methods, and practices followed by the applicator (US-EPA, 2000). EPA's Office of Pesticide Programs (OPP), which regulates the use of pesticides and herbicides in the U.S., encourages pesticide applicators to use all feasible means available to minimize off-target drift. EPA-OPP has introduced several initiatives to help address and prevent the problems associated with drift. EPA-OPP is evaluating new guidance for pesticide drift labeling and the identification of BMPs to control such drift (US-EPA, 2009a) as well as identifying scientific issues surrounding field volatility of conventional pesticides (US-EPA, 2010). Additionally, EPA-OPP and its Office of Research and Development are developing a new voluntary program, the Drift Reduction Technology (DRT) Program, which encourages the development, marketing, and use of application technologies verified to significantly reduce spray drift (US-EPA, 2009a).

EPA's core pesticide risk assessment and regulatory processes ensure that protections are in place for all populations of non-target species potentially exposed to pesticides, including humans. These assessments provide EPA with information needed to develop label use restrictions for the pesticide. Growers are required to use pesticides, such as dicamba and glyphosate, consistent with the application instructions provided on the EPA-approved pesticide label. Labels can include restrictions related to minimizing drift or exclusion distances from bodies of water when necessary. These label restrictions carry the weight of law and are enforced by EPA and the states (FIFRA 7 USC 136j (a)(2)(G) Unlawful Acts).

Pesticide Regulation & Registration (Monsanto, 2013)

APHIS does not have any statutory authority to regulate herbicide uses in agriculture. Instead the use of a pesticide is regulated by the U.S. Environmental Protection Agency (EPA) under the Federal Insecticide Fungicide and Rodenticide Act (FIFRA).[1]

EPA considers possible effects from offsite movement as part of the pesticide registration process under FIFRA. Additionally, pesticide registrants must report drift incidents to EPA as an adverse effect in order to ensure the pesticide continues to meet FIFRA requirements for registration. 40 C.F.R. § 159.195(a)(2). Before any registered herbicide can be applied to any new use site (including any deregulated GE-derived crop), EPA must approve a label amendment setting out the use pattern and specific application requirements for that new use site. Specifically, in order to approve a new use of a pesticide, EPA must conclude that no unreasonable adverse effects on the environment will result from the new use when applied according to label directions, which includes potential offsite movement. Offsite impacts are diminished when herbicides are applied in accordance with label instructions. Registered herbicides, including dicamba and glufosinate, are assessed by EPA for potential risks to non-target plants. A detailed discussion of the use of dicamba and glufosinate in the U.S. can be found in Appendix 4.

Use of Dicamba on DT soybean and DGT Cotton (Monsanto, 2013)

Dicamba (3,6-dichloro-2-methoxybenzoic acid) is a broad-spectrum, selective, post-emergence systemic herbicide with activity on a wide range of annual and perennial broadleaf plants. It was first registered in the United States in 1967 and is widely used in agricultural, industrial and residential settings. Dicamba controls annual, biennial and perennial broadleaf weeds in monocotyledonous crops and grasslands, and it is used to control brush and bracken in pastures. Because of the sensitivity of broadleaf plants to dicamba, the uses of dicamba in broadleaf crops until now have been limited to early pre-emergence and pre-harvest applications. DT soybean and DGT cotton have been developed to exhibit tolerance to dicamba herbicide applications by the insertion of a demethylase gene from *Stenotrophomonas maltophilia*. As a result DT soybean and DGT cotton express the dicamba mono-oxygenase (DMO) protein that rapidly demethylates dicamba to form the herbicidally inactive metabolite DCSA.

The use of dicamba is projected to increase if DT soybean and DGT cotton are deregulated. Please see Appendix A to this Environmental Report for a detailed discussion of the projections for increased use of dicamba in this scenario.

Offsite movement of herbicide to sensitive crops and plants during application is a concern during the growing season (Jordan *et al.,* 2009). The potential for effects to off-target crops from offsite movement due to spray drift is generally greatest with a postemergence application

[1] 7 U.S.C. §136 et seq.

because the treatment is made directly to the crop and requires the spray equipment to be higher above the ground, which results in more spray drift potential. In addition, postemergence herbicides typically have foliar activity, thereby increasing the potential of foliar effects or visual symptoms on desirable plants. The presence of dicamba can cause visible morphological effects to trees and certain sensitive crops, particularly beans (e.g., dry and snap beans), cotton, flowers, fruit trees, grapes, ornamentals, peas, potatoes, soybean, sunflower, tobacco, tomatoes, and other broadleaf plants when contacting their roots, stems or foliage (BASF, 2008; Jordan *et al.*, 2009). These plants are most sensitive to dicamba during their development or growing stage (BASF, 2008).

Spray Drift (Monsanto, 2013)

Spray drift of herbicides is a familiar and well-studied phenomenon, notably by the Spray Drift Task Force, of which Monsanto is a member. EPA defines drift as "the movement of pesticide through air at the time of application or soon thereafter, to any site other than that intended for application" (US-EPA, 2000). Factors affecting the occurrence of spray drift include application equipment and method, weather conditions, topography, and the type of crop being sprayed (US-EPA, 2000). Aerial application is associated with an increased drift potential compared to ground spray application because the herbicide is released at a greater distance above the crop canopy. In addition to the method of application, spray drift potential is also impacted by equipment type (e.g., nozzle types and ratings), settings (e.g., spray pressure, application speed, and application volume), equipment maintenance, environmental conditions (wind speed, temperature inversion), applicator behavior and distance from the edge of the application area (SDTF, 1997; Felsot *et al.*, 2010).

Prevention of Spray Drift (Monsanto, 2013)

Growers and commercial herbicide applicators have been applying dicamba to agricultural row crops for over 40 years. This experience has provided valuable knowledge and learning on the proper application of dicamba for effective weed control and also for minimizing offsite movement to sensitive crops. Spray drift can be reduced during application by using industry standard procedures for minimizing spray drift. Depending upon the herbicide being used, factors for managing the potential for spray drift include the selectivity and sensitivity of the herbicide, local weather conditions at the time of application (wind, temperature, humidity, inversion potential), droplet size distribution, application volume, boom height (height of the application equipment above the crop canopy), sprayer speed, and distance from the edge of the application area (SDTF, 1997; Felsot *et al.*, 2010). The minimization of droplets less than 150 microns is important in reducing any potential for spray drift. Droplet size can be increased by requiring the use of certain nozzle types, reducing spray pressure, increasing volume per minute spray rates, and by specifying an application volume per acre rate of at least 10 gallons (SDTF, 1997; TeeJet Technologies, 2011). Arvidsson et al. (Arvidsson *et al.*, 2011) investigated meteorological and technical factors affecting total spray drift and determined that boom height and wind speed were the primary factors affecting the potential for spray drift among those tested, followed by air temperature, driving speed and vapor pressure deficit. Arvidsson et al. (Arvidsson *et al.*, 2011) demonstrated that drift increased with driving speed. This increase was attributed to either air flows associated with the forward movement of the sprayer or to increased vertical boom movement.

EPA's Office of Pesticide Programs (OPP), which regulates the use of pesticides in the U.S., encourages pesticide applicators to use all feasible means available to them to minimize off-target drift. The Agency has introduced several initiatives to help address and prevent issues associated with drift. EPA is evaluating new regulations for pesticide drift labeling and the identification of best management practices to control such drift (US-EPA, 2009a), as well as identifying scientific issues surrounding field volatility of conventional pesticides (US-EPA, 2010). Additionally, OPP and EPA's Office of Research and Development are developing a new voluntary program, the Drift Reduction Technology (DRT) Program, which encourages the development, marketing and use of application technologies verified to significantly reduce spray drift (US-EPA, 2009a).

When herbicides are applied according to the FIFRA label application instructions, offsite impacts can be avoided. EPA concluded in the dicamba Registration Eligibility Decision (RED) (US-EPA, 2006; 2009b) that existing label language to mitigate offsite movement was sufficient to reduce the potential risk of damage to adjacent vegetation. Because the proposed application rates for dicamba on DT soybean and DGT cotton are less than or equivalent to rates for dicamba established for other uses in the dicamba RED, and because these uses were evaluated by EPA as part of the RED and the proposed label contains the offsite movement mitigation language, it is reasonable to conclude that the use of dicamba on DT soybean and DGT cotton also meets the FIFRA no unreasonable adverse effects on the environment standard for drift and offsite movement (US-EPA, 2006; 2009b).

Growers and commercial applicators follow label directions and restrictions, and are educated by university specialists and industry representatives on the proper application equipment, equipment setup, and climatic conditions to maximize herbicide performance and minimize offsite movement of herbicides. Equipment manufacturers have developed spray nozzles that provide uniform coverage for effective weed control while applying larger spray droplets to reduce the potential for particle drift.

Monsanto's Proposed Label Instructions (Monsanto, 2013)

Monsanto is proposing a multi-faceted approach to address potential for off-site movement of dicamba used on DT soybean and DGT cotton. Monsanto has proposed a range of application restrictions on its dicamba label. Collectively, these restrictions (which are currently pending before EPA) would go far beyond any other currently applicable limitations on dicamba application—indeed go beyond any label restrictions ever imposed on dicamba in the nearly half century that dicamba has been on the market.[2] Monsanto proposes to EPA that the supplemental labels for M1691 Herbicide use on DT soybean and DGT cotton contain application requirements that would minimize dicamba offsite movement, summarized as follows:

- No aerial application of M1691 Herbicide.

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[2] For example, Monsanto's proposed limits are far more restrictive than those for Dicamba Max 4, which allows aerial applications and does not require the use of drift-reducing additives. *See* Dicamba Max 4 Label, *http://www.kellysolutions.com/erenewals/documentsubmit/KellyData/ND/pesticide/Product%20Label/83222/83222-14/83222-14_DICAMBA_MAX_4_3_10_2009_6_06_42_PM.pdf*.

- Use only spray nozzles that produce extremely coarse to ultra-coarse spray droplets and minimal amounts of fine spray droplets as defined by the American Society of Agricultural and Biological Engineers (ASABE S-572.1) and follow nozzle manufacturer's recommendations to deliver desired droplet size.

- Apply using a minimum of 10 gallons of spray solution per acre.

- Select a ground speed under 15 mph that will deliver the desired spray volume while maintaining the desired spray pressure.

- Spray at the appropriate boom height based on nozzle selection and nozzle spacing (not more than 24 inches above target pest or crop canopy). Set boom to lowest effective height over the target pest or crop canopy based on equipment manufacturer's directions.

- When making applications in low relative humidity, set up equipment to produce larger droplets to compensate for evaporation.

- Do not apply during a temperature inversion.

- Survey the application site for neighboring sensitive areas prior to application. A potential way of locating sensitive areas is through the use of sensitive crop registries.[3]

- Do not apply when the wind is blowing in the direction of a sensitive area at a wind speed greater than 10 mph. Sensitive areas include known habitat for threatened or endangered species, non-target sensitive crops, residential areas, and greenhouses.

- Implement a spray buffer (to be determined by EPA) between the last treated row and the closest downwind edge of any sensitive area when the wind is blowing in the direction of a sensitive area at a speed of 10 mph or less.

- Do not apply if wind speed is greater than 15 mph.

- Do not use crop oil concentrate or methylated seed oil as adjuvants when applied with glyphosate-based agricultural products. Do not add acidifying buffering agents.

- Clean equipment immediately after using this product using the procedures outlined in the label.

These proposed label instructions and/ or any measures imposed by EPA will limit the offsite movement of dicamba via spray drift and inadvertent spray application for the reasons described in more detail in the following paragraphs.

[3] For example, www.driftwatch.org

Reduction of Small Droplets (Monsanto, 2013)

Monsanto has taken a variety of measures to reduce offsite spray drift, including proposing label requirements to minimize the factors that result in small droplet generation, suspension, and movement into non-target areas. The factors that affect spray drift and associated impacts to adjacent areas can be divided into three main categories: a) droplet size and number, b) droplet transport, and c) the physical location of the spray. Droplet size and number is controlled by the nozzle type, application volume, spray pressure, and additives in the tank. Droplet transport is affected by wind speed, boom height, air temperature, vapor pressure deficit[4], and application speed. The third factor includes the proximity to sensitive non-target species which can be controlled through a mandate that applicators be aware of sensitive areas - including areas where threatened or endangered species may be present - that could be impacted from a dicamba application and implement a no-spray buffer as specified on the label.

Droplet Size and Number (Monsanto, 2013)

The minimization of droplets less than 150 microns is important in reducing any potential for spray drift. Nozzles used for application of agricultural products do not produce droplets of one uniform size, but rather produce a spectrum of droplet sizes (TeeJet Technologies, 2011). Nozzles are generally classified as very fine, fine, medium, coarse, very coarse, extremely coarse, or ultra-coarse by comparison of a nozzle's droplet size distribution when spraying water to that of a set of standard nozzles. ASABE has established a nozzle classification system in its published standard, ASABE S-572.1 (ASABE, 2009; Wilson, 2011b), which is the U.S. industry standard for agricultural spray drop size classification. Nozzles classified as Extremely Coarse to Ultra Coarse have a small percentage of the spray volume in droplets with diameters less than 150 microns.

Nozzle orifice size and operating pressure also affect the droplet size spectrum for a given nozzle type (SDTF, 1997). The relationship between orifice size, operating pressure, spray volume delivered, and droplet size classification can be found in the nozzle manufacturers' catalogs. The use of a larger orifice size allows the application to be made at a higher volume per minute rate without increasing the operating pressure, and consequently reducing the droplet size classification (TeeJet Technologies, 2011). Additionally, a higher volume per minute rate allows the spray volume per acre to be higher at a given operating speed. Specifying an application volume per acre of at least 10 gallons may result in the use of larger orifice nozzles for some equipment to reduce the percentage of small droplets with the higher potential to drift.

The proposed label instructions direct the applicator to employ all of the relevant practices – including nozzle type, operating pressure, and application volume – to ensure that the droplet size distribution can be classified as extremely coarse to ultra-coarse – which limits the percentage of spray droplets in the size category that has the potential to move offsite.

[4] Vapor pressure deficit is the difference between the amount of water vapor in the air and the amount of water vapor in the air at saturation. Evaporation reduces droplet size, and the greater the vapor pressure deficit the more rapid the evaporation and the greater the potential for drift.

Reduction of the Transport of Small Droplets (Monsanto, 2013)

Arvidsson et al. (Arvidsson *et al.*, 2011) investigated meteorological and technical factors affecting total spray drift and determined that boom height and wind speed were the primary factors affecting the potential for spray drift among those tested, followed by air temperature, driving speed and vapor pressure deficit. Establishing a maximum wind speed (15 mph, or 10 mph if sensitive areas are downwind) limits the distance that fine droplets will travel before settling. A temperature inversion[5] can result when wind speeds are less than 3 mph, and can cause the suspension of the small spray droplets for extended periods of time. Prohibiting application during inversion conditions avoids the potential for suspension and farther transport of fine spray droplets (Wilson, 2011a).

Boom height is also restricted in the proposed application use instructions for dicamba to the minimum height required to get a uniform spray pattern in order to minimize the amount of time that spray droplets are suspended before settling to the ground (Wilson, 2011b). As shown in the Spray Drift Task Force information booklet on Ground Applications (SDTF, 1997), a difference in boom height between 20 and 50 inches can impact the extent to which spray volume may move offsite by allowing additional time for the droplets to be blown offsite before settling. Prohibiting aerial application and limiting the boom height for ground applications to 24 inches above the target pest or crop canopy will minimize the amount of time that spray droplets are suspended and available to move offsite.

Arvidsson et al. (Arvidsson *et al.*, 2011) demonstrated that drift increased with driving speed. This increase was attributed to either air flows associated with the forward movement of the sprayer or to increased vertical boom movement. Limiting driving speed to 15 mph or less will minimize this potential contributing factor.

Physical Location of the Spray and Use of Wind Buffers (Monsanto, 2013)

Awareness of the presence of sensitive areas and whether the wind direction at the time of application may move any suspended spray droplets toward a sensitive area are important considerations at the time of application. Since the implementation of the DriftWatch™ [6]program in Indiana, drift incidents onto sensitive crops have been significantly reduced (Hahn *et al.*, 2011). This program has now been expanded to several states across the major Midwest soybean growing area and to some Great Plains states as well (IL, IN, MI, MN, MO, WI, CO, MT, and NE). Under some circumstances, a buffer may be needed to provide further protection to a sensitive area. This method is highly effective when used.

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[5] A temperature inversion occurs when the air at the soil surface is cooler than the air above. Since cool air sinks, the surface air layer does not mix with upper layers of air. Under this condition, spray droplets are trapped near the surface and may stay suspended for increased periods of time.

[6] Driftwatch is a voluntary program that allows growers to reports locations of fields in which sensitive crops are being grown (and also identified other types of sensitive areas such as organic fields). The sensitive crop information is presented on a website in a map format which can then be utilized by pesticide applicators prior to application.

For these reasons, the proposed FIFRA product labels state that applicators should consult with available sensitive crop registries prior to making dicamba applications to DT soybean or DGT cotton. Many state lead agriculture agencies (IA, IL, IN, KS, MI, MN, MO, NE, OK, WI) have developed tools and resources to assist the applicator in the location of sensitive areas, such as vegetable or organic production fields, in an effort to minimize commercial impacts associated with pesticide offsite movement. Furthermore, prior to commercialization of DT soybeans and DGT cotton, Monsanto will implement an endangered species mitigation system for dicamba. The implemented system will either be an EPA-specific system and/or a web-based system, similar to that currently available for glyphosate at PreServe.org. This will facilitate applicator and grower implementation of use restrictions for protection of threatened and endangered non-monocotyledonous terrestrial plant species.

Determination of Proper Buffer Distances (Monsanto, 2013)

Monsanto has submitted information to the EPA that summarizes studies conducted at eight field locations to assess the buffer distance required to be protective of survival, growth, and reproduction of plant species that are very sensitive to dicamba (Orr *et al.*, 2012). These studies utilized nozzles that fit the droplet size classification requirements, the minimum application volume and the maximum boom height requirements specified above.

Justification for use of soybean plant height as the endpoint for risk assessment

Soybean was selected as the test species since it has been shown to be a highly sensitive indicator species for post-emergence dicamba effects. In the vegetative vigor study conducted in a greenhouse with the DGA salt of dicamba, soybean had the lowest endpoint of the ten species tested (Porch *et al.*, 2009). Comparable sensitivity for soybean to that observed in the greenhouse has also been displayed in field studies (Wax *et al.*, 1969; Auch and Arnold, 1978; Weidenhamer *et al.*, 1989; Al-Khatib and Peterson, 1999; Kelley *et al.*, 2005). See Table 7-1 for a summary of endpoints from these studies.

Higher Dicamba rates are needed to cause effects on soybean yield than are needed to cause effects on soybean plant height at early growth stages

Effects of dicamba on plant growth have been evaluated by considering effects on plant height at very sensitive early growth stages. Effects of dicamba on plant reproduction can be evaluated by assessing the effect of dicamba on plant species seed or fruit yields. A number of the field studies (Wax *et al.*, 1969; Auch and Arnold, 1978; Weidenhamer *et al.*, 1989; Al-Khatib and Peterson, 1999; Kelley *et al.*, 2005; Wright, 2012) indicate that soybean yield is no more sensitive, and is generally less sensitive, to dicamba treatment than is soybean plant height at the early growth stages at which studies to estimate buffer distances have been conducted. Additionally, results of these studies demonstrate that significant morphological effects in soybeans such as plant height reduction do not always result in yield reduction, but yield reduction in soybeans occurs at rates greater than that affecting soybean plant height at the early vegetative stages which were used in studies for buffer distance estimation. See Table 7-2 for a summary of the results of these studies.

Dicamba effects on yields of other crops occur at rates greater than or equal to rates affecting soybean plant height

The effects of dicamba on crop yield have been reported by a number of investigators in at least eleven other crops besides soybean. Monsanto has submitted field data on soybean to EPA and conducted an extensive review of relevant literature for use by EPA in establishing an appropriate buffer distance from potentially sensitive plant communities. The field data was generated across multiple growing seasons with diverse geographic and climatic conditions. The literature review included results from studies testing 12 possible sensitive crops, with many crops tested across multiple growing seasons and/or geographies and/or growth stages. The potential sensitive crops included in these studies were soybean, tomato, cantaloupe, cotton, pea, peanut, pepper, potato, sugarbeet, sunflower, tobacco, and watermelon.

These studies also indicate that the dicamba no effect rate for soybean plant height at vegetative growth stages is a lower value (approximately 0.3 g a.e./ha) than the dicamba no effect rates for plant yield in these other species that have been tested. See Table 7-3 for a summary of endpoints from these studies.

Because soybean plant height measured at vegetative growth stages is a more sensitive endpoint for dicamba effects than soybean yield or yield of eleven other plant species in five additional plant families, the use of the soybean plant height endpoint is appropriate to assess potential dicamba effects on survival, growth, and reproduction of sensitive species.

Monsanto's application management practices, including buffer distances that have been determined to not result in soybean plant height reduction after dicamba applications, can therefore be considered effective measures for mitigation of potential effects of dicamba on non-target plants.

Table 7-1. Soybean Field Studies with Dicamba

Growth Stage & Other Treatment Information	Dicamba Salt [a]	Time of Measurement	Plant Height No Effect Rate (g a.e./ha)[b]	Reference
2-3 trifoliate 1997	Not Specified	60 DAT	<5.6	(Al-Khatib and Peterson, 1999)
2-3 trifoliate 1998	Not Specified	60 DAT	5.6	(Al-Khatib and Peterson, 1999)
1-2 trifoliate - 1974	DMA	At maturity	56	(Auch and Arnold, 1978)
3-4 trifoliate - 1974	DMA	At maturity	1	(Auch and Arnold, 1978)
6-7 trifoliate - 1974	DMA	At maturity	1	(Auch and Arnold, 1978)
V3	DMA	At maturity	< 1.1	(Wax *et al.*, 1969)
Williams - prebloom 1980 (41 DAP)	DMA	At maturity	0.32[c]	(Weidenhamer *et al.*, 1989)
Elf - prebloom 1980 (41 DAP)	DMA	At maturity	1.3[c]	(Weidenhamer *et al.*, 1989)
V3	DGA	Full height before leaf senescence	< 0.56	(Kelley *et al.*, 2005)
V7	DGA	Full height before leaf senescence	< 0.56	(Kelley *et al.*, 2005)

[a] DMA – dimethylamine; DGA – diglycolamine

[b] For conversion of g a.e./ha to lb a.e./A divide the g a.e./ha value by 1120. Application rates expressed as oz/A were assumed to be of a 4 lb a.e./gal formulation and were converted to g a.e./ha

[c] Highest rate at which less than 10% effect on height was observed based on Table 2 of the publication

Table 7-2. Comparison of No Effect Rates for Plant Height and Yield from Dicamba Application to Soybeans

Growth Stage & Other Treatment Information	No Effect Rate (g a.e./ha)[a]		Reference
	Plant Height	Yield	
Williams - prebloom 1980	0.32[b,c]	20[b]	(Weidenhamer *et al.*, 1989)
Elf - prebloom 1980	1.3[b,c]	10[b]	(Weidenhamer *et al.*, 1989)
8-12 inches, 3 WAE[d], RM1 2009	--	11	(Johnson *et al.*, 2012)
8-12 inches, 3 WAE, RM2 2009	--	41	(Johnson *et al.*, 2012)
8-12 inches, 3 WAE, RM1 2010	--	3	(Johnson *et al.*, 2012)
8-12 inches, 3 WAE, RM2 2010	--	3	(Johnson *et al.*, 2012)
2-3 trifoliate 1997	5.6[e]	17	(Al-Khatib and Peterson, 1999)
2-3 trifoliate 1998	<5.6[e]	17	(Al-Khatib and Peterson, 1999)
V3[f] - SE Farm	--	< 5.6	(Andersen *et al.*, 2004)
V3 - Brookings Farm	--	< 5.6	(Andersen *et al.*, 2004)
V3	< 1[c]	1	(Wax *et al.*, 1969)
V3	< 0.56[c]	< 0.56[g]	(Kelley *et al.*, 2005)
1-2 trifoliate - 1974	56[c]	56	(Auch and Arnold, 1978)
3-4 trifoliate - 1974	1[c]	56	(Auch and Arnold, 1978)
6-7 trifoliate - 1974	1[c]	56	(Auch and Arnold, 1978)
V7[h]	< 0.56[c]	0.56	(Kelley *et al.*, 2005)
Early bloom - 1974	1[c]	11	(Auch and Arnold, 1978)
Early bloom - 1975	1[c,i]	1	(Auch and Arnold, 1978)
Early bloom - 1976	< 11[c]	< 11	(Auch and Arnold, 1978)
R2[j]	NA[k]	< 1	(Wax *et al.*, 1969)
R2	NA	0.56	(Kelley *et al.*, 2005)
Elf - midbloom 1980	NA	40[b]	(Weidenhamer *et al.*, 1989)
Mid-bloom - 1976	NA	28	(Auch and Arnold, 1978)
Williams - midbloom 1980	NA	10[b]	(Weidenhamer *et al.*, 1989)
Williams - midbloom 1981	NA	7.4[b]	(Weidenhamer *et al.*, 1989)
Early-pod - 1975	NA	11	(Auch and Arnold, 1978)
Early pod - 1976	NA	11	(Auch and Arnold, 1978)
Late pod - 1976	NA	28	(Auch and Arnold, 1978)

[a] For conversion of g a.e./ha to lb a.e./A divide the g a.e./ha value by 1120. Application rates expressed as oz/A were assumed to be of a 4 lb a.e./gal formulation and were converted to g a.e./ha

[b] Highest rate at which less than 10% and 20% effect on height and yield, respectively, were observed based on Table 2 & Table 3 of the publication

[c] Height at maturity

[d] WAE – weeks after emergence
[e] Assessed at 60 days after treatment
[f] At V3 growth stage the third trifoliate leaf is unfolded (http://extension.agron.iastate.edu/soybean/production_growthstages.html)
[g] Yield reduction was statistically significant but not considered biologically significant at rates of 0.56 and 5.6 g a.e./ha because a ten-fold increase in rate did not cause an increase in the yield reduction, and the percent reduction is small compared to the untreated control (i.e., less than 10% yield reduction).
[h] At V7 growth stage the seventh trifoliate leaf is unfolded.
[i] A height reduction of 18% was observed at rates above 1 g a.e./ha, but this reduction was not statistically significant
[j] R2 growth stage is when there is an open flower at one of the two uppermost nodes (http://extension.agron.iastate.edu/soybean/production_growthstages.html)
[k] Rates at which no effect on plant height are provided in the literature references, but are not provided here since yield values are being compared to rates causing plant height effects at earlier time points.

Table 7-3. Effect of Dicamba on Yield in Plant Species Other than Soybean

Crop	Growth Stage & Other Treatment Information	Effect	No Effect Rate (g a.e./ha)[a]	Reference
Soybean	pre-bloom	Plant Height	0.32[b]	(Weidenhamer *et al.*, 1989)
Cantaloupe	3 Weeks after transplanting	Total Harvest	560	(Hynes and Weller, 2010)
Cantaloupe	3 Weeks after transplanting	Total Harvest	11.2	(Hynes *et al.*, 2011)
Cotton	Cot – 2 Leaf	Lint Yield	140	(Everitt and Keeling, 2009)
Cotton	4-5 Leaf Pinhead Square First Bloom	Lint Yield	14	(Everitt and Keeling, 2009)
Cotton	20-30 cm tall RM 2009 LW 2009 LW 2010	Yield	140	(Johnson *et al.*, 2012)
Cotton	20-30 cm tall RM 2010	Yield	11	(Johnson *et al.*, 2012)
Cotton	6-8 Leaf	Lint Yield	2.8	(Marple *et al.*, 2007)
Cotton	3-4 Leaf 8-node 14-node 18-node	Lint Yield	2.8	(Marple *et al.*, 2007)
Pea	Flower buds formed	Yield	6.25 [c]	(Al-Khatib and Tamhane, 1999)
Pea	Vegetative & Flowering	Seed dry weight	5.63	(Olszyk *et al.*, 2009)
Peanut	15-20 cm width RM 2010	Yield	140	(Johnson *et al.*, 2012)
Peanut	15-20 cm width RM 2009 LW 2010	Yield	41	(Johnson *et al.*, 2012)
Peanut	15-20 cm width LW 2009	Yield	11	(Johnson *et al.*, 2012)
Pepper	3 Weeks after transplanting	Total harvest	11.2	(Hynes and Weller, 2010)
Pepper	3 Weeks after transplanting	Total harvest	560	(Hynes and Weller, 2010)
Pepper	3 Weeks after transplanting	Total harvest	560	(Hynes *et al.*, 2011)
Potato	11-15 Days after emergence	Tuber fresh weight	5.58	(Olszyk *et al.*, 2010)

Crop	Growth Stage & Other Treatment Information	Effect	No Effect Rate (g a.e./ha)[a]	Reference
Potato	15% flowering	Tuber Yield	11.2	(Leino and Haderlie, 1985)
Sugarbeet	10-15 leaf	Extractable sucrose	70	(Schroeder *et al.*, 1983)
Sugarbeet	10-15 leaf	Root yield	>140	(Schroeder *et al.*, 1983)
Sunflower	2-4 leaf	Yield	1.6	(Derksen, 1989)
Tomato	Full bloom - 1972	Total Yield	1	(Jordan and Romanowski, 1974)
Tomato	Green fruit stage 1971	Total Yield	20	(Jordan and Romanowski, 1974)
Tomato	Green fruit stage 1972	Total Yield	100	(Jordan and Romanowski, 1974)
Tomato	3 Weeks after transplanting	Total Yield Fruit weight	11.2 5.6	(Hynes and Weller, 2010)
Tomato	3 Weeks after transplanting	Total Yield	560	(Hynes *et al.*, 2011)
Tomato	15 cm tall Early vegetative	Marketable Fruit	0.9[d]	(Kruger *et al.*, 2012)
Tomato	25 cm tall Early bloom	Marketable Fruit	0.5[d]	(Kruger *et al.*, 2012)
Watermelon	3 Weeks after transplanting	Total Harvest	11.2	(Hynes and Weller, 2010)
Watermelon	3 Weeks after transplanting	Total Harvest	560	(Hynes *et al.*, 2011)

[a] For conversion of g a.e./ha to lb a.e./A divide the g a.e./ha value by 1120. Application rates expressed as oz/A were assumed to be of a 4 lb a.e./gal formulation and were converted to g a.e./ha

[b] Lowest rate from

[c] Next rate below rate with greater than a 25% effect on yield (lowest such rate of 5 sites). 25% effect on yield was chosen due to high variability.

[d] Value from dose response curve estimated to result in 1% fruit loss

Applicator Education and Awareness (Monsanto, 2013)

As mentioned above, growers and commercial applicators are aware of the sensitivity of certain crops to dicamba and the extra precautions that should be taken in making dicamba applications when these crops are nearby. In addition, growers and commercial applicators follow label directions and restrictions, and growers are educated by university specialists and industry representatives on the proper application equipment, equipment setup, and climatic conditions to maximize herbicide performance and minimize offsite movement of herbicides. To provide growers with specific information for dicamba applications to dicamba-tolerant crops, Monsanto is implementing a robust stewardship program that will include a strong emphasis on grower and applicator training. In addition, U.S. EPA and state agencies have enforcement authority over the use of any registered pesticide in a manner inconsistent with its labeling.

Equipment manufacturers developed spray nozzles that provide uniform coverage for effective weed control while applying larger spray droplets to reduce the potential for particle drift. Similarly, offsite movement of dicamba has been managed with the knowledge of the proper spray equipment and equipment setup, climatic conditions for accurate, on-target applications, and based on the requirements for applying dicamba at an appropriate distance from sensitive crops and plants (Jordan *et al.*, 2009).

Volatilization (Monsanto, 2013)

Volatilization of fertilizers and pesticides from soil and plant surfaces also introduces certain chemicals to the air and can cause offsite movement. A substance is volatile if it is likely to vaporize at atmospheric pressure. The USDA Agricultural Research Service (ARS) is conducting a long-term study to identify factors that affect pesticide levels in the Chesapeake Bay region airshed (USDA-ARS, 2011). This study has determined that volatilization is highly dependent upon exposure of disturbed unconsolidated soils, and that variability in measured compound levels is correlated with temperature and wind conditions. Another ARS study of volatilization of certain herbicides after application to fields has found moisture in dew and soils in higher temperature regimes significantly increases volatilization rates (USDA-ARS, 2011).

Physicochemical characteristics of the individual chemical have been shown to have little impact on spray drift. However, unlike spray drift, the potential for post-application volatilization is primarily a function of the physicochemical properties of the chemical, (e.g., vapor pressure, Henry's Law constant, etc.), method of application (e.g., soil-incorporated or not), and the local environmental conditions (e.g., temperature, humidity, wind speed). Due to this complexity, the potential for post-application vapor loss is often measured experimentally.

In EFED's Chapter in the Dicamba RED, laboratory volatility data have been summarized for potassium and dimethylamine (DMA) salts of dicamba from a moist soil. Monsanto has also submitted information to the EPA that summarizes a field study that was conducted to measure the volatilization rate of a dicamba DGA salt formulation from foliage.

DGA Salts Reduce Volatilization (Monsanto, 2013)

Monsanto seeks to minimize volatile loss from treated soybean and cotton fields by labeling optimal formulations and salt forms of dicamba. The DGA salt formulation of dicamba, which is proposed for use on DT soybean and DGT cotton, has low volatility. Side-by-side field experiments have indicated that a formulation of the diglycolamine (DGA) salt of dicamba dramatically reduced volatilization of dicamba compared to a similar formulation of the DMA salt form and that volatility is not a significant component of offsite movement for the DGA salt of dicamba (Egan and Mortensen, 2012). The use of formulations of, or similar to, the DGA salt of dicamba will help to limit non-target plant risk due to post-application vapor loss. In the publication, the authors state, "Our data demonstrate that the diglycolamine formulation has a dramatic effect on reducing dicamba vapor drift. Estimates of total gram acid equivalent vapor drift outside of the treated area were reduced 94% relative to the dimethylamine formulation, and the dose-distance curves indicate that predicted mean exposures drop close to zero only short distances away from the treated area." Additionally, measured air concentrations when using the DGA salt were at least 70-fold lower than those in the potassium and DMA salt laboratory studies EFED evaluated, even though the application rate was twice that of DMA (Mueller *et al.*, 2013).

Monsanto has requested the use of dicamba on DT soybean and DGT cotton only for low-volatility salts, including the DGA salt formulation (U.S. EPA Reg. No. 524-582). Specific application requirements on the proposed FIFRA product label (currently pending before EPA), and/or any other measures imposed, by EPA will minimize dicamba offsite movement. Monsanto plans to continue to invest in research and development of new dicamba formulations for use with DT soybean and DGT cotton. Monsanto and BASF have submitted separate applications to EPA seeking the approval of novel dicamba formulations (EPA File Symbols 7969-GUL, 524-ANO and 524-ARN). EPA will review relevant data and information as a part of its registration process and confirm that the product when used according to the approved label directions meets the FIFRA standard before granting a registration including the use on DT soybean or DGT cotton. Furthermore, Monsanto has indicated that it does not plan to allow growers to use dimethylamine salt (DMA) of dicamba and/or dicamba acid on DT soybean or DGT cotton.

References:

Al-Khatib, K and Peterson, D (1999) "Soybean (Glycine max) response to simulated drift from selected sulfonylurea herbicides, dicamba, glyphosate, and glufosinate." *Weed Technology.* 13 p 264-70. http://www.bioone.org/doi/full/10.1614/WT02-025.

Al-Khatib, K and Tamhane, A (1999) "Dry Pea (Pisum sativum L.) Response to Low Rates of Selected Foliar- and Soil-Applied Sulfonylurea and Growth Regulator Herbicides." *Weed Technology.* 13 (4): p 753-58. http://www.jstor.org/stable/3989007.

Andersen, SM; Clay, SA; Wrage, LJ; and Matthees, D (2004) "Soybean foliage residues of dicamba and 2,4-D and correlation to application rates and yield." *Agronomy Journal.* 96 p 750-60. https://www.agronomy.org/publications/aj/pdfs/96/3/0750.

Arvidsson, T; Bergstrom, L; and Kreuger, J (2011) "Spray drift as influenced by meteorological and technical factors." *Pest Management Science.* 67 p 586-98. http://onlinelibrary.wiley.com/doi/10.1002/ps.2114/abstract;jsessionid=2427D371D51395EFCD21AAB01085130D.f02t02.

ASABE (2009) "Spray Nozzle Classification by Droplet Spectra." American Society of Agricultural and Biological Engineers. http://www.sherwoodpumps.com/FileAttachments/Spray/en-us/Spray%20Tip%20Classification%20by%20Droplet%20Size.pdf.

Auch, DE and Arnold, WE (1978) "Dicamba Use and Injury on Soybeans (Glycine max) in South Dakota." *Weed Science.* 26 (5): p 471-75. http://www.jstor.org/stable/pdfplus/4042904.pdf?acceptTC=true&jpdConfirm=true.

BASF. "Clarity® herbicide label." Esearch Triangle Park, NC2008. 22. http://agproducts.basf.us/products/label-and-msds/clarity-herbicide-label.pdf.

Carpenter, J; Felsot, A; Goode, T; Hammig, M; Onstad, D; and Sankula, S (2002) "Comparative Environmental Impacts of Biotechnology-derived and Traditional Soybean, Corn, and Cotton Crops." www.cast-science.org.

Derksen, DA (1989) "Dicamba, chlorsulfuron, and clopyralid as sprayer contaminants on sunflower (Helianthus-annuus), mustard (Brassica juncea), and lentil (Lens culinaris), respectively." *Weed Science.* 37 p 616-21.

Egan, JF and Mortensen, DA (2012) "Quantifying Vapor Drift of Dicamba Herbicides Applied to Soybean." *Environmental Toxicology and Chemistry.* 31 (5): p 1023-31. http://onlinelibrary.wiley.com/doi/10.1002/etc.1778/pdf.

Everitt, JD and Keeling, JW (2009) "Cotton Growth and Yield Response to Simulated 2,4-D and Dicamba Drift." *Weed Technology.* 23 (4): p 503-06. http://www.bioone.org/doi/pdf/10.1614/WT-08-061.1.

Felsot, AS; Unsworth, JB; Linders, JBHJ; Roberts, G; Rautman, D; Harris, C; and Carazo, E (2010) "Agrochemical spray drift; Assessment and mitigation." *Journal of Environmental Science and Health.* B (46): p 889-911. http://www.tandfonline.com/doi/pdf/10.1080/03601234.2010.515161.

Fishel, F (1997) "Pesticides and the Environment."

Hahn, L; Theller, L; Reimer, A; and Engel, B. "Pesticides sensitive crops and habitats: Registry implementation results." Washington, DC: American Chemical Society, 2011. http://www.agrodiv.org/documents/denver11/Endangered%20Species%20Act%20and%20Regulation/AGRO223_Hahn_Leighanne.pdf.

Hynes, DP and Weller, SC (2010) "Low dose effects of 2,4-D and dicamba on solanaceae and curcurbitaceae vegetables." *2010 North Central Weed Science Society 65th Annual Meeting:* Lexington, KY.

Hynes, HDP; Johnson, WG; and Weller, SC (2011) "Injury and yield response of transplanted Solanaceae and Cucurbitaceae vegetables to low-dose applications of 2,4-D or dicamba." *North Central Weed Science Society 66th Annual Meeting:* Milwaukee, WI.

Johnson, VA; Fisher, LR; Jordan, DL; Edmisten, KE; Stewart, AM; and York, AC (2012) "Cotton, peanut, soybean response to sublethal rates of dicamba, glufosinate, and 2,4-D." *Weed Technology.* 26 p 195-206.

Jordan, T; Glenn, N; Johnson, B; and Bauman, T (2009) "Reducing Spray Drift from Glyphosate and Growth Regulator Herbicide Drift Caution." Purdue University Weed Science. http://www.ag.purdue.edu/btny/weedscience/Documents/ReducingDrift09.pdf.

Jordan, TN and Romanowski, RR (1974) "Comparison of dicamba and 2,4-D injury to field-grown tomatoes." *Hortscience.* 9 p 74-75.

Kelley, KB; Wax, LM; Hager, AG; and Riechers, DE (2005) "Soybean response to plant growth regulator herbicides is affected by other postemergence herbicides." *Weed Science.* 53 p 101-12. http://www.bioone.org/doi/pdf/10.1614/WS-04-078R.

Kruger, GR; Johnson, WG; Doohan, DJ; and Weller, SC (2012) " Dose Response of Glyphosate and Dicamba on Tomato (Lycopersicon esculentum) Injury." *Weed Technology.* 26 p 256-60.

Leino, P and Haderlie, L (1985) "Simulated herbicide drift injury in potatoes." p 93-99.

Marple, ME; Al-Khatib, K; Shoup, D; Peterson, D; and Claassen, M (2007) "Cotton response to simulated drift of seven hormonal-type herbicides." *Weed Technology.* 21 p 987-92. http://www.bioone.org/doi/pdf/10.1614/WT-07-010.1.

Monsanto (2013) "Petitioner's Environmental Report for Dicamba-Tolerant Soybean MON 87708 and Dicamba and Glufosinate Tolerant Cotton MON 88701."

Mueller, TC; Wright, DR; and Remund, KM (2013) "Effect of formulation and application time of day on detecting dicamba in the air under field conditions." *Weed Science.* 61 p 586-93.

Olszyk, D; Pfleeger, T; Lee, EH; and Plocher, M (2009) "Pea (Pisum sativum) seed production as an assay for reproductive effects due to herbicides." *Environmental Toxicology and Chemistry.* 28 p 1920-29. http://onlinelibrary.wiley.com/doi/10.1897/08-244.1/full.

Olszyk, D; Pfleeger, T; Lee, EH; and Plocher, M (2010) "Potato (Slanum tuberosum) greenhouse tuber production as an assay for asexual reproduction effects from herbicides." *Environmental Toxicology and Chemistry.* 29 p 111-21. http://onlinelibrary.wiley.com/doi/10.1002/etc.12/full.

Orr, TB; Wright, JP; and Honegger, JL (2012) "Summary of Investigations of the Potential for Off-Site Movement through the Air of the Herbicide MON 54140 Following Ground Applications." Monsanto.

Porch, JR; Krueger, HO; Kendall, TZ; and Holmes, C (2009) "BAS 183 09 H (Clarity): A Toxicity Test to Determine the Effects of the Test Substance on Vegetative Vigor of Ten Species of Plants." BASF.

Schroeder, GL; Cole, DF; and Dexter, AG (1983) "Sugarbeet (Beta valgaris L.) response to simulated spray drift." *Weed Science.* 31 p 831-36.

SDTF (1997) " A summary of ground application studies." Spray Drift Task Force. http://www.agdrift.com/PDF_FILES/Ground.pdf.

TeeJet Technologies (2011) "Catalog 51." Last Accessed: November 27, 2011 http://www.teejet.com/media/408987/cat51-us_lores_all.pdf.
Tu, M; Hurd, C; and Randall, J (2001) *Weed Control Methods Handbook: Tools and Techniques for Use in Natural Areas*. Ed. Conservancy, The Nature: UC Davis, CA.
University of Missouri (1997) "Pesticides and the Environment." http://extension.missouri.edu/p/G7520.
US-EPA (2000) "Profile of the Agricultural Crop Production Industry." U.S. Environmental Protection Agency-Office of Compliance Sector Notebook Profile. http://www.epa.gov/compliance/resources/publications/assistance/sectors/notebooks/agcrop.pdf.
US-EPA (2006) "Reregistration Eligibility Decision for Dicamba and Associated Salts." Environmental Protection Agency. http://www.epa.gov/oppsrrd1/REDs/dicamba_red.pdf.
US-EPA (2009a) "Pesticides; Draft guidance for pesticide registrants on pesticide drift labeling." http://www.gpo.gov/fdsys/pkg/FR-2009-11-04/pdf/E9-26594.pdf.
US-EPA (2009b) "Sodium and Potassium Dimethyldithiocarbamate Salts Amendment to the Ferbam (PC Code 034801) and Ziram (PC Code 034805) Reregistration Eligibility Decisions." Environmental Protection Agency. http://www.epa.gov/opp00001/reregistration/REDs/ddcsalts-red-amended.pdf.
US-EPA (2010) "Pesticide Registration Manual: Chapter 11 - Tolerance Petitions." U.S. Environmental Protection Agency. http://www.epa.gov/pesticides/bluebook/chapter11.html.
US-EPA (2012) "Pesticide issues in the works: pesticide volatilization." http://www.epa.gov/opp00001/about/intheworks/volatilization.htm.
USDA-ARS (2011) "At ARS, the Atmosphere Is Right for Air Emissions Studies." USDA-Agricultural Research Service. Last Accessed: November 19, 2013 http://www.ars.usda.gov/is/AR/archive/jul11/emissions0711.htm?pf=1.
USDA-NRCS (2000) "Conservation Buffers to Reduce Pesticide Losses." USDA. http://www.in.nrcs.usda.gov/technical/agronomy/newconbuf.pdf.
Wax, LM; Knuth, LA; and Slife, FW (1969) "Response of soybeans to 2,4-D, dicamba, and picloram." *Weed Science.* 31 p 831-36. http://pioneer-chem.blogspot.com/2012/02/response-of-soybeans-to-24-d-dicamba.html.
Weidenhamer, JD; Triplett, GB; and Sobotka, FE (1989) "Dicamba injury to soybean." *Agronomy Journal.* 81 p 388-93. https://www.agronomy.org/publications/aj/pdfs/81/4/AJ0810040637.
Wilson, J (2011a) "Evaluating the weather." South Dakota Cooperative Extension Service. Last Accessed: November 28, 2011 http://pesticidestewardship.org/drift/Pages/EvaluatetheWeatherConditions.aspx.
Wilson, J (2011b) "Managing Drift with Nozzles and Boom Height." South Dakota Cooperative Extension Service. http://pesticidestewardship.org/drift/Pages/ManagingDriftwithNoozles.aspx.
Wright, JP (2012) "Potential Effects of MON 54140 on Soybean Plants when Applied at Low Application Rates in the Field." Monsanto.
Wright, RJ; Witkowski, JF; and Schulze, LD. "Best Management Practices for Agricultural Pesticides to Protect Water Resources." *Neb Guide G93-1182-A*: University of Nebraska Cooperative Extension: University of Nebraska-Lincoln, 1996. http://infohouse.p2ric.org/ref/20/19700.htm.

Appendix 8. EPA Assessment of Herbicides Used on MON 87708 Soybean and MON 88701 Cotton

EPA Regulation of Pesticides
The use of pesticides is regulated by EPA under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). The purpose of the Agency's review is to ensure that the pesticide, "when used in accordance with widespread and commonly recognized practice," will not cause "unreasonable adverse effects on the environment" FIFRA 3(c)(5)(D).

If the pesticide may be used on food or feed crops, EPA ensures the safety of the food supply by establishing the amount of each pesticide that may safely remain in or on foods. These maximum pesticide residue levels (called "tolerances") limit the amount of the pesticide residue that can legally remain in or on foods. EPA undertakes this analysis under the authority of the Federal Food, Drug, and Cosmetic Act (FFDCA), as amended by the Food Quality Protection Act of 1996 (FQPA), and must conclude that such tolerances will be safe, meaning that there is a reasonable certainty that no harm will result from aggregate (food, water and non-occupational residential/recreational) exposure to the pesticide residues (US-EPA, 2013b). In addition, when multiple pesticides affect the same target organs through the same toxicological mode- of-action, EPA considers the cumulative effect of those pesticides. In addition, the FDA and the USDA monitor foods for pesticide residues and work with the EPA to enforce these tolerances (USDA-AMS, 2013).

The use of registered pesticides is further governed by labels, which are legally enforceable and define maximum application rates, total annual application limits, methods of application, and other use restrictions.

To register a new pesticide product, EPA evaluates potential risks to humans and the environment, and typically requires applicants to submit more than 100 different scientific studies conducted according to EPA's harmonized test guidelines. The data required by EPA are used to evaluate whether a pesticide has the potential to cause adverse effects on humans (including acute, chronic, reproductive, and carcinogenic risk), wildlife, fish, and plants (including endangered species and other non-target organisms, *i.e.*, organisms against which the pesticide is not intended to act). FIFRA was amended in 1988 to require the reregistration of products with active ingredients registered prior to November 1, 1984. In 1996, FIFRA was amended by the FQPA to require reevaluation of all pesticide active ingredient at fifteen year (or shorter) intervals thereafter (a process called Registration Review). The amendments called for the development and submission of data to support the continued registration of the active ingredient, as well as a review of all data submitted to the EPA. During the reregistration and registration review processes, EPA thoroughly reviews the scientific database since a pesticide's original registration.

EPA has responsibility to regulate the use of pesticides (including herbicides) that may be used on feed crops, and must establish pesticide tolerances (maximum pesticide residue levels) for the amount of pesticide residue that can legally remain in or on the feed crop. EPA undertakes this analysis under the authority of the FFDCA, and must conclude that such tolerances will be safe, meaning that there is a "reasonable certainty that no harm" to human health will result from the use of the pesticide. This finding of reasonable certainty of no harm is obligated under the FFDCA, as amended by the FQPA of 1996. Similar to the establishment of pesticide tolerances for food, the EPA will consider the toxicity of the pesticide and its break-down products, pesticide use rate and frequency of application; and how much of the pesticide (i.e., the residue) remains in or on food by the time is it marketed and prepared in its establishment of tolerance for animal feed (US-EPA, 2013b).

MON 87708 Soybean and MON 88701 Cotton

Two petitions were submitted by Monsanto to APHIS seeking determinations of nonregulated status for GE soybean and cotton cultivars engineered for resistance to herbicides.

APHIS Petition 10-188-01p is for GE soybean (*Glycine max*), designated as event MON 87708 soybean. It contains a demethylase gene from *Stenotrophomonas maltophilia* that expresses a dicamba mono-oxygenase (DMO) protein to confer resistance to the broadleaf herbicide dicamba. DMO protein rapidly demethylates dicamba to the inactive metabolite 3,6-dichlorosalicylic acid (DCSA), a known metabolite of dicamba in non-GE cotton, soybean, livestock and soil.

APHIS Petition 12-185-01p is for GE cotton (*Gossypium* spp.), designated as event MON 88701 cotton, that is also resistant to dicamba as a result of the expression of the DMO protein. MON 88701 cotton also contains a bialaphos resistance (*bar*) gene from *Streptomyces hygroscopicus* that expresses the phosphinothricin N-acetyltransferase [PAT (*bar*)] protein to confer tolerance to the herbicide glufosinate. The PAT (*bar*) protein acetylates the free amino group of glufosinate to produce non-herbicidal N-acetyl glufosinate, a known metabolite in glufosinate-tolerant plants (OECD, 2002).

As with any other GE crop deregulated by APHIS, deregulated status of these two events would include dicamba-resistant soybean, dicamba- and glufosinate-resistant cotton, any progeny derived from crosses between MON 87708 soybean and conventional or other previously deregulated GE soybean varieties, and any progeny derived from crosses between MON 88701 cotton and conventional or other previously deregulated GE cotton varieties. Monsanto has indicated that both MON 87708 soybean and MON 88701 cotton will be combined with glyphosate-resistance traits utilizing traditional breeding techniques.

Monsanto has submitted pesticide registration petitions to EPA requesting Section 3 registration for the use of dicamba on dicamba-resistant soybean and cotton. For these petitions, Monsanto is requesting to establish new tolerances for dicamba-resistant soybean forage at 45 ppm and for dicamba tolerant soybean hay at 70 ppm. Monsanto is also requesting to amend the cotton un-delinted seed tolerance from 0.2 ppm to 3.0 ppm and establish a new tolerance for cotton gin byproducts at 70.0 ppm.

A brief overview of the three herbicides (dicamba, glufosinate, and glyphosate) that are intended to be used on the two Monsanto events are presented in the following sections. Additionally, the proposed uses of these herbicides on MON 87708 soybean and MON 88701 cotton and any EPA assessments performed assessing the potential effects from the new uses are summarized.

Dicamba

Background and Current Uses

Dicamba (benzoic acid, 3,6-dichloro-2-methoxy-, aka 3,6-dichloro-*o*-anisic acid) is a selective systemic herbicide belonging to the benzoic acid chemical family. Dicamba is a broadleaf selective herbicide that was approved by the EPA for agricultural application uses in 1967 (US-

EPA, 2006; 2009c). Dicamba is registered for use on agricultural crops and for use as spot and broadcast treatments on turf, in addition to residential uses. Dicamba is currently labeled for weed control in corn, soybean, cotton, sorghum, wheat, barley, oats, millet, pasture, rangeland, asparagus, sugarcane, turf, grass grown for seed, conservation reserve programs, and fallow croplands. The herbicide is currently registered for use on both soybeans and cotton as pre-plant applications and not as post emergence applications because crop injury could occur if dicamba were to come in contact with roots, stems, or foliage.

Dicamba belongs to the auxin class of herbicides, which is the oldest class of known synthetic herbicides. This class includes 2,4-D, 2,4-DB, mecoprop, MCPA, clopyralid, and several other active ingredients, and is WSSA Herbicide Group Number 4 (HRAC, 2009).[1] On the basis of their structural and chemical properties, auxinic herbicides have been classified into several sub-groups, viz., phenoxyalkanoic acids (e.g., 2,4-D, MCPA), benzoic acids (e.g., dicamba, chloramben), pyridines (e.g., picloram, clopyralid), and quinolinecarboxylic acids (e.g., quinclorac, quinmerac). Generally, auxinic herbicides are effective against broadleaf (dicotyledonous) plant species, allowing them to often be used in production of narrow leaf (monocotyledonous) crops.

Various salt formulations of dicamba are formulated as standalone herbicide products and marketed by several companies under various trade names such as Banvel®, Clarity®, Diablo®, Rifle®, Sterling®, and Vision®. These dicamba products can also be tank-mixed with one or more active ingredients depending on the crop to be treated. For example, Clarity® can be tank mixed with over 75 herbicide products in labeled crops. Additionally, dicamba is currently formulated as a premix product with one or more other herbicide active ingredients, including glyphosate, 2,4-D, diflufenzopyr, atrazine, nicosulfuron, metsulfuron, primsulfuron, triazulfuron, rimsulfuron, and halosulfuron.

Dicamba-treated acreage has ranged from 17.4 to 36.3 million acres between 1990 and 2011. Usage of dicamba peaked during the period of 1994 through 1997, where 1994 was the peak year when 36 million crop acres were treated with 9.4 million pounds of dicamba. The use of dicamba steadily declined to 17.4 million treated acres with 2.7 million pounds applied in 2006. The reduction in dicamba use has been attributed to the competitive market introductions of sulfonylurea herbicides (chlorsulfuron, metsulfuron-methyl, and thifensulfuron-methyl) in wheat, new broadleaf herbicide active ingredients in corn, and introduction of glyphosate-tolerant corn. More recently, however, dicamba-treated acres have been on the rise and have increased by as much as 7.9 million acres between 2006 to 2011. Most of this increase has occurred in fallow, pastureland, sorghum, and cotton (pre-plant) (Monsanto, 2012). Dicamba-treated acres have increased in cotton, in particular, because it is a common pre-plant herbicide recommendation for glyphosate-resistant marestail (horseweed) and Palmer amaranth in the Midsouth region (McClelland *et al.*, 2006). Figure 8-1 shows the changes in dicamba use by year and crop from 1992 through 2011.

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[1] There are several systems of herbicide mode-of action classification. Among the most widely used are those of the Herbicide Resistance Action Committee (HRAC) and the Weed Science Society of America.

Approximately 25.3 million acres of crops were treated with dicamba in 2011 (see Table 8-1 for a summary of the dicamba-treated acres by crop in 2011). Figure 8-2 shows a map reflecting the estimated agricultural use for dicamba in 2011. Heavy dicamba usage occurred in the Mid-West and states along the Mississippi River. Dicamba is currently labeled for use in conventional or glyphosate-resistant soybean, although dicamba use is extremely limited because applications are restricted to very early preplant and/or preharvest applications due to soybean (crop) injury concerns. The dicamba-treated acreage in 2011 soybean production was approximately 872,000 acres, representing 1.2 % of the total soybean acreage (Table 8-1) (Monsanto, 2012). Dicamba can currently be applied to cotton in the U.S. as a pre-plant application, at least 21 days prior to planting.

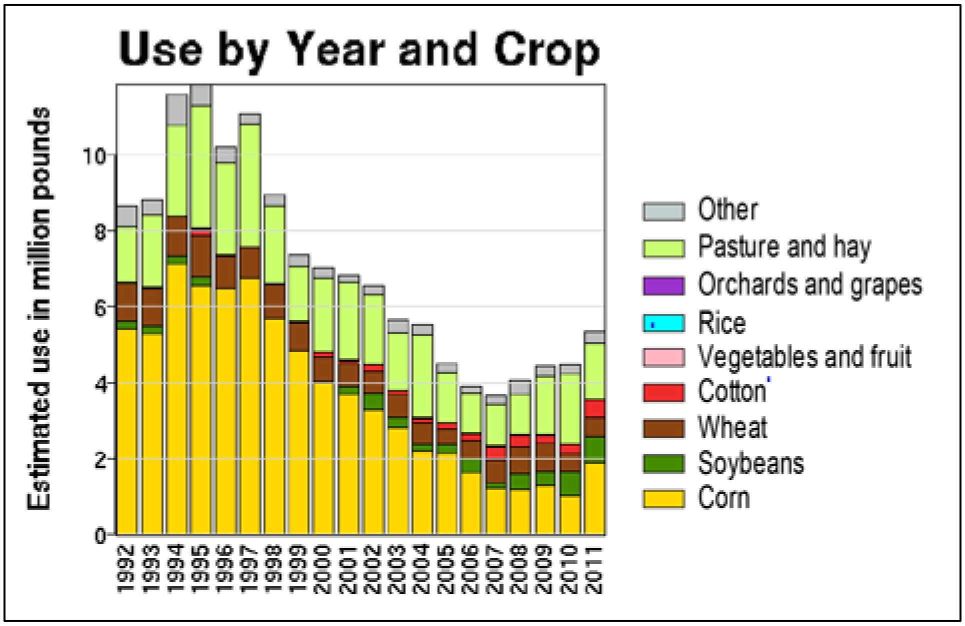


Figure 8-1. Dicamba Use by Year and Crop, 1992-2011.
Source: (USGS, 2013a)

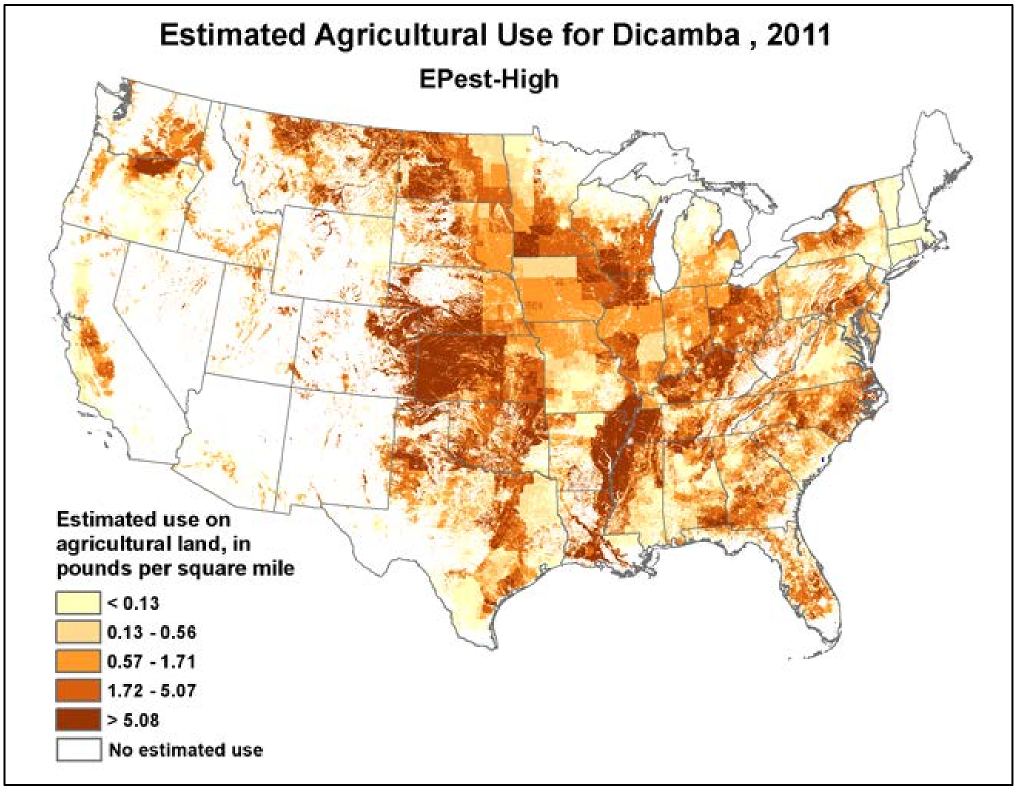


Figure 8-2. Estimated Agricultural Use for Dicamba, 2011.
Source: (USGS, 2013a).

Table 8-1. Dicamba-Treated Acres and Amounts Applied for Labeled Crops, 2011

Crop	Total Crop Acres (x1,000)	Dicamba-Treated Acres (000)	% U.S. Dicamba-Treated Acres[2]	% Crop Acres Treated with Dicamba[3]	Dicamba (a.e.) (x1,000 lb)
Asparagus	29	2	0.01	NA	<1
Barley	2,460	80	0.3	3.2	6
Corn	92,146	10,880	43.0	10.3	1,531
Cotton	14,533	1,416	5.6	9.6	364
Fallow	14,899	3,966	15.7	18.7	597
Pastureland	95,532	2,009	7.9	2.0	438
Sorghum	5,315	1,316	5.2	18.1	206
Soybean	74,835	872	3.4	1.2	233
Sugarcane	825	163	0.6	15.6	36
Wheat, all	53,223	4,532	17.9	7.4	418
All other uses	NA	65	0.3	NA	9
Total		**25,301**	**100.0**		**3,837**

Definitions: a.e. = acid equivalent; lbs = pounds; NA = not applicable.
[1] Source: (Monsanto, 2012; 2013).
[2] The percentage of the total dicamba-treated acres for all labeled crops and uses.
[3] Percentages calculated from crop acres treated with dicamba (data not shown).

Based on USDA-NASS ((USDA-NASS, 2005; 2007; 2010; 2011; 2012)) statistics, dicamba application rates ranged from 0.07 to 0.24 pounds per acre with the average number of applications ranging from 1 to 1.9 applications per cropping season. Dicamba rates are lowest in barley, wheat and oats, where typically more than one application is made in these crops per cropping season (see Table 8-2) (Monsanto, 2012).

Table 8-2. Dicamba Applications – Average Number and Rates to Labeled Crops[1]

Crop	# of Dicamba Applications	Rate of Dicamba per Application	Rate of Dicamba per Crop Year
Corn	1.2	0.209	0.249
Cotton	1.0	0.244	0.244
Sorghum	1.9	0.159	0.298
Soybean	1.0	0.223	0.223
Barley	1.0	0.112	0.112
Wheat, spring	-	0.110	0.113
Wheat, winter	1.7	0.149	0.247
Oats	1.00	0.066	0.066

[1]Source: (USDA-NASS, 2005)(oats), (USDA-NASS, 2007)(cotton), (USDA-NASS, 2010)(corn), (USDA-NASS, 2011)(barley & sorghum), (USDA-NASS, 2012)(soybean & wheat); (Monsanto, 2013).

EPA has evaluated dicamba and has concluded that it has a complete and comprehensive regulatory database (toxicity, environmental fate, and ecological toxicity). EPA completed the reregistration process for dicamba and a Registration Eligibility Decision (RED) was issued in 2006 and subsequently amended in 2008 and 2009 (US-EPA, 2006; 2009c). EPA concluded there is a reasonable certainty that no harm will result to the general population, or to infants and children, as a result of aggregate (combined) exposure to dicamba residues; and that the available data submitted for dicamba are complete and adequate to support the continued registration of dicamba products and uses including current uses on commercial cotton and soybean. Part of EPA's risk assessment included exposure to drinking water using a conservative modeled scenario that assumed that essentially all (87%) crop acres within the watershed were treated with dicamba (US-EPA, 2006; 2009c; 2011).

EPA reassessed all dicamba pesticide food and feed tolerances as part of the dicamba RED, including the 10 ppm soybean seed tolerance supporting the existing use in conventional soybean (US-EPA, 2006; 2009c). A complete listing of dicamba feed tolerances can be found at 40 CFR § 180.227. Permanent tolerances are established under 40 CFR §180.227(a)(1) for dicamba and its 3,6-dichloro-5-hydroxybenzoic acid (5-hydroxydicamba) metabolite. Additional tolerances are established under 40 CFR §180.227(a)(2) for dicamba and its 3,6-dichloro-2-hydroxybenzoic acid (aka 3,6-diclorosalicyclic acid or DCSA) metabolite, as well as under 40 CFR §180.227(a)(3) for dicamba, 5-hydroxydicamba, and the DCSA metabolite. Table 8-3 lists the current tolerances established for commodities of cotton and soybean.

Table 8-3. Tolerances for Residues of Dicamba

Commodity	Tolerance (parts per million)
Cotton, undelinted seed	0.2
Soybean, hulls[1]	30.0
Soybean, seed[1]	10.0

Source: 40 CFR §180.227 Dicamba; tolerances for residues.

[1] Tolerance established for residues of the herbicide dicamba, 3,6-dichloro-o-anisic acid, including its metabolites and degradates, in or on the commodities. Compliance with the tolerance levels is to be determined by measuring only the residues of dicamba, 3,6-dichloro-o-anisic acid, and its metabolites, 3,6-dichloro-5-hydroxy-*o*-anisic acid, and 3,6-dichloro-2-hydroxybenzoic acid, calculated as the stoichiometric equivalent of dicamba.

EPA Assessments of Proposed Section 3 New Uses on Dicamba-resistant Soybean and Cotton

Before any application of dicamba can be made onto commercially cultivated dicamba-resistant soybean or cotton, the EPA must first approve a label describing the conditions of use of the herbicide in connection with dicamba-resistant soybean and cotton – including the appropriate application rates and timing, and other measures necessary to address potential impacts of dicamba offsite movement.

The dicamba product used for treating dicamba-tolerant soybean and cotton proposed for registration is the M1691 Herbicide (EPA Reg. No. 524-582) which is a soluble (flowable) concentrate formulation. This end–use product contains 56.8% active ingredient in the form of the diglycolamine salt (DGA) of dicamba (equivalent to 4.0 lb ae/gal). A summary of the proposed directions for use taken directly from the supplemental M1691 herbicide label provided by the registrant are presented below in Table 8-4.

Monsanto has submitted an application to U.S. EPA to amend Registration Number 524-582, a low volatility DGA salt formulation, to remove all preemergence planting restrictions (intervals and rainfall) and to allow in-crop postemergence dicamba applications to MON 87708 soybean through the R1/R2 growth stage. Once approved, growers would be authorized to apply dicamba alone or in mixtures with glyphosate or other herbicides for preplant or in-crop postemergence applications on MON 87708 soybean. Dicamba would be authorized to be applied preemergence up to crop emergence as a single application or split applications up to a total of 1.0 lb a.e. per acre, and up to two postemergence applications up to 0.5 lb a.e. per acre each through the R1/R2 growth stage of soybean. The maximum annual application rate of dicamba on MON 87708 soybean is 2.0 lb dicamba a.e. per acre. The proposed dicamba use on soybean is summarized in Table 8-4.

If the proposed label is approved by EPA, dicamba would be authorized to be applied up to 1.0 lb a.e. per acre any time prior to cotton emergence, and postemergence in-crop up to 0.5 lbs a.e. per acre per application up through seven days prior to harvest. Maximum application amounts for dicamba would be 1.0 lb a.e. per acre for preplant/preemergence applications and 0.5 lb a.e. per acre per in-crop application with the combined total not to exceed 2.0 lbs a.e. dicamba per year for all applications. The proposed application rates on MON 88701 cotton would be less than or equivalent to rates for dicamba established for other uses in the dicamba RED including the 2.0 lbs a.e. dicamba per year for all applications (US-EPA, 2006; 2009c). The proposed dicamba use on soybean is summarized in Table 8-4.

Following EPA approval of the dicamba label amendment, growers would be authorized to apply dicamba alone or in mixtures with glyphosate, glufosinate, or other registered herbicides for pre-plant or post-emergence in-crop applications on MON 87708 soybean and MON 88701 cotton.

Dicamba residue levels in soybean seed harvested from dicamba tolerant (DT) soybean treated with dicamba at more than twice the anticipated commercial in-crop application rate were less than 0.1 ppm, which is well below the established 10 ppm pesticide residue tolerance supporting dicamba use on commercial soybean. Soybean forage and hay, which can be feed to livestock, have no established tolerance, for that reason Monsanto is also petitioning (Pesticide Petition # 0F7725) the agency for the establishment of new tolerances on forage (45 ppm) and hay (70 ppm).

Monsanto has requested a registration of an expanded use of a low-volatility DGA dicamba formulation on DT soybean, and petitioned (Pesticide Petition # 0F7725) the EPA to establish new feed tolerances on soybean forage (45 ppm) and soybean hay (70 ppm). Tolerances for soybean forage and hay for current dicamba uses in conventional soybean were not previously established because the current preharvest application is made past the stage where the crop would be useful as forage or hay. No other revisions to dicamba pesticide residue tolerances are needed including animal products such as meat or milk.

Monsanto has petitioned (Pesticide Petition # 0F7725) EPA to establish new feed tolerances on soybean forage (45 ppm) and soybean hay (70 ppm). Tolerances for soybean forage and hay for current dicamba uses in conventional soybean were not previously established because the current preharvest application is made past the stage where the crop would be useful as forage or hay. No other revisions to dicamba pesticide residue tolerances are needed including animal products such as meat or milk.

Dicamba residue levels in cottonseed harvested from dicamba-glufosinate tolerant (DGT) cotton treated with dicamba at the anticipated commercial in-crop application rate, and were 0.54 ppm, which is greater than the established 0.2 ppm pesticide residue tolerance supporting dicamba use on commercial cotton (40 CFR § 180.227) which is for the combined residues of parent dicamba and its metabolite 5-hydroxy dicamba. Cotton gin by-products, which serve as a ruminant feed supplement, have no established dicamba tolerance PP 2F8067 for the expanded use of dicamba on MON 88701, an increase in the dicamba residue tolerance from 0.2 ppm to 3 ppm for cottonseed, the establishment of a tolerance of 70 ppm for cotton gin by-products, and the inclusion of DCSA in the residue definitions for cottonseed and gin by-products.

Based on the studies submitted on the DGA salt formulation of dicamba by Monsanto, EPA has conducted draft assessments on the potential environmental fate, ecological effects, and human health effects of the proposed new uses of dicamba DGA salt. The conclusions from those assessments are summarized in this section. EPA will be publishing these complete draft analyses in the Federal Register for public comment.

Table 8-4. Summary of Directions for Proposed Uses of Dicamba on MON 87708 Soybean and MON 88701 Cotton

Formulation [EPA Reg. No.]	Applic. Timing, Type, and Equip.	Max. Applic. Rate (lb ae/A)	Max. No. Application per Season	Max. Seasonal Application Rate (lb ae/A)	Combined Max. Seasonal Application Rate (lb ae/A)	RTI[1] (days)	PHI[2] (days)	Use Directions and Limitations[3]
MON 87708 Soybean								
M1691 4.0 lb ae/gal SL [524-582]	Pre-emergence Broadcast (20 gal/A)	1.0	NS[4]	1.0	2.0	7	7	The maximum rate for any single, in-crop (post-emergence) application must not exceed 0.5 lb dicamba a.e. per acre. A second post-emergence application may follow up to the R1 reproductive stage
	Post-emergence, Broadcast (20 gal/A)	0.5	NS	2.0				
MON 88701 Cotton								
M1691 4.0 lb ae/gal SL [524-582]	Pre-emergence Broadcast (20 gal/A)	1.0	NS[4]	1.0	2.0	7	7	Use of a COC or MSO is not recommended with Roundup branded herbicides. These adjuvants are only used when other products require them. For best results apply at min spray rate of 10 GPA.
	Post-emergence, Broadcast (20 gal/A)	0.5	NS	2.0				

[1] RTI = Re-Treatment Interval
[2] PHI = Pre-Harvest Interval
[3] COC = Crop Oil Concentrate; MSO = Methylated Seed Oil.
[4] NS = Not Specified

Human Health Risk Assessment

The EPA Health Effects Division (HED) of the Office of Pesticide Programs (OPP) is charged with estimating the risk to human health from exposure to pesticides. HED evaluated hazard and exposure data and conducted dietary, residential (non-occupational), aggregate, and occupational exposure assessments to estimate the risk to human health that will result from the proposed new use of the DGA salt formulation of dicamba on dicamba-resistant soybean and cotton. Based on information contained in Monsanto's pesticide petition and the label conditions HED has concluded that the request for a registration for the use of the DGA salt formulation of dicamba on dicamba-resistant soybean and cotton would pose a reasonable certainty of no harm to humans. A summary of the results of the assessment are provided, below. The draft assessment will be published by EPA in the Federal Register for public review and comment.

> "Monsanto has submitted new metabolism studies for dicamba-tolerant soybean and cotton, which show that dicamba generally follows the same metabolic pathway to other plants. Dicamba applied to dicamba-tolerant soybean and cotton is converted to the non-herbicide metabolite 3,6-dichlorosalicylic acid (DCSA) and its glycosidic conjugates, which are the main metabolites formed. In a minor metabolic pathway, DCSA is hydroxylated at the 5-position, to form 2,5-dichloro-3,6-dihydroxybenzoic acid (DCGA) and its glycosidic conjugates, which are found in amounts less than 10% of the total radioactive residue (TRR). The dicamba metabolite 5-hydroxydicamba was not identified in the TRR of dicamba-tolerant soybean and cotton.
>
> The nature of residues for dicamba-tolerant soybean and cotton is understood. The residues of concern (ROC) for monitoring the tolerance under 40 CFR §180.227(a)(3) for soybean includes parent dicamba, and the metabolites 5-hydroxydicamba, and DCSA remains appropriate. Data from the newly submitted metabolism and field trial studies support including residues of DCSA to the tolerance expression for cotton to fall under 40 CFR §180.227(a)(3). These data also necessitate including DCGA to the ROCs for the risk assessment of soybean which include the residues established for tolerance expression (parent, 5-hydroxydicamba, and DCSA).
>
> The nature of dicamba residues in animals and in rotational crops were previously determined based on acceptable studies. The establishment of a tolerance on soybean forage and hay, as well as on cotton gin byproducts will not increase livestock dietary burden; therefore, no new revised tolerances on livestock commodities are required to support this petition.
>
> The residue values obtained from the field trial studies were evaluated using the Organization for Economic Cooperation and Development (OECD) calculation procedures for estimating tolerances/Maximum Residue Limits (MRLs). Using the OECD calculation procedures, and inputting the total residue, which includes the sum of the parent compound, and its metabolites 5-OH dicamba, and DCSA, expressed as parent equivalents, tolerances of 60 ppm for soybean forage and 100 ppm for soybean hay are recommended. The current tolerances of 10 ppm in soybean seed and 30 ppm in soybean hull are adequate. For cotton, the OECD calculation procedures determined that the recommended tolerances of 3.0 ppm for cotton undelinted seed and 70.0 ppm for cotton

gin byproducts are appropriate. The US EPA and PMRA (Canada) established a harmonized tolerance (MRL) for soybean on seed at 10 ppm.

There are currently no Mexican, Canadian or Codex MRLs established for soybean forage and hay as well as in cotton gin byproducts. There are MRLs of 0.2 ppm in Mexico and 0.04 ppm established by Codex on cotton seed currently established. Since the registrant has requested a late season use of dicamba on dicamba-tolerant cotton, the currently established international tolerances are inadequate to cover residues likely from the newly proposed use in the U.S. In addition, the dicamba residues of concern for dicamba-tolerant cotton also include the DCSA metabolite which is not found nor regulated in the other common varieties of cotton. Therefore, harmonization is not possible at this time for cotton seed. Since there are no international tolerances on cotton gin byproducts, there is no issue of international harmonization relevant to that tolerance.

There are no proposed residential uses at this time; however, there are existing residential uses that have been reassessed in this document to reflect updates to HED's 2012 Residential Standard Operating Procedures (SOPs). The residential handler and post-application risk estimates are not of concern for dicamba for all scenarios and all routes of exposure.

The label-required personal protective equipment (PPE) include that mixers, loaders, applicators and other handlers wear a long-sleeved shirt and long pants, socks, shoes, and chemical-resistant gloves (except for applicators using ground boom equipment, pilots or flaggers). The restricted entry interval (REI) on the proposed label is 24 hours. The occupational handler and post-application risk estimates are not of concern for dicamba for all scenarios and all routes of exposure for the use on herbicide-tolerant cotton and soybean."

Environmental Fate and Ecological Risks

The Environmental Fate and Effects Division (EFED) has completed a review of the new use request for the herbicide dicamba [M1691 Herbicide, EPA Reg. No. 524-582 diglycolamine salt of dicamba (DGA); PC code 128931)] for use on dicamba-tolerant soybeans (MON 87708). Dicamba is currently registered for use on soybeans at applications rates similar to those proposed for the new use. The use of dicamba on soybeans was assessed by the Environmental Fate and Effects Division (EFED) in 2005 (USEPA, 2005, D317696). The primary difference between the proposed new use on soybeans and the previous soybean use assessed is the timing of the applications. The current registration for dicamba use on soybeans is limited to pre-emergence applications; however, for the proposed new use on dicamba-tolerant soybeans, dicamba could be applied pre-emergence and/or post-emergence. Therefore, an abbreviated ecological risk assessment is provided.

The draft assessment will be published by EPA in the Federal Register for public review and comment. The results are summarized as follows:

"Based on the proposed maximum application rates, there is a potential for direct adverse effects to listed and non-listed birds (acute exposure), listed and non-listed mammals (chronic exposure), listed vascular aquatic plants, and listed and non-listed terrestrial dicots from the proposed new use. This assessment uses new submitted information on the toxicity of diglycolamine salt of dicamba (DGA) to terrestrial plants. Although for monocots toxicity of the DGA salt formuation is decreased compared to TGAI dicamba acid, the vegetative vigor data indicate that toxicity in the DGA salt formulation is enhanced for dicots. It is unclear if the enhanced toxicity to dicots is due to synergistic effects with surfactants and adjuvants in the formulation used (Clarity Herbicide, EPA Reg No. 7969-137, 56.8% DGA salt) or due to the DGA salt itself. The study with TGAI dicamba acid did not use surfactants or adjuvants. Although levels of concern were not exceeded for listed and non-listed species of monocots, exceedances for monocots would occur if toxicity data for dicamba acid was used in place of the data for the DGA salt. Risks to aquatic animals from chronic exposure to dicamba could not be assessed at this time because of a lack of data; therefore, since risk to these taxa cannot be precluded, it is assumed.

At this time, no federally-listed taxa can be excluded from the potential for direct and/or indirect effects from the proposed new use of dicamba, since there is a potential for indirect effects to taxa that might rely on plants, birds, aquatic animals, and/or mammals for some stage of their life-cycle. A complete co-occurrence analysis could not be completed for listed species at this time, since the specific use site associated with the proposed new use of dicamba (dicambatolerant soybeans) is not available for analysis in LOCATES. Therefore, without further refinement, no species currently listed as federally threatened or endangered can be excluded from the potential for adverse effects from the proposed new use of dicamba.

Although the risks, based on standard risk assessment methods used by the Environmental Fate and Effects Division (EFED), are not expected to differ from the previous assessment done for dicamba use on soybeans (because the rates are similar to those already assessed), there is potential for other ecological concerns that would not normally be captured using our standard risk assessment methods. These concerns are related to a potential increase in usage of dicamba products and the proposed changes in the timing of applications. In general, there is also a potential for increased susceptibility of late season plants to direct impact from off-site transport. Thus, unlike previous assessments of dicamba the risk conclusions in this assessment have increased uncertainty."

Glufosinate Ammonium

Glufosinate is a nonselective herbicide that is registered for preplant and post-emergent applications to control broadleaf weeds in a variety of crop and non-crop areas. Additionally, it is also used as a defoliant and as a means of conducting chemical burndown.

Since it is a nonselective herbicide it injures or kills crop plants that it contacts. Glufosinate is a contact herbicide which is taken up by the plant primarily through the leaves. There is no uptake from the soil through the roots, presumably because of the rapid degradation of glufosinate by soil microorganisms. There is limited translocation of glufosinate within the plant.

Glufosinate herbicides contain the active ingredient phosphinothricin and are in the phosphinic acid family of herbicides. The herbicide acts by blocking the plant enzyme glutamine synthetase, which is responsible for nitrogen metabolism and for detoxifying ammonia, a by-product of plant metabolism. The exposed plant dies by the over-accumulation of ammonia (US-EPA, 2008).

First registered with EPA in 1993, initial glufosinate end-use products were designed for home owners; light industrial, non-food users; and farmstead, weed-control users (OSTP, 2001). Glufosinate is registered for use on apples, berries, canola, citrus, corn, cotton, currants, grapes, grass grown for seed, olives, pome fruit, potatoes, rice, soybeans, stone fruit, sugar beets, and tree nuts. Registrations for noncrop areas include golf course turf, residential lawns, ornamentals, and a variety of industrial and public areas.

Application rates of glufosinate range significantly by use pattern, with the highest rate allowed for broadcast (ground) spray applications, at 1.5 lb a.i./A, on orchard nuts and fruits, grapes, grasses grown for seed, and golf course turf. On the low end of application rates, labeled uses of glufosinate on turf and patio are at 0.03 lb a.i./A. Multiple applications are allowed by most labels, although the interval is not generally specified (US-EPA, 2008).

Based on its proprietary data for the period from 2007–2011, EPA estimated that the highest annual agricultural uses of glufosinate are in corn (1.3 million lb), almonds (200,000 lb), cotton (200,000 lb), grapes (200,000 lb), canola (100,000 lb) and soybeans (100,000 lb) (Table 8-5) (US-EPA, 2012a). Almonds, cotton, and grapes are also appreciable uses reported in the BEAD analysis. Uses which have not been calculated do not imply zero use, though they are likely low in comparison to those uses that are quantified in Table 8-5. Stone fruits, such as peaches, cherries, and plums/prunes, are new uses which were approved in 2012. Registered non-agricultural uses, such as fallow fields, lawns and gardens, conifer tree areas, and non-crop areas (*e.g.*, farmstead building foundations, shelter belts, along fences, *etc.*) are not captured in the above data. These data do not include non-agricultural uses (US-EPA, 2013a).

The map in Figure 8-3 shows the use of glufosinate from 2011, with most use of glufosinate concentrated in the Midwest (USGS, 2013b). Figure 8-4 shows the increasing use of glufosinate in crops (USGS, 2013b).

Table 8-5. Estimates of Agricultural Usage of Glufosinate, 2007-2011.

Crop	Lbs. ai	Percent Crop Treated		Average Single App. Rate (lbs ai/A)	Average Number of Apps.
		Average (%)	Maximum (%)		
Almonds	200,000	15	40	0.96	NR
Apples	4,000	<1	<2.5	0.82	NR
Blueberries	10,000	5	15	NR	NR
Canola	100,000	25	35	0.37	1.0
Cherries	1,000	<1	<2.5	NR	NR
Corn	1,300,000	5	10	0.38	1.0
Cotton	200,000	5	10	0.40	1.4
Fallow	<500	<1	<2.5	NR	NR
Grapes	200,000	15	30	0.91 – 1.05	NR
Hazelnuts	6,000	10	25	0.71	NR
Peaches	2,000	<2.5	10	0.79	NR
Peanuts	1,000	<1	<2.5	NR	NR
Pecans	1,000	<1	<2.5	NR	NR
Pistachios	50,000	20	45	1.01	NR
Plums/Prunes	2,000	<2.5	10	0.55	NR
Potatoes	30,000	10	20	0.36	1.1
Rice	5,000	<1	<2.5	NR	NR
Soybeans	100,000	<1	<2.5	0.43	1.2
Sweet Corn	<500	<1	<2.5	NR	NR
Walnuts	30,000	10	20	0.87	NR

All numbers rounded. App(s).: Application(s). NC: Not calculated. NR: Not reported.
Data sources: Screening Level Usage Analysis (SLUA), OPP/BEAD, 19 March 2012; EPA Proprietary Data: 2007-2011, C. Doucoure, OPP/BEAD; any proprietary data have been obscured from their source(s).

Source: (US-EPA, 2012a; 2013a).

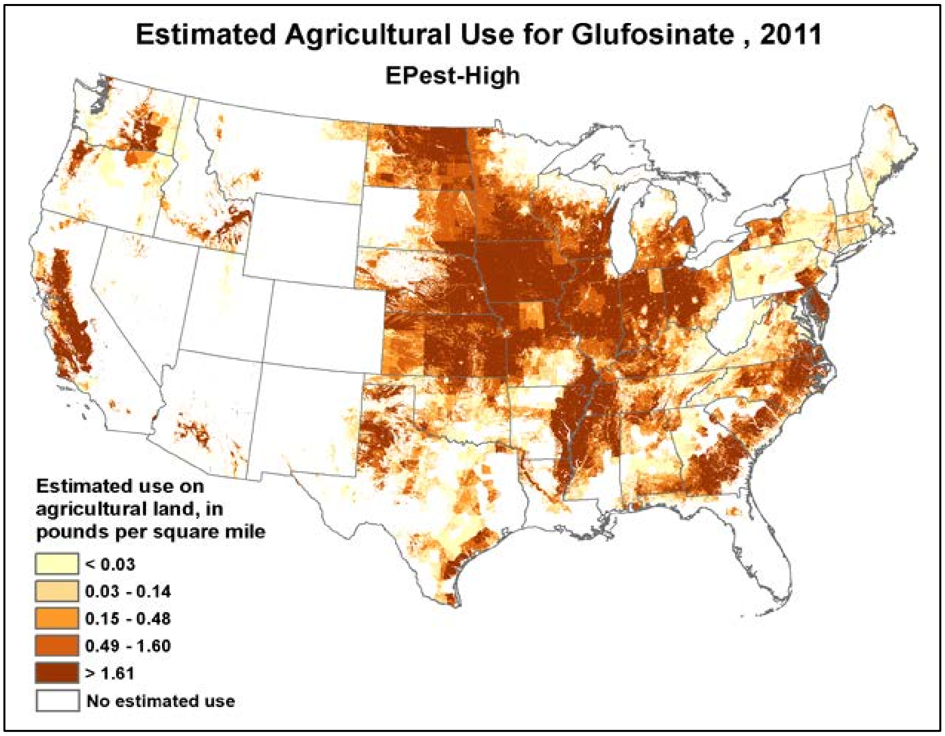


Figure 8-3. Estimated Annual Agricultural Use of Glufosinate in the U.S.
Source: (USGS, 2013b).

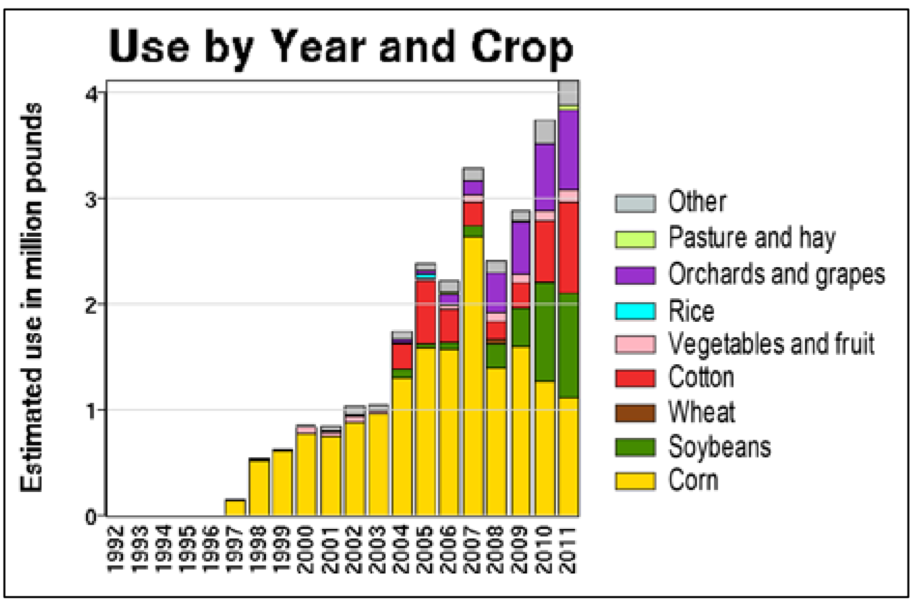


Figure 8-4. Glufosinate Use by Year and Crop, 1992 to 2011
Source: (USGS, 2013b).

Both aerial and ground spray is allowed for most uses, although some applications are limited to methods using hand wands and backpack sprayers. As glufosinate is designed primarily to control broadleaf weeds, applications are normally ground applications, to prevent damage to crops. Aerial application is considered a viable option for genetically modified crops (e.g., canola, corn, cotton, rice, sugarbeets, and soybeans) that are resistant to glufosinate's herbicidal properties, and for burndown applications.

Several crop plants have been modified by inserting a gene that produces an enzyme which detoxifies glufosinate by converting the herbicide into a non-active form. The PAT (*bar*) protein acetylates the free amino group of glufosinate to produce non-herbicidal N-acetyl glufosinate, a known metabolite in glufosinate-tolerant plants (OECD, 2002). Bayer Crop Science has registered glufosinate for use on glufosinate-resistant crops, including corn, soybean, and cotton. Ignite 280 SL Herbicide (EPA Reg. No. 264-829) is a commercially available glufosinate containing herbicide with directions for use on glufosinate-resistant crops. Glufosinate is currently labeled for in-crop application with glufosinate-tolerant cotton from emergence through early bloom growth stage (Bayer CropScience, 2011) (Table 8-6).

Table 8-6. Current Labeled Application Rates for Glufosinate-resistant Cotton.

Use Pattern	1st Application (Burndown)	2nd Application	3rd Application	Season Maximum
Cotton Use Pattern 1	22-29 fl oz/A	22-29 fl oz/A	22-29 fl oz/A	87 fl oz/A
Cotton Use Pattern 2	30-43 fl oz/A	22-29 fl oz/A	None	72 fl oz/A

Source: (Bayer CropScience, 2011).

Due to its nonselective activity, glufosinate has a weed management spectrum similar to glyphosate and its use has grown, particularly in areas with glyphosate-resistant weeds (Southeast Farm Press, 2012). In the southeast in 2011, glufosinate was the ninth most frequently used herbicide on soybean. Glufosinate use is likely to continue to follow the recent trend of increased use associated with the adoption of glufosinate-resistant crops.

Although glufosinate provides an additional means of weed control, it is not as versatile as glyphosate. For example, glufosinate needs to be applied to smaller weeds with finer droplet sizes and larger carrier volumes to achieve adequate control. This is in part because, unlike glyphosate which translocates readily throughout the plant, glufosinate has limited mobility and thus requires better coverage for control (hence the larger carrier volumes and smaller droplet sizes) (Monsanto, 2013).

Products include Derringer® (Reg. No.432-1228), Derringer® F Herbicide (Reg. No. 432-960), Finale® Super Concentrate (Reg. No.432-954), Finale® Ready-to-Use (Reg. No. 432-955), Finale® Concentrate (Reg. No. 432-956), Finale® Herbicide (Reg. No. 432-1229), Glufosinate 280 (Reg. No. 88685-2), Liberty® (Reg. No. 264-660), Liberty® ATZ (Reg. No. 264-668), Liberty 280® (Reg. No. 264-829), Rely® (Reg. No. 264-652), and Remove® (Reg. No. 264-663). The EPA-established glufosinate residue tolerances are 4.0 ppm and 15.0 ppm for cottonseed and gin by-products, respectively (40 CFR 180.473). Both of these tolerances include the combined residues of parent glufosinate and its metabolites N-acetyl glufosinate and 3-methylphosphinico-propionic acid.

Currently glufosinate is undergoing Registration Review at EPA with a decision expected by the end of 2013 (US-EPA, 2008). It is expected that EPA will affirm the safety and efficacy of glufosinate and approve its continued use in the marketplace upon completion of the registration process.

Glufosinate Use on MON 88701 Cotton

Glufosinate use on MON 88701 cotton will be equivalent to currently deregulated glufosinate-resistant cotton. The use pattern and rate of glufosinate application on MON 88701 cotton will follow the existing glufosinate-resistant cotton uses outlined on the existing glufosinate herbicide label (Bayer Crop Science, 2007). Like commercially available glufosinate-resistant cotton, MON 88701 cotton enables application of up to 0.53 lb a.i. per acre per application of glufosinate from emergence through early bloom growth stage. Monsanto has confirmed that glufosinate residues on MON 88701 cotton treated with commercial glufosinate rates are below the established pesticide residue tolerances established by EPA for both cottonseed and gin by-products (40 CFR 180.473). Consequently, Monsanto is not pursuing any changes in the glufosinate label or the established tolerances for its use on MON 88701 cotton (Monsanto, 2013).

Glyphosate

Glyphosate acid is a broad spectrum, nonselective systemic herbicide widely used to control most annual and perennial grass and broadleaf weeds in agricultural crops and non-agricultural sites. The herbicide is registered for pre- and post-emergence application on a variety of fruit, vegetable, and field crops, as well as for aquatic and terrestrial uses. Labeled uses of glyphosate include over 100 terrestrial food crops as well as other non-food sites including forestry, greenhouse, non-crop, and residential. Glyphosate can also be used as a plant growth regulator and accelerate fruit ripening. Additionally, glyphosate is registered for use on GE glyphosate-resistant crops, including canola, corn, cotton, soybeans, alfalfa, and sugar beets. Glyphosate is the most widely used herbicide on U.S. corn, soybean, and cotton.

Glyphosate was first introduced under the trade name of Roundup™ by Monsanto in 1974. Glyphosate salts serve as the source of the active ingredient (a.i.) *N*-(phosphonomethyl) glycine and improve handling, performance, and concentration of the glyphosate acid. Glyphosate is distributed in several forms, including technical grade glyphosate, isoproplyamine salt, monoammonium salt, diammonium salt, N-methylmethanamine salt , trimethylsulfonium salt, or potassium salt (US-EPA, 2009b). Isopropylamine salt is the most typically used form in formulated products (Henderson, 2010).

Glyphosate acid is a nonselective Group 9 herbicide and kills plants by inhibiting the 5-enolpyruvylshikimate-3-phosphate synthase (ESPS) enzyme. This enzyme is essential for the biosynthesis of aromatic amino acids (e.g., tyrosine, tryptophan, and phenylalanine) and other aromatic compounds in algae, higher plants, bacteria and fungi. By creating a deficiency in EPSP enzyme and aromatic amino acids production, glyphosate affects protein synthesis and plant growth (US-EPA, 2009b). Glyphosate is absorbed across the leaves and stems of plants and moves throughout the plant, concentrating in the meristem tissue (Henderson, 2010).

Glyphosate use is concentrated heavily in the Midwest, along the Mississippi River, the Southeast seaboard, and the Central Valley of California, as depicted in Figure 8-5.

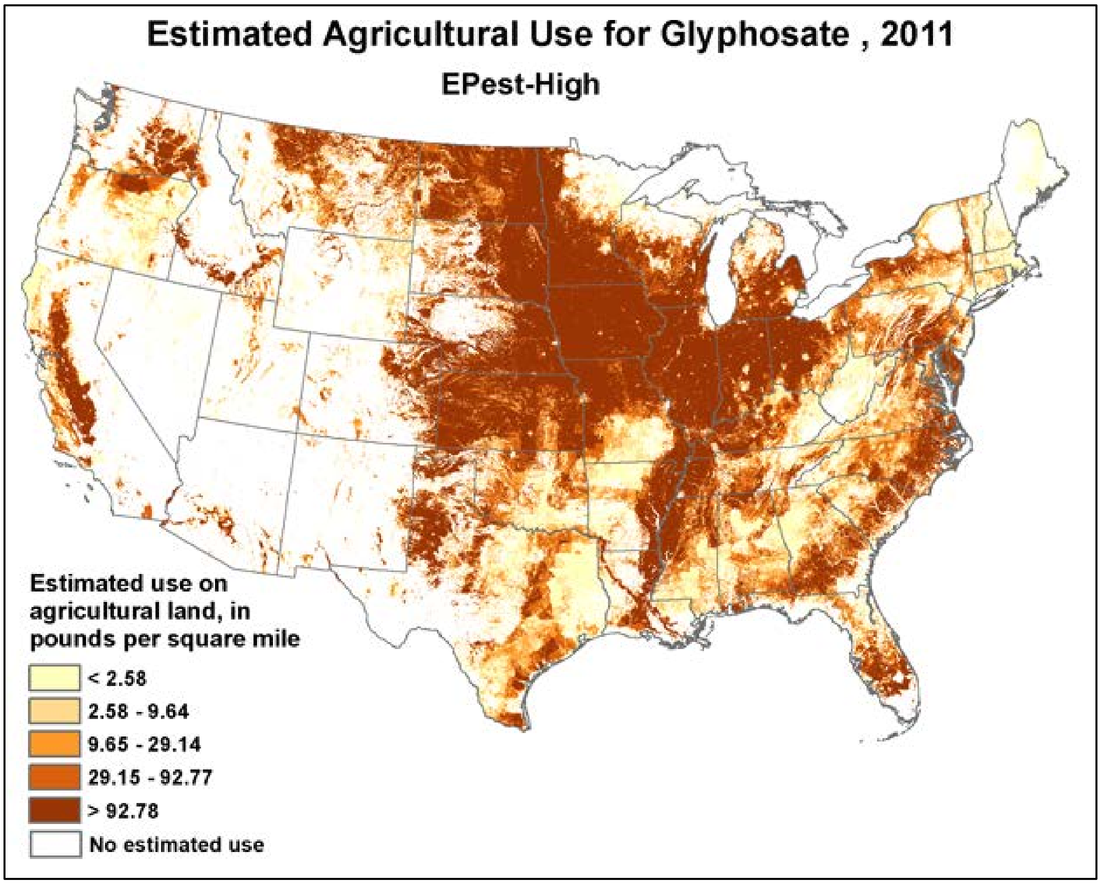


Figure 8-5. Estimated Agricultural Use for Glyphosate, 2011
Source: (USGS, 2013c).

Based on pesticide usage data from USDA-NASS, private pesticide market research, and California Department of Pesticide Regulation (DPR), EPA estimated glyphosate usage from 2004 through 2011. The crops with the highest glyphosate uses (based on average treated fraction of acreage) were: almond (85%), apples (55%), apricots (55%), asparagus (55%), avocados (45%), barley (20%), blueberries (20%), canola (65%), cherries (65%), corn (60%), cotton (85%), cucumbers (20%), dates (20%), dry beans/peas (25%), fallow (55%), figs (40%), grapefruit (80%), grapes (70%), hazelnuts (70%), kiwifruit (30%), lemons (70%), nectarines (45%), olives (45%), onions (30%), oranges (90%), peaches (55%), peanuts (20%), pears (65%), pecans (35%), peppers (20%), plums (65%), pumpkins (20%), rice (25%), sorghum (40%), soybeans (95%), squash (20%), sugar beets (50%), sugarcane (45%), sunflowers (55%), tangelos (55%), tangerines (65%), tomatoes (35%), walnuts (75%), and wheat (25%). All other treated crops averaged 15% or less of the total acreage grown (US-EPA, 2012b). Figure 8-6 shows the glyphosate use on crops from 1992 to 2011.

The current approved maximum pre-emergence application of glyphosate on glyphosate-resistant corn or soybeans is 3.7 lb a.e./acre. A glyphosate post-emergence application from 0.75 to 1.5 lb a.e./acre (total 2.25 lb/acre/season post-emergence) and an additional pre-harvest application of 0.77 lb a.e./acre are permitted. The current maximum total seasonal use rate for glyphosate on glyphosate-resistant corn and soybean is 6 lb a.e./acre.

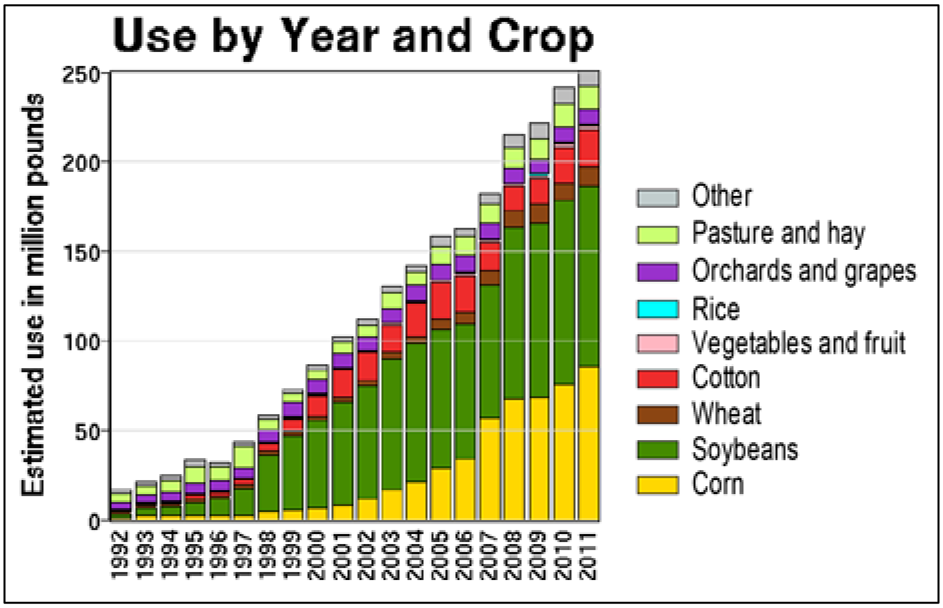


Figure 8-6. Glyphosate Use by Year and Crop, 1992 to 2011.
Source: (USGS, 2013c).

Pesticide residue tolerances for glyphosate are listed in 40 CFR Part 180.364, representing combined residues of glyphosate, N-(phosphonomethyl)glycine and its metabolite N-acetyl-glyphosate (expressed as glyphosate) (US-EPA, 2010). Table 8-7 shows the current tolerances for residues of glyphosate established for corn and soybean commodities.

Table 8-7. Glyphosate Tolerances for Corn and Soybean Commodities

Commodity	Residue (parts per million)
Cotton, gin byproducts	210
Soybean, forage	100
Soybean, hay	200
Soybean, hulls	120
Soybean, seed	20

Source: 40 CFR 180.364

EPA is currently conducting a registration review of glyphosate which was begun in 2009 and is currently scheduled to be completed in 2015 (US-EPA, 2009a). According to EPA, as part of their review, "the Agency plans to require a number of ecological fate and effects studies, an acute and subchronic neurotoxicity study, and an immunotoxicity study through a data call-in, which is expected to be issued in 2010. The new information will be used to conduct a comprehensive ecological risk assessment, including an endangered species assessment, as well as a revised occupational human health risk assessment, for all glyphosate pesticidal uses (US-EPA, 2009a)."

All documents related to the glyphosate registration review can be viewed at the registration review docket:

http://www.regulations.gov/#!docketDetail;D=EPA-HQ-OPP-2009-0361

MON 87708 soybean and MON 88701 cotton are intended to be combined with glyphosate-resistant varieties utilizing traditional breeding techniques. The combined system will support long term sustainability of weed management in soybean and cotton and, in turn, support sustained, economic cotton production.

References:

Bayer Crop Science. "Liberty® herbicide label." *Bayer CropScience*. Research Triangle Park, North Carolina: Bayer Crop Science, 2007.

Bayer CropScience (2011) "Ingite 280 SL Herbicide Label 5a " Bayer CropScience. http://fs1.agrian.com/pdfs/Ignite_280_SL_Herbicide_Label5a.pdf.

Henderson, AMG, J. A.; Luukinen, B.; Buhl, K.; Stone, D. "Glyphosate Technical Fact Sheet." Ed. National Pesticide Information Center, Oregon State University Extension Services.2010. 14. http://npic.orst.edu/factsheets/glyphotech.pdf.

HRAC (2009) "Classification of herbicides according to mode of action." Herbicide Resistance Action Committee. http://www.hracglobal.com/Publications/ClassificationofHerbicideModeofAction/tabid/222/Default.aspx.

McClelland, MR; Smith, KL; and Norsworthy, JK (2006) "Managing Glyphosate-Resistant Horseweed in Conservation-Tillage Cotton Production: Final Summary and Recommendations." *AAES Research Series.* p 108-11.

Monsanto. "Unpublished grower survey data performed by a contracting agency." St. Louis, Missouri: Monsanto Company, 2012.

Monsanto. "Petitioner’s environmental report for dicamba-tolerant soybean MON 87708 and dicamba- and glufosinate-tolerant cotton MON 88701." St. Louis, Missouri: Monsanto Company, 2013. Vol. November 22, 2013.

OECD (2002) "Module II: Herbicide biochemistry, herbicide metabolism and the residues in glufosinate-ammonium (Phosphinothricin)-tolentant transgenic plants."

OSTP (2001) "Case Studies of Environmental Regulation for Biotechnology: Herbicide-Tolerant Soybean." The White House Office of Science and Technology Policy. http://www.whitehouse.gov/files/documents/ostp/Issues/ceq_ostp_study4.pdf.

Southeast Farm Press (2012) "Glufosinate herbicide shortage sparks controversy." http://southeastfarmpress.com/cotton/glufosinate-herbicide-shortage-sparks-controversy.

US-EPA (2006) "Reregistration Eligibility Decision for Dicamba and Associated Salts." Environmental Protection Agency. http://www.epa.gov/oppsrrd1/REDs/dicamba_red.pdf.

US-EPA (2008) "Glufosinate final work plan registration review: August 2008."

US-EPA (2009a) "Glyphosate Final Work Plan (FWP) - Registration Review Case Number 0178." Office of Prevention, Pesticides, and Toxic Substances,. http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OPP-2009-0361-0042.

US-EPA (2009b) "Registration Review- Preliminary Problem Formulation for the Ecological Risk and Drinking Water Exposure Assessments for Glyphosate and Its Salts (PC Code 417300, 103601, 103604, 103607, 103608, 103613, 103603, 103605,

128501)." http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OPP-2009-0361-0007.
US-EPA (2009c) "Sodium and Potassium Dimethyldithiocarbamate Salts Amendment to the Ferbam (PC Code 034801) and Ziram (PC Code 034805) Reregistration Eligibility Decisions." Environmental Protection Agency. http://www.epa.gov/opp00001/reregistration/REDs/ddcsalts-red-amended.pdf.
US-EPA (2010) "40 CFR §180.364 - Glyphosate; tolerances for residues. ." U.S. Environmental Protection Agency. http://cfr.vlex.com/vid/180-364-glyphosate-tolerances-residues-19814904.
US-EPA (2011) "2011 edition of the drinking water standards and health advisories."
US-EPA (2012a) "Glufosinate (128850) Screening Level Usage Analysis (SLUA)." Office of Chemical Safety and Pollution Prevention. http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OPP-2008-0190-0029.
US-EPA (2012b) "Updated Screening Level Usage Analysis (SLUA) Report in Support of Registration Review of Glyphosate." Office of Chemical Safety and Pollution Prevention. http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OPP-2009-0361-0045.
US-EPA (2013a) "Preliminary Ecological Risk Assessment for the Registration Review of the Herbicide, Glufosinate-ammonium."
US-EPA (2013b) "Setting tolerances for pesticide residues in foods." Last Accessed: November 5, 2013 http://www.epa.gov/opp00001/factsheets/stprf.htm.
USDA-AMS (2013) "Pesticide data program annual summary, calendar year 2011." http://www.ams.usda.gov/AMSv1.0/getfile?dDocName=stelprdc5102692.
USDA-NASS (2005) "Agricultural Statistics 2005." USDA- National agricultural Statistics Service.
USDA-NASS (2007) "Census of Agriculture: Summary and State Data Volume 1 • Geographic Area Series • Part 51." USDA-National Agricultural Statistics Service.
USDA-NASS (2010) "Agricultural Statistics 2010." USDA-National Agricultural Statistics Service.
USDA-NASS (2011) "Agricultural Statistics 2011." UDSA-National Agricultural Statistics Service.
USDA-NASS (2012) "Census of Agricultrue-Preliminary Report." USDA-National Agricultural Statistics Service.
USGS. "Pesticide Use Maps - Dicamba." *Pesticide National Synthesis Project* 2013a. http://water.usgs.gov/nawqa/pnsp/usage/maps/show_map.php?year=2011&map=DICAMBA&hilo=L&disp=Dicamba.
USGS. "Pesticide Use Maps - Glufosinate." *Pesticide National Synthesis Project* 2013b. http://water.usgs.gov/nawqa/pnsp/usage/maps/show_map.php?year=2011&map=GLUFOSINATE&hilo=H&disp=Glufosinate.
USGS. "Pesticide Use Maps - Glyphosate." *Pesticide National Synthesis Project* 2013c. http://water.usgs.gov/nawqa/pnsp/usage/maps/show_map.php?year=2011&map=GLYPHOSATE&hilo=H&disp=Glyphosate.

Appendix 9. Monsanto Tillage Report

[*This document has been submitted by Monsanto Company for use by USDA APHIS in support of a request for nonregulated status for Xtend soybean and cotton crops. USDA APHIS has chosen to include this section in its entirety because it is the most recent and comprehensive regional analysis of agricultural tillage.]*

Introduction

Recently there have been speculation and in some cases, reports, that the growth of conservation tillage acres and, in particular, no-till acres has slowed or is reversing in some parts of the country. Accordingly, Monsanto undertook an analysis of grower market research information from an independent market research company and follow up consultation with leading conservation tillage experts to understand more precisely current tillage trends and reasons for these trends in key soybean, corn and cotton growing areas.

Multiple factors could influence conservation tillage practices. Growth in the spread of glyphosate-resistant weed populations has been speculated or reported to be one such factor, because of the need for some farmers to incorporate more tillage into their farming operations in order to control some difficult to control weed species, such as Palmer amaranth. For example, where populations of glyphosate-resistant Palmer amaranth have grown large in areas such as Georgia, western Tennessee, and Arkansas, weed control experts recommend deep pre-plant tillage as one way to reduce the population before other weed control measures are applied (Culpepper, et al. 2013; Culpepper, et al. 2011; Price, et al. 2011). However, growers and leading conservation experts themselves report a range of factors other than weed management that can and do influence farmer practices relative to conservation tillage practices.

Materials and Methods

This analysis used market research data from an unpublished national grower survey conducted by a third party market research company. The data retrieved from this database included the number of crop acres planted conventionally, in a no-till system, or in a reduced tillage system. No-till acres are defined as those in which the farmer does not till the ground after the harvest of the last crop and before planting a new crop. Reduced tillage (reduced-till) is defined as situations where the farmer practices various types of reduced tillage after harvest of the last crop and before planting the new crop where significant crop residues (~15%-30%) are left on the soil surface. Examples of reduced tillage practices include ridge-till (planting row crops on permanent ridges), strip-till (planting crops directly in narrow strips that had been tilled), and mulch-till (any reduced tillage system that leaves at least 1/3 of soil surface covered with crop residue). Conventional tillage (conventional) is defined as situations where the farmer conducts several tillage operations such that the new crop is planted into soil with little to no surface residue.

The farmer market research data was sorted by crop (soybeans, cotton, and corn) and state. Selected states were combined into growing regions (East, Midwest, Southeast, Mid-South, and West, as indicated in Table 1). Data was retrieved for the period from 1998 through 2013 for soybeans and corn, and through 2012 for cotton (Note: 2013 cotton data from the market research company is not currently available). The estimated acreage of each tillage type for each crop and growing region was converted to percent of total crop planted acreage and submitted for statistical regression analysis over the designated time period. The data was analyzed to fit a linear or quadratic regression model at the 5% level of significance. Details of the statistical analysis are provided in the statistical report found in Appendix A [of the Environmental Report (ER)].

To understand possible reasons for some of the changes observed in this data set, Monsanto worked with CTIC (Conservation Tillage Information Center, www.ctic.org) to conduct a survey of leading conservation tillage experts in select Midwest, Southeastern and Mid-South. (Note: experts from these areas were surveyed because they represent the major regions for the production of soybean, corn and cotton, and because they represent the areas with the highest levels of herbicide resistant weeds). In this survey, the experts were asked to indicate the level of importance of 11 different factors to farmers as they make decisions as to which tillage system and in general how much tillage they will use on their farm(s). Examples of factors included "manage excess crop residue," "manage existing weeds," "manage disease," "economics," and "prevent weed resistance." To rank the factors, a number from 1 to 4 was assigned to each response category, with 1 assigned to "not important or not mentioned" and 4 assigned to "extremely important". The experts were not limited in the number of factors to which they could assign an individual ranking. (i.e., the experts could rank all – or none – of the 11 factors as "extremely important"). The assigned number was multiplied by the number of responses from the experts and then added together for each factor. The factors with the 5 highest numerical sums are listed in Table 3 for each crop and region. The detailed results of this survey for corn, soybeans and cotton can be found in Appendix B [of the ER] .

Table 1. States in each Geographic Region

Region	Crop Focus	States
East	Corn, soybean	Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, West Virginia
Southeast	Corn, cotton, soybean	Alabama, Georgia, S. Carolina, N. Carolina, Virginia, Florida
Mid-South	Corn, cotton, soybean	Mississippi, Louisiana, Arkansas, Tennessee
Midwest	Corn, cotton, soybean	Ohio, Michigan, Indiana, Illinois, Wisconsin, Missouri, Minnesota, Iowa, Kentucky, Kansas, Nebraska, N. Dakota, S. Dakota
West	Corn, cotton, soybean	Arizona, California, New Mexico, Oklahoma, Texas, Colorado, Idaho, Montana, Nevada, Utah, Washington, Wyoming

Results and Discussion

A summary of the results of the grower market research data analysis on tillage trends can be found in Table 2. Key points are as follows:

- From 1998 to 2007, the conventional tillage acreage decreased and no-till acres increased across all crops and geographic areas. Likewise, reduced tillage acres generally increased during this time period, although for some areas and crops, no significant relationship between the tillage practice and time could be detected. The growth in no-till and reduced tillage acres coincides with, and was facilitated by, the growth in glyphosate-tolerant corn, soybean and cotton acres (Givens, et al. 2009a; Givens, et al. 2009b; McClelland, et al. 2000; Osteen and Fernandez-Cornejo 2013; Sankula 2006; Towery and Werblow 2010).

- Since 2007, however, some crops in some geographic areas have continued to see growth in no-till acreage, while other crops in other geographic areas have seen decreases in no-till acreage, accompanied by an increase in conventional and/or reduced tillage acreage. A more detailed, crop-by-crop discussion is presented below.

- **Corn:** From 1998 to 2007, the conventional tillage acreage decreased and no-till acres increased across all geographic areas. From 2007 through 2013, the trends varied across regions:
    - In the West and East, conventional tilled corn acres continued to decrease, and no-till acreage continued to increase. Reduced tillage acres also increased in the West, but there was no clear trend in the East.
    - In the Midwest, conventional tilled corn acres continued to decrease but there appeared to be a shift from strict no-till practices to reduced tillage acres where some tillage is practiced but significant (15% -30%) crop residues remain on the surface at planting.
    - In the Southeast, conventional tillage acres planted to corn tended to level off or increase while no-till acres tended to decrease.
    - In the Mid-South, there were no significant trends in conventional or no-till acreage, but reduced till acres increased throughout the time period.
- **Soybean:** From 1998 to 2007, the conventional tillage acreage decreased and no-till acres increased across all geographic areas. From 2007-2013, the trends varied across region:
    - In the West, conventional tilled soybean acres continued to decrease, and no-till acreage continued to increase. There was no significant trend for reduced tillage acres.
    - In the East, Midwest, Southeast and Mid-South regions, conventional tilled soybean acres were flat or increasing, while no-till acres were flat or decreasing. Reduced tillage acres in the Midwest increased during the same time period, but there was no clear relationship between time and reduced tillage plantings in the

East, Southeast or Mid-South regions (not significant at the 95% confidence interval). Thus, in the Midwest, the reduction in no-till acres appears in large part to be offset by an increase in reduced tillage acres, but similar offsetting does not appear to be occurring in other regions.

- **Cotton:** From 1998 to 2007, the conventional tillage acreage decreased and no-till acres increased across all geographic areas. From 2007-2012, the trends varied across regions:
    - In the West, conventional tilled soybean acres continued to decrease, and no-till acreage continued to increase. Reduced tillage acres also continued to increase.
    - In the Midwest, Southeast and Mid-South, conventionally-tilled cotton acres tended to be flat or increase, while a clear increase was found in the Mid-South region. Reduced tillage acres increased in the Midwest and Southeast during this period, but both no-till and reduced tillage acreages decreased in the Mid-South region. Thus, in the Midwest and Southeast, the reduction in no-till acres appears in large part to be offset by an increase in reduced tillage acres, but similar offsetting does not appear to be occurring in the Mid-South.

Overall, changes in tillage practices from 2007 to 2012 (cotton)/2013 (soybean and corn) varied by crop and region relative to changes seen in the earlier period from 1998 to 2006 where consistent trends were observed across all the regions (i.e., increase in no-till and reduced tillage with a decrease in conventional tillage systems).

In order to understand the reasons growers adopt specific tillage practices, a survey was conducted of top conservation tillage experts across the Midwest (for corn and soybeans), Southeast and Mid-South regions (combined, for corn, soybeans, and cotton). In Table 3, the top 5 factors, according to conservation tillage experts, governing farmer decisions relative to which tillage practice they adopt for their farm are provided by crop and region of the country. Key findings included:

- Economics (i.e., the importance of cost of production and/or commodity prices), and managing soil moisture (i.e., less tillage conserves soil moisture) were top-5 factors across all the crops and regions.
- Seed bed preparation was a top-5 factor in 4 out of 5 crop x region segments.
- Managing excessive crop residue (i.e., excessive prior crop residue may require more tillage) and managing weeds (existing weeds or preventing weed resistance) were important factors in 3 out of 5 crop x region segments.
- Managing weeds was an important factor across all soybean and cotton regional segments, but was not a top 5 factor for corn in either regional segment. The difference between corn and the other crops is likely because growers have a broad range of herbicide options (including atrazine, dicamba and 2,4-D) that are effective against species that are difficult to control in soybeans and cotton, i.e., glyphosate resistant Palmer amaranth and waterhemp.

This survey of conservation tillage experts highlights that farmers consider multiple factors when making decisions as to what type tillage system to employ.

Conclusions

From 1998-2007, no-till acreage increased steadily across all crops and all regions, with an accompanying decrease in conventional tillage. A more complicated picture emerged after 2007, with some crops and regions continuing to experience increases in no-till and decreases in conventional tillage, while other crops and regions experienced decreases in no-till acreage, either accompanied by increases in reduced tillage acreage and/or in conventional tillage.

Based upon information provided by conservation tillage experts regarding the most important factors governing farmer's decisions with respect to tillage practices, no one factor is driving these changes. Managing existing herbicide resistance and/or mitigating the potential for resistance to develop is a factor is some regions. For example, academics have been recommending more pre-plant tillage in parts of the Southeast and Mid-South (AR, western TN, and MS) in order to better manage glyphosate-resistant Palmer amaranth. But weed resistance management/mitigation does not appear to be a driver for other crops and regions. Indeed, the survey results indicate that higher corn and soybean grain prices, along with more focus on seed bed preparation, is likely to be a reason for some of switch to conventional tillage since a better stand (and thus higher potential yields) can usually be achieved in conventional tillage systems. Moreover, newer corn varieties can produce excessive crop residue, which may also be causing a move to more tillage and may be needed to optimize crop stands in this period of high grain prices.

Based upon the tillage trends seen over the last 5-6 years and with the information on the factors most influencing farmers' decision on tillage practices, more study, appropriately directed research, education, and new technology from a weed management and crop production standpoint are needed to maintain and further grow conservation tillage practices. In some areas and for some crops, managing existing herbicide resistance and/or mitigating the potential for resistance to develop has been reported as an important factor in influencing farmer tillage decisions. DT soybean and DGT cotton are two new herbicide technologies that have the characteristics that can significantly assist in reversing stagnated and downward trends and promote new growth in conservation tillage acres. Weed management has always been a limiting factor for many farmers in determining whether to adopt no-till production practices because farmers had to rely primarily on soil residual herbicides. Glyphosate, in glyphosate-tolerant crops, with its broad spectrum post-emergence control provided a way to achieve consistent weed control in these situations and facilitated an increase in adoption of no-till and, in general, conservation tillage practices (Fawcett and Towry, 2002). The effectiveness of dicamba to provide post-emergent control of broadleaf weeds, suggests that it too will promote adoption of no-till and conservation tillage practices. Additionally, dicamba's ability to control glyphosate resistant broadleaf weeds and its compatibility with glyphosate are characteristics that will facilitate the promotion of conservation tillage practices.

Table 2. Trends in Tillage Practices in Soybean, Corn and Cotton

Crop	Geography	Tillage system	Trend	
			1998-2007	2007-2012/13
Corn	West	Conventional	Dec	Dec
		No-till	Inc	Inc
		Reduced-till	Inc	Inc
	Midwest	Conventional	Dec	Dec
		No-till	Inc	Flat/Dec[1]
		Reduced-till	Dec	Inc
	Southeast	Conventional	Dec	Flat/Inc[1]
		No-till	Inc	Dec
		Reduced-till	NS	NS
	Mid-South	Conventional	NS	NS
		No-till	NS	NS
		Reduced-till	Inc	Inc
	East	Conventional	Dec	Dec
		No-till	Inc	Inc
		Reduced-till	NS	NS
Soybeans	West	Conventional	Dec	Dec
		No-till	Inc	Inc
		Reduced-till	NS	NS
	Midwest	Conventional	Dec	Flat/Inc[1]
		No-till	Inc	Dec
		Reduced-till	Dec	Inc
	Southeast	Conventional	Dec	Flat
		No-till	Inc	Flat
		Reduced-till	NS	NS
	Mid-South	Conventional	Dec	Inc
		No-till	Inc	Dec
		Reduced-till	NS	NS
	East	Conventional	Dec	Flat/Inc[1]
		No-till	Inc	Flat/Dec[1]
		Reduced-till	NS	NS

Table 2 (continued). Trends in Tillage Practices in Soybean, Corn and Cotton

Crop	Geography	Tillage system	Trend	
			1998-2007	2007-2012/13
Cotton	West	Conventional	Dec	Dec
		No-till	Inc	Inc
		Reduced-till	Inc	Inc
	Southeast	Conventional	Dec	Flat/Inc[1]
		No-till	Inc	Dec
		Reduced-till	Inc	Inc
	Midwest	Conventional	Dec	Flat/Inc[1]
		No-till	Inc	Dec
		Reduced-till	Inc	Inc
	Mid-South	Conventional	Dec	Inc
		No-till	Inc	Dec
		Reduced-till	Inc	Dec
NS=no significant trend at 5% Confidence Interval Inc= Increase Dec=decrease Flat=no change				

Source of data is propriety grower market research data (Monsanto, 2013).

[1]Where the trend is indicated as two phases (i.e. Flat/Dec), this means that statistically the trend is for no change over the designated time period but the slope over the last two years of the time period tended to be either reflective of an increase or a decrease.

Table 3. Top 5 Factors Governing Farmer's Tillage Practice Decisions

Factor	Midwest Corn (14 Experts)	Midwest Soybeans (13 Experts)	South Corn (6 Experts)	South Soybeans (6 Experts)	South Cotton (6 Experts)
1	Managing soil moisture	Excessive crop residue	Economics	Economics	Economics
2	Seed bed preparation	Seed bed preparation	Seed bed preparation	Managing existing weeds	Managing existing weeds
3	Economics	Economics	Excessive crop residue	Seed bed preparation	Availability of Labor
4	Excessive crop residue	Managing existing weeds	Improving water penetration	Managing soil moisture	Managing soil moisture
5	Managing soil temperature	Managing soil moisture	Managing soil moisture	Preventing weed resistance	Use of strip till / vertical tillage tools

References:

Culpepper, A.S., J. Kichler and A.C. York. 2013. University of Georgia programs for controlling Palmer amaranth in 2013 cotton. University of Georgia Cooperative Extension, Athens, Georgia.

Culpepper, A.S., A.C. York and L.E. Steckel. 2011. Glyphosate-resistant Palmer amaranth management in cotton. 2011 Proceedings, Southern Weed Science Society, San Juan, Puerto Rico.

Fawcett, R. and D. Towery. 2002. Conservation tillage and plant biotechnology: How new technologies can improve the environment by reducing the need to plow. Conservation Technology Information Center, Purdue, Indiana.

Givens, W.A., D.R. Shaw, W.G. Johnson, S.C. Weller, B.G. Young, R.G. Wilson, M.D.K. Owen and D. Jordan. 2009a. A grower survey of herbicide use patterns in glyphosate-resistant cropping systems. Weed Technology 23:156-161.

Givens, W.A., D.R. Shaw, G.R. Kruger, W.G. Johnson, S.C. Weller, B.G. Young, R.G. Wilson, M.D.K. Owen and D. Jordan. 2009b. Survey of tillage trends following the adoption of glyphosate-resistant crops. Weed Technology 23:150-155.

McClelland, M.R., J.L. Barrentine, K.J. Bryant and E.P. Webster. 2000. Roundup Ready cotton programs in conservation tillage. Pages 197-201 in Proceedings of the 2000 Cotton Research Meeting, Fayetteville, Arkansas.

Osteen, C.D. and J. Fernandez-Cornejo. 2013. Economic and policy issues of U.S. agricultural pesticide use trends. Pest Management Science 69:1001-1025.

Price, A.J., K.S. Balkcom, S.A. Culpepper, J.A. Kelton, R.L. Nichols and H. Schomberg. 2011. Glyphosate-resistant Palmer amaranth: A threat to conservation tillage. Journal of Soil and Water Conservation 66:265-275.

Sankula, S. 2006. Quantification of the impacts on US agriculture of biotechnology-derived crops planted in 2005. National Center for Food and Agricultural Policy, Washington, D.C.

Towery, D. and S. Werblow. 2010. Facilitating conservation farming practices and enhancing environmental sustainability with agricultural biotechnology: Exective summary. Conservation Technology Information Center, West Lafayette, Indiana.

Appendix A: Statistical Analysis of Tillage Market Research Data

Summary of Statistical Analysis of Tillage Data

Purpose

Assess if tillage practices have significantly changed between 1998 and 2007, and between 2007 and 2013 (or 2012, for cotton).

Data Description

For the analysis PROC MEANS in SAS was used to calculate the acres that utilized each tillage type and total acres for each crop, region and year. The percent of total acres was calculated by dividing acres that utilized each tillage type by total acres.

Statistical Methods and Results

A quadratic regression model of the following form was fit for each crop, region and tillage type combination:

$$\text{Percent of total acres} = \beta_0 + \beta_1\text{*Year} + \beta_2\text{*Year* Year} + \varepsilon \quad (1)$$

in which β_0 is the intercept, β_1 is the linear slope, β_2 is the quadratic slope and ε is the residual error. PROC MIXED in SAS was used to fit model (1) separately for each crop, region and tillage type combination. Tests were performed to determine if the quadratic slopes of the regression lines were significantly different from zero. These tests are displayed in Table 1. Twenty of the 42 tests observed quadratic slopes that were significantly different from zero at the 5% level of significance.

In the 20 cases where the quadratic slopes were significant, a quadratic regression model was deemed appropriate. For the 22 cases where the quadratic slopes were not significant, a linear regression model of the following form was fit for each crop, region and tillage type combination:

$$\text{Percent of total acres} = \beta_0 + \beta_1\text{*Year} + \varepsilon \quad (2)$$

in which β_0 is the intercept, β_1 is the linear slope and ε is the residual error. PROC MIXED in SAS was used to fit model (2) separately for each crop, region and tillage type combination. Tests were performed to determine if the linear slopes of the regression lines were significantly different from zero. These tests are displayed in Table 2. Fourteen of the 22 tests observed linear slopes that were significantly different from zero at the 5% level of significance.

In the 14 cases where the linear slopes were significant, a linear regression model was deemed appropriate. For the 8 cases where the linear slopes were not significant, there was no significant change in tillage practices over time.

Conclusions

In 8 of the 42 crop, region and tillage type combinations there was no significant change over time.

In 14 of the 42 crop, region and tillage type combinations the change over time can be described using a linear regression model.

In 20 of the 42 crop, region and tillage type combinations the change over time can be described using a quadratic regression model.

The regression parameter estimates for the crop and region combinations with a significant the change over time, are displayed in Table 3.

Plots of the percent total acres data and model fit are displayed in the Appendix.

Table A-1. Tests to Determine if the Quadratic Slopes of the Regression Lines Were Significantly Different From Zero

Crop	Region	Tillage_Type	P-value	
Corn	East	Conservation	0.1381	
Corn	East	Conventional	0.6663	
Corn	East	No-Till	0.1161	
Corn	MidSouth	Conservation	0.5547	
Corn	MidSouth	Conventional	0.1925	
Corn	MidSouth	No-Till	0.0582	
Corn	MidWest	Conservation	0.0218	*
Corn	MidWest	Conventional	0.5444	
Corn	MidWest	No-Till	0.0015	*
Corn	Southeast	Conservation	0.1322	
Corn	Southeast	Conventional	0.0038	*
Corn	Southeast	No-Till	0.0018	*
Corn	West	Conservation	0.9108	
Corn	West	Conventional	0.2174	
Corn	West	No-Till	0.1183	
Cotton	MidSouth	Conservation	0.0018	*
Cotton	MidSouth	Conventional	<.0001	*
Cotton	MidSouth	No-Till	<.0001	*
Cotton	MidWest	Conservation	0.2096	
Cotton	MidWest	Conventional	0.0017	*
Cotton	MidWest	No-Till	<.0001	*
Cotton	Southeast	Conservation	0.7367	
Cotton	Southeast	Conventional	0.0002	*
Cotton	Southeast	No-Till	<.0001	*
Cotton	West	Conservation	0.0539	
Cotton	West	Conventional	0.0582	
Cotton	West	No-Till	0.8615	
Soybeans	East	Conservation	0.4610	
Soybeans	East	Conventional	0.0051	*

Table A-1 (continued). Tests to Determine if the Quadratic Slopes of the Regression Lines Were Significantly Different From Zero

Crop	Region	Tillage_Type	P-value	
Soybeans	East	No-Till	0.0017	*
Soybeans	MidSouth	Conservation	0.5038	
Soybeans	MidSouth	Conventional	0.0003	*
Soybeans	MidSouth	No-Till	0.0013	*
Soybeans	MidWest	Conservation	0.0006	*
Soybeans	MidWest	Conventional	0.0056	*
Soybeans	MidWest	No-Till	0.0002	*
Soybeans	Southeast	Conservation	0.3208	
Soybeans	Southeast	Conventional	0.0495	*
Soybeans	Southeast	No-Till	0.0447	*
Soybeans	West	Conservation	0.1184	
Soybeans	West	Conventional	0.0921	
Soybeans	West	No-Till	0.7472	

Note: Twenty of the 42 tests observed quadratic slopes that were significantly different from zero at the 5% level of significance. The tests that were significant at the 5% level are marked with an '*'.

Table A-2. Tests to Determine if the Linear Slopes of the Regression Lines Were Significantly Different From Zero

Crop	Region	Tillage_Type	P-value	
Corn	East	Conservation	0.2078	
Corn	East	Conventional	<.0001	*
Corn	East	No-Till	<.0001	*
Corn	MidSouth	Conservation	0.0195	*
Corn	MidSouth	Conventional	0.4904	
Corn	MidSouth	No-Till	0.3690	
Corn	MidWest	Conventional	0.0011	*
Corn	Southeast	Conservation	0.0835	
Corn	West	Conservation	0.0011	*
Corn	West	Conventional	<.0001	*
Corn	West	No-Till	0.0114	*
Cotton	MidWest	Conservation	0.0210	*
Cotton	Southeast	Conservation	<.0001	*
Cotton	West	Conservation	<.0001	*
Cotton	West	Conventional	<.0001	*
Cotton	West	No-Till	0.0001	*
Soybeans	East	Conservation	0.1917	
Soybeans	MidSouth	Conservation	0.1896	
Soybeans	Southeast	Conservation	0.6675	
Soybeans	West	Conservation	0.1233	
Soybeans	West	Conventional	0.0067	*
Soybeans	West	No-Till	0.0002	*

Note: Fourteen of the 22 tests observed linear slopes that were significantly different from zero at the 5% level of significance. The tests that were significant at the 5% level are marked with an '*'.

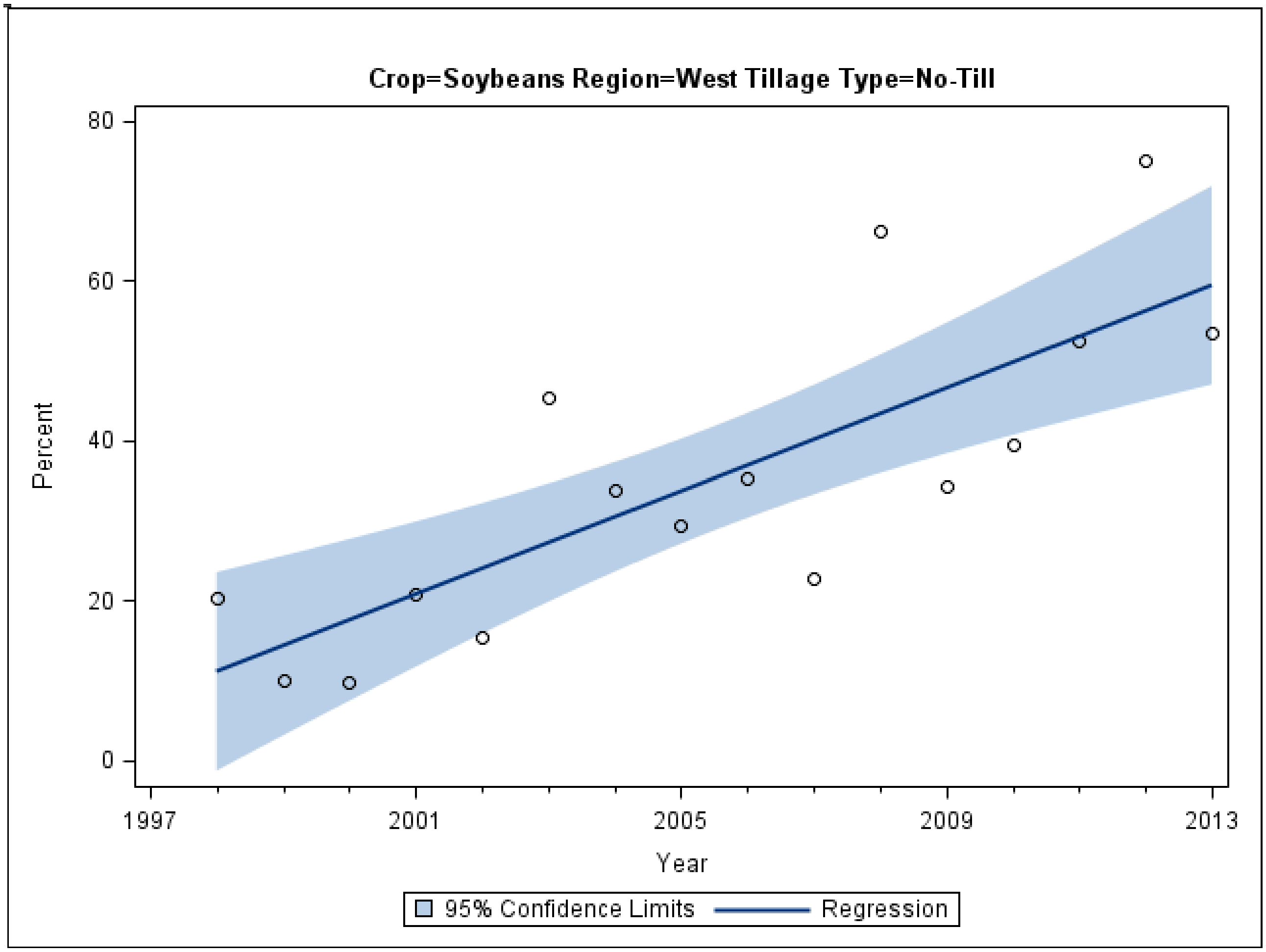
Table A-3. Regression Parameter Estimates for the Crop and Region Combinations with a Significant the Change in Tillage Over Time

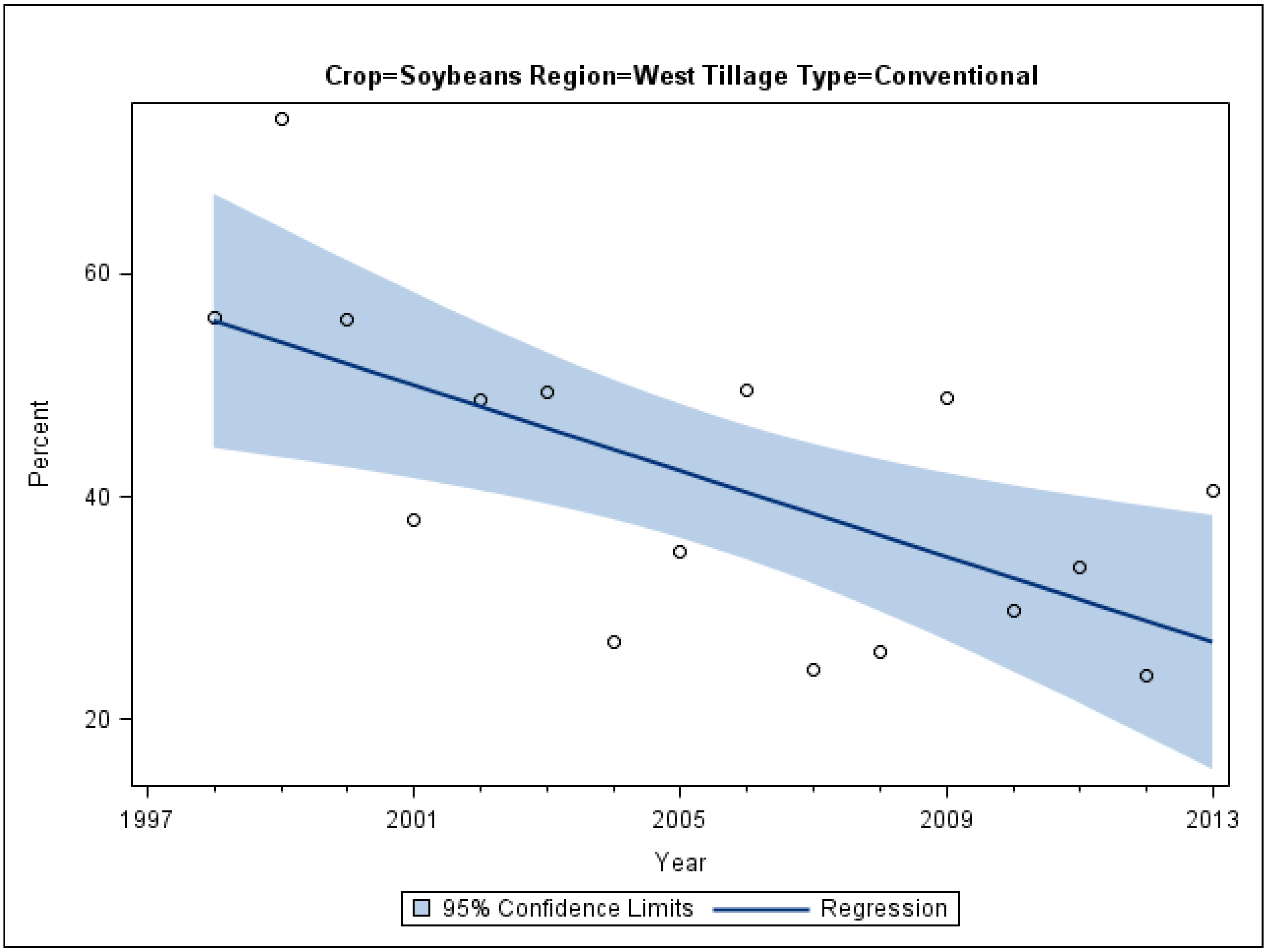
Crop	Region	Tillage Type	Intercept	Year	Year*Year
Corn	East	Conventional	3466.72	-1.7079	.
Corn	East	No-Till	-3039.87	1.5340	.
Corn	MidSouth	Conservation	-1769.03	0.8933	.
Corn	MidWest	Conservation	300587	-299.62	0.07467
Corn	MidWest	Conventional	1114.90	-0.5355	.
Corn	MidWest	No-Till	-383597	381.93	-0.09506
Corn	Southeast	Conventional	766604	-763.20	0.1900
Corn	Southeast	No-Till	-1202619	1198.66	-0.2987
Corn	West	Conservation	-2375.58	1.1991	.
Corn	West	Conventional	3782.79	-1.8592	.
Corn	West	No-Till	-1307.20	0.6601	.
Cotton	MidSouth	Conservation	-1044452	1041.04	-0.2594
Cotton	MidSouth	Conventional	2648507	-2639.72	0.6577
Cotton	MidSouth	No-Till	-1603955	1598.68	-0.3983
Cotton	MidWest	Conservation	-2277.83	1.1529	.
Cotton	MidWest	Conventional	1707629	-1701.22	0.4237
Cotton	MidWest	No-Till	-2295716	2289.07	-0.5706
Cotton	Southeast	Conservation	-3534.42	1.7786	.
Cotton	Southeast	Conventional	1405216	-1399.58	0.3485
Cotton	Southeast	No-Till	-1304016	1300.48	-0.3242
Cotton	West	Conservation	-2656.63	1.3372	.
Cotton	West	Conventional	4244.03	-2.0828	.
Cotton	West	No-Till	-1487.40	0.7456	.
Soybeans	East	Conventional	902937	-899.02	0.2238
Soybeans	East	No-Till	-1061879	1057.33	-0.2632
Soybeans	MidSouth	Conventional	1373279	-1368.84	0.3411
Soybeans	MidSouth	No-Till	-1208347	1204.77	-0.3003
Soybeans	MidWest	Conservation	387479	-386.03	0.09615
Soybeans	MidWest	Conventional	311116	-309.83	0.07714

Table A-3 (continued). Regression Parameter Estimates for the Crop and Region Combinations with a Significant the Change in Tillage Over Time

Crop	Region	Tillage Type	Intercept	Year	Year*Year
Soybeans	MidWest	No-Till	-698495	695.85	-0.1733
Soybeans	Southeast	Conventional	600500	-597.28	0.1485
Soybeans	Southeast	No-Till	-768636	765.12	-0.1904
Soybeans	West	Conventional	3901.95	-1.9250	.
Soybeans	West	No-Till	-6423.22	3.2204	.

Appendix A Figures

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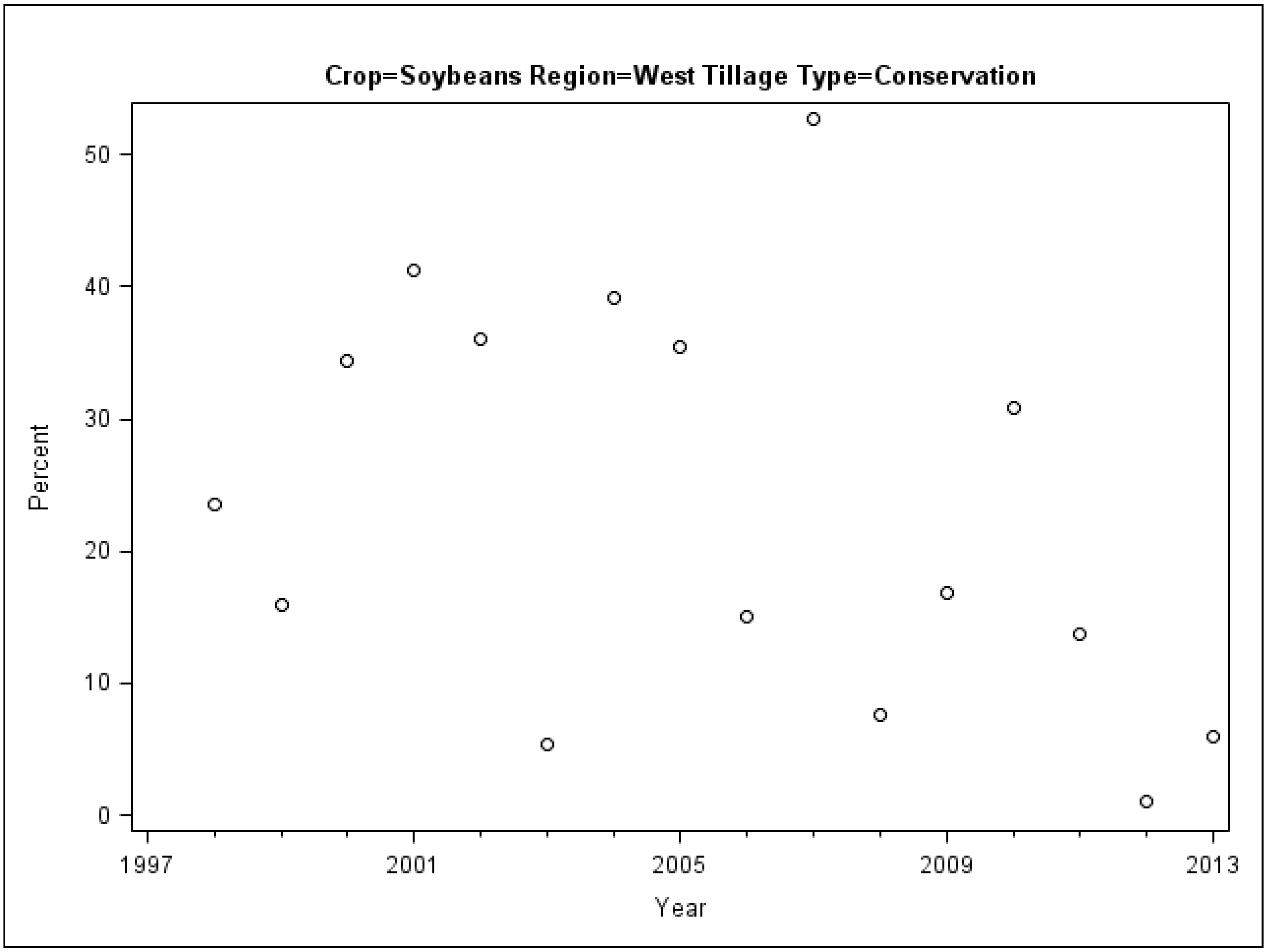
Percent
60
40
20
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression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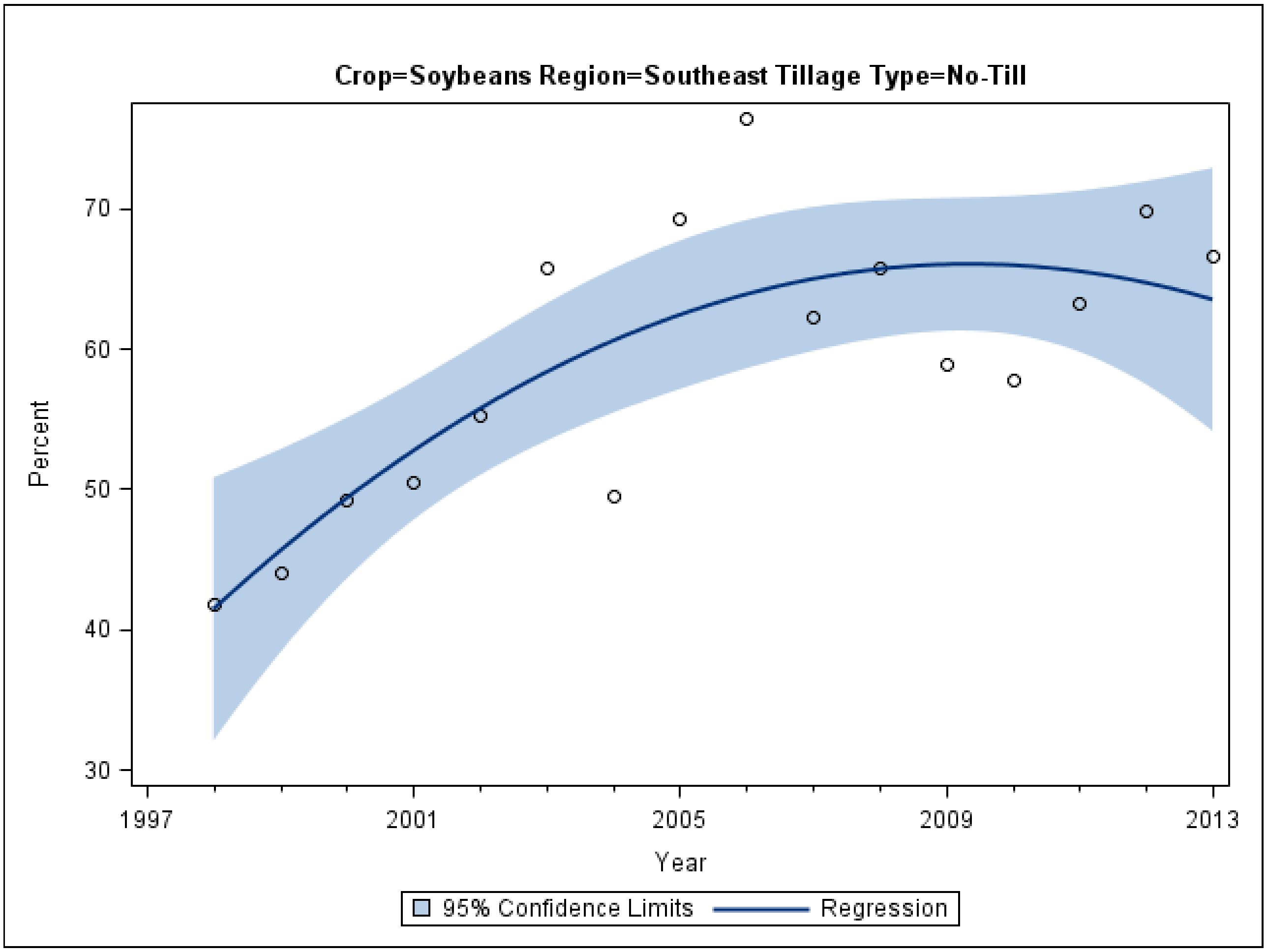
10
20
30
40
50
1997
2001
2005
2009
2013
Year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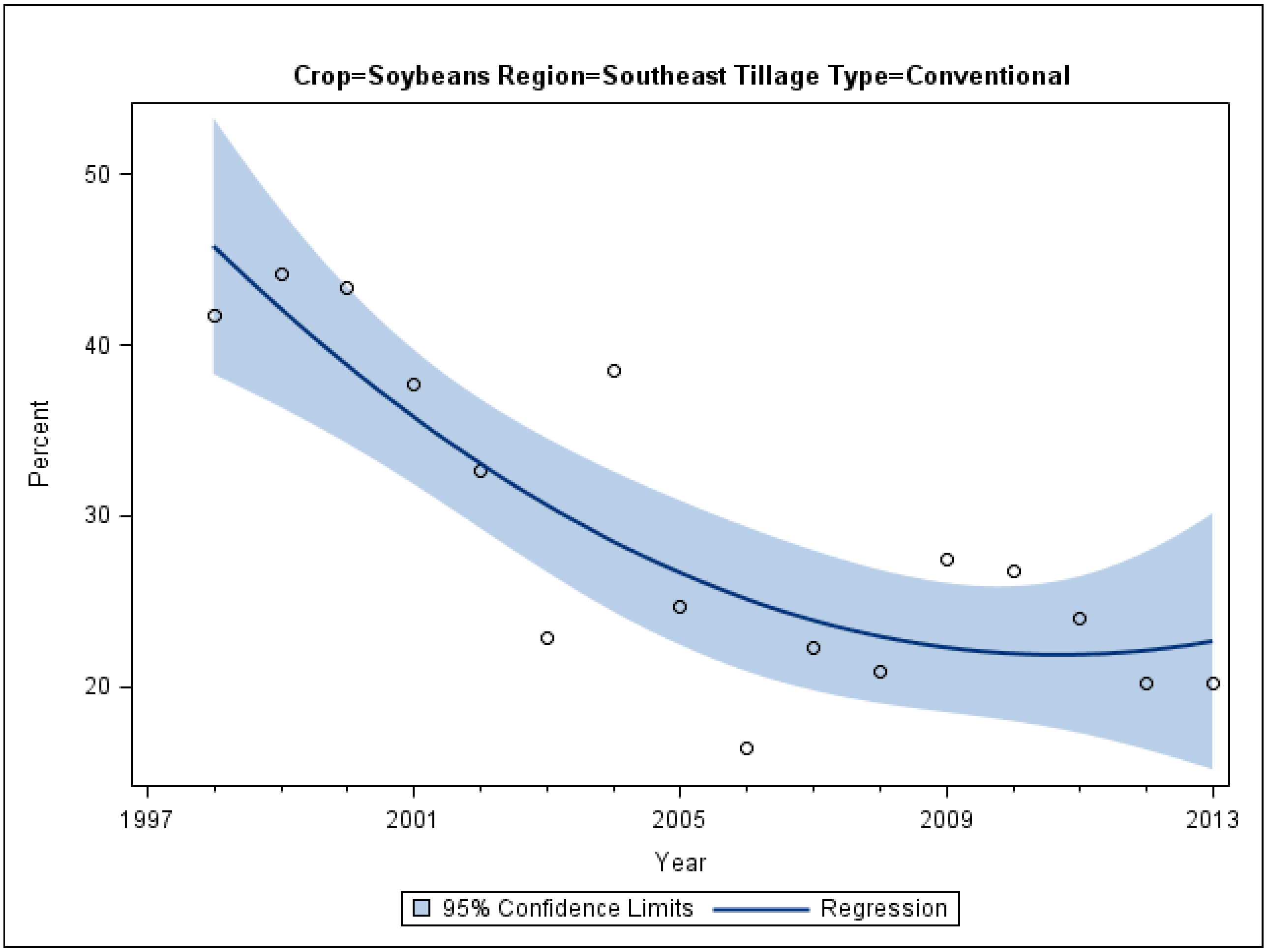
Percent
30
40
50
60
70
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression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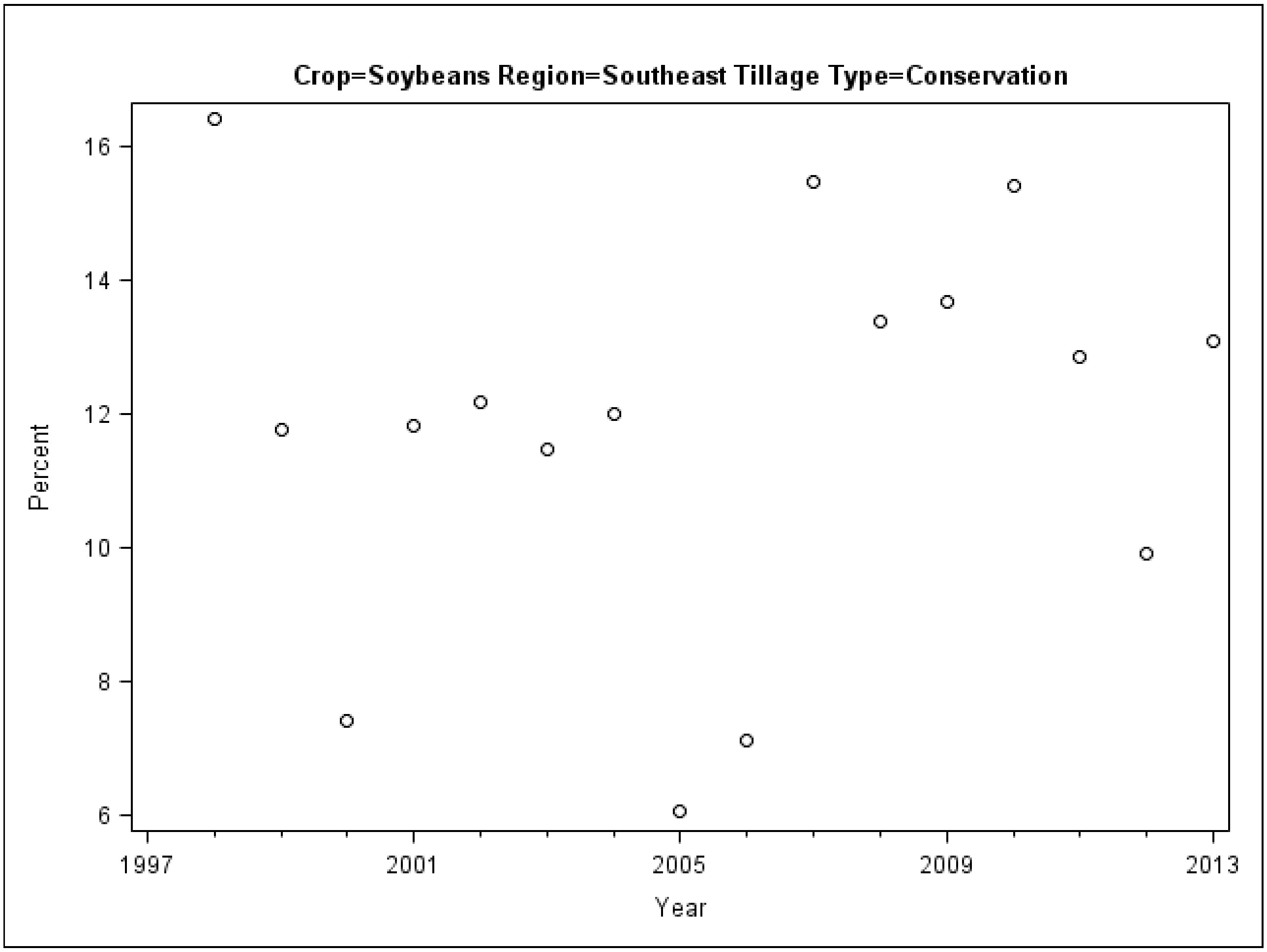
50
40
30
20
Percent
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression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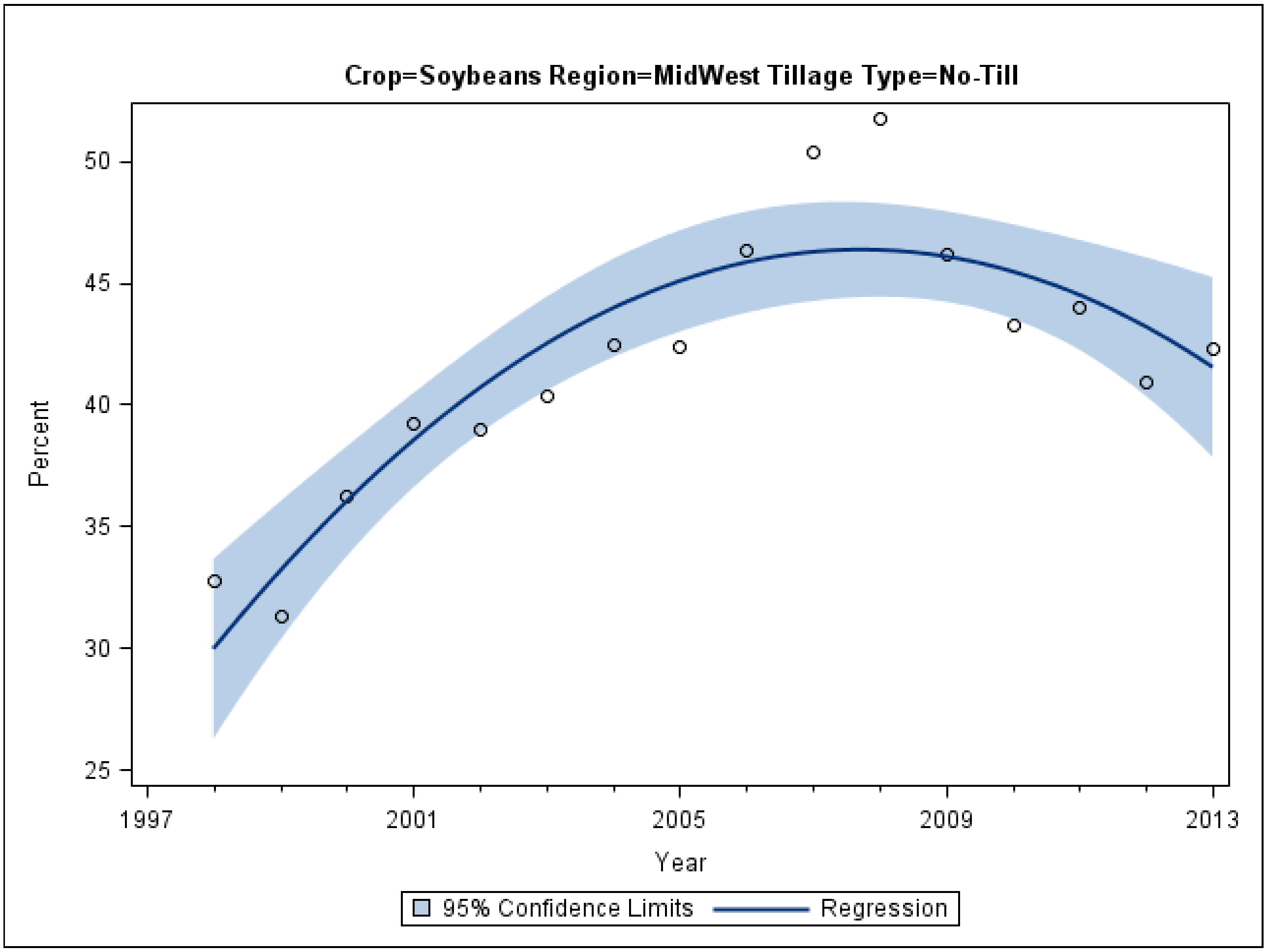
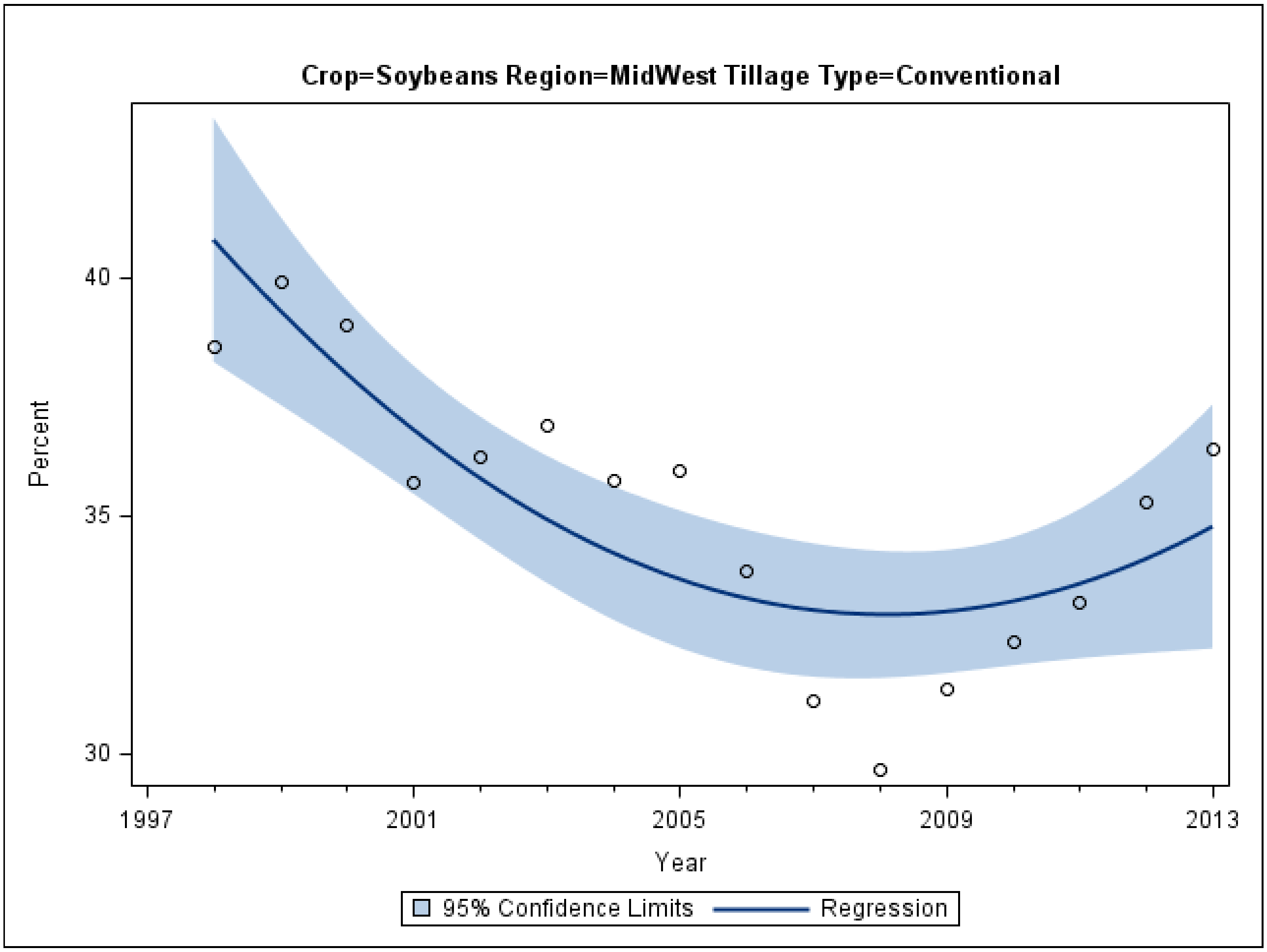
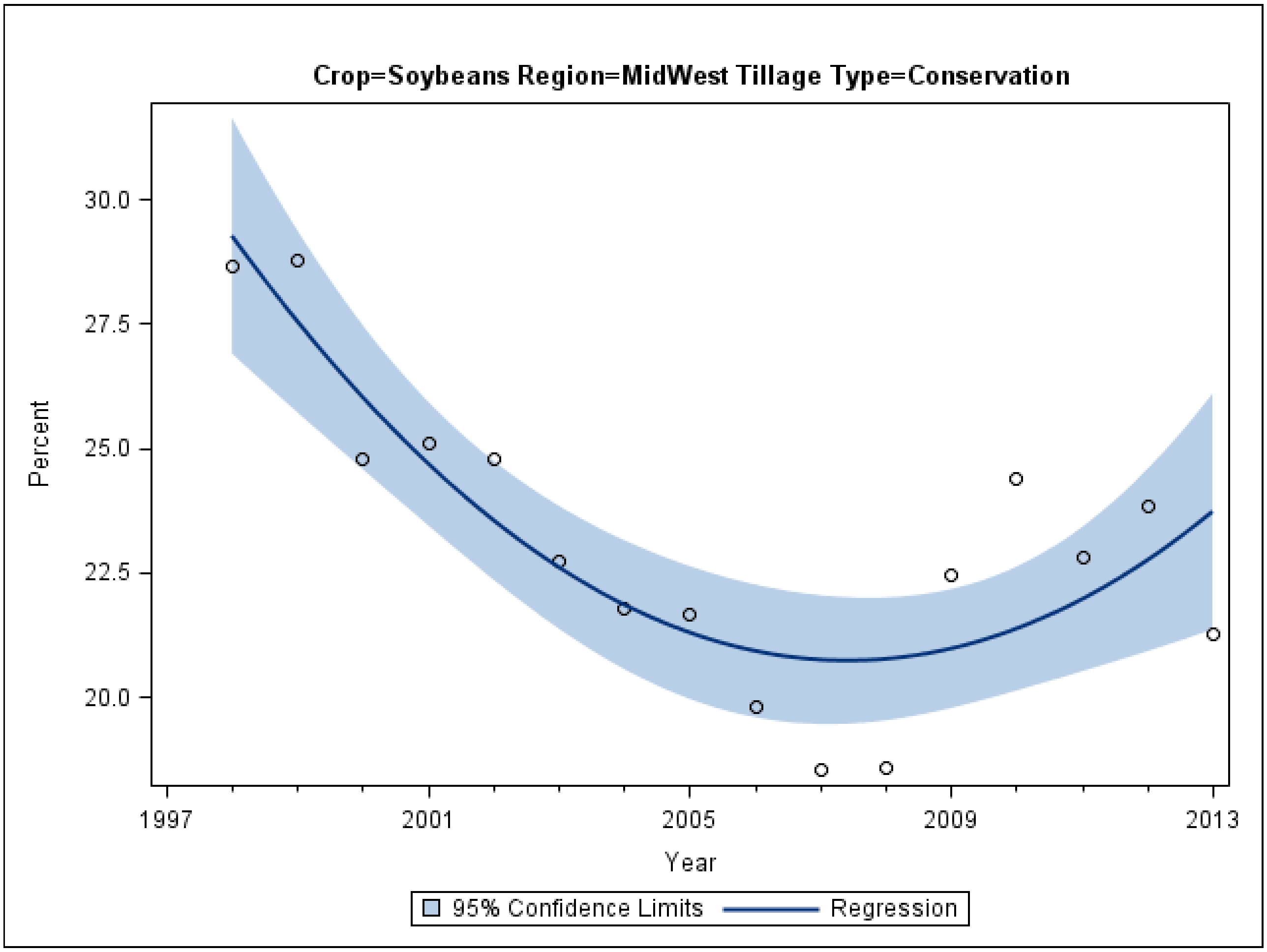
Percent
16
14
12
10
8
6
1997
2001
2005
2009
2013
Year

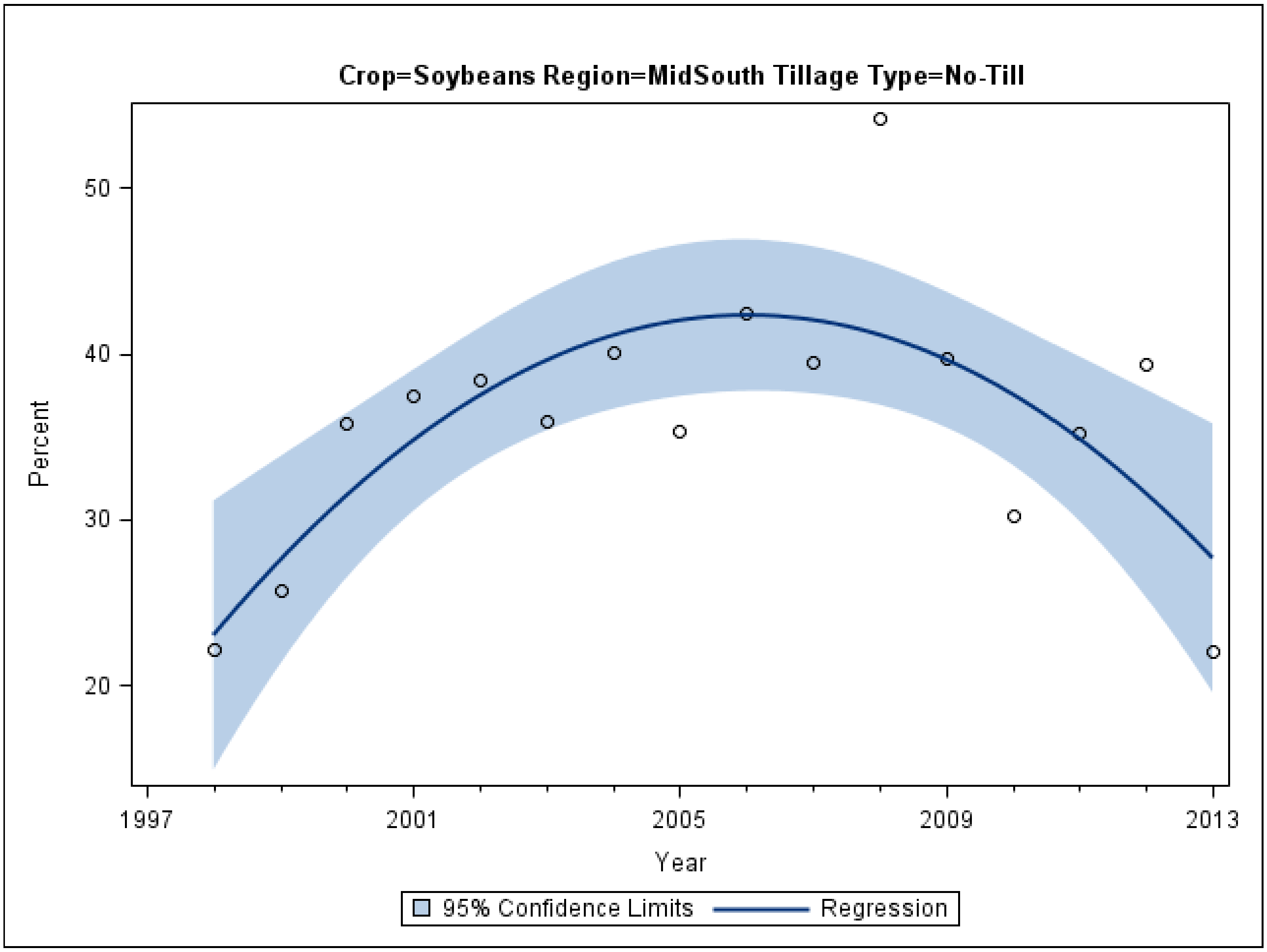

Crop=Soybeans Region=MidWest Tillage Type=No-Till
Percent
50
45
40
35
30
25
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression



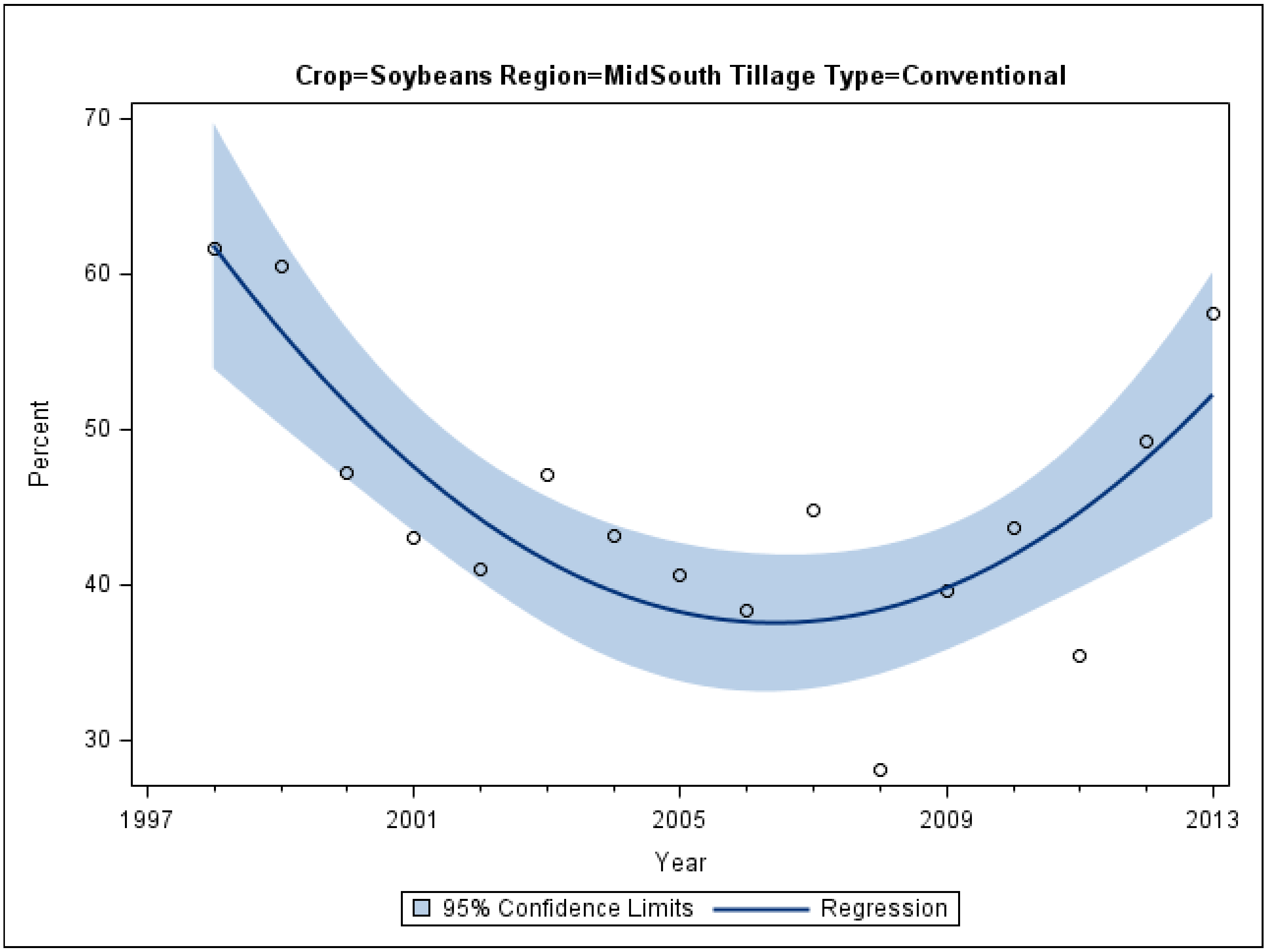
Crop=Soybeans Region=MidWest Tillage Type=Conventional
Percent
40
35
30
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression

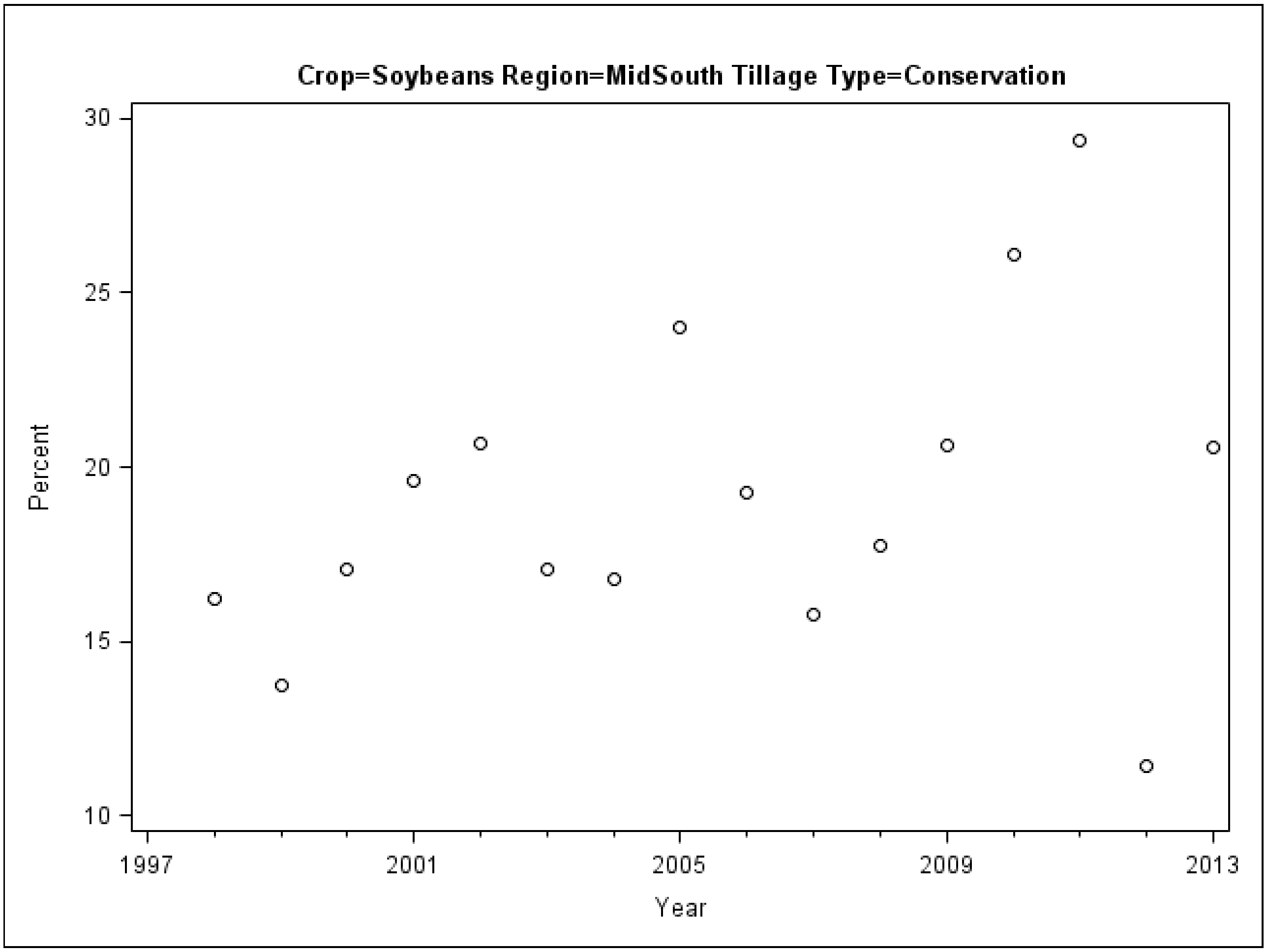


Crop=Soybeans Region=MidWest Tillage Type=Conservation
30.0
27.5
25.0
22.5
20.0
Percent
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression



Crop=Soybeans Region=MidSouth Tillage Type=No-Till
50
40
30
20
Percent
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression


Crop=Soybeans Region=MidSouth Tillage Type=Conventional
70
60
50
40
30
Percent
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression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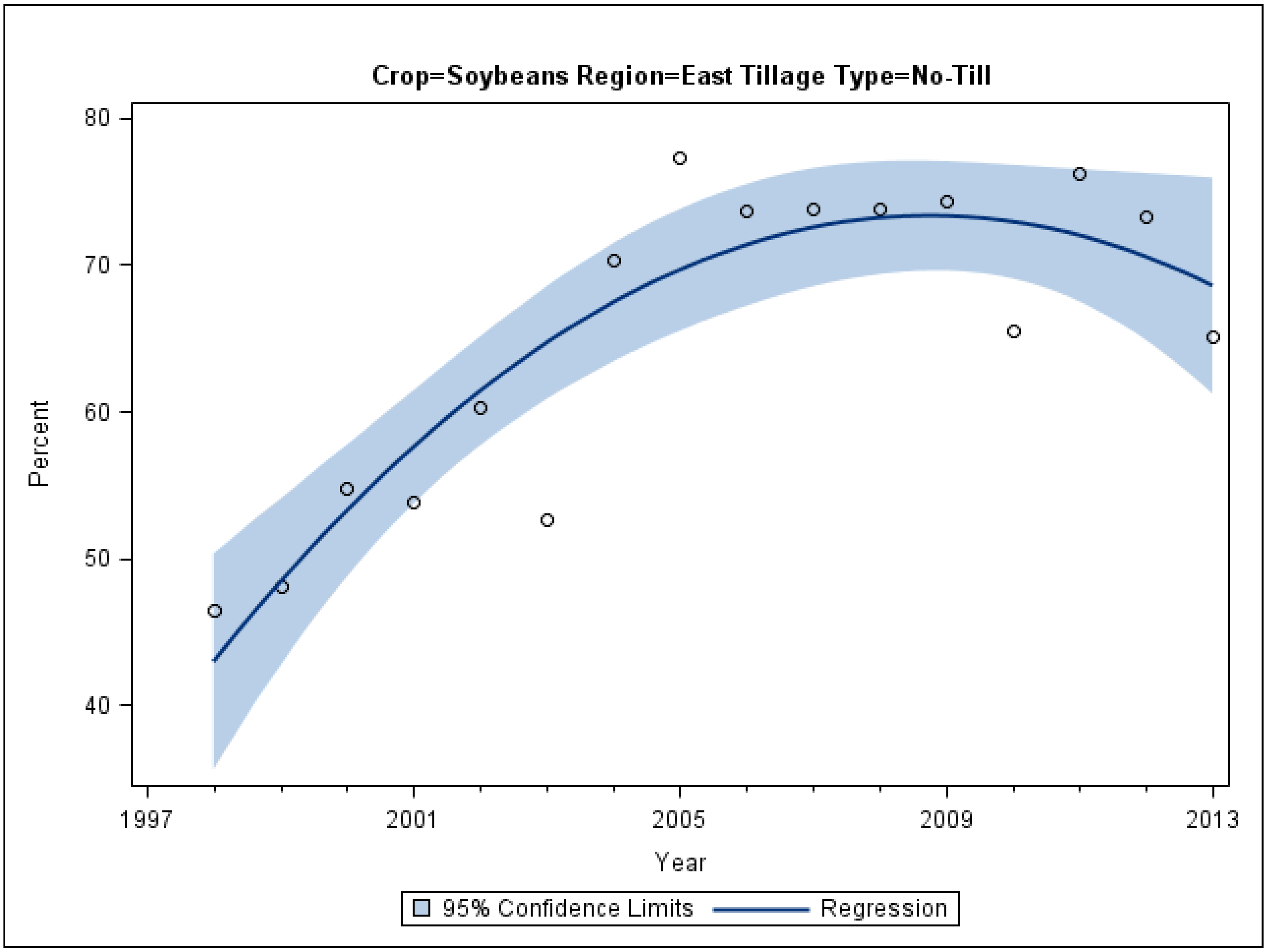
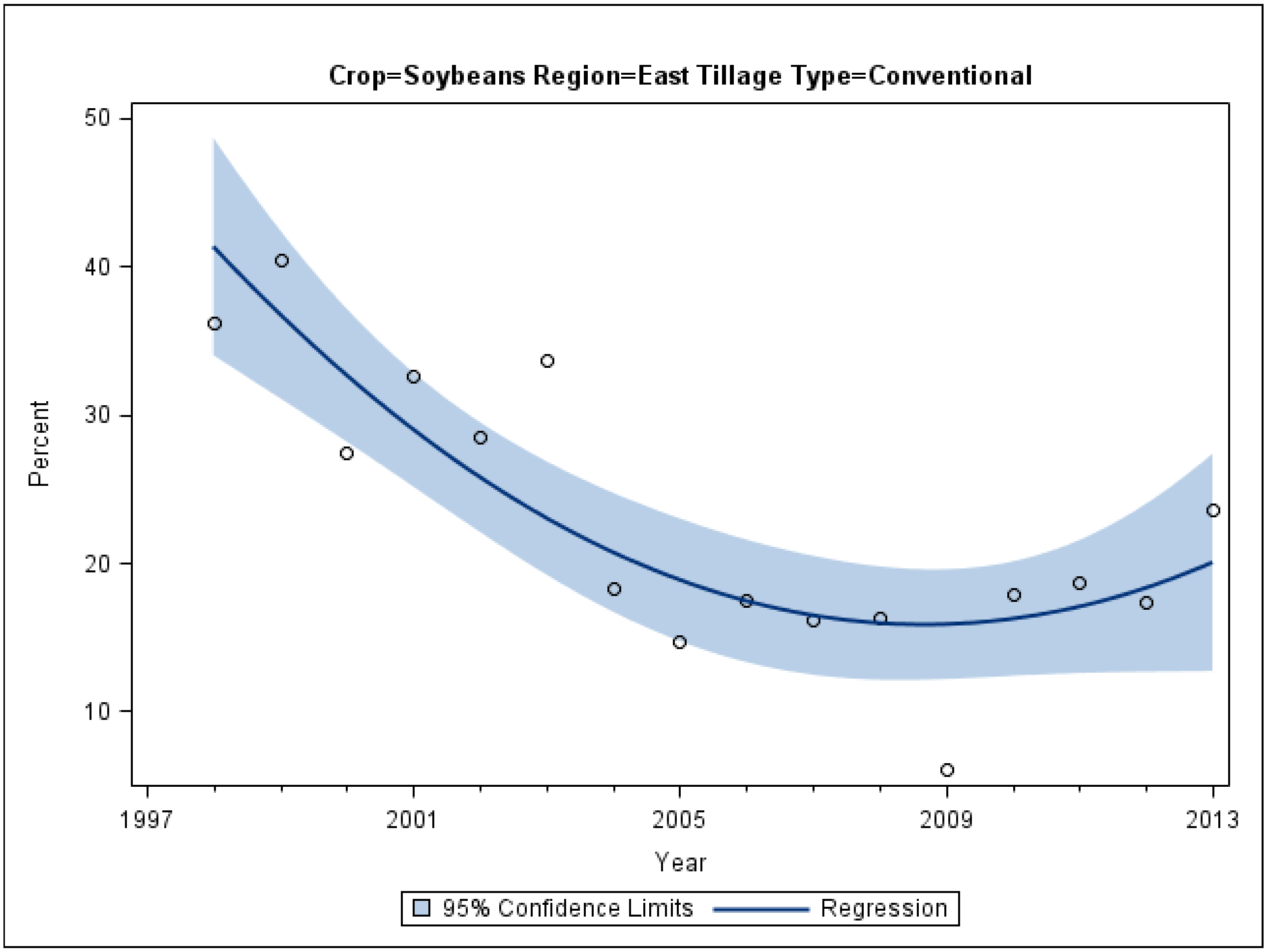
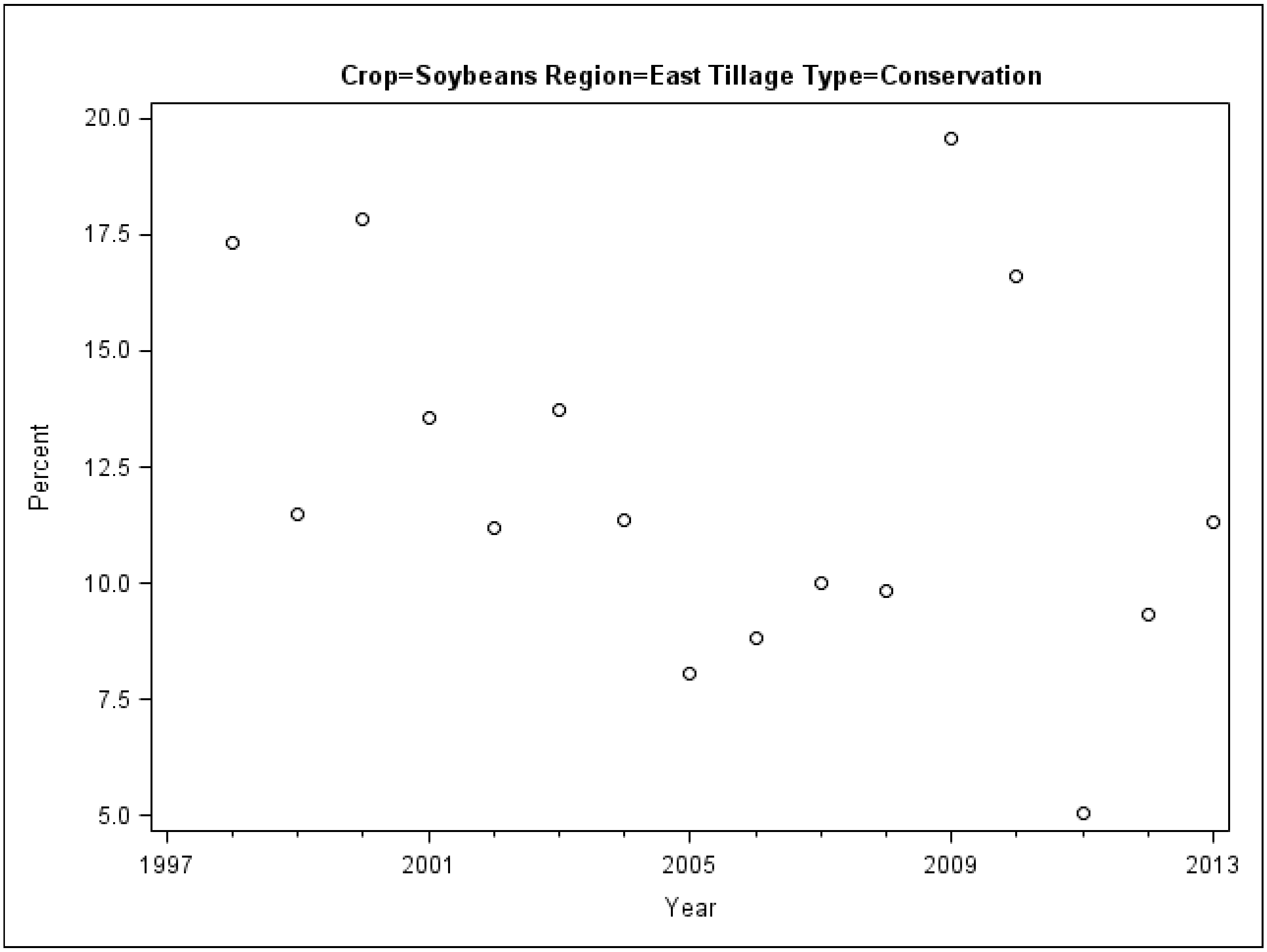
30
25
20
15
10
Percent
1997
2001
2005
2009
2013
Year


Crop=Soybeans Region=East Tillage Type=No-Till
Percent
80
70
60
50
40
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression


Crop=Soybeans Region=East Tillage Type=Conventional
Percent
50
40
30
20
10
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression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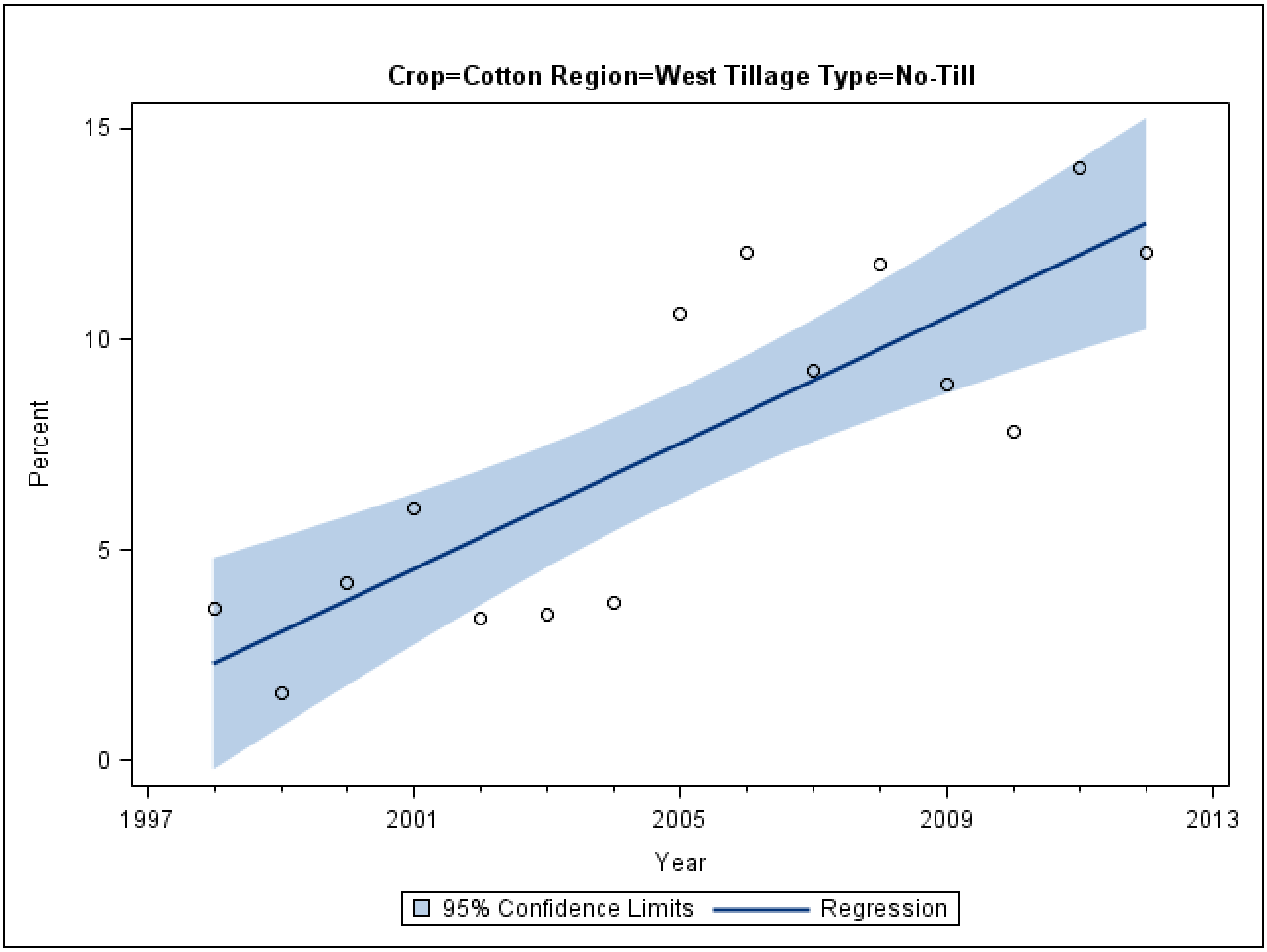
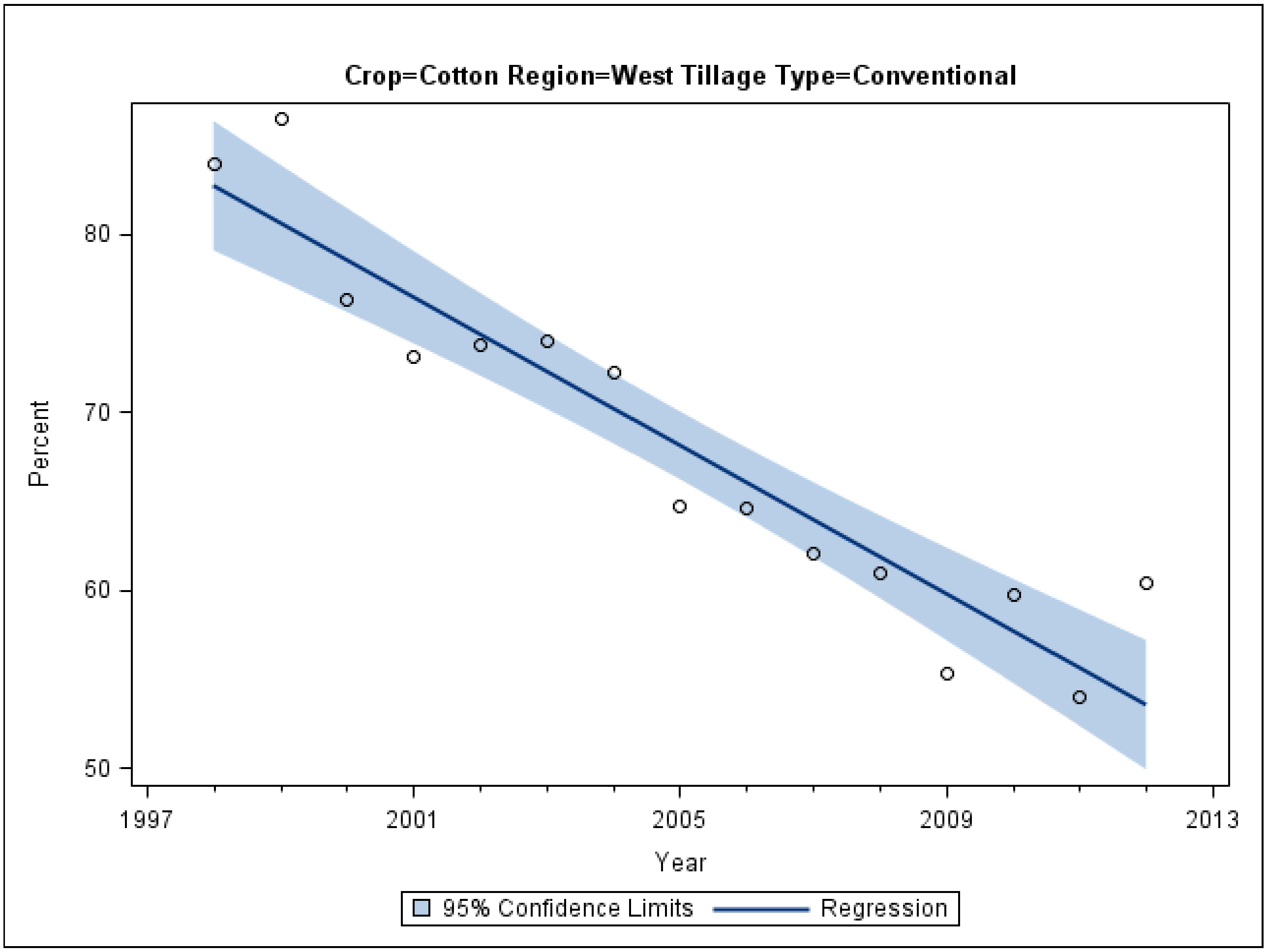
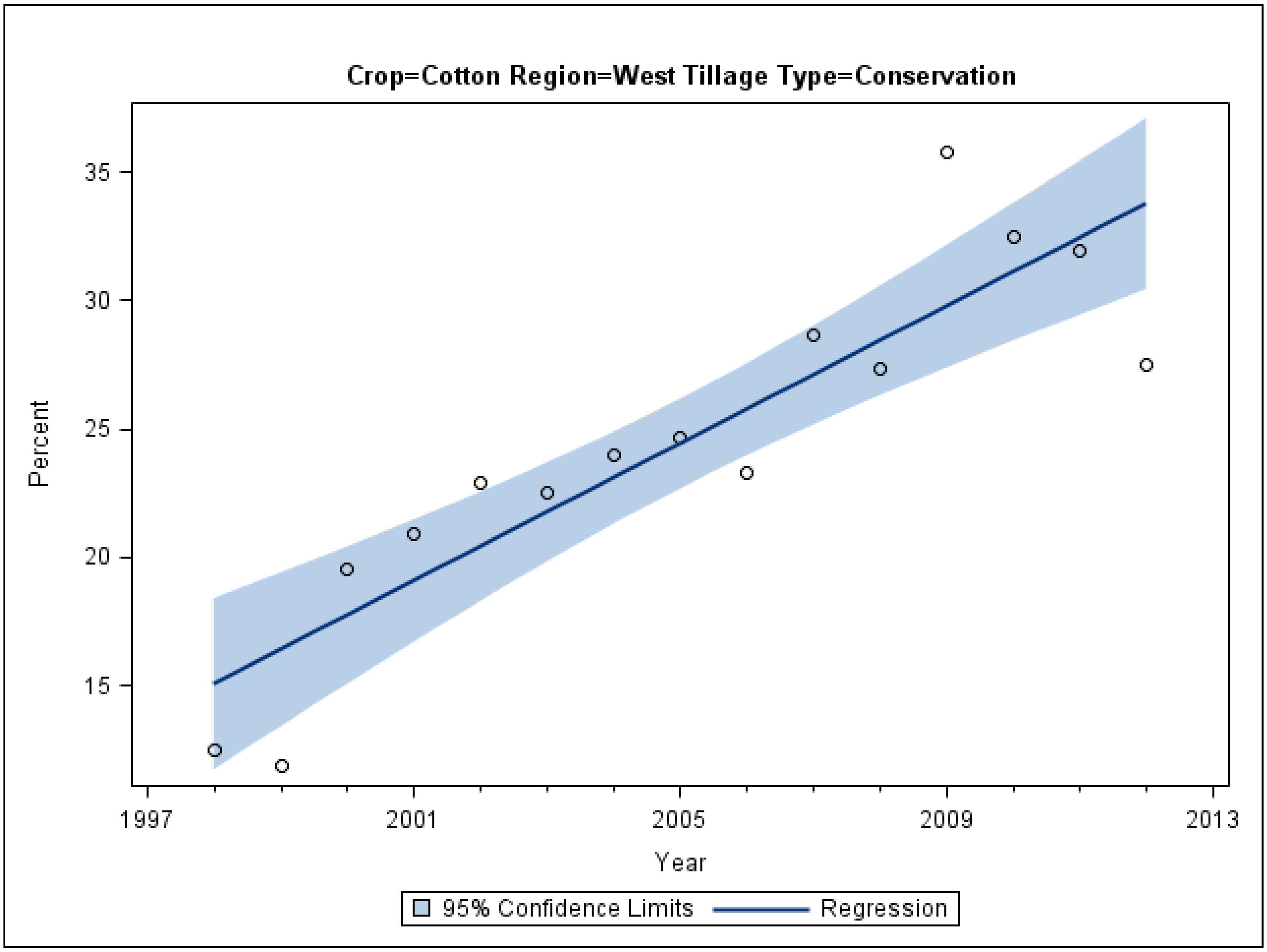
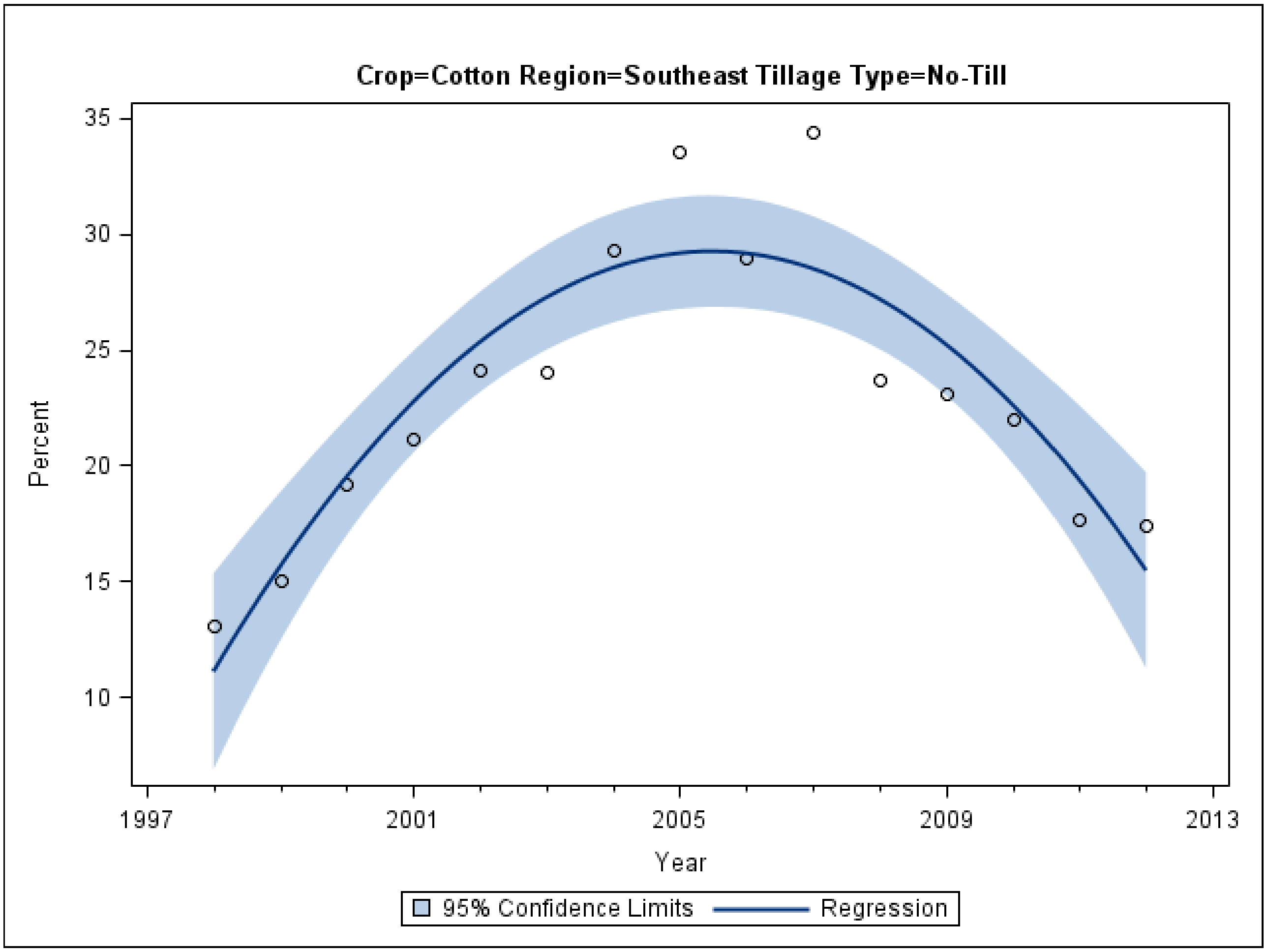
20.0
17.5
15.0
12.5
10.0
7.5
5.0
Percent
1997
2001
2005
2009
2013
Year

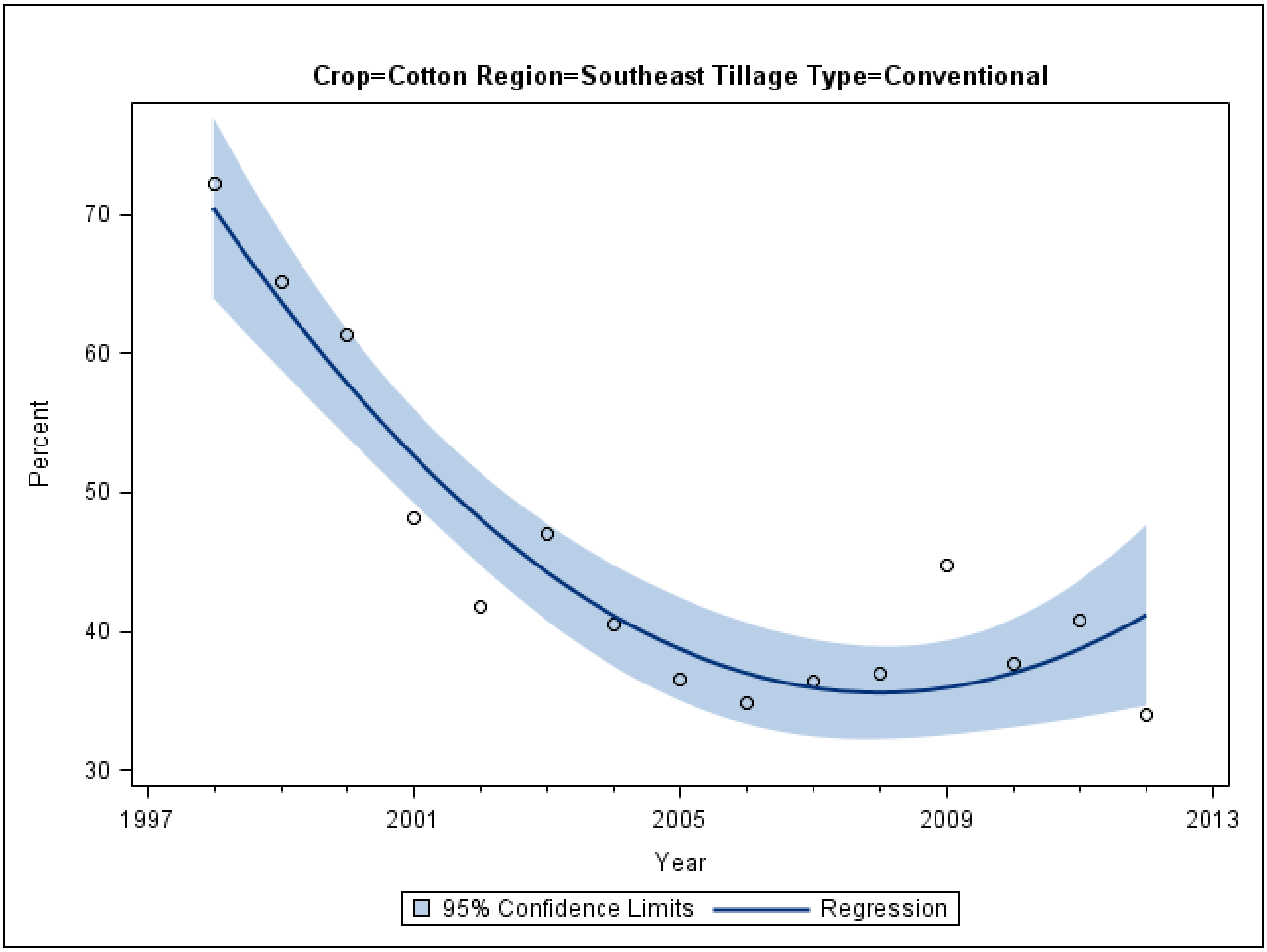


Crop=Cotton Region=West Tillage Type=No-Till
15
10
5
0
Percent
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression

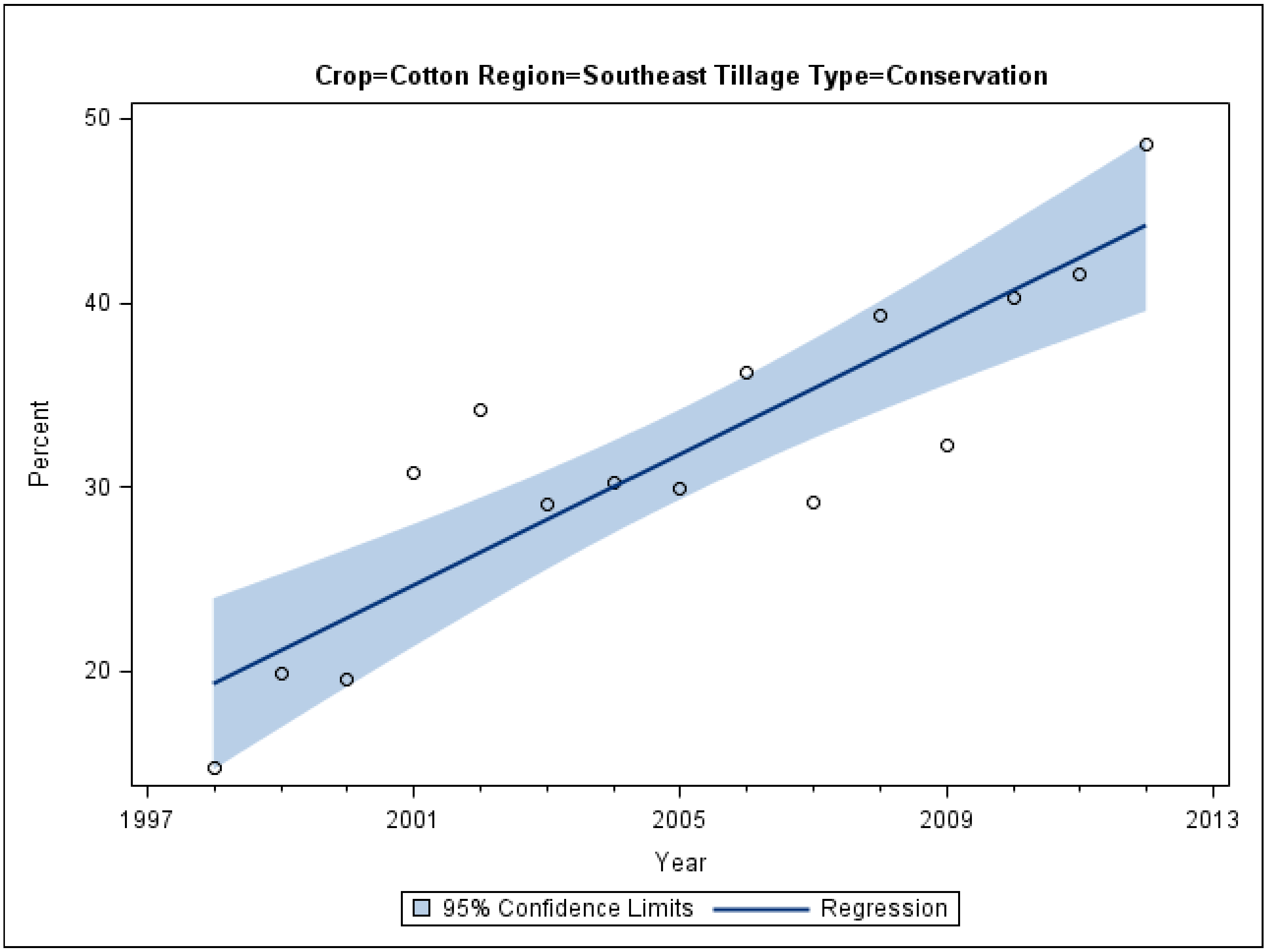

Crop=Cotton Region=West Tillage Type=Conventional
Percent
80
70
60
50
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression

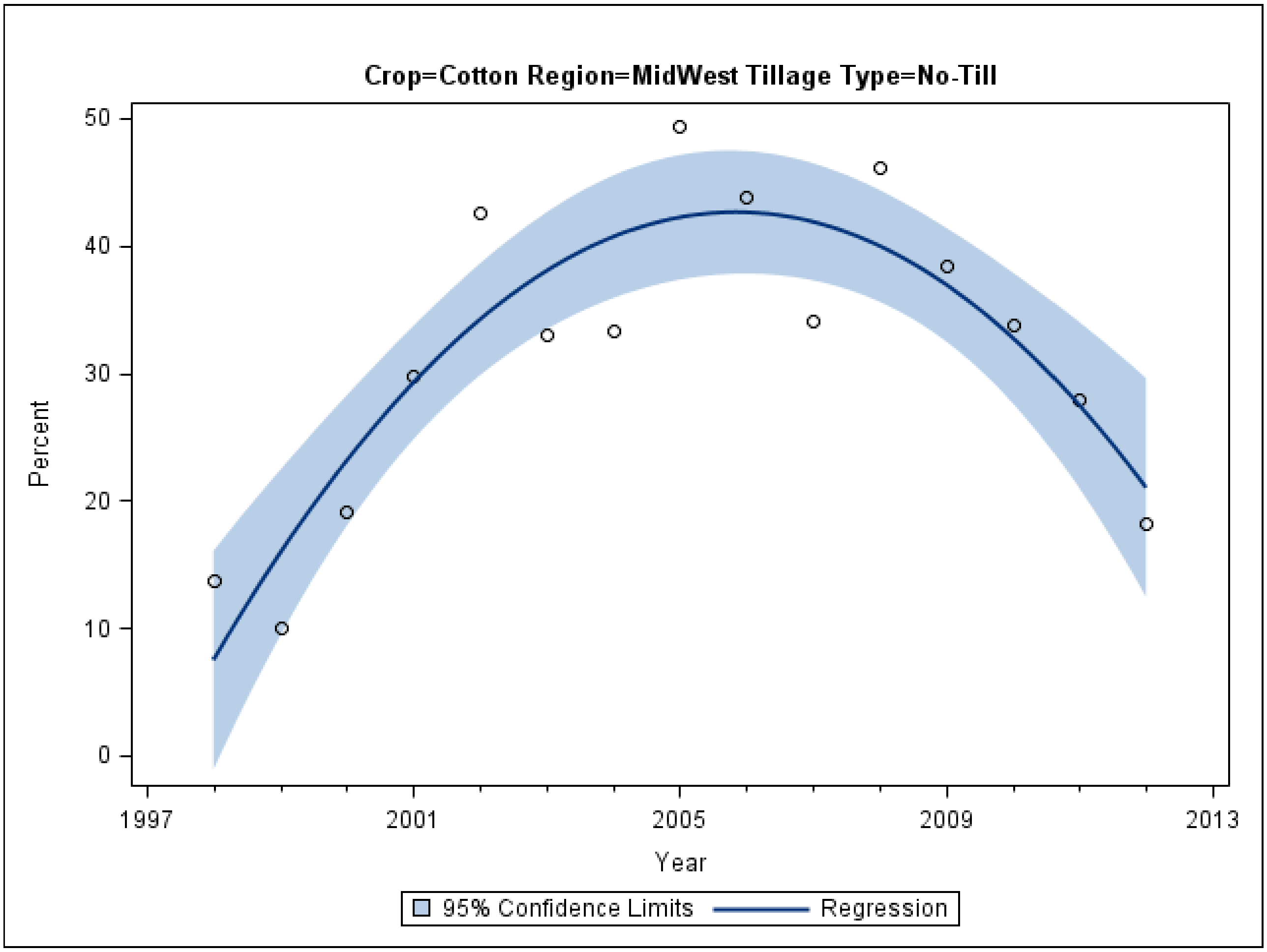

Crop=Cotton Region=West Tillage Type=Conservation
Percent
35
30
25
20
15
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression

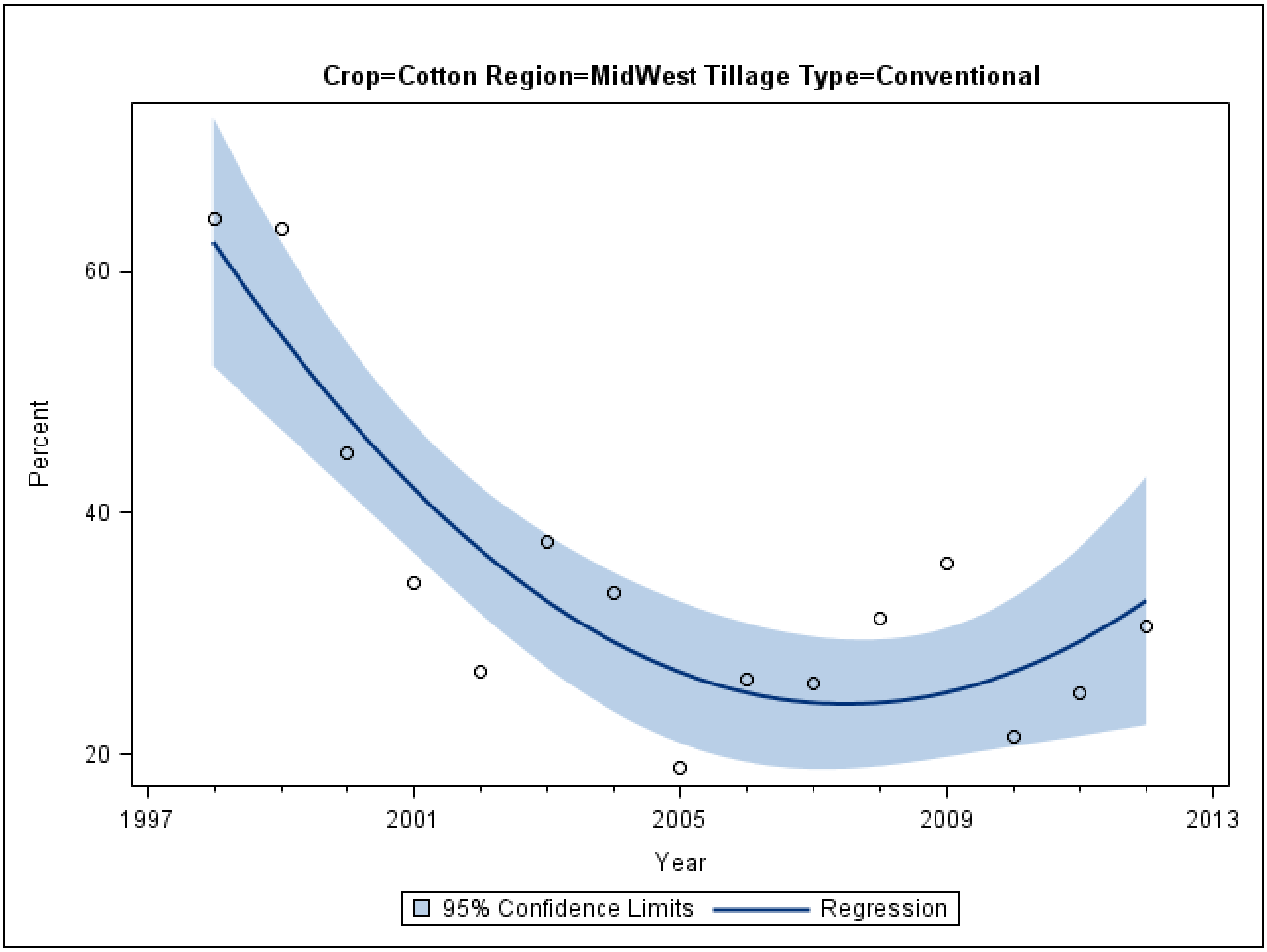

Crop=Cotton Region=Southeast Tillage Type=No-Till
35
30
25
20
15
10
Percent
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression

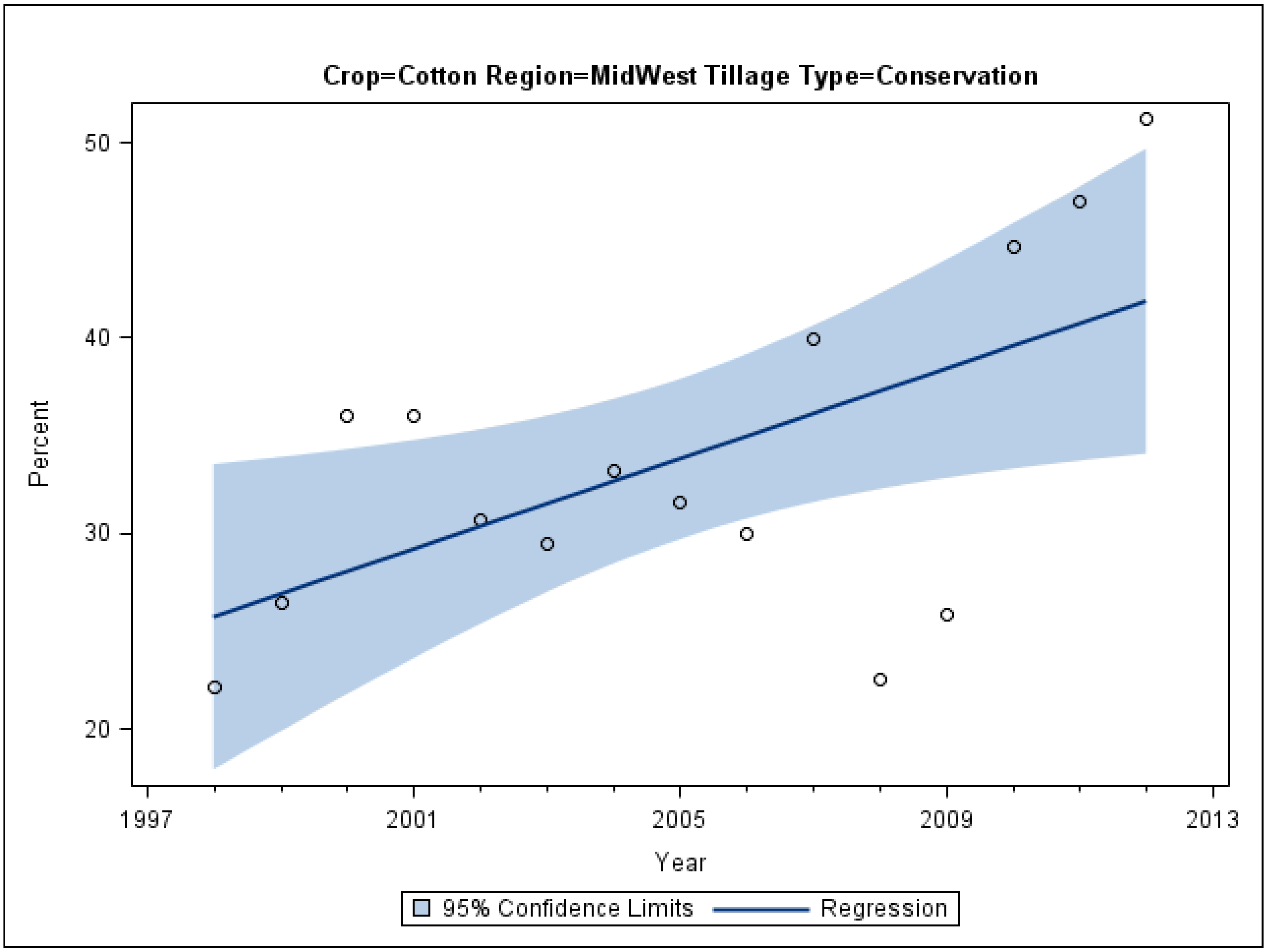


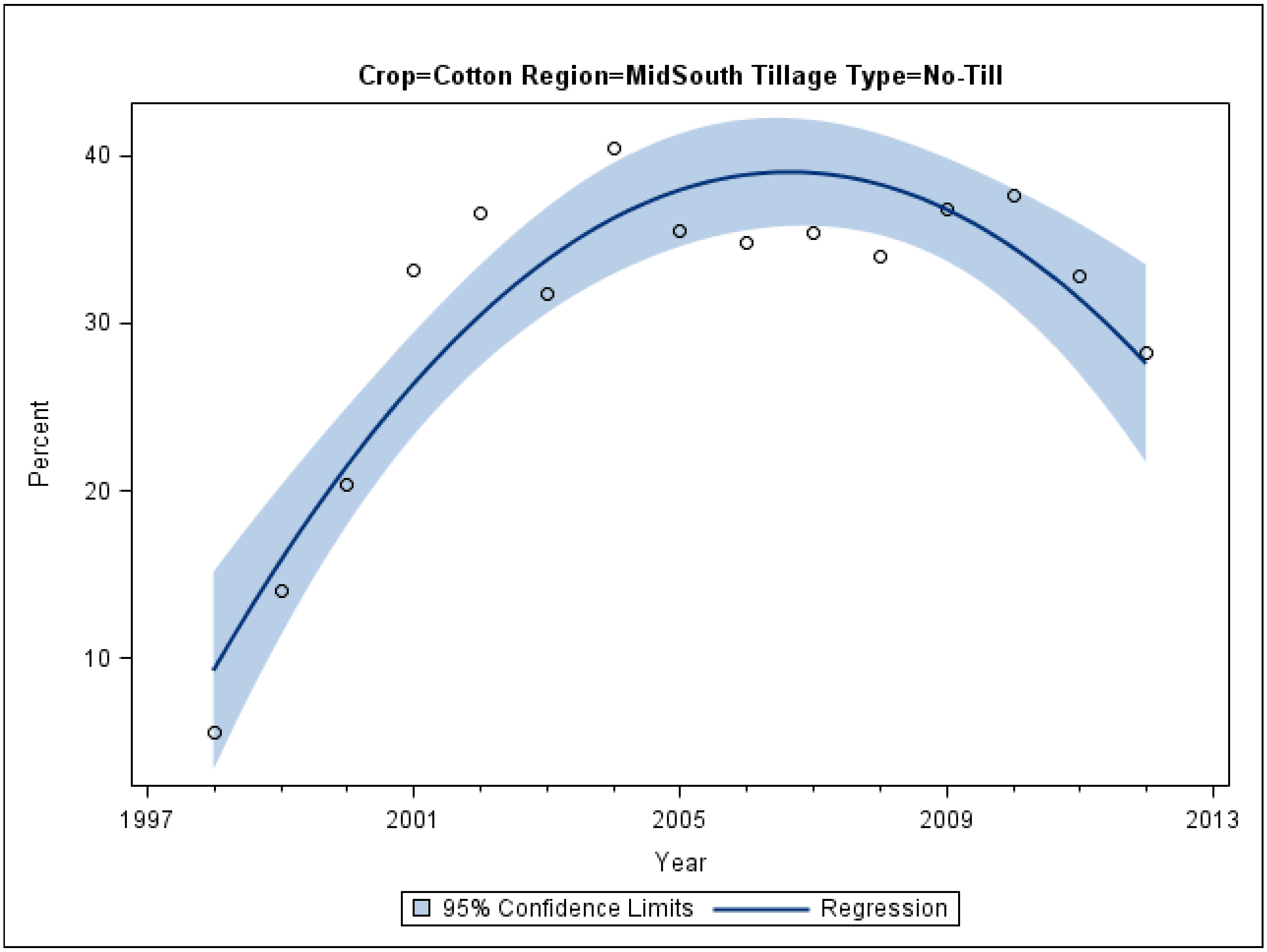
Crop=Cotton Region=Southeast Tillage Type=Conventional
Percent
70
60
50
40
30
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression

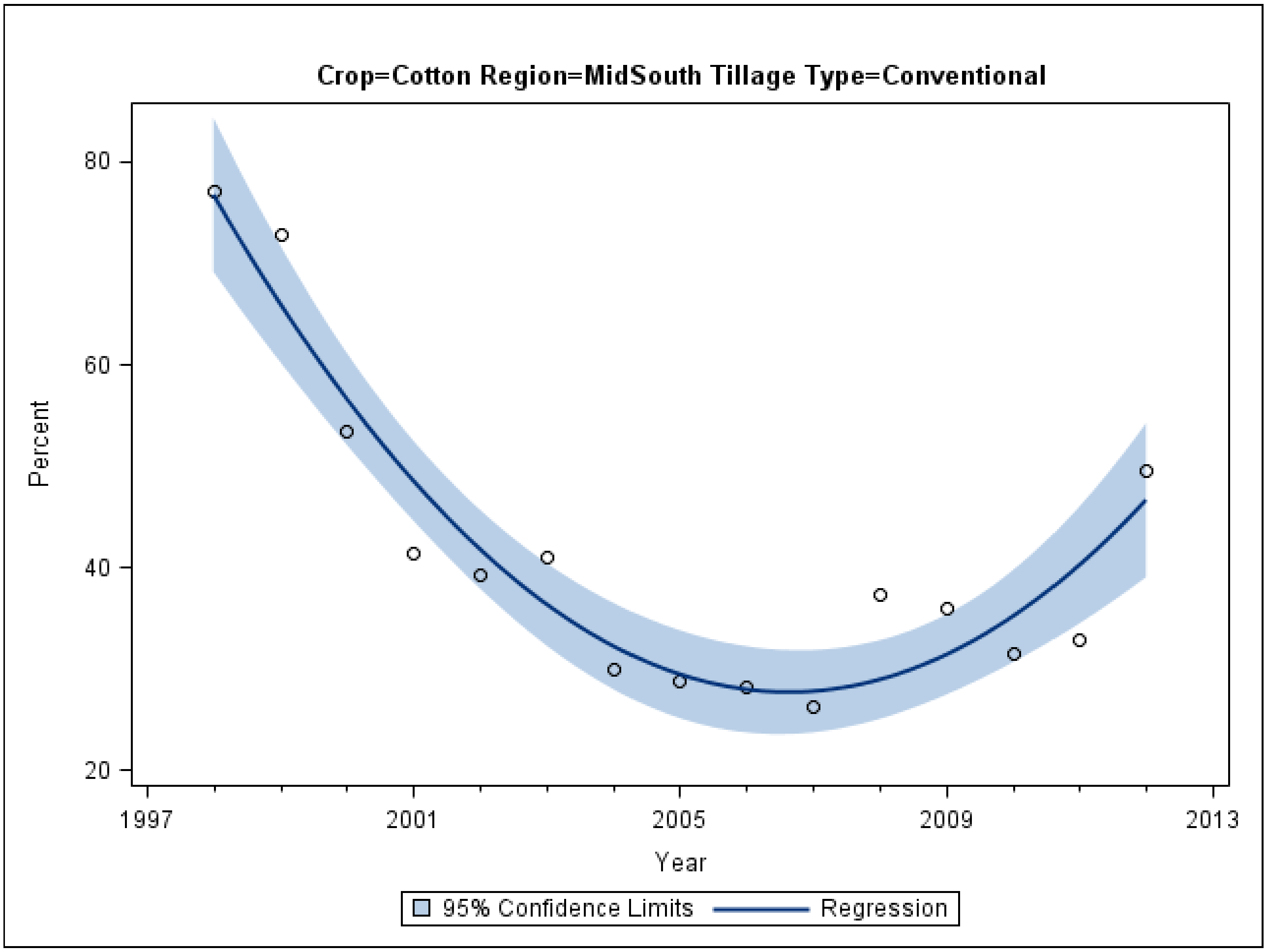

Crop=Cotton Region=Southeast Tillage Type=Conservation
50
40
30
20
Percent
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression


Crop=Cotton Region=MidWest Tillage Type=No-Till
Percent
50
40
30
20
10
0
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression

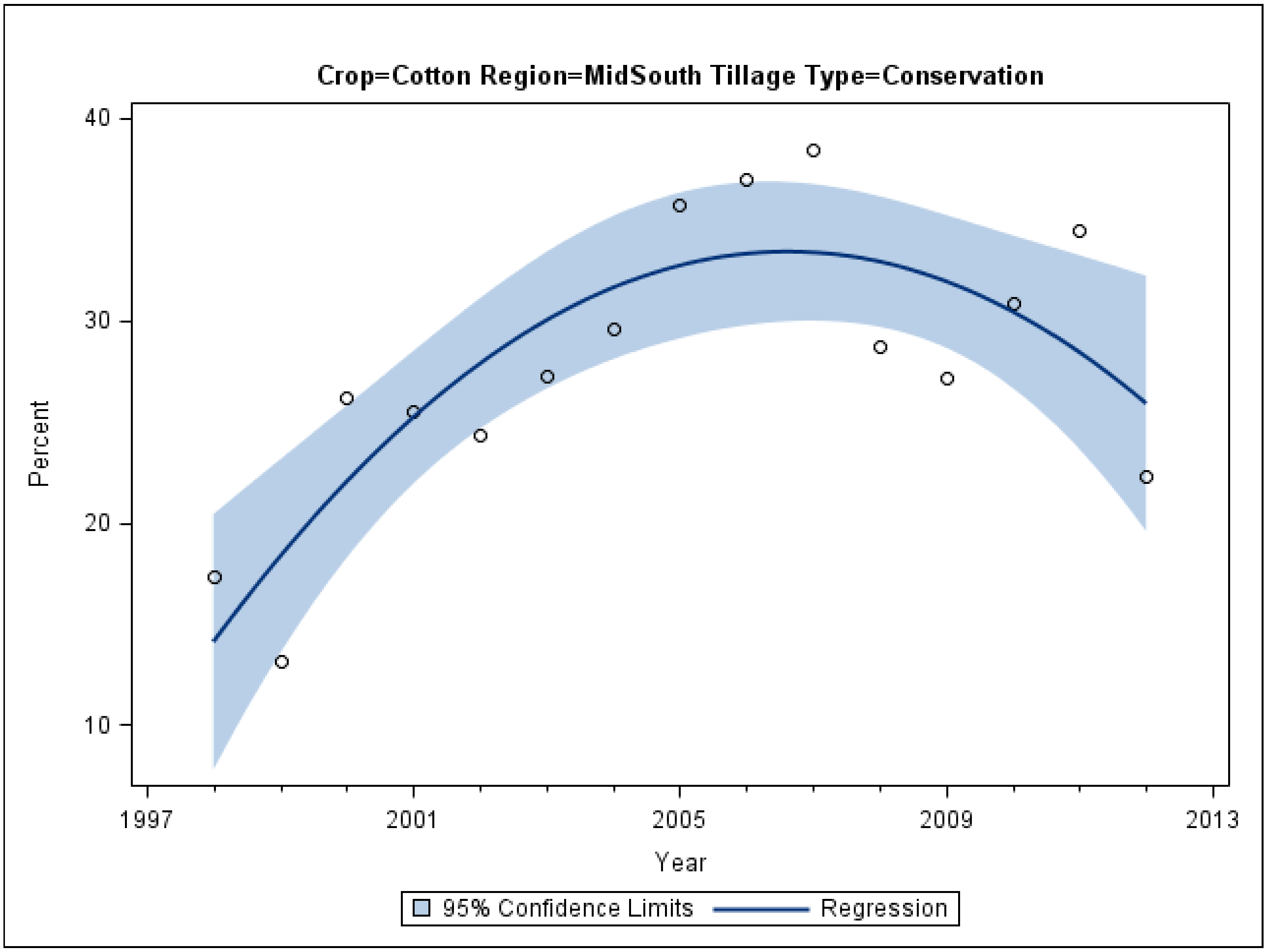

Crop=Cotton Region=MidWest Tillage Type=Conventional
Percent
60
40
20
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression

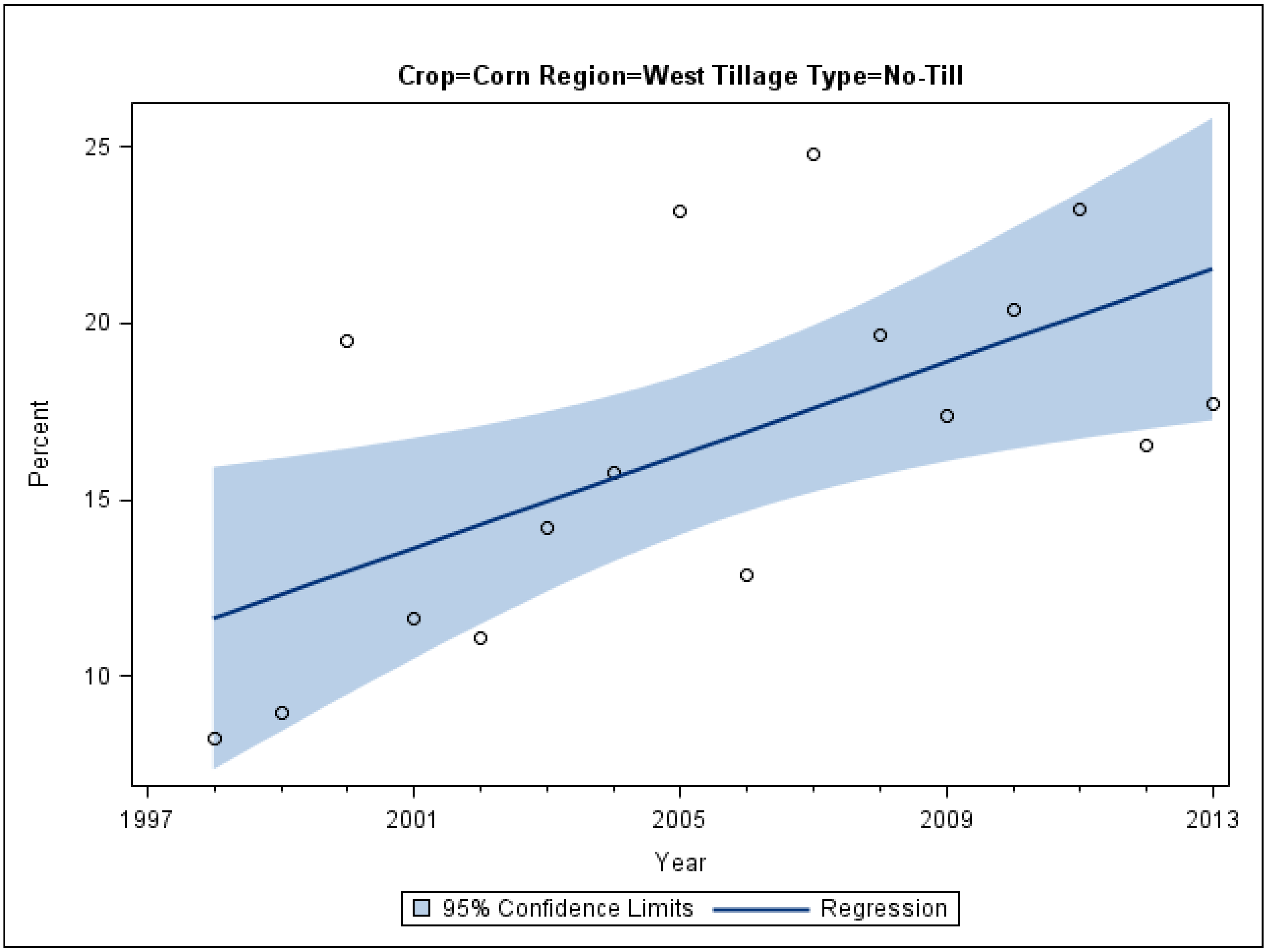

Crop=Cotton Region=MidWest Tillage Type=Conservation
50
40
30
20
Percent
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression


Crop=Cotton Region=MidSouth Tillage Type=No-Till
40
30
20
10
Percent
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression

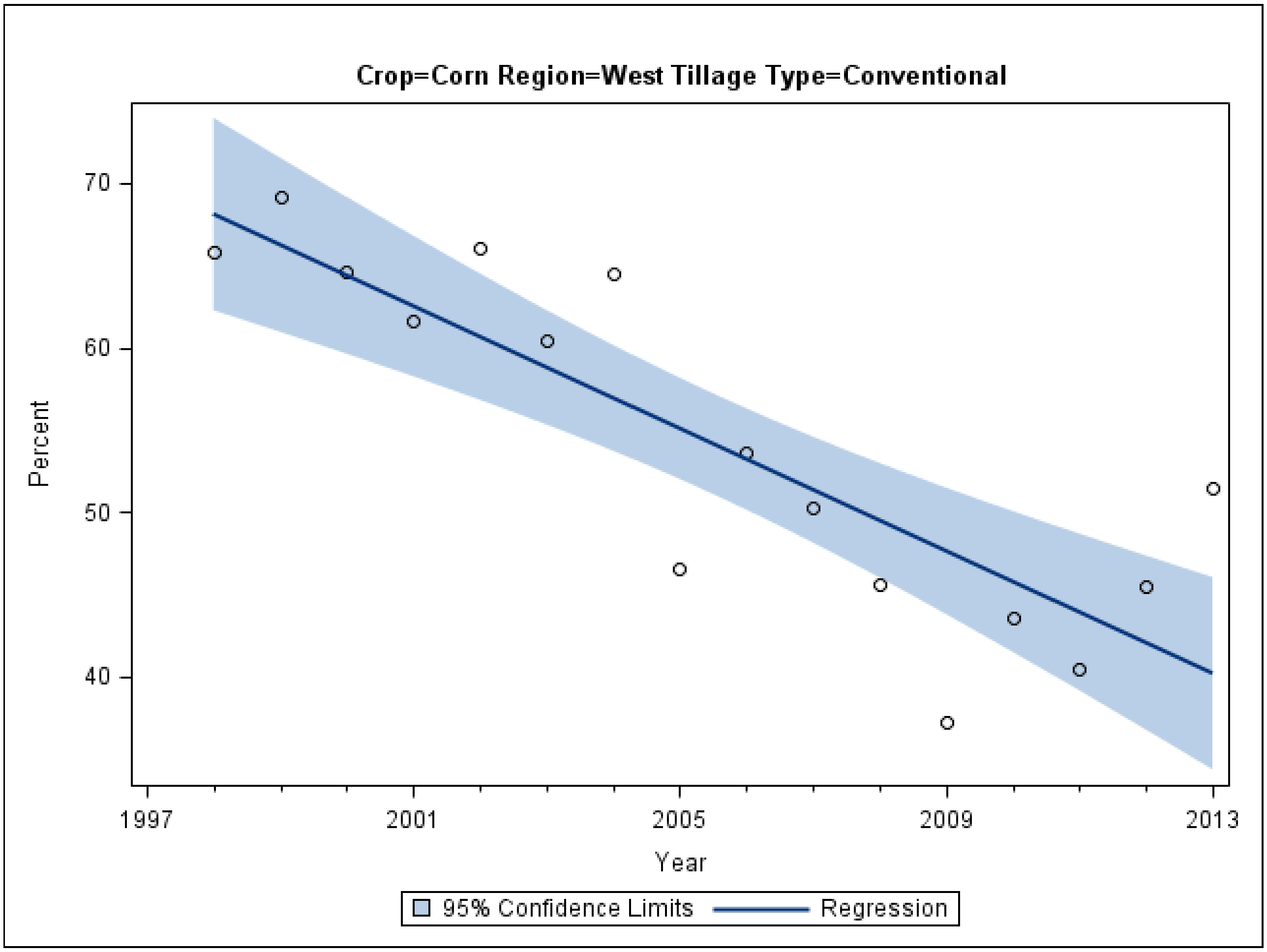


Crop=Cotton Region=MidSouth Tillage Type=Conventional
80
60
40
20
Percent
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression

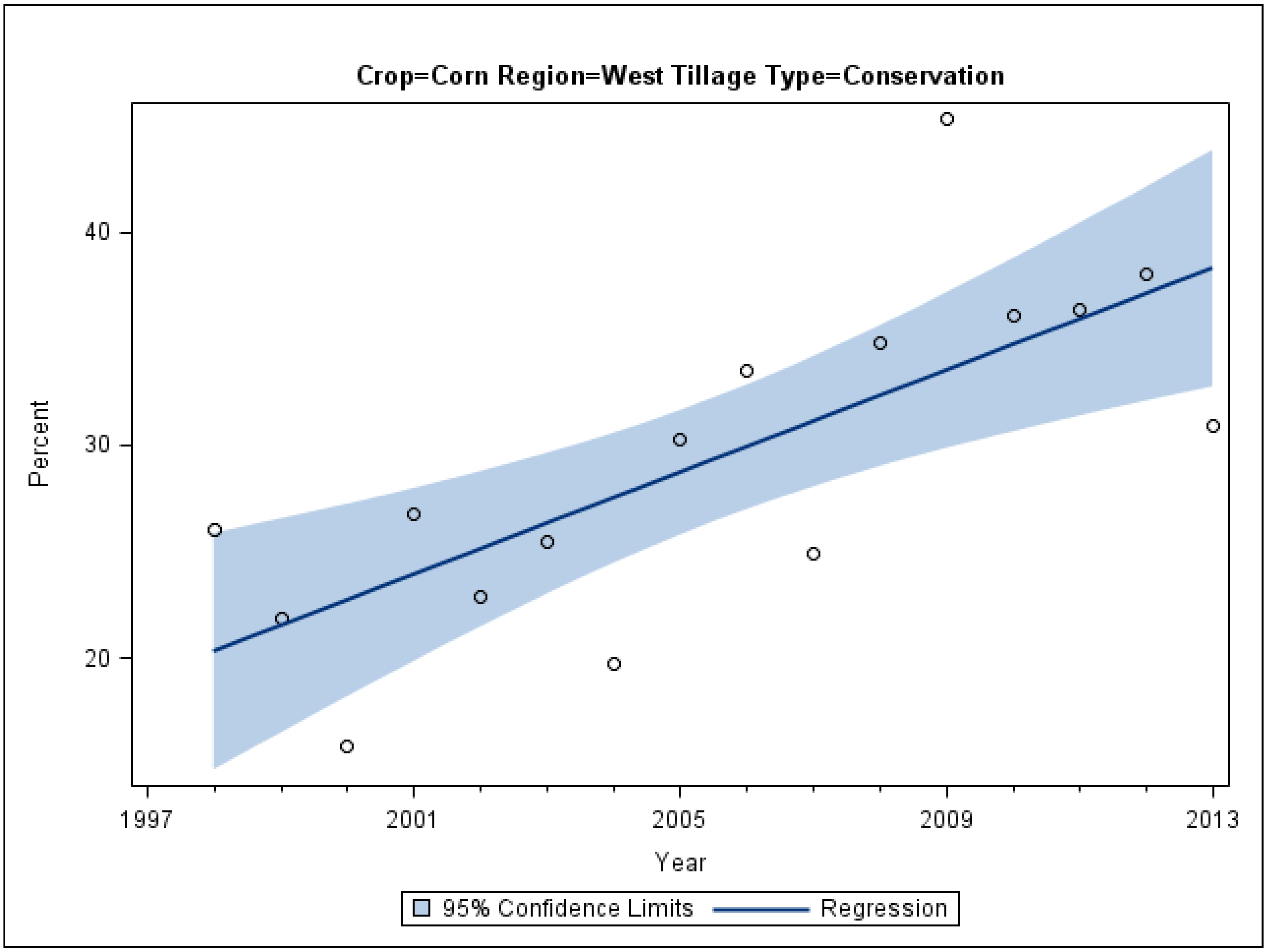

Crop=Cotton Region=MidSouth Tillage Type=Conservation
40
30
20
10
Percent
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression

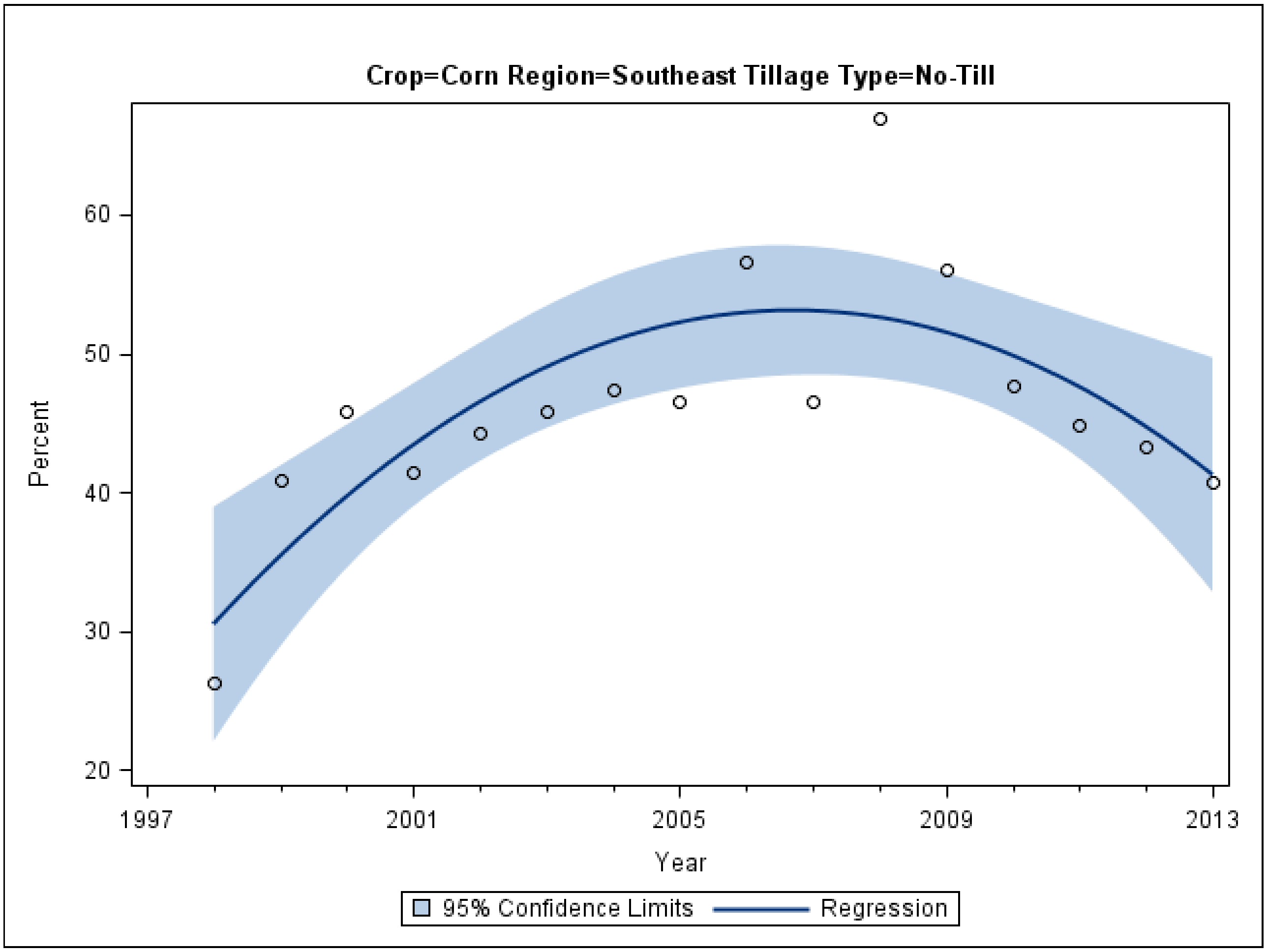


Crop=Corn Region=West Tillage Type=No-Till
Percent
25
20
15
10
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression

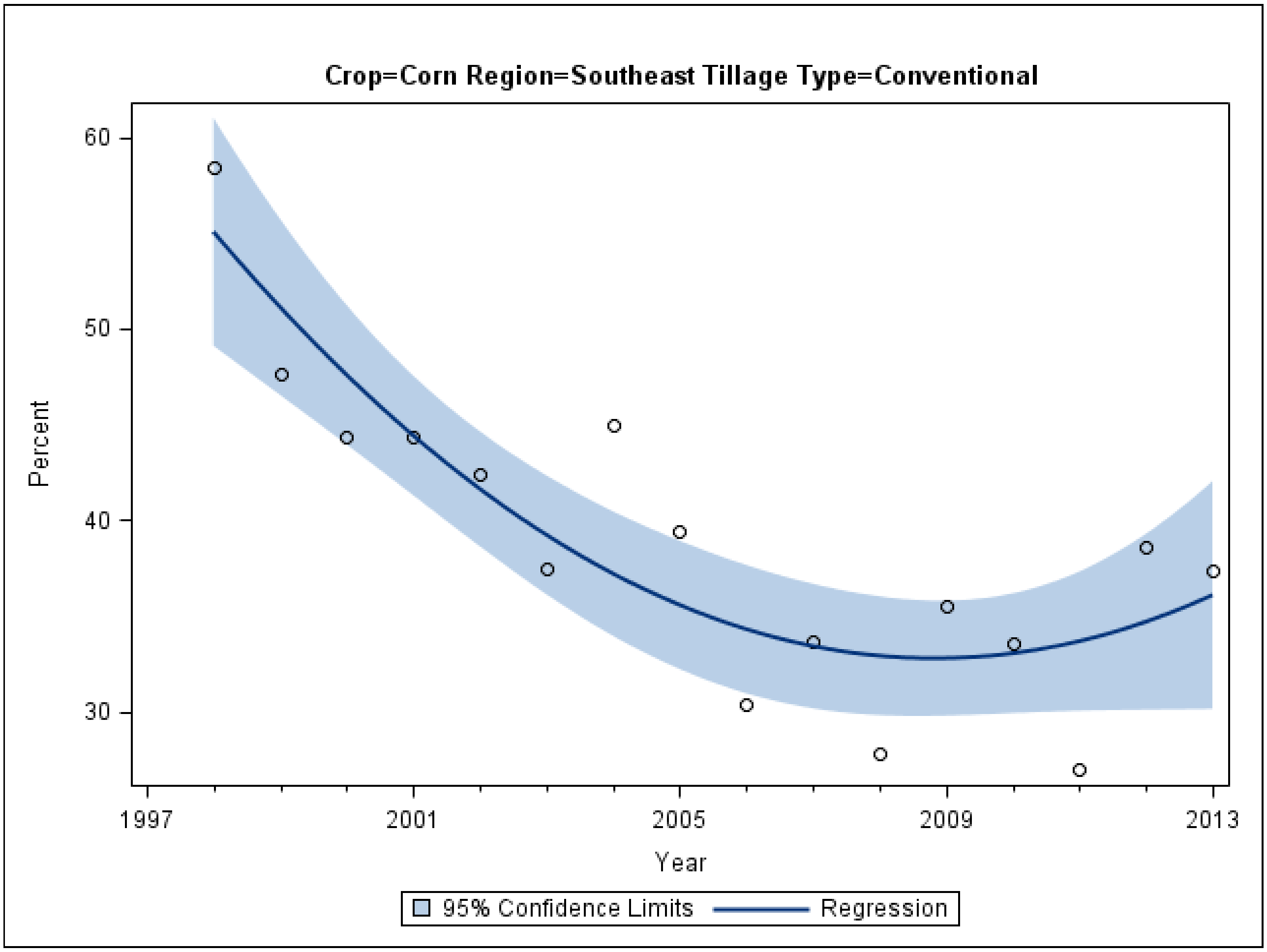


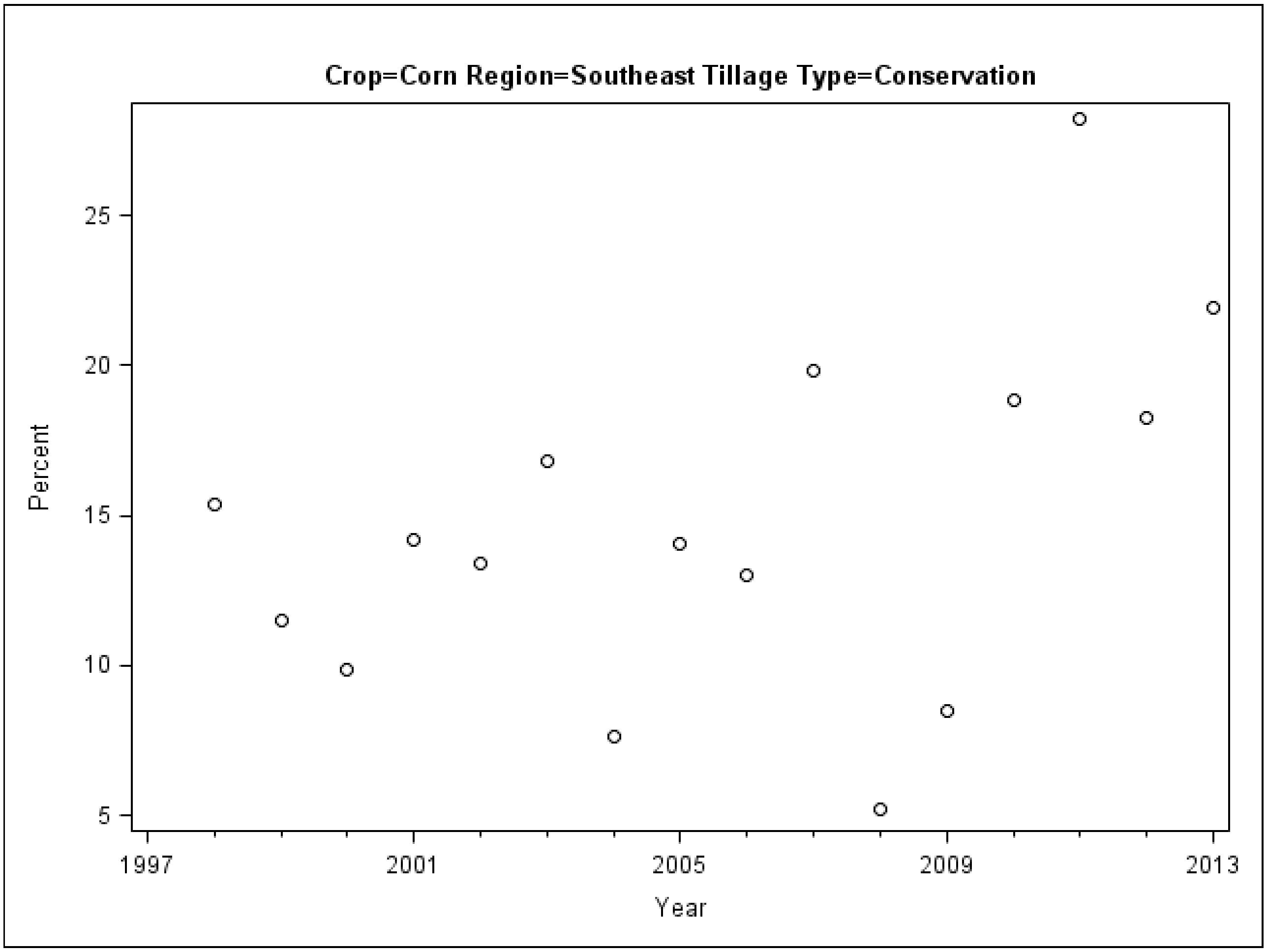
Crop=Corn Region=West Tillage Type=Conventional
70
60
50
40
Percent
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression

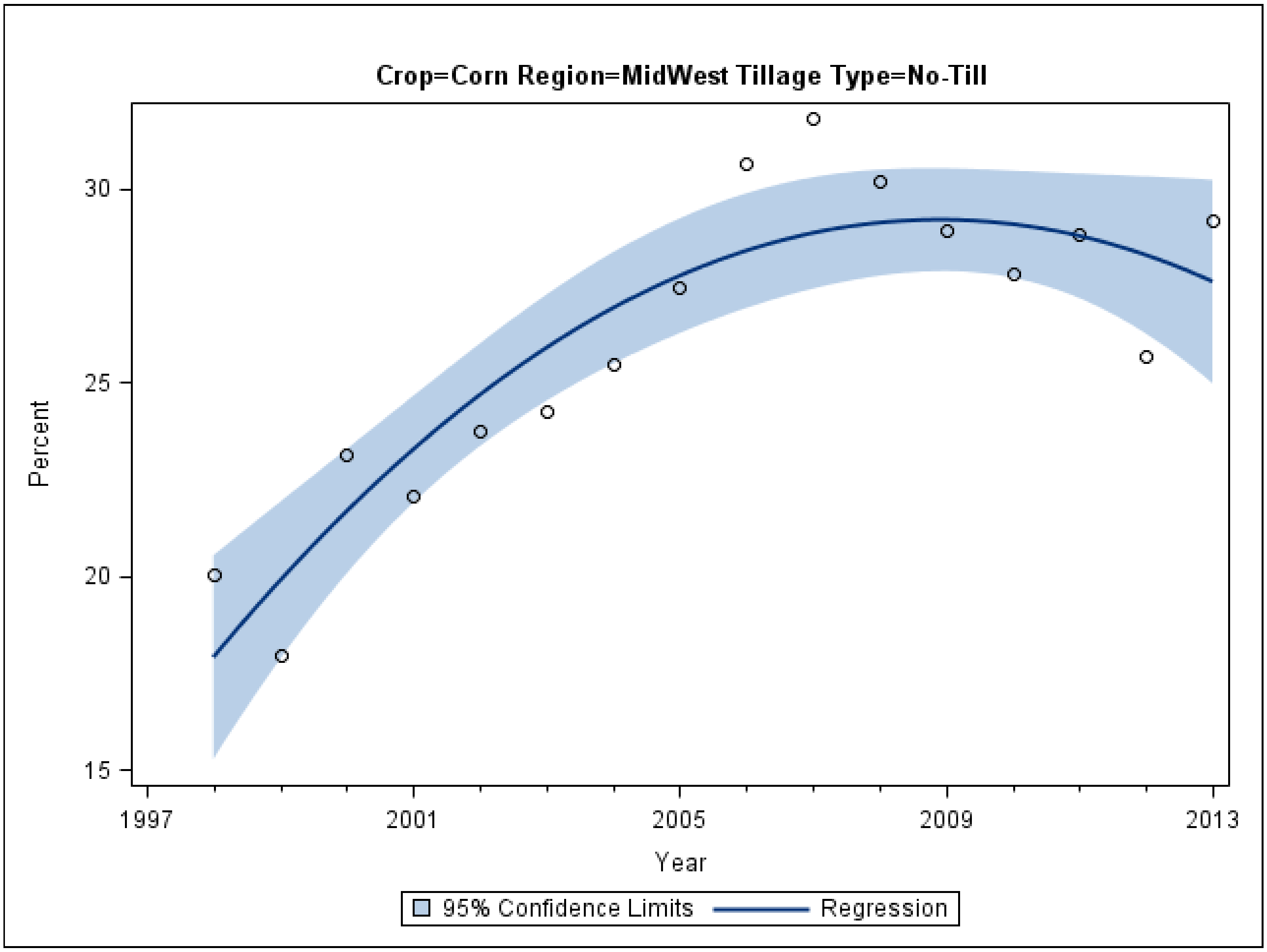

Crop=Corn Region=West Tillage Type=Conservation
Percent
40
30
20
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression

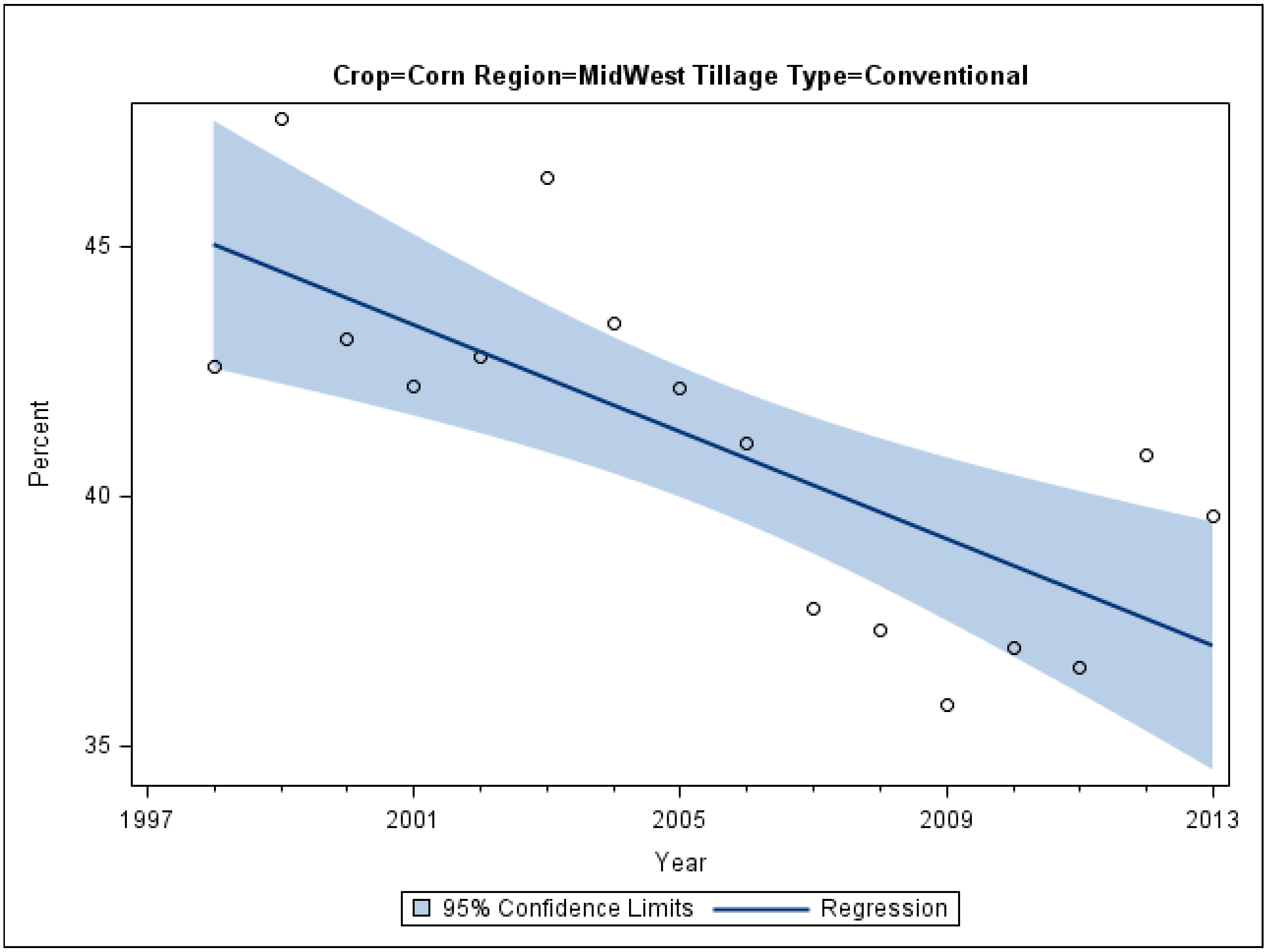


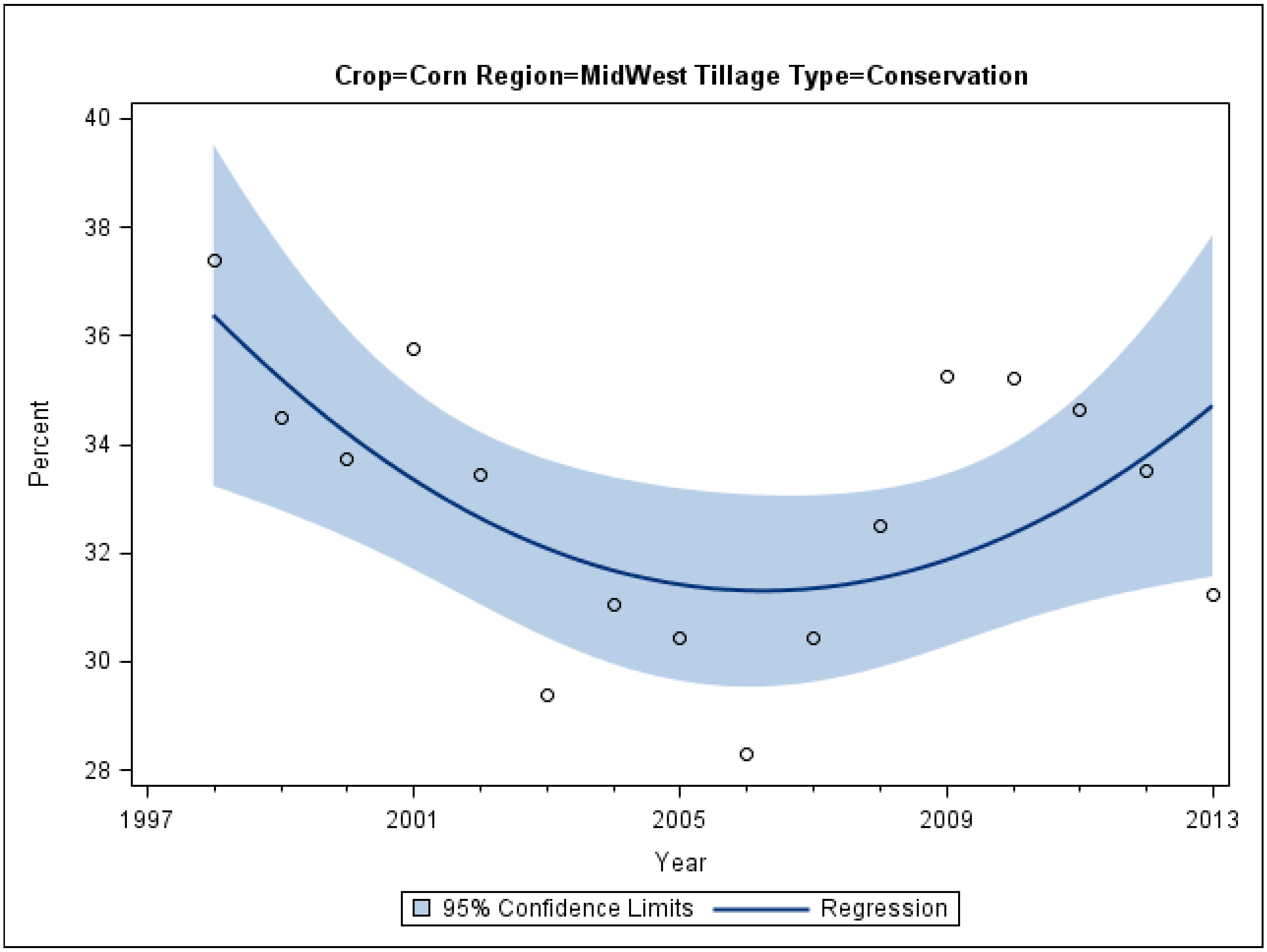
Crop=Corn Region=Southeast Tillage Type=No-Till
Percent
60
50
40
30
20
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression

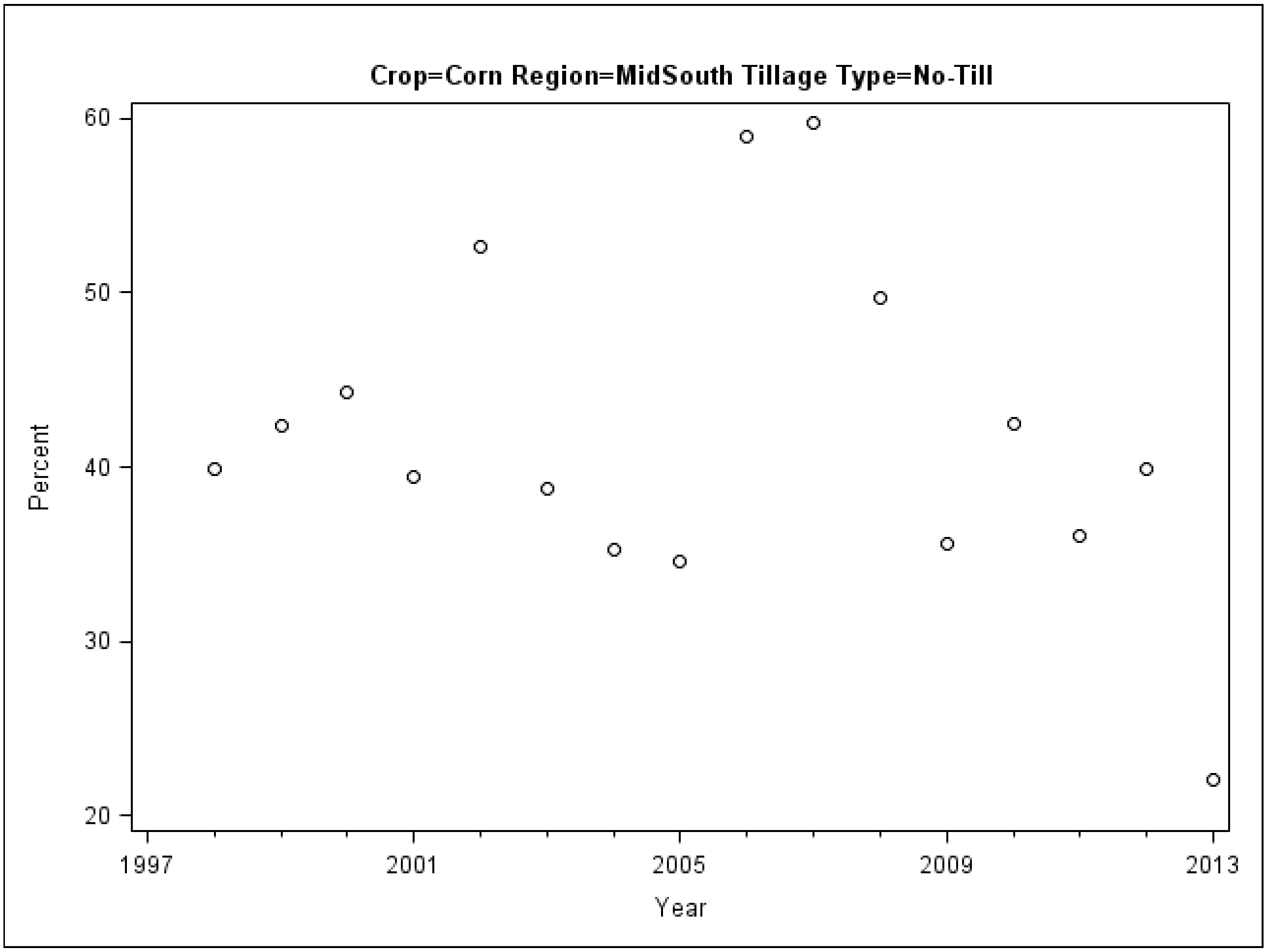

Crop=Corn Region=Southeast Tillage Type=Conventional
Percent
60
50
40
30
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression


Crop=Corn Region=Southeast Tillage Type=Conservation
Percent
25
20
15
10
5
1997
2001
2005
2009
2013
Year

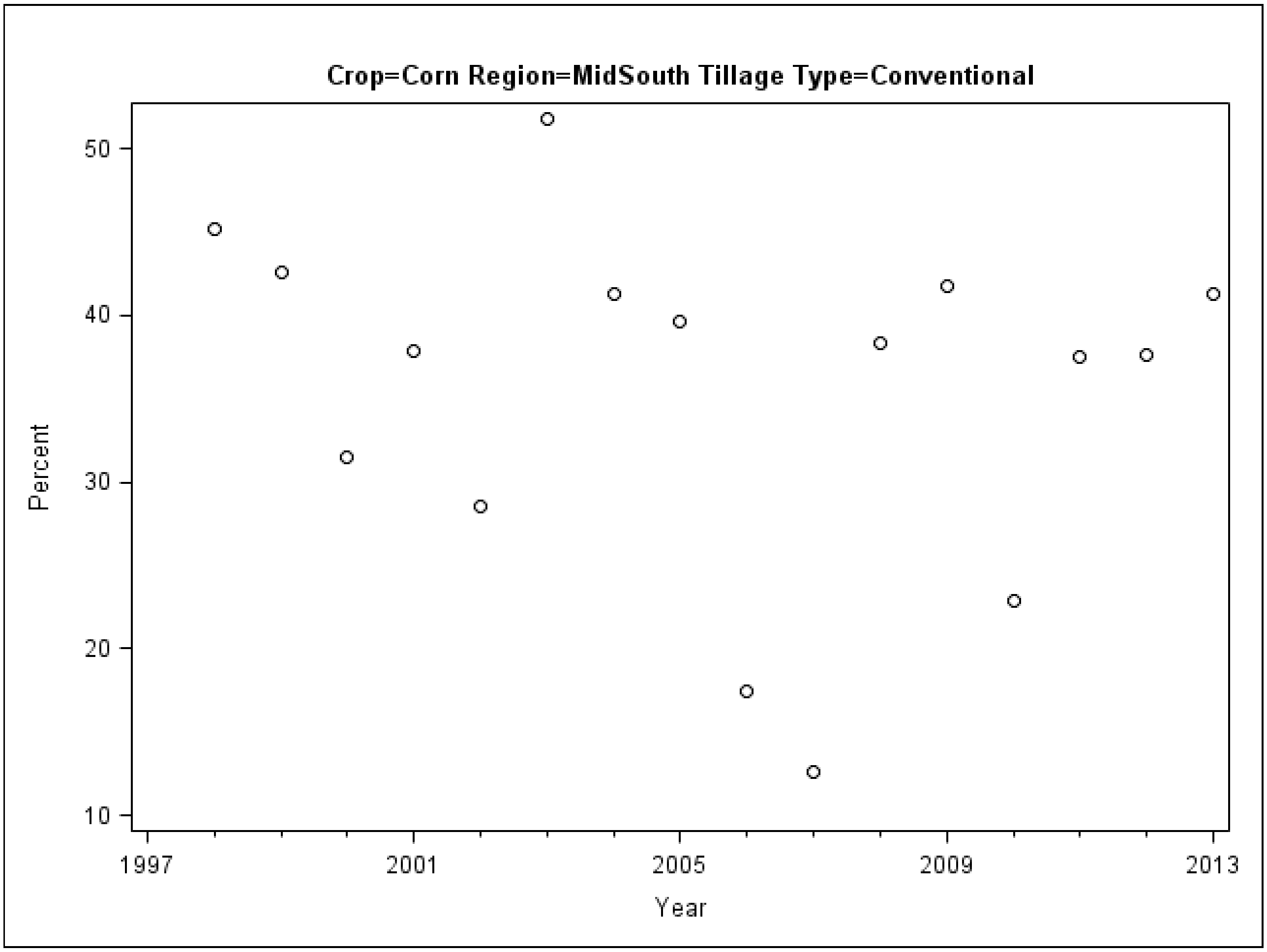

Crop=Corn Region=MidWest Tillage Type=No-Till
Percent
30
25
20
15
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression

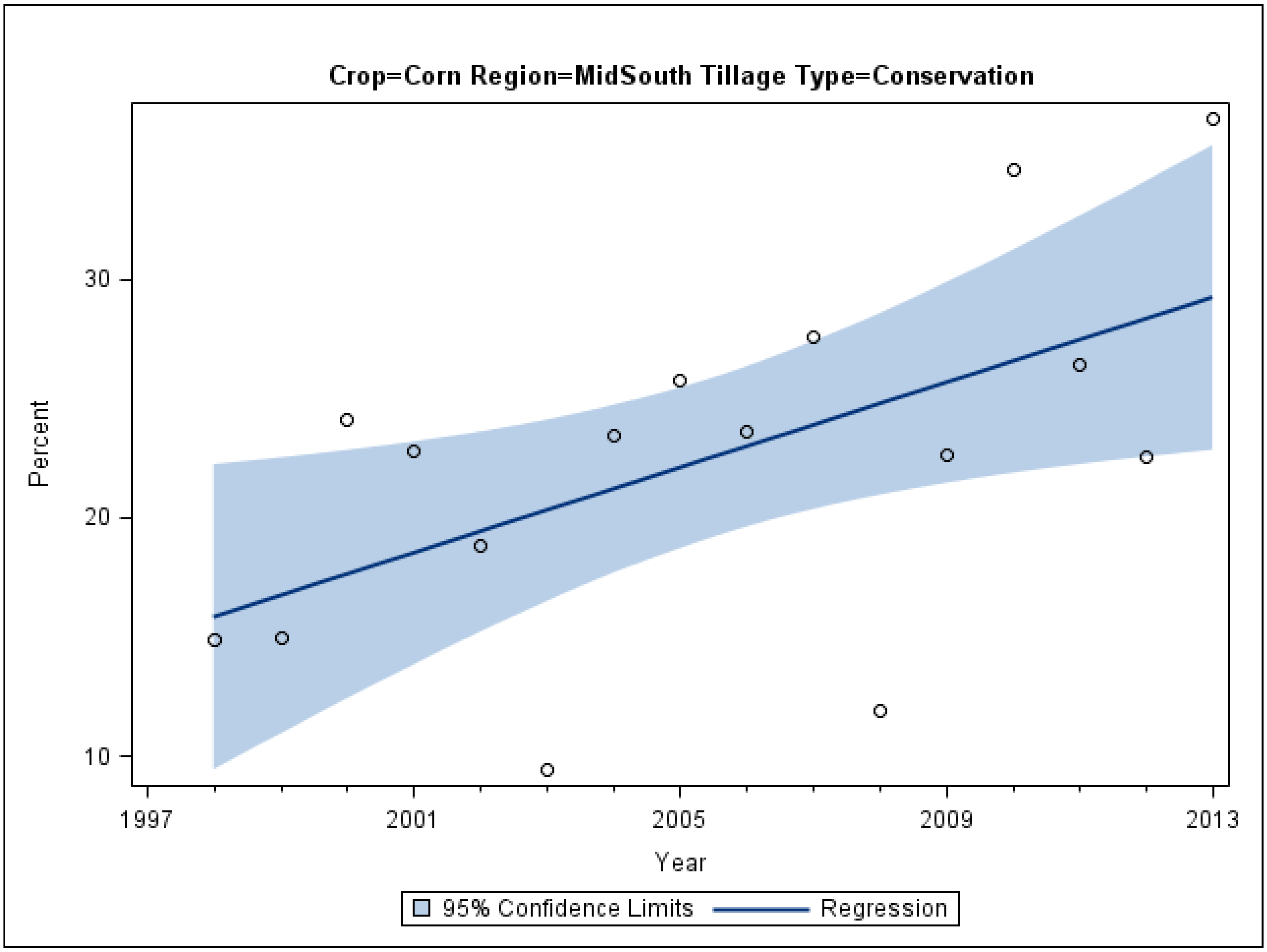

Crop=Corn Region=MidWest Tillage Type=Conventional
Percent
45
40
35
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression


Crop=Corn Region=MidWest Tillage Type=Conservation
Percent
40
38
36
34
32
30
28
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression

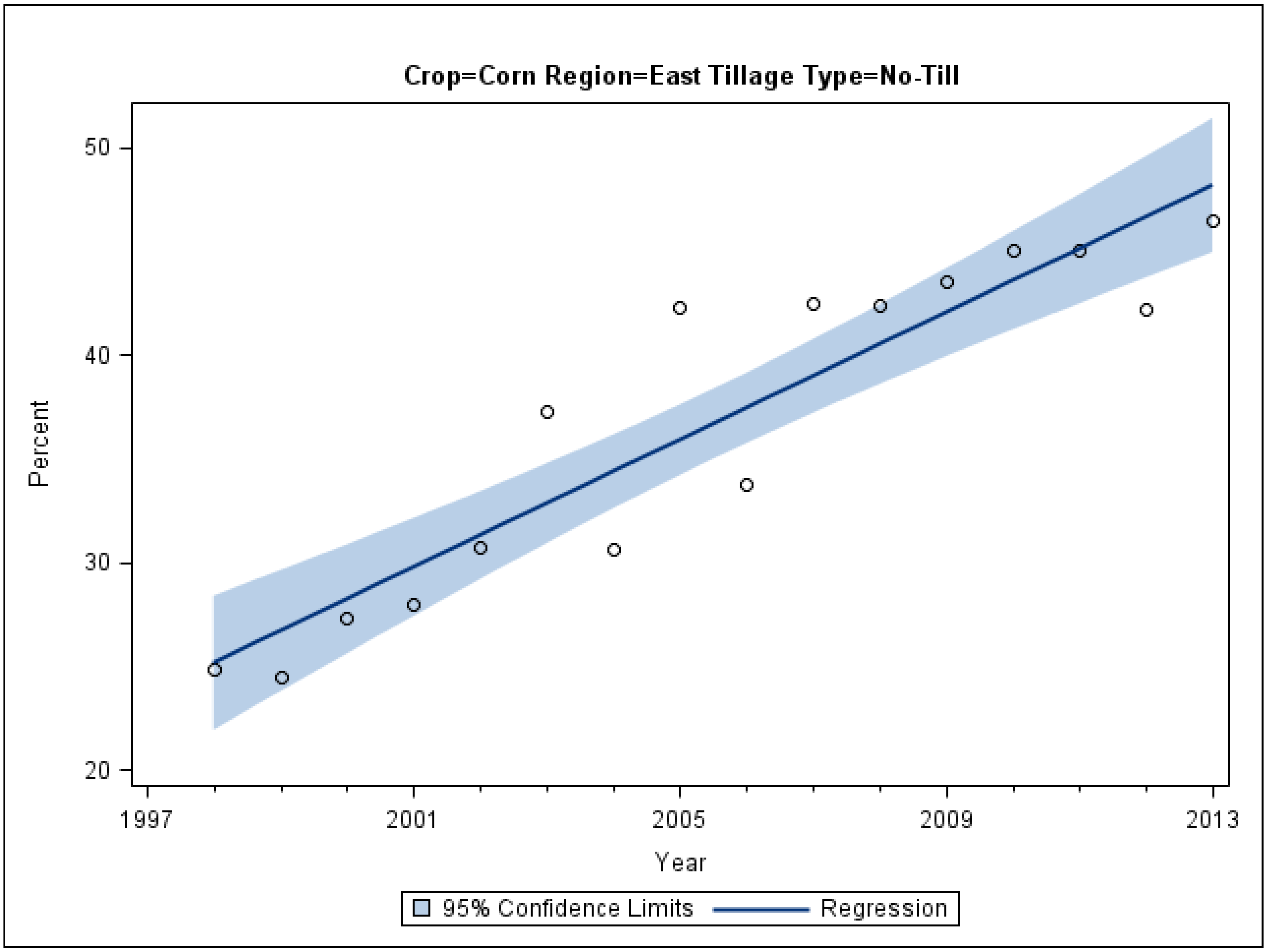


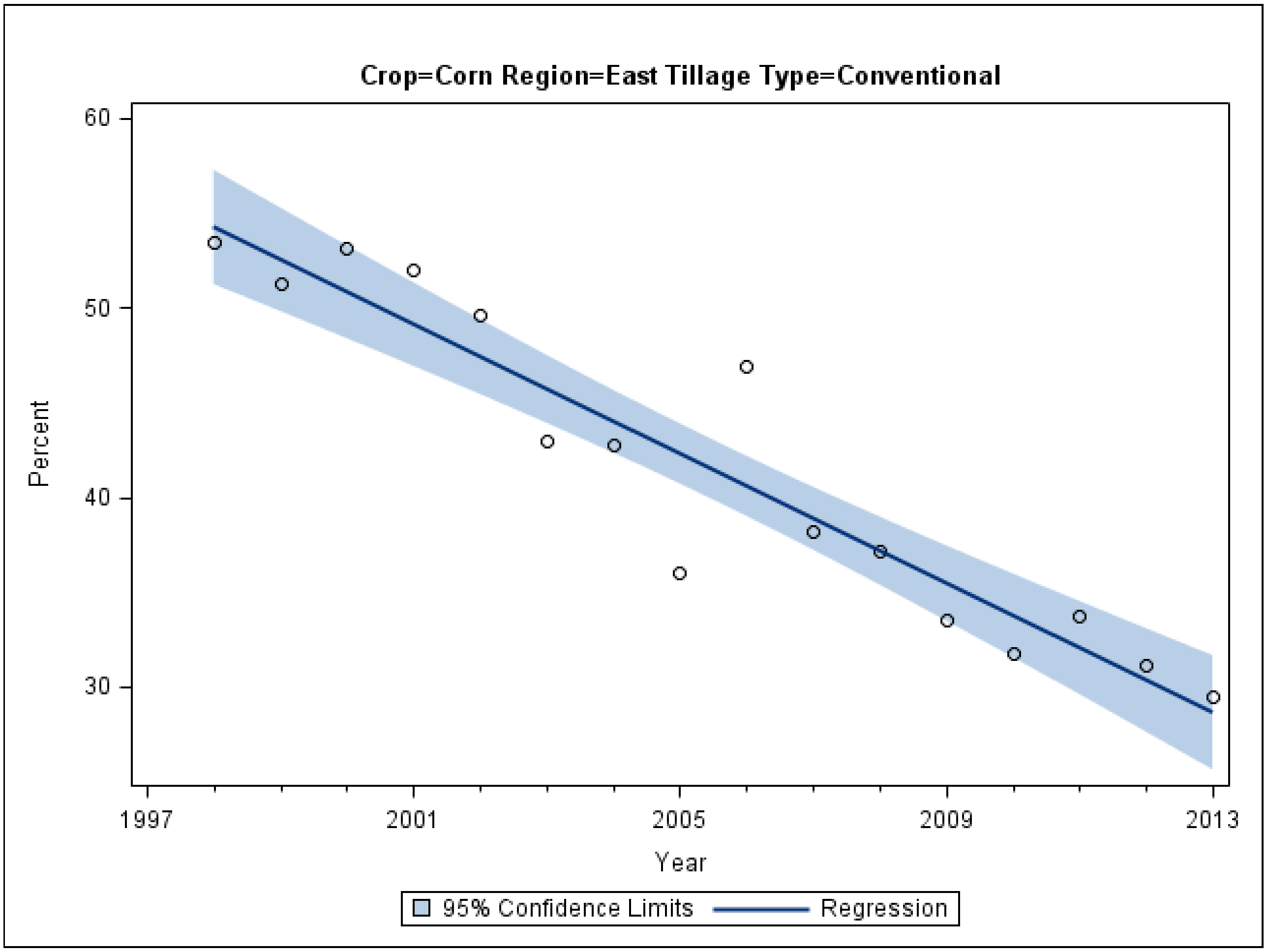
Crop=Corn Region=MidSouth Tillage Type=No-Till
Percent
Year
60
50
40
30
20
1997
2001
2005
2009
2013

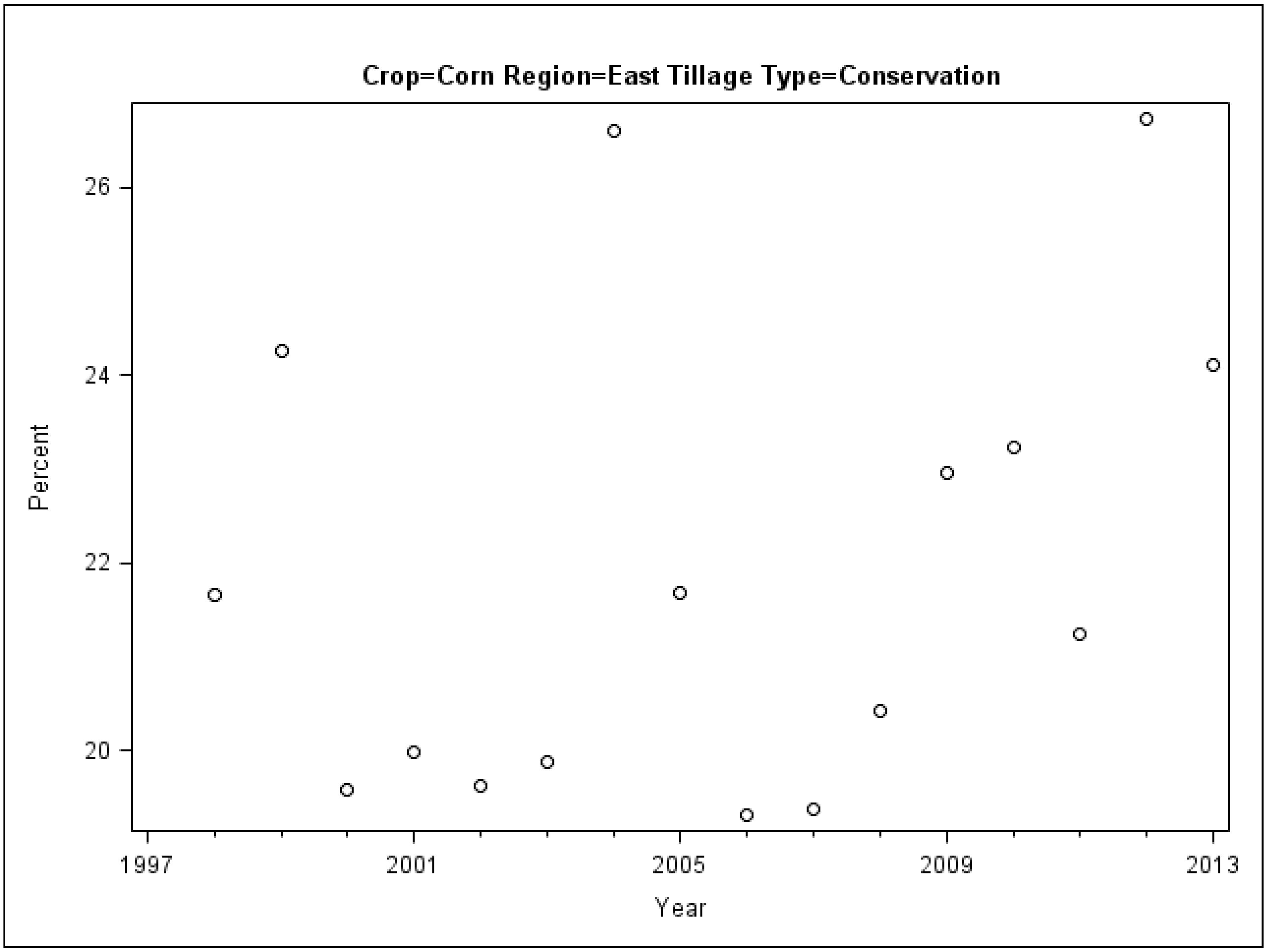

Crop=Corn Region=MidSouth Tillage Type=Conventional
50
40
30
20
10
Percent
1997
2001
2005
2009
2013
Year



Crop=Corn Region=MidSouth Tillage Type=Conservation
Percent
30
20
10
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression


Crop=Corn Region=East Tillage Type=No-Till
50
40
30
20
Percent
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression


Crop=Corn Region=East Tillage Type=Conventional
60
50
40
30
Percent
1997
2001
2005
2009
2013
Year
95% Confidence Limits
Regression


Crop=Corn Region=East Tillage Type=Conservation
Percent
26
24
22
20
1997
2001
2005
2009
2013
Year

Appendix B: CTIC Survey Results of Leading Conservation Tillage Experts

The following pages summarize the results of the CTIC (Conservation Tillage Information Center) survey of 21 total (14 in Midwest and 7 in South) leading conservation tillage experts across the key agronomic regions of the U.S. for soybean, corn and cotton production. These experts were asked to rate the importance of 11 factors that could influence tillage practices of growers in their region. Responses the the question below are summarized on the following pages.

Question: In general, how important are the following factors to the majority of the farmers in your region as they determine the total amount of tillage done to produce corn, regardless of whether the tillage is done prior to planting or done during the growing season? Choose the rating below that best reflects the importance of each factor in determining the amount of tillage being used.

Table B-1. Midwest Corn (14 total Experts)

	Number of Experts Responding										
	Manage excess crop residue	**Manage existing weeds**	**Manage disease**	**Manage soil moisture**	**Manage soil temperature**	**Prevent weed resistance**	**Seed bed preparation**	**Use of strip till / vertical tillage tools**	**Economics**	**Availability of labor**	**Water penetration**
Not important / Not mentioned	4	6	4	4	4	8	4	6	6	8	6
Sometimes important	4	3	5	3	3	2	2	3	1	2	4
Quite important	2	2	4	5	5	2	3	2		3	2
Extremely important	4	3	1	2	2	2	5	3	7	1	2
Ranking Sum[1]	34	30	30	33	33	26	37	30	36	25	28

[1]Ranking Sum was calculated as follows, a number from 1 to 4 was assigned to each response category, with 1 assigned to 'not important or not mentioned' and 4 assigned to 'extremely important'. The assigned number was multiplied by the number of responses from the experts and then added together for each factor.

Table B-2. Midwest Soybean (13 total Experts)

	Number of Experts Responding										
	Manage excess crop residue	**Manage existing weeds**	**Manage disease**	**Manage soil moisture**	**Manage soil temperature**	**Prevent weed resistance**	**Seed bed preparation**	**Use of strip till / vertical tillage tools**	**Economics**	**Availability of labor**	**Water penetration**
Not important / Not mentioned	6	4	7	3	5	6	4	10	4	2	4
Sometimes important	0	4	2	6	4	3	2	1	3	6	5
Quite important	1	2	2	2	1	2	3	0	2	3	2
Extremely important	6	3	2	2	3	2	4	2	4	1	1
Ranking Sum[1]	33	30	25	29	28	26	33	20	32	27	24

[1]Ranking Sum was calculated as follows, a number from 1 to 4 was assigned to each response category, with 1 assigned to 'not important or not mentioned' and 4 assigned to 'extremely important'. The assigned number was multiplied by the number of responses from the experts and then added together for each factor.

Table B-3. South Corn (6 total Experts)

	Number of Experts Responding										
	Manage excess crop residue	**Manage existing weeds**	**Manage disease**	**Manage soil moisture**	**Manage soil temperature**	**Prevent weed resistance**	**Seed bed preparation**	**Use of strip till / vertical tillage tools**	**Economics**	**Availability of labor**	**Water penetration**
Not important / Not mentioned	2	2	3		1	2		2		1	2
Sometimes important	1	1	2	4	5	2	1	2	1	3	1
Quite important	3	1	1	2		1	4	2	2	1	1
Extremely important		1				1	1		3	1	2
Ranking Sum[1]	13	11	10	14	11	13	18	12	20	14	15

[1]Ranking Sum was calculated as follows, a number from 1 to 4 was assigned to each response category, with 1 assigned to ‘not important or not mentioned’ and 4 assigned to ‘extremely important’. The assigned number was multiplied by the number of responses from the experts and then added together for each factor.

Table B-4. South- Soybean (6 total Experts)

	Number of Experts Responding										
	Manage excess crop residue	**Manage existing weeds**	**Manage disease**	**Manage soil moisture**	**Manage soil temperature**	**Prevent weed resistance**	**Seed bed preparation**	**Use of strip till / vertical tillage tools**	**Economics**	**Availability of labor**	**Water penetration**
Not important / Not mentioned	3		4		2			1		1	1
Sometimes important	2	2	1	3	4	1	2	3	1	2	3
Quite important	1	3	1	2		4	3	2	3	1	1
Extremely important		1		1		1	1		2	1	1
Ranking Sum[1]	10	17	9	16	10	18	17	13	19	12	14

[1]Ranking Sum was calculated as follows, a number from 1 to 4 was assigned to each response category, with 1 assigned to ‘not important or not mentioned’ and 4 assigned to ‘extremely important’. The assigned number was multiplied by the number of responses from the experts and then added together for each factor.

Table B-5. South- Cotton (6 total Experts)

	Number of Experts Responding										
	Manage excess crop residue	**Manage existing weeds**	**Manage disease**	**Manage soil moisture**	**Manage soil temperature**	**Prevent weed resistance**	**Seed bed preparation**	**Use of strip till / vertical tillage tools**	**Economics**	**Availability of labor**	**Water penetration**
Not important / Not mentioned			3		2		1				2
Sometimes important	4	3	2	2	3	4	1	3		2	1
Quite important	1	1	1	3	1	1	3	2	4	3	2
Extremely important	1	2		1		1	1	1	2	1	1
Ranking Sum[1]	15	17	10	17	11	18	16	16	20	17	14

[1]Ranking Sum was calculated as follows, a number from 1 to 4 was assigned to each response category, with 1 assigned to ‘not important or not mentioned’ and 4 assigned to ‘extremely important’. The assigned number was multiplied by the number of responses from the experts and then added together for each factor.

Appendix 10. EPA Resistance Management Requirements for Registration of Dow Agrosciences Enlist Duo™

The following text in this appendix contains excerpts regarding the weed resistance management requirements specified in the U.S. EPA's Proposed Registration of Enlist Duo™ Herbicide. EPA may require similar requirements be added to the proposed registration of Monsanto's dicamba formulation, ExtendiMax.

IV. Resistance Management

The emergence of herbicide resistant weeds is an increasing problem that has become a significant economic issue to growers. This has led to a concern that the use of 2,4-D on GE crops may result in more resistant weeds. In an effort to address this issue going forward, EPA is requiring that DAS develop a stewardship program that will aggressively promote resistance management efforts.

The overall goal of the stewardship plan is to assist and support responsible use of the product. With regard to weed resistance management, the plan mandates that DAS must immediately investigate any claims of non-performance. The initial mechanism users can use for communicating directly with DAS is a toll-free number to get advice on how to resolve any uncontrolled weeds.

Academia, growers, USDA, and other leaders involved with pest management acknowledge the importance of field scouting. For this reason, the Enlist Duo™ label includes a requirement to scout treated fields. Field scouting before application will be essential to determining the weed species present as well as their stage of growth. Scouting 7-21 days after herbicide application will be used to assess the performance of weed control. In the event that a user encounters a non-performance issue, the toll-free number could be used to initiate an intervention against that weed population.

The DAS response to reports of non-performance must be immediate and must ensure that possible incidents of resistance are promptly investigated and resolved. EPA proposes that when a non-performance issue is identified , DAS or its representative will conduct a site visit and evaluate the issue using decision criteria identified by leading weed science experts (Norsworthy, et al.), in order to determine if "likely herbicide resistance" is present. This is distinct from, and more broad than, the term "likely herbicide resistance," as explained below. For purposes of this decision, a report of non-performance to DAS will be the trigger for a site visit.

Non-performance refers to any cause that results in inadequate weed control after an herbicide application. "Lack of herbicide efficacy" refers to inadequate weed control with various possible causes, including but not limited to: application rate, stage of growth, environmental conditions, herbicide resistance, plugged nozzle, boom shut off, tank dilution, post-application weed flush, unexpected rainfall event, weed misidentification, etc. EPA recognizes that it can be challenging to determine emerging weed resistance at an early stage. Therefore, EPA is selecting criteria that it feels will be helpful to DAS and to users in identifying when instances of "lack of herbicide efficacy" in fact constitute "likely herbicide resistance." These "likely herbicide resistance" criteria are: (1) failure to control a weed species normally controlled by the herbicide at the dose applied, especially if control is achieved on adjacent weeds; (2) a spreading patch of uncontrolled plants of a particular weed species; and (3) surviving plants mixed with controlled individuals of the same species (Norsworthy, et al., 2012).

When DAS or its representative applies the Norsworthy, et al., criteria cited above and likely herbicide resistance is identified, then DAS must take immediate action to eradicate likely resistant weeds in the infested area. This may be accomplished by re-treating with an herbicide or using mechanical control methods. If herbicide re-treatment is used to eliminate the likely resistant weed(s), follow-up scouting will be required to confirm that the lack of herbicide efficacy has been resolved. DAS must also notify EPA that likely herbicide resistance has been identified and report this on a monthly basis. In addition, samples of the likely herbicide resistant weeds and/or seeds must be taken, and prior to the next growing season laboratory or greenhouse testing must be initiated in order to determine whether resistance is the reason for the lack of herbicide efficacy. DAS must also work to develop a laboratory diagnostic test to quickly identify herbicide resistance, and report to EPA its progress toward developing such a diagnostic test.

In addition to reporting incidents of likely resistance, on or before October 15 of each year, DAS will submit annual summary reports to EPA. These reports must include a summary of the number of instances of likely and confirmed resistance to Enlist Duo™ by weed species, crop, county and state. They will also summarize the status of laboratory or greenhouse testing for resistance, as well as the status of the development of a laboratory test. The annual reports will also address the disposition of incidents of likely or confirmed resistance reported in previous years.

Users and other stakeholders must be informed of reports of likely and confirmed herbicide resistance to Enlist Duo™, if any. The information will include details of weed species and crop. To accomplish this, EPA expects that DAS will establish a website to facilitate delivery of resistance information.

Several management practices that are designed to help users avoid initial occurrences of weed resistance will appear on the product labeling under the Resistance Management heading of the label. These practices are discussed in Section VII.B.3 of this document.

Refer to Section VII.C below for EPA's delineation of necessary terms of registration to address the issue of weed resistance.

VII. Proposed Registration Decision

B. Labeling Requirements

3. Resistance Management

a. Herbicide Selection:

- Apply full rates of GF-2726 for the most difficult to control weed in the field at the specified time (correct weed size) to minimize weed escapes.
- Rotate the use of this product with non-Group 4 and non-Group 9 herbicides.

- Utilize sequential applications of herbicides with alternative modes of action.
- Avoid using more than two applications of GF-2726 and any other Group 4 or Group 9 herbicide within a single growing season unless mixed with another mode of action herbicide with overlapping weed spectrum.
- Use a broad spectrum soil applied herbicide with other modes of action as a foundation in a weed control program.

b. Crop Selection and Cultural Practices:

- Incorporate additional weed control practices whenever possible, such as mechanical cultivation, crop rotation, and weed-free crop seeds, as part of an integrated weed control program.
- Do not allow weed escapes to produce seeds, roots or tubers.
- Thoroughly clean plant residues from equipment before leaving fields suspected to contain resistant weeds.
- Scout fields before application to ensure herbicides and rates will be appropriate for the weed species and weed sizes present.
- Scout fields between 7 and 21 days after application to detect weed escapes or shifts in weed species.
- If resistance is suspected, treat weed escapes with an alternate mode of action or use nonchemical methods to remove escapes.
- User report any incidence of non-performance of this product against a particular weed species to the DAS representative.

C. Registration Terms

EPA has determined that certain registration terms are needed to ensure that likely weed resistance as discussed in section IV can be adequately addressed. EPA believes that it is important to address likely weed resistance and not wait until confirmation of resistance has been found. EPA is basing the registration terms on a list of criteria, presented in the peer-reviewed publication, Norsworthy, et al., “Reducing the Risks of Herbicide Resistance: Best Management Practices and Recommendations,” *Weed Science* 2012 Special Issue: 31–62 (Norsworthy criteria).

1. Stewardship Program

EPA has determined that the registration must contain a term that requires DAS to have a stewardship program for Enlist Duo™. DAS has begun developing its program which it states is focused on educating and training retailers, farmers and applicators on the appropriate use of the Enlist™ technology. EPA has determined that the stewardship program must include the following measures (also to be included as terms on the registration) that would minimize the potential for off-target movement and avoid the development of weed resistance.

a. Investigation

EPA has determined that the registration must contain a term that requires DAS or its representative to investigate reports of non-performance as reported by users following required "scouting" (in accordance with labeling requirements). When investigating these reports, DAS or its representative would be required to conduct site visits.

b. Reporting of the Incidence of Likely Herbicide Resistance

EPA has determined that the registration must contain a term that requires DAS to use the Norsworthy criteria for determining likely herbicide resistance and inform EPA if likely resistance has been identified. This information must be submitted to the Agency on a monthly basis.

c. Remediation

EPA has determined that the registration must contain a term that requires DAS to take immediate action to eradicate likely resistant weeds in the infested area as well as requiring DAS to collect material for further testing.

d. Annual Reporting of Herbicide Resistance to EPA

EPA has determined that the registration must contain a term that requires DAS to submit annual summary reports to EPA that include a summary of the number of instances of likely and confirmed weed resistance by weed species, crop, county and state. The annual reports must include summaries of the status of laboratory or greenhouse testing for resistance. The annual reports would also address the disposition of incidents of likely or confirmed resistance reported in previous years. These reports would not replace or supplement adverse effects reporting required under FIFRA 6(a)(2).

e. Reporting of Likely Resistance to other Interested Parties

EPA has determined that the registration must contain a term that requires DAS to inform growers and other stakeholders of likely and confirmed resistance to Enlist Duo™. The information will include details of weed species and crop. EPA understands that DAS already plans to provide this information though a devoted website.

f. Reporting on the development of diagnostic tests

EPA has determined that the registration must contain a term that requires that DAS would inform EPA of DAS's progress toward diagnostic testing for evaluating resistant weed species.

g. Monitoring the use of Enlist DuoTM on Enlist™ Seed

EPA believes it is important to require DAS to monitor whether Enlist Duo™ is being used on the Enlist™ seed purchased from DAS. EPA has determined that the registration must contain a term that requires DAS to provide EPA with a protocol to survey whether Enlist Duo™ is being used on Enlist™ seed purchased from DAS and not the non-choline 2,4-D products that are not registered for these application windows. EPA expects that a protocol would be agreed upon quickly so that monitoring the use of Enlist Duo™ can begin shortly thereafter.

h. Training and Education

EPA has determined that the registration must contain a term that requires DAS to provide training on the use of Enlist Duo™ when it provides training on the Enlist™ Seed technology. The training would focus on proper use of the technology to avoid off-target movement as well as avoid weed resistance.

2. EPA's Continued Control over the Registration

Because the issue of weed resistance is an extremely important issue to keep under control and can be very fast moving, EPA has determined that the registration must contain terms that ensure that EPA retains control to easily and quickly modify or cancel the registration if necessary.

References:

Jason K. Norsworthy, Sarah M. Ward, David R. Shaw, Rick S. Llewellyn, Robert L. Nichols, Theodore M. Webster, Kevin W. Bradley, George Frisvold, Stephen B. Powles, Nilda R. Burgos, William W. Witt, and Michael Barrett, Reducing the Risks of Herbicide Resistance: Best Management Practices and Recommendations, *Weed Science* 2012 60 (sp1), 31-62.