Appendix 1. USDA Notifications and States Approved for Environmental Releases of DAS-40278-9 corn, DAS-68416-4 soybean, and DAS-44406-6 soybean

Table 1-1. USDA Notifications and States Approved for Environmental Releases of DAS-40278-9 corn

USDA Notification Number	Notification Authorization Date	Notification Expiration Date	State(s)
09-086-105n	4/20/2009	4/20/2010	IL, IN, IA, MN, MO, NE, WI
09-090-107n	4/21/2009	4/21/2010	CA, GA, IL, IA, IN, KS, MI, MN, MO, OH, NE, NJ, OK, PA, TX
09-075-106n	3/26/2009	3/26/2010	HI, IA, IL, IN, MN, NE, NE, SD, WI
09-061-005n	4/6/2009	4/6/2010	IA, MN, MS, NY, OH
09-005-107n	1/15/2009	1/15/2010	HI, IL, IN, IA, NE, PR
08-259-103n	10/15/2008	10/15/2009	HI
08-133-107n	6/1/2008	6/1/2009	IL (1), TX (1)
08-021-110n	4/1/2008	4/1/2009	IA
08-021-104n	3/20/2008	3/20/2009	IL (7), IN (11), IA (6), MN (4), MS (1), NE (4), WI (3)
07-242-103n	10/15/2007	10/15/2008	HI
06-338-101n	1/29/2007	1/29/2008	HI
05-308-03n	12/13/2005	12/13/2006	HI

Table 1-2. USDA Notifications and States Approved for Environmental Releases of DAS-68416-4 soybean

USDA Notification Number	Notification Authorization Date	Notification Expiration Date	State(s)
09-259-105n	9/25/2009	9/25/2010	PR
09-086-101n	5/30/2009	5/30/2010	IL, IN, IA, MN, MO, NE, WI
09-084-110n	4/15/2009	4/15/2010	AL, AR, CA, GA, IL, IN, IA, MI, MN, MO, MS, NE, OH
09-075-105n	4/15/2009	4/15/2010	HI, IN, IA, PR
09-068-101n	4/13/2009	4/13/2010	AR, IL, IN, IA, MD, MI, MO, ND, NE, OH, PR, WI
09-061-104n	4/6/2009	4/6/2010	AR, IL, IN, IA, MN, MS, NY, OH, TN
09-005-108n	1/1/2009	1/1/2010	HI
08-323-102n	12/3/2008	12/3/2009	PR
08-254-110n	9/26/2008	9/26/2009	PR
08-170-103n	6/26/2008	6/26/2009	MO
08-137-103n	6/5/2008	6/5/2009	MD
08-121-103n	5/14/2008	5/14/2009	IA
08-121-102n	5/15/2008	5/15/2009	IL, IN, MO, NE, OH
08-071-107n	4/14/2008	4/14/2009	CA, IL, IN, IA, MN, MN, NE
07-242-107n	9/30/2007	9/30/2008	PR
06-292-105n	12/1/2006	12/1/2007	IN

Table 1-3. USDA Notifications and States Approved for Environmental Releases of DAS-44406-6 soybean

USDA Notification Number	Notification Authorization Date	Notification Expiration Date	State(s)
11-095-105n	4/29/2011	4/29/2012	MS
11-087-114n	4/20/2011	4/20/2012	AL, AR, GA, IL, IN, MD, NE
11-067-105n	3/30/2011	3/30/2012	AR, CA, IA, IN, IL, LA, MN, MO, MS, OH, WI
10-243-104n	9/30/2010	9/30/2011	PR
10-085-103n	4/19/2010	4/19/2011	GA, IA, IN,IL, MI, MO, NE
10-083-105n	4/22/2010	4/22/2011	IA, IN, MO,MS
10-077-107n	4/14/2010	4/14/2011	GA, IA, IN,IL, MD, MO,NE, OH, PR
09-259-108n	10/5/2009	10/5/2010	PR
09-068-103n	4/1/2009	4/1/2010	IN, PR
08-254-109n	9/30/2008	9/30/2009	PR

[1]Pending reports as of June 21, 2011 to be submitted within six months of the notification expiration date.

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 DowAgrosciences (DAS) petitions 09-233-01p (event DAS-40278-9 corn), 09-349-01p (event DAS-68416-4 soybean), and 11-234-01p (event DAS-44406-6 soybean). APHIS published a NOI to prepare an EIS for the three 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-2013-0042.

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 41 comments (see summary in Table 2-1) with an additional 9 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 50 public comments were received with 41 public comments submitted to the docket folder on the NOI for the preparation of an EIS on 2,4-D-resistant corn and soybean and an additional 9 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 NOI 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.

Overall, the comments submitted echoed the issues previously raised in the public comments made on the petitions and/or draft EAs for the three events. Most of the comments continued to voice concern over the potential increased use of 2,4-D by growers with adoption of the three deregulated events. While APHIS recognizes these concerns, APHIS does not regulate pesticide use. EPA is reviewing and analyzing the information DAS has submitted in support of the registration of their new 2,4-D choline salt 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 2,4-D formulation; therefore, those issues are not analyzed in this EIS.

The public comments on the NOI, the two draft EAs, and the petitions were grouped into several main themes. Below is a summary of the issues identified in the public scoping comments.

1. Alternatives

- Consider an alternative involving mandatory weed resistance management.
- Provide an assessment of Integrated Weed Management (IWM) systems or non- chemical tactics as an alternative to deregulation of DAS-68416-4 soybean for the stated purpose of Dow's product, to provide a means to control glyphosate-resistant weeds
- 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.

2. Inserted Genes/Plant Composition

- Degree of resistance conferred by the transgene in different plant parts and stages of development.
- APHIS did not take into account the potential toxicity of DAS-40278-9 corn, DAS-68416-4 soybean, and DAS-44406-6 soybean to listed species that might eat leaves, roots, stems, or flower parts. Migrating birds, for example, eat parts of the soybean plant. Bees consume the pollen and nectar, and presumably other insects do as well. Soybean detritus washes into wetlands.
- APHIS should initiate consultations with FWS and NMFS concerning the approval of DAS-40278-9 corn, DAS-68416-4 soybean, and DAS-44406-6 soybean.
- Assess the characteristics of DAS-40278-9 corn conferred by the activity of the novel enzyme AAD-1 and potential impacts.
- Analyze composition of the AAD-1 protein in the crop after exposure of DAS-40278-9 corn to 2,4-D or quizalofop.
- Perform additional research and information regarding any impacts to the nutritive value of DAS-68416-4 soybean compared to non-GE soybean. The commenter stated that the U.S. Food and Drug Administration (FDA) noted several differences in the compositional analysis of DAS soybean. Although the FDA recognized DAS-68416-4 Soybean as safe, the commenter requested a description of the differences, including supporting data, to confirm the DAS soybean is as safe as conventional soybean varieties. The commenter also requested additional research beyond the initial 15-day study to determine the safety of the

AAD-12 protein to confirm the nutritional differences would not affect human or animal health.

- More research must be done to show that these nutritional differences do not result in any functional differences that could affect human or animal health when this corn is present in food or animal feed.
- Information on the degree of resistance conferred by the transgene in different plant parts and stages of development should be available for review by APHIS and the public.
- Information on the expression of the transgene in pollen, nectar, and levels of herbicide residues. Metabolites in pollen and nectar should be available for review by APHIS and the public.

3. Miscellaneous

- Prove the deregulation will neither jeopardize any species nor harm any critical habitat anywhere the crop system may be grown.
- The conversion of natural areas and Conservation Reserve Program lands to corn production and the resultant increase in herbicide use would result in adverse impacts to listed threatened and endangered species, because these areas have not been previously farmed and are likely to support native species.
- Tillage can greatly reduce selection pressure on herbicides and thus aid in prevention of herbicide resistance. Tillage can also aid in management of resistant weeds once they become a problem. Tillage, however, is not an option in most cases. Our growers have worked hard to make no-till a success on their farms. They adopted no-till partly because of conservation compliance requirements in the past several farm bills. But regardless of conservation compliance, the major driving force was economics. Savings in fuel, labor, and equipment through no-till production helped growers remain competitive. A return to tillage would be a step backwards in terms of productivity and environmental protection. Moreover, growers simply do not have the labor and equipment to go back to tillage.
- Address the cumulative impact of seed market concentration. The seed market concentration impacts of a deregulation of 2,4-D resistant corn constitute a significant intertwined socioeconomic impact that is reasonably foreseeable.
- Assess economic impact of the higher cost of 2,4-D resistant corn to farmers.
- 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.
- Consider the possible impacts that yet another genetic trait can have on farmers in Mexico and around the world where native maize and wild corn relatives are not only grown, but an indispensable part of their culture and the economy.
- Conduct a larger analysis of domestic socioeconomic impacts given that biotech soybeans are more costly than non-biotech seeds and would increase costs for farmers.
- Herbicide tolerant crops have made the no-till system much more timely and cost effective for our operation. The no-till system is so effective at controlling erosion in our area that if we had to go back to tillage to control resistant weeds, the long-term cost would be very high in soil loss alone.
- Biotechnology has allowed plant breeders to develop soybeans that are tolerant to herbicides, thus allowing soybean farmers to better control weeds and implement no-till

and conservation tillage practices that save fuel, reduce erosion, and protect the environment.

- APHIS must assess 2,4-D-resistant corn and soybeans as crop systems comprising the herbicide-resistant crop itself and associated use of 2,4-D.
- APHIS should examine both short-term and long-term impacts of the proposed herbicide-resistant crop systems in the light of what has been learned from real-world experiences with previously-approved herbicide-resistant crop systems. What are the likely similarities and differences in terms of environmental health and economic concerns?
- 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."
- The USDA's Environmental Impact Statement must include, at a minimum research on how the ingestion of foods manufactured from these crops will affect human health and how the continued use of the herbicide in agriculture could endanger agricultural workers and the general public.
- 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 pre-plant 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.
- The introduction of soybeans tolerant to 2,4-D 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.
- 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.

4. Herbicide-Resistant Weeds

- Provide analysis of the prevalence/emergence of glyphosate-resistant weeds.
- 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."
- Overuse of any herbicide technology leads to selection pressure for development of resistance to that technology. Resistance to other herbicides was problematic previously and thus will continue to present management problems for growers in terms of herbicide

alternatives that remain as effective options. New cases of weed resistance will evolve in response to current soybean weed management programs.

- 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.
- 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.
- Growers need multiple modes of action to help manage herbicide-resistant weeds.
- Because of the resistance threat, growers are now more likely than ever to utilize multiple weed management strategies (tillage, row spacing, cover crops, residual herbicides, mechanical cultivation, and hand-weeding) in combination with herbicide-resistant crops.
- APHIS provides no empirical assessment of farmer use of resistant weed mitigation measures at all, but rather flaccidly relies on Dow's stewardship program, which is quite similar to Monsanto's stewardship program for RR crops.
- APHIS fails to provide any critical assessment of Dow's stewardship plan.
- Evaluate the potential for the increased use of 2,4-D associated with the adoption of DAS corn and soybean events to exacerbate the problems of herbicide-resistant weeds by accelerating the evolution of 2,4-D resistant weed populations.
- The Enlist™ technology will not be an exclusive answer to resistance development, but will be an extremely important tool in the development of comprehensive, science-based approaches to resistance management.
- APHIS fails to provide any assessment of the special proclivity of HR crop systems, or DAS-68416-4 soybean in particular, to trigger evolution of resistant weeds. The rapid emergence of GR weeds in RR crop systems is evidence of the resistant weed-promoting effect of HR crop systems in general and a proper analysis would have provided APHIS with important insights into the risks of resistant weed evolution in the context of the DAS-68416-4 soybean system.
- Evaluate the potential for 2,4-D-resistant weeds in 2,4-D resistant cropping systems. APHIS must take into account the reasonably foreseeable impact of future 2,4-D resistant crop deregulations in analyzing the development of superweeds that are resistant to 2,4-D and "fop" herbicides. Multiple resistance will develop in response to widespread use of 2,4-D in corn and soon, if approved, in soybean and cotton.
- Without effective herbicide options for controlling resistant weeds, growers are left with no choice but to re-introduce intensive tillage systems for weed management.
- Resistance to auxin herbicides has not been prevalent throughout the world (relative to other commonly used herbicides such as atrazine, imazethapyr, or glyphosate) due to at least three main reasons: (l) auxin herbicides have a complicated mode or action with multiple target sites (Kelley and Riechers, 2007), (2) weeds that evolve resistance to auxin herbicides have typically displayed a 'fitness cost', which means that the plant is less physiologically fit or less competitive in the absence of the herbicide in relation to wildtype (i.e., sensitive to 2,4-D) plants, and (3) auxin herbicides have rarely been used by themselves but are instead typically applied in tank mixtures.

- 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.

5. Impacts Resulting from the Increase of Resistant Weeds

- Assess the reasonably foreseeable impact of increased tillage, soil erosion, and herbicide use to control weeds that become resistant to 2,4-D, quizalofop, and/or glyphosate.
- APHIS provides no meaningful assessment of the costs to farmers or U.S. agriculture from the reasonably foreseeable evolution of weeds resistant to 2,4-D or glufosinate.
- Provide assessment of the impacts or costs to farmers of past herbicide resistance that has triggered patterns of weed control, the use of herbicides, and the increased cost to farmers.
- Discuss the increasing costs and labor to combat resistant weeds that persist and spread in fields.
- Because the development of herbicide-resistant weeds and volunteer corn are reasonably foreseeable impacts of 2,4-D resistant corn cultivation, the analysis needs to consider the negative impacts on conservation tillage.
- Herbicide-resistant weeds lead directly to adverse impacts on farmers, the environment and public health. Adverse impacts include the increased costs incurred by growers for additional herbicides to control them, greater farmer exposure to herbicides, consumer exposure to herbicide residues in food and water, soil erosion, greater fuel use and emissions from increased use of mechanical tillage to control resistant weeds, environmental impacts from herbicide runoff, and in some cases substantial labor costs for manual weed control. These are some of the costs of unsustainable weed control practices, the clearest manifestation of which is evolution of herbicide-resistant weeds.
- 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. 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.
- 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.
- 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.

6. Weed Resistance Management

- Evaluate in detail the farmer use of resistant-weed mitigation measures or effectiveness of the mitigation measures.
- Provide an assessment of weed resistance stewardship, including the flaws of past stewardship plans or how they might be improved.
- APHIS failed to consider that the value of crop rotation for suppressing weeds is undermined when rotated crops are resistant to the same herbicides.
- 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.

7. Volunteer Corn/Soybean

- Estimate the cost to farmers for controlling volunteer DAS- 40278-9 corn which will become a problematic "resistant weed" in its own right by virtue of its resistance to two to four herbicides.
- Assess the dispersal of herbicide resistance traits via pollen or seed dispersal or its implications for stewardship practices.
- Dow discusses the potential for DAS-68416-4 soybean to cross with soybeans possessing other herbicide resistance traits to produce soybean volunteers with resistance to additional herbicides. Indeed, three different GE soybean events with resistance to dicamba (Monsanto), the HPPD inhibitor isoxaflutole (BASF), and imidazolinone herbicides (Bayer) are presently pending deregulation decisions by USDA (APHIS Pending Dereg 2012). Such crossing could result in volunteer soybeans resistant to four or more classes of herbicide.
- Soybean is primarily a self-pollinating crop, but the potential for perhaps considerable cross-pollination is suggested by the frequency with which pollinators – bees (honeybees and wild bees), wasps, and flies – visit soybean fields (Anonymous 2012, O'Neal & Gill 2012). Insect pollinators are known to effect pollination at considerable distances from the source plants, including from primarily self-pollinating crops (e.g. Pasquet et al. 2008).
- Even if soybean cross-pollination is relatively uncommon, it could give rise to problematic volunteer HR soybean control problems where it does occur, with the adverse consequences noted above.
- 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.
- 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.

8. Impacts on Organic and Non-GE Crops

- Assess the socioeconomic impacts of transgenic contamination on the entire organic industry.

- Complete a full analysis of the economic impacts due to GE contamination for organic and non-GE growers. GE crops can cross-pollinate with non-GE crops, contaminating conventional or organic crops. This contamination can result in a rejection of loads by the Organic Trade Association, resulting in economic losses for farmers, previously estimated at 40 million dollars annually. APHIS needs to reevaluate the effect of DAS-40278-9 corn on organic corn, as cross-pollination may pose a plant pest risk.
- Include an analysis of the cost of testing, tracing and separating DAS- 40278-9 corn and DAS-68416-4 soybeans to avoid contamination of non-GE crops and the subsequent impact on exports.
- Assess the potential impacts of deregulating 2,4-D-resistant corn on the supply of organic corn feed.
- Genetic admixture is an environmental concern that can cause the alteration of a plant's deoxyribonucleic acid (DNA) by transmitting a GE gene to a non-GE plant, in turn, causing a loss of biodiversity that could result in the potential elimination or reduction of conventional and organic corn varieties.
- Evaluate the impact of deregulating 2,4-D resistant corn and the subsequent transgenic contamination on both the public's and the grower's ability to choose non-GE corn; and consider individual choice or the social or economic impact of eliminating that choice.
- Evaluate the impacts of GE admixture through feed and food products on animal and human food chains, and related human health impacts.

9. Cumulative Impacts

- Address the potential cumulative environmental impacts resulting from reasonably foreseeable future crops with "stacked" genetic traits.
- Consider the cumulatively significant impacts of all synthetic auxin herbicide-tolerant crops.
- Impact analysis should consider drift not only from 2,4-D resistant corn, but also the use of 2,4-D in other reasonably foreseeable 2,4-D-resistant GE crop systems that are now pending before APHIS.
- Assessment of the resistant weed impact of DAS-68416-4 soybean grown in rotation with Enlist™ corn.
- Dow plans to sell this GE 2-4,D soy "stacked" with resistance to glyphosate and glufosinate herbicides, yet neither Dow nor USDA has analyzed the potential synergistic or cumulative impacts that these planned combinations pose. Glufosinate has both reproductive and neurological toxicity to mammals, and on this basis is slated to be banned in the EU by 2017.
- Assess the cumulative impacts of growing multiple HR crops, including changes in herbicide use patterns, weed resistance, human health effects, environmental effects from herbicide drift and runoff, and harm to wildlife, in particular threatened and endangered species and their critical habitats.
- APHIS must take into account any reasonably foreseeable impacts of conferring multiple herbicide-resistant traits via stacking of different resistance traits in the same crops, growing crops with different resistance traits in the vicinity of each other within a given year, and using the same resistance traits in rotation crops, for example.

The following issues related to herbicide use were identified from public comments. As noted, above, herbicide use is regulated by EPA. EPA is evaluating DAS' submission for their new 2,4-D choline salt formulation and will be making those assessments available to public. Therefore, these issues are listed here but for the most part are not being addressed in this EIS. When these issues are covered, they are included in the Appendices.

<u>Herbicide Use and Impacts from Herbicide Use</u>

- Examine the potential for increased use of 2,4-D, glyphosate, glufosinate, and quizalofop associated with deregulation of DAS-40278-9 corn, DAS-68416-4 soybean, and DAS-44406-6 soybean. Consider the rate applied per application, number of applications per season, and number of acres planted.
- Project the shift in herbicide use patterns associated with DAS-40278-9 corn, DAS-68416-4 soybean, and DAS-44406-6 soybean.
- USDA has not thoroughly assessed the environmental risks associated with many of these transgenic crops. 2,4-D is a volatile herbicide, which can easily drift onto nearby crops, vegetables and flowers. In fact, a comparative risk assessment found that 2,4-D was 400 times more likely to cause non-target plant injury than glyphosate.
- The transgene confers resistance to 2,4-D, glufosinate, and glyphosate, and in conjunction with the insertion site and genetic background of the host plant, determines how much 2,4-D, glufosinate, and glyphosate can be applied and when during the growing season without injuring the crop. Thus the pattern of tolerance to the herbicide(s) is event-specific and should be described by the applicant in the Petition, and the implications rigorously explored by APHIS in a robust analysis pursuant to the National Environmental Policy Act (NEPA) and the Plant Protection Act.
- Compare increased herbicide use to conventional varieties.
- APHIS must disclose and analyze the impacts of herbicides used on a deregulating DAS-40278-9 corn on both organic and conventional non-GE corn.
- Fully address impacts from the shift of use rates among different herbicides that may accompany deregulation of DAS-40278-9 corn, DAS-68416-4 soybean, and DAS-44406-6 soybean.
- Provide a detailed examination of the cumulative effects of stacking 2,4-D resistant corn with other herbicide tolerances.
- Acreage likely to shift in herbicide use from glyphosate to synthetic auxin herbicides is not identified.
- If an engineered crop is immune to injury even at rates higher than allowed by label or at later times in development, experience has shown that growers will push or exceed the label limits in situations where there is weed pressure. APHIS needs to explore the implications of removing biological constraints to herbicide use in their assessments.
- USDA must consider the biological opinion of the National Marine Fishery Service regarding 2,4-D registration.
- Benefits of 2,4-D technology for the Georgia cotton grower would include: 1) Improved weed control; 2) Prevention of additional herbicide resistance development; 3) Reduction in herbicide use; and 4) Reduction in tillage, wind erosion, and soil erosion.

- 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.
- 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.
- 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.

<u>Herbicide Use - General</u>

- Any questions or concerns about the use of 2,4-D in a 2,4-D-tolerant soybean cropping system should continue to be addressed through the authority of the Environmental Protection Agency (EPA) to regulate the safe use of registered herbicides.
- Assess potential impacts to animals in fields of DAS-68416-4 soybean in light of the foreseeable increase in exposure to herbicides and their metabolites based on realistic use scenarios and a wide range of relevant independent scientific studies in order to compare alternatives.
- Assess the potential of the Enlist™ corn and soybean systems to increase drift-related crop injury as well as potential mitigation measures.
- Assess the negative environmental impacts of pesticide drift associated with the prevalence of glyphosate-resistant weeds.
- Assess cumulative impact of a combination of herbicides on water resources, including the impacts to surface water from off-site movement of herbicides.
- APHIS should consider late, off-label treatment of crops, and include protection of insects, birds, reptiles, amphibians or other animals.
- Examine impacts that increased herbicide use in DAS-68416-4 soybean would have on those nearby habitats.
- The potential impact on the plant population diversity within treated fields of DAS-40278-9 corn and the resulting impacts to animals from those changes should be evaluated.
- Concerns about the impacts to plant and animal biodiversity in and around cornfields from increased pesticide use due to implementation of DAS-40278-9 crop systems.
- The estimated increase in herbicide use would likely jeopardize species and critical habitats protected under the Endangered Species Act (ESA). A "failure by USDA to recognize the risks of jeopardizing endangered species and adversely modifying their critical habitats would not be in compliance with the statutory requirements of the National Environmental Policy Act (NEPA)."
- Dow plans to sell this GE 2-4,D soy "stacked" with resistance to glyphosate—the active ingredient in Roundup—and glufosinate herbicides, yet neither Dow nor USDA has

analyzed the potential synergistic or cumulative impacts that these planned combinations pose.

- The ability to effectively control weeds is one of the most important factors in profitable crop production. The use of glyphosate in Roundup Ready crops was a highly cost-effective approach to weed control for many years, but heavy reliance on glyphosate-only weed control programs eventually led to the development of glyphosate resistant weeds, including marestail, waterhemp, Palmer amaranth, kochia and giant ragweed, that are difficult to control with current technologies.
- Weed management will be much more successful if post-emergence 2,4-D treatments are used in conjunction with pre-emergence residual herbicides that can provide extended control. The use of pre-emergence 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. This approach helps minimize potential for early season weed competition and provides more flexibility and better efficacy with the post-emergence treatment. The other huge benefit is that by utilizing more herbicide modes of action, the risk of developing herbicide resistant weeds is greatly diminished.

Herbicide Use - 2,4-D

- Assess impacts associated with the potential increases in use of 2,4-D, quizalofop, and their metabolites on non-target animal communities, particularly on the honeybee population.
- Thoroughly evaluate the likely increase in 2,4-D application, along with the associated environmental and public health impacts.
- Adequately account for the unique risks associated with 2,4-dichlorophenoxyacetic acid (2,4-D) herbicides.
- Evaluate health risks posed by drift of 2,4-D onto unsuspecting victims. There is no worse herbicide for drifting long distances and damaging fruit and vegetable plants than 2,4-D, and the introduction of these resistant varieties will make it far more likely that such drift will be occurring with increasing frequency in the future. For some growers, it will make their livelihoods untenable and for homeowners in the country, they will see increasing damage of their gardens and trees of 2,4-D drift.
- 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.
- 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 2,4-D can be prevented through proper stewardship, application techniques, equipment settings and consideration of environmental conditions during application, such as wind speed….. newer 2,4-D formulations have been developed to substantially reduce volatility compared to first-generation 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 2,4-D label, including a wind-directional buffer when sensitive areas are present, and the use of low volatility 2,4-D formulations.
- Adequately assess the potential for an increased health risk to farmers and farmworkers using 2,4-D.

- APHIS needs to reconsider potential risks to animal communities from eating DAS-68416-4 soybean tissues or drinking runoff containing residues of 2,4-D and the unique metabolites.
- The developer in the future may petition the EPA for an increased tolerance for 2,4-D simply because residues increase with increased 2,4-D use, and that APHIS should consider the health implications of such higher levels of 2,4-D likely to be found in food. USDA must consider the effects that higher 2,4-D residues in food would have on human health.
- Account for the risks associated with 2,4-D and their severity relative to the potential harm associated with other herbicides.
- Increase in 2,4-D use would increase the amount of herbicide in surface waters, adversely impacting drinking water quality. This will have implications for fragile wetland areas, especially those under conservation.
- Impacts need to be assessed not only for the direct toxicity of the herbicides (2,4-D and quizalofop) and their metabolites on animal communities, but also for animals that may be indirectly exposed by over-spraying, brushing up against newly sprayed foliage, or feeding on corn leaves that may receive a higher dose of herbicide, as well as drinking surface water potentially impacted from surface runoff containing the herbicides.
- 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).
- 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.

<u>Herbicide Use – Glufosinate</u>

- Analyze the health impacts stemming from the expected increase in use of glufosinate.
- Glufosinate poses significant ecological risks to non-target plants and animals and the implications from increased use as a result of the determination of nonregulated status of DAS-68416-4 Soybean should be included in the EA.
- Analyze the potential impact from the metabolite of glufosinate, methylphosphinicopropionic acid (MPPA), which could also pose human health risks, especially to pregnant women and their fetuses. Research should be completed on this metabolite to ensure that it will not be detrimental to wildlife, especially those plants and animals protected by the Endangered Species Act.

<u>Herbicide Use – Quizalofop</u>

- Need complete information on the environmental impacts of 2,4-D and quizalofop.
- Perform human health assessment of the occupational exposure to quizalofop
- Assess impacts associated with the potential increases in use of 2,4-D, quizalofop, and their metabolites on non-target animal communities, particularly on the honeybee population.

- Impacts need to be assessed not only for the direct toxicity of the herbicides (2,4-D and quizalofop) and their metabolites on animal communities, but also for animals that may be indirectly exposed by over-spraying, brushing up against newly sprayed foliage, or feeding on corn leaves that may receive a higher dose of herbicide, as well as drinking surface water potentially impacted from surface runoff containing the herbicides.
- Synergistic effects of the combined use of 2,4-D and quizalopfop have not been considered for the increased ecological risks.

Herbicide Use - Dioxin Impurities in 2,4-D

- USDA and EPA should conduct an assessment of the greatly increased exposure to dioxins that would be triggered by Enlist™ soybeans and corn in light of EPA's ongoing review of dioxin toxicity, both cancer and non-cancer risks.
- Include analysis for the health impacts from dioxin contamination in 2,4-D. Impacts to human reproduction and to workers from exposure to dioxin (especially 2,3,7,8-TCDD) have not fully been considered and analyzed and request that these impacts be analyzed.
- Assess potential short- and long-term impacts on animals from the dioxin impurities, as well as 2,4-D.
- Evaluate potential effects of the dioxin impurities on treated pollen from DAS-40278-9 corn on honeybees and other animal populations that are in contact with/collect pollen.
- Need cumulative effects on human health and environment from dioxin and potential effects on surface water quality and non-target plants and animals (including endangered species).
- Assess the increased dioxin emissions and exposure associated with incineration of unrinsed 2,4-D containers that would result from the vastly increased use of 2,4-D with Enlist™ soybeans and corn.
- USDA should conduct or commission independent dioxin testing of 2,4-D formulations.

Herbicide Use - 2,4-D Metabolites

- APHIS failed to fully consider the impacts of increased 2,4-D use, related DCP-conjugates, and increased glyphosate.
- APHIS needs to consider the impacts to human health of exposure to DCP and DCP conjugates that are a result of the activity of the engineered AAD-12 enzyme in DAS-68416-4 soybean.
- The types and levels of DCP and DCP conjugates in DAS-68416-4 soybean forage and hay after 2,4-D applications need to be compared with independent research on 2,4-D and DCP metabolism in conventional soybeans (Pascal-Lorber et al. 2003), with any differences explained.
- DCP conjugates were not included in the evaluation of whether DAS-40278-9 corn will meet tolerance requirements in forage and fodder, and suggested that, if DCP conjugates had been included, with the assumption of similar toxicity to free DCP, tolerance levels would be exceeded
- APHIS should consider levels of all expected toxic residues and metabolites; and assess impacts to non-target organisms of the novel, potentially toxic constituents expected to

result when 2,4-D with DAS-68416-4 soybeans under a variety of anticipated application scenarios.

- Evaluate potential impacts of pollen containing residues and metabolites not found in conventional pollen that might make it toxic to organisms that come in contact with it.
- APHIS did not take into account independent research and Dow studies showing that potentially toxic metabolites do occur as a result of the engineered trait. USDA should carefully consider the impacts of the accumulation of novel molecules with similarity to known toxins in DAS-68416-4 soybean. APHIS needs to know if the AAD-12 enzyme alters *metabolism* in DAS-68 416-4 soybean such that the plants have a new composition after 2,4-D is used, and thus have the potential to harm non-target species. APHIS must consider whether DCP and its conjugates are present in soluble fractions of DAS-68416-4 soybeans after AAD-12 enzyme acts upon 2,4-D in order to fully assess the impacts to non-target organisms and on human health.
- APHIS should consider whether DCP and its conjugates are present in soluble fractions of DAS-40278-9 corn after the AAD-1 enzyme acts upon 2,4-D in order to fully assess the "plant pest risks" to non-target organisms
- Consider the possible toxicity of the metabolites that are present in DAS-40278-9 corn exposed to herbicide substrates of the ADD-1 protein, and the impact of this toxicity to listed species requiring formal USFWS consultation.
- Information on the herbicide residues and metabolites in plant tissues from the time of application through post-harvest should be available for review by APHIS and the public

Table 2-1. EIS Public Scoping Comments Submitted Online

Comment #	Comment ID	Commenter	Comment Excerpt	Topic Area
1	APHIS-2013-0042-0002	Jean Public	The American Public wants this permit denied. Monsanto and Dow are releasing harmful items to the American Public with these unregulated soybean and corns.	N/A
2	APHIS-2013-0042-0003	Carl Bausch	Undertaking the National Environmental Policy Act process for the identified petitions is both wasteful and superfluous.	N/A
			Granting (with or without conditions) or denying a petition does not constitute “alternatives” to be considered in the NEPA process; rather, they are decision options for the agency. Alternatives that must be considered under NEPA relate directly to the purpose and need for a proposed action, the statement of which, again, is missing from the notice.	
3	APHIS-2013-0042-0004	Illinois Farm Bureau (IFB) – Philip Nelson	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.	
4	APHIS-2013-0042-0006	U.S. Department of Interior, National Park Service – Roxanne Runkel	The National Park Service supports the objective identified or development of science that addresses the Environmental Issues for Consideration identified o pages 28799 [of the Federal Register notice]. The NPS is 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.	Herbicide use - effects on soil and water
5	APHIS-2013-	Louis Metzman	I implore you to not approve release of 2,4-D resistant plants. I have	Herbicide drift

Comment #	Comment ID	Commenter	Comment Excerpt	Topic Area
	0042-0007	(grower)	had collateral damage from 2,4-D drift to my fruit orchard and my 5 acre tree planting and to landscape plants at my house 6 times over the past 14 years - this is a very dangerous herbicide that tends to vaporize and cause damage to neighboring plants. This damage is all too common with this particular herbicide. Forester Mike Warner, with Mike Warner ARBORTERRA Consulting, tells me he has been asked to check on 15 claims of what he feels are 2,4-D damage so far this year. I can only imagine the damage we will see with more widespread use of this very dangerous chemical. It causes damage very far away to plants - how will we know who did the damage, and how will we hold them responsible? And, with no accountability, they can spray with impunity. Also, perhaps in future years we will find out it was also harmful to the people who are also exposed to it.	
6	APHIS-2013-0042-0009	David Ortman	• The EIS should include an alternative prohibiting field testing of herbicide resistant corn and soybeans. • The EIS should provide an estimate and analysis of the quantities of 2,4-D and glyphosate that would enter watercourses and waterbodies, including within our nation's coastal zone, under alternatives that would ban herbicide resistant corn and soybeans; that would continue herbicide resistant corn and soybeans as regulated articles; and under Dow AgroSciences LLC's request for nonregulated status. • The EIS should set out a testing protocol for determining the level of Glyphosate and 2,4-D in water bodies in order to establish a baseline for future evaluations of Glyphosate and 2,4-D use due to "herbicide resistant" corn and soybeans. • The EIS should set out a testing protocol for determining the level of Glyphosate residues in shellfish and fish to assure that residue tolerances are not exceeded and to ensure that	

Comment #	Comment ID	Commenter	Comment Excerpt	Topic Area
			2,4-D residues are not present.	
7	APHIS-2013-0042-0011	Carl Bausch	• Where specifically in chapter 104 of title 7 of the United States Code is APHIS authorized to regulate the introduction (importation, interstate movement, or release into the environment) of genetically engineered organisms and products? • Why does APHIS feel it is necessary to undertake a costly (to industry and taxpayers), unnecessary environmental impact statement process when a conventional risk assessment establishes that the organism is not a plant pest and that APHIS therefore lacks jurisdiction (see my earlier comment for explanation)? • 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 unanswered, but oft-	

Comment #	Comment ID	Commenter	Comment Excerpt	Topic Area
			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.	

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			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.	
	APHIS-2013-0042-0010	Carl Bausch	Duplicate of comment APHIS-2013-0042-0003	N/A
8	APHIS-2013-0042-0012	Tess Cramer	Once GMO's are introduced into the environment, there is no way to recall them OR their genetic pollution to organic crops.	N/A
9	APHIS-2013-0042-0013	Arthur Tesla	These plants will turn up as volunteer weeds in other farmers fields	Plant Communities
10	APHIS-2013-0042-0014	MS	Lower glyphosate and Round Up now. Do not do what you're planning on doing, EPA and raise the limits. It's already at very toxic levels and raising the limits of poison is not only going to be doing the exact opposite of what you're supposed to be in your job but the very exact opposite. Do not allow your ethics and conscience from deep within to be override by greed and money. Do what's right for the environment and protect it.	Herbicide use – glyphosate limit
11	APHIS-2013-0042-0015	Renae Hockaday	• Why is nonregulation even being considered? • There's too much impact on people's health and neighboring (organic and non) producers. • To put GMO into foods without being listed as GMO in the ingredients is blatant dishonesty. At the very least products from GMO must be listed in the ingredients label.	FDA - labeling
12	APHIS-2013-0042-0016	Jordan Scheibel (grower)	• There is no worse herbicide for drifting long distances and damaging fruit and vegetable plants than 2,4-D, and the introduction of these resistant varieties will make it far more likely that such drift will be occurring with increasing frequency in the future. For some growers, it will make their livelihoods untenable and for homeowners in the country, they	Herbicide use - drift

Comment #	Comment ID	Commenter	Comment Excerpt	Topic Area
			will see increasing damage of their gardens and trees of 2,4-D drift. • The introduction of these varieties is an implicit admission that glyphosate resistant varieties are failing, weeds are becoming resistant, and stronger herbicides are needed. I shudder to think what herbicides will be necessary in 5 or 10 years as herbicide resistance continues to grow and the regulatory bodies that are supposed to be considering the long term implications of introducing these herbicide resistant varieties continue to rubber stamp them.	
13	APHIS-2013-0042-0017	Martin Johnstone	As there is no actual requirement for GM food, what makes you think you have the right to impose it upon the people without asking them if they want it? Is this the case: Ask the people if they want GM products. You will never ask, because you know the answer will be no. Therefore you continue without asking, forcing people to 'accept' your products? You don't have the right to do that.	N/A
14	APHIS-2013-0042-0018	Arthur Tesla	History has shown these crops will appear as volunteer weeds in farmers fields and be difficult to control because they are herbicide resistant/ They are plant pests! They are also plant pests to consumers who don't want to eat these Dangerous genetically engineered foods.	Plant communities - volunteers
15	APHIS-2013-0042-0019	Anonymous Against Crop Oppression	America does not want to purchase biotechnology as a food source or fuel source. Europe does not want to purchase biotechnology as a food source or fuel source. The rest of the world does not want to have biotechnology as a food or fuel source imposed on them. There is no market for genetically modified, genetically engineered, genetically enhanced or altered food crops used for food or fuel.	N/A
16	APHIS-2013-0042-0020	Klaas Raater	Please consider the environmental impact of every country in the world hating America for its corporate fascism. I am already boycotting every American product. The same goes for my family and my friends. You have alienated yourself from the rest of the world. Way to go America!	N/A

Comment #	Comment ID	Commenter	Comment Excerpt	Topic Area
			And i will not even spend a single holiday at your country anymore for the rest of my life. You want war with the rest of the world? No problem, you got it! I'd rather die than eat your Frankenfoods!	
17	APHIS-2013-0042-0021	Doris Headley	For some time now, knowing that what I purchase was produced in North America or the UK was my only safety net. If you take that away, I shudder to think what I could be consuming.	N/A
18	APHIS-2013-0042-0022	Marina Vrouvlianis	Stop poisoning the world	N/A
19	APHIS-2013-0042-0023	Tanya Molyneux	Weeds are becoming resistant to the chemicals we treat them with and the answer to just apply more herbicide is poisoning our ground and drinking water, the food that we feed to our animals and the food we are eating. Stop the insanity before its too late for the human race.	N/A
20	APHIS-2013-0042-0024	JS Deran	I am against any increase in herbicide resistant corn and soybeans. I don't think these crops should be allowed at all. I have seen the non-biased reports from France and read of problems on farms and ranches in many countries that used GE crops. I think that all the herbicide resistant corn and soybeans should be banned from use. There is so much evidence that shows these crops to be detrimental to people AND animals that to allow further use should be criminal.	N/A
21	APHIS-2013-0042-0025	Donna Deran	Weeds treated with Glyphosate have become stronger from exposure so now they want to treat the SUPER weeds with more Glyphosate and then what will we have? Toxic wastelands with FRANKENWEEDS that nothing can kill!!! When will this madness stop? Our land and food are already contaminated with this chemical and now they want to make it worse by increasing allowable toxic exposure!!! JUST SAY NO !!! The EPA's first job is supposed to be protecting people from harmful toxins, not selling us out for the BIG BUCKS, from BIG CHEMICAL companies.	N/A
22	APHIS-2013-0042-0026	Dale Moore - American Farm Bureau Federation (Farm Bureau)	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	Oppose preparation of EIS

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			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.	
23	APHIS-2013-0042-0027	Drew Kershen (The University of Oklahoma, College of Law)	• If these seeds and plants are not plant pests, USDA-APHIS should deregulate without further study. • In the Notices for both docket items, USDA-APHIS indicates that concerns about weed resistance related to herbicide usage is the driver behind the Notice to complete EISs. Yet, under statutory authority, EPA, through FIFRA, has the authority to regulate herbicides, including taking into account the environmental impact of weed resistance issues. EPA has exercised its authority under FIFRA and has authorized dicamba and 2,4-D has herbicides. When EPA exercises its authority under FIFRA, the EPA has performed an environmental analysis that is "functionally equivalent" to an EIS under NEPA.	Oppose preparation of EIS
24	APHIS-2013-0042-0028	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.	
	APHIS-2013-0042-0028	A. Stanley Culpepper -	• Herbicide-resistance has significantly changed agriculture forever in the Southeast; especially for cotton growers. To	

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		University of Georgia, Weed Scientist, and grower	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.	
	APHIS-2013-0042-0028	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); however, weed management systems including these herbicides are more consistently effective than current standards (Braxton et al.	

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			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	

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			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 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	

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			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.	
	APHIS-2013-0042-0028	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 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	

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			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.	
25	APHIS-2013-0042-0029	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 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"). ASTA and its members support a science-based, federal environmental review process for new biotechnology seed products. That process must recognize the distinct products, federal actions, and statutory mandates of the regulatory agencies involved. We are concerned, however, that by basing its decision to prepare EISs on the potential environmental effects of the herbicides rather than the associated herbicide tolerant crops, APHIS has failed to recognize those	Oppose preparation of EIS

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			distinctions. Moreover, the EIS preparation process will unnecessarily delay issuance of determinations of nonregulated status for these crops with no additional benefit to the environment.	
26	APHIS-2013-0042-0030	Danny Murphy - American Soybean Association	Soybean farmers need new technologies such as 2,4-D-tolerant soybeans to increase yields, manage weed resistance and maintain profitability. In light of the recent ruling by the Ninth Circuit Court 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 – ASA strongly urges USDA to reconsider its decision to require an EIS. According to the Notice of Intent, USDA's basis for conducting the EIS all relate to herbicide uses, and the recent Ninth Circuit decision made clear the Framework[1] under which regulatory authority is allocated among USDA, Food and Drug Administration (FDA) and EPA, and where USDA has no jurisdiction over herbicides nor for consideration of herbicide impacts related to its obligations under the Plant Protection Act. Conducting a time-consuming analysis already within the responsibilities of other federal agencies will cause a significant delay in bringing needed technologies to growers and is not consistent with the Plant Protection Act and the Administrative Procedure Act. The Ninth Circuit decision leaves no doubt that USDA does not need to analyze herbicide resistance or other impacts related to herbicide use in connection with petitions to deregulate herbicide-tolerant crops. It remains EPA's responsibility to prescribe the conditions in which it may be used. Further, the Ninth Circuit made clear that APHIS' regulatory jurisdiction ceases once APHIS determines that a crop is unlikely to	Oppose preparation of EIS

[1] Congress allocated regulatory authority of biotechnology derived crops under the Coordinated Framework. 51 Federal Register 23302-09. June 26, 1986.

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			pose a plant pest risk. The Court ruled, "If APHIS concludes that the presumptive plant pest does not exhibit any risk of plant pest harm, APHIS must deregulate it since the agency does not have the jurisdiction to regulate organisms that are not plant pests." APHIS already has determined that Enlist™ soybeans are unlikely to pose a plant pest risk. Thus, proceeding with an EIS would be contrary to the decision of the Ninth Circuit.	
	APHIS-2013-0042-0030	Danny Murphy - American Soybean Association	With mounting pressure to manage resistant weeds, soybean growers need new multiple-mode-of-action weed management tools not only to preserve yields, but also to maintain the economic and non-pecuniary benefits realized from using the glyphosate-tolerant systems. 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 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 introduction of soybeans tolerant to 2,4-D 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.	Oppose preparation of EIS Soybean growers need new multiple-mode-of-action weed management tools Soybeans tolerant to 2,4-D will allow an additional mode of action
	APHIS-2013-0042-0030	Danny Murphy - American Soybean Association	While ASA appreciates concerns about off-target movement of 2,4-D, 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 2,4-D can be prevented through proper	

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			stewardship, application techniques, equipment settings and consideration of environmental conditions during application, such as wind speed. ASA is pleased that newer 2,4-D formulations have been developed to substantially reduce volatility compared to first-generation 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 2,4-D label, including a wind-directional buffer when sensitive areas are present, and the use of low volatility 2,4-D formulations. ASA believes that when recommended label practices are followed, farmers of various crops can co-exist and prosper.	
27	APHIS-2013-0042-0031	Wenonah Hauter – Food & Water Watch	The USDA's Environmental Impact Statement, must include, at a minimum: • An analysis on how 2,4-D-tolerant corn and soybeans will facilitate more use of 2,4-D, leading to the evolution of 2,4-D-resistant weeds and the abandonment of conservation tillage practices; • Data on the levels of dioxin that will likely be released due to an increase in 2,4-D use, and the potential cumulative effects on human health and the environment; • Studies on the effects of increased application of 2,4-D on surface water quality and impacts on non-target plants and animals, including endangered species; • A hard look at how the volatility of 2,4-D will result in more occurrences of pesticide drift into neighboring fields, affecting plant health and costing nearby farmers; • Research on how the ingestion of foods manufactured from these crops will affect human health and how the continued use of the herbicide in agriculture could endanger agricultural workers and the general public; and • A detailed examination of the cumulative effects of stacking	• Herbicide use • Evolution of 2,4-D-resistant weeds • Human health – ingestion • Cumulative effects of stacking on cost of contamination and 2,4-D- and glyphosate-resistant weeds to non-GE farmers

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			2,4-D-tolerant corn and soybeans with other herbicide tolerances, including the costs of contamination to non-GE farmers and the costs that 2,4-D and glyphosate resistant weeds will impose on these growers.	
	APHIS-2013-0042-0031	Wenonah Hauter – Food & Water Watch	USDA's Environmental Assessments for 2,4-D-tolerant corn and soybeans were inadequate for these genetically engineered traits because they failed to thoroughly cover the cumulative effects that the use of these chemicals under realistic projections. The chemical treadmill model cannot be continued indefinitely. Weed resistance to these chemicals will continue to abound and the application of more noxious herbicides will increase exponentially. These new corn and soybean varieties are not only unsafe and inefficient, but are a completely unsustainable solution to the broader problems caused by high-input production agriculture and associated environmental pressures.	Herbicide use
28	APHIS-2013-0042-0032	Pam Johnson - National Corn Growers Association	USDA has not offered any new scientific reason to justify the decision to prepare an EIS. APHIS identifies two issues for consideration in an EIS, namely possible development of weed resistance and increased herbicide use. However, APHIS' regulatory authority is based in the Plant Protection Act and the agency's oversight is limited to evaluating the potential for the GE plant to pose a plant pest risk. Triggering an EIS based on the justification stated in the Federal Register notice is therefore outside the scope of APHIS' jurisdiction. The U.S. Environmental Protection Agency (EPA) has jurisdiction over pesticide use under the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA). In addition, a recent ruling in the U.S. Court of Appeals for the Ninth Circuit (*Center for Food Safety v. Vilsack*, 9th Cir. May 17, 2013) explicitly clarified USDA is not responsible for assessing herbicide use or resistance development under the PPA. Growers need new tools for weed management. With additional modes of action, growers will be able to more effectively manage	Oppose preparation of EIS

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			glyphosate-resistant and conventional weeds. Based upon APHIS' assessment, 2,4-D tolerant corn and soybeans do not pose a plant pest risk. Therefore, USDA should immediately convey nonregulated status on these traits and make them available to U.S. growers.	
29	APHIS-2013-0042-0033	Dallas Peterson - Kansas State University Department of Agronomy	The ability to effectively control weeds is one of the most important factors in profitable crop production. The use of glyphosate in Roundup Ready crops was a highly cost-effective approach to weed control for many years, but heavy reliance on glyphosate-only weed control programs eventually led to the development of glyphosate resistant weeds, including marestail, waterhemp, Palmer amaranth, kochia and giant ragweed, that are difficult to control with current technologies. New technologies such as 2,4-D tolerant crops would provide an additional tool that could be incorporated into an integrated weed management program to improve overall weed management, including glyphosate resistant weeds.	
	APHIS-2013-0042-0033	Dallas Peterson - Kansas State University Department of Agronomy	The introduction of 2,4-D tolerant soybeans would likely increase the potential for developing 2,4-D resistant weeds, but I feel the potential benefits of helping to control existing herbicide resistant weeds far outweighs the risk of developing 2,4-D resistant weeds. I also believe the risk of developing 2,4-D resistant weeds if this technology is introduced is much lower than what has occurred with glyphosate in recent years. Glyphosate plus 2,4-D is not a viable stand-alone approach to successful weed management. Timing is very critical to effective control of most weeds with postemergence herbicides. 2,4-D needs to be applied to small actively growing weeds for good control. 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 postmergence herbicides like glyphosate and 2,4-D. Consequently, weed management will be much more successful if postemergence 2,4-D treatments are used in conjunction	

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			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 more herbicide modes of action, the risk of developing herbicide resistant weeds is greatly diminished. Finally, I believe 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.	
30	APHIS-2013-0042-0034	Cathleen Enright - Biotechnology Industry Organization (BIO)	In developing its implementing biotechnology regulations under the Federal Plant Pest Act and Plant Quarantine Act, APHIS acknowledged that its oversight of the Introduction of genetically engineered (GE) plants and other organisms would be In accordance with NEPA. The assessment of potential environmental effects has always been an important element of the federal regulatory process for products of biotechnology whether for plants and other organisms under NEPA at APHIS or for pesticides under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) at EPA. The basis for the APHIS Notices, however, was not any potential environmental impacts associated with the plants under review. Rather, the Notices identify two issues for consideration In an EIS - the potential selection of herbicide resistant weeds and increased herbicide use. As discussed in greater detail herein, the law is clear that potential impacts associated	Oppose preparation of EIS

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			with herbicide use are EPA's responsibility under FIFRA and are neither subject to APHIS's jurisdiction under the Plant Protection Act (PPA) nor an appropriate basis for preparation of an EIS for an action proposed under the PPA. BIO and its members are also concerned that the decision to prepare EISs for 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. APHIS's regulations require a petition for determination of nonregulated status to either be approved in whole or in part or denied within 180 days of the Agency's receipt of the completed petition. Yet, the earliest deregulation petition for the subject crops was filed with APHIS nearly four years ago and declared complete shortly thereafter, and none of the pending petitions for which an EIS would be prepared has yet to be resolved. APHIS estimates completing the two EISs in the summer of 2014 at the earliest, nearly five years after the earliest deregulation petition was filed with APHIS and over four years after APHIS's own regulatory deadline. 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	

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			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.	
31	APHIS-2013-0042-0035	- Agricultural Retailers Association - American Farm Bureau Federation - American Seed Trade Association - American Soybean Association - American Sugarbeet Growers Association - Biotechnology Industry Organization - National Association of Wheat Growers	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 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. Additionally, 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. Any further delay is unacceptable, particularly when APHIS's own regulations require APHIS to respond to a petition for determination of nonregulated status within 180 days of the Agency's receipt of the petition. 7 C.F.R. § 340.6(d)(3).	Oppose preparation of EIS

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		- National Corn Growers Association - National Cotton Council	Our members support a science-based, federal environmental review process for new agricultural biotechnology products. The Notices of Intent issued by APHIS, however, identify two issues for consideration in an EIS (i.e., weed resistance and increased herbicide use), both of which are subject to the sole jurisdiction of the U.S. Environmental Protection Agency ("EPA") under the Federal Insecticide, Fungicide, and Rodenticide Act ("FIFRA"). These pesticide issues are unequivocally *not* subject to APHIS's jurisdiction under the Plant Protection Act.	
32	APHIS-2013-0042-0036	Dow Agrosciences, LLC (DAS)	DAS supports a science-based, federal environmental review process for those products. That process must of necessity recognize that the crops and herbicides are subject to the jurisdiction of two different regulatory agencies operating under their own independent statutory mandates and differing environmental review standards. DAS is concerned that APHIS's planned preparation of an EIS for the determinations of nonregulated status requested by DAS for its herbicide tolerant crops fails to recognize these distinctions. Moreover, the EIS preparation process contemplated by APHIS will unnecessarily delay issuance of determinations of nonregulated status (deregulation) for these crops resulting in irreparable harm to farmers and DAS with no additional benefit to the environment. Indeed, delays inherent in the EIS preparation process will likely force many com and soybean growers to use less sustainable weed management practices resulting in soil runoff and other adverse environmental effects. Most significantly, these delays will deny growers the new tools they need to combat weeds and maximize yields. Weed resistance is a well understood scientific phenomenon that farmers must manage. [1] It is not unique to biotechnology or any other form of agriculture. Different herbicides attack weeds by different methods or "modes of action." Reliance on a single herbicide and its unique mode of action is certainly a contributor to development of weed resistance. The applications submitted to EPA by DAS and other	Oppose preparation of EIS

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			companies for use of their herbicides with the associated herbicide tolerant crops are intentionally designed to provide growers with herbicides that act by different modes of action, significantly enhancing growers' ability to address weed problems, increase yields and maintain environmentally preferable, no-till and low-till agricultural practices. Delays inherent in the EIS process will also place U.S. growers at a further disadvantage to com, soybean and cotton growers in other nations that are now completing their regulatory reviews for biotechnology-derived crops on a far more expedited basis than the United States. Finally, the decision to prepare a EIS will also be costly to DAS, forcing the company to continue producing seed under the burdensome APHIS permitting process, in addition to suffering a further delay in commercializing and offering its new herbicide tolerant crops for sale. For all of these reasons DAS objects to the preparation of an EIS for deregulation of its crops.	
33	APHIS-2013-0042-0037	Rachel Lattimore, Senior Vice President, General Counsel, Secretary - CropLife America	On May 16,2013, APHIS published in the Federal Register notices announcing its intention to conduct Environmental Impact Statements (EISs) related to several new technologies: dicamba tolerant soybeans, dicamba tolerant cotton, 2,4-D tolerant corn, and 2,4-D tolerant soybeans.[1] APHIS's declared intent to conduct these EISs focuses solely on pesticide issues regulated by the United States Environmental Protection Agency (EPA). We strongly urge you to reconsider the need for EISs for these technologies due to clear limitations on APHIS's Congressional mandate and in light of a recent ruling by the Ninth Circuit Court of Appeals clarifying EPA and APHIS's respective jurisdictions in this area.[2] 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. Congress's well-established distribution of regulatory authority over	Oppose preparation of EIS

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			agricultural technologies and recent Ninth Circuit case law establish that APHIS's proposed EISs are unnecessary, redundant, and potentially in conflict with EPA's authority. In light of these concerns and the substantial cost and delay that would be incurred due to such a review, CropLife America strongly urges APHIS to reconsider its decision to conduct these EISs.	
34	APHIS-2013-0042-0038	Steve Smith, Chairman - Save Our Crops Coalition	We urge the granting of approval for the Dow 2,4 D Enlist™ system but maintain grave concerns (as addressed in comments specifically on the dicamba petition) about the widespread use of dicamba on the environment, which prompted our original petition. Monsanto continues to promote practices that will be of great environmental risk if widespread use of dicamba is approved without the reasonable restrictions that Dow recognized and implemented.	Support approval of Dow petitions
35	APHIS-2013-0042-0039	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.	Herbicide use
36	APHIS-2013-0042-0040	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 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	

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			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.	
	APHIS-2013-0042-0040	Lee Van Wychen, Director Science Polidy - WSSA	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.	
	APHIS-2013-0042-0040	Lee Van Wychen, Director Science Polidy - WSSA	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.	
	APHIS-2013-0042-0040	Lee Van Wychen, Director Science Polidy - WSSA	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.	
	APHIS-2013-0042-0040	Lee Van Wychen, Director Science Polidy - WSSA	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.	
	APHIS-2013-0042-0040	Lee Van Wychen, Director Science Polidy - WSSA	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	

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			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. 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.	
	APHIS-2013-0042-0040	Lee Van Wychen, Director Science Polidy - WSSA	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.	
	APHIS-2013-0042-0040	Lee Van Wychen, Director Science Polidy - WSSA	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.	Herbicide use - drift
37	APHIS-2013-0042-0041	Kenneth Isley, Vice President, General Counsel, Secretary -	Dow AgroSciences LLC ("DAS") respectfully submits this petition to the United States Department of Agriculture ("USDA"), Animal and Plant Health Inspection Service ("APHIS"), amending and requesting	

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		Dow Agrosciences, LLC (DAS)	that APHIS immediately grant DAS's pending petitions for determination of nonregulated status for DAS-40278-9 Corn (Petition No. 09-233-01 p), DAS-68416-4 Soybean (Petition No. 09-349-0lp), and DAS-44406-6 Soybean (Petition No. 11-234-01 P) (collectively, the "Enlist™ Plants"). *See* 7 C.F.R. § 340.6(a). Under the unique circumstances presented here, DAS respectfully requests that APHIS: • immediately grant DAS's pending petitions for determination of nonregulated status for the Enlist™ Plants; and • immediately reconsider and withdraw its decision to prepare an EIS as to the Enlist™ Plants and terminate the NEPA process. APHIS's unwarranted delay in the issuance of determinations of nonregulated status for the Enlist™ Plants has caused and will continue to cause significant harm to American farmers and DAS. This harm will be especially acute, and irreparable, in the event that determinations of nonregulated status are not issued before the fall 2013 harvest. Thus, DAS respectfully requests that APHIS respond to this petition within the next thirty (30) days, by July 18, 2013.	
38	APHIS-2013-0042-0042	Center for Food Safety	Copy of comments submitted to USDA-APHIS under Docket No APHIS-2012-0019 (DAS 68416-4 soybean) – Comments to USDA APHIS on Draft Environmental Assessment and Draft Plant Pest Risk Assessment for Dow AgroSciences Petition (09-349-01p) for Determination of Nonregulated Status of Event DAS-68416-4: 2,4-D - and glufosinate-resistant soybean	
Attachment	APHIS-2013-0042-0043	Center for Food Safety	Copy of comments submitted to U.S. EPA - Comments to EPA on Notice of Receipt of Applications to Register New Uses of 2,4-D on Enlist™ AAD-1 Corn and Soybean	
39	APHIS-2013-0042-0044	Center for Food Safety	Copy of comments submitted to USDA-APHIS under Docket No APHIS-2012-0103 (DAS-40278-9 corn)	
40	APHIS-2013-0042-0045	Center for Food Safety	**2,4-D-resistant crops must be viewed as weed control systems** In preparing the EIS, APHIS must assess 2,4-D-resistant corn and	

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			soybeans as crop systems comprising the herbicide-resistant crop itself and associated use of 2,4-D. Monsanto describes its Roundup Ready (RR) crops as RR crop systems. Dow describes 2,4-D-resistant crops as the "Enlist™ weed control system." "System" is defined as "a set or arrangement of things so related or connected as to form a unity or organic whole,"[1] meaning there is no need for elements not encompassed by the system to accomplish its purpose. Exclusive or near-exclusive use of glyphosate as the sole weed control measure with Roundup Ready crop systems is a major factor in the epidemic of glyphosate-resistant in U.S. agriculture. A similar dynamic will be in play with 2,4-D-resistant crop systems, so they must be assessed as systems.	
	APHIS-2013-0042-0045	Center for Food Safety	**Impacts of 2,4-D-resistant crop systems on herbicide use** For all practical purposes, 2,4-D-resistant corn and soybeans eliminate the severe biological constraints on use of this herbicide with all other types of corn and soybeans ever developed or grown. Label rates of 2,4-D coincide roughly with rates that begin to cause crop damage, and the imperative to avoid crop damage is as or more effective than the label in keeping 2,4-D use within bounds. Once the crop injury constraint is lifted, there is no biological reason for the farmer to follow the label. From a modestly used pre- -emergence herbicide in soybeans and early POST herbicide in corn, 2,4-D will become one of the major herbicides for weed control in Enlist™ crop systems (likely with additional use of glyphosate, ACCase inhibitors and/or glufosinate if stacked with resistance to these herbicides). APHIS must assess the shift in 2,4-D use patterns to be expected in various 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 2,4-D crops on overall herbicide use, keeping in mind that 2,4-D would likely displace little if any glyphosate, which has a broader spectrum of activity, including (unlike 2,4-D) activity on grass	

Comment #	Comment ID	Commenter	Comment Excerpt	Topic Area
			family weeds. We refer APHIS to our comments, where CFS makes such projections.	
	APHIS-2013-0042-0045	Center for Food Safety	**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 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	

Comment #	Comment ID	Commenter	Comment Excerpt	Topic Area
			obvious factors of exclusivity and frequency of use.	
	APHIS-2013-0042-0045	Center for Food Safety	**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.	
	APHIS-2013-0042-0045	Center for Food Safety	**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	

Comment #	Comment ID	Commenter	Comment Excerpt	Topic Area
			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.	
	APHIS-2013-0042-0045	Center for Food Safety	**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.	
	APHIS-2013-0042-0045	Center for Food Safety	**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	

Comment #	Comment ID	Commenter	Comment Excerpt	Topic Area
			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.	
	APHIS-2013-0042-0045	Center for Food Safety	**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.	
	APHIS-2013-0042-0045	Center for Food Safety	**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	

Comment #	Comment ID	Commenter	Comment Excerpt	Topic Area
			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.	
	APHIS-2013-0042-0045	Center for Food Safety	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.	
	APHIS-2013-0042-0045	Center for Food Safety	**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.	
	APHIS-2013-0042-0045	Center for Food Safety	**Health impacts of increased 2,4-D use with 2,4-D-resistant crop systems** 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.	Human health – 2,4-D use
	APHIS-2013-	Center for Food	**2,4-D-resistant crops and tillage**	2,4-D-resistant

Comment #	Comment ID	Commenter	Comment Excerpt	Topic Area
	0042-0045	Safety	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.	weed development – impacts on tillage and soil erosion
	APHIS-2013-0042-0045	Center for Food Safety	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-2013-0042-0045	Center for Food Safety	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:	

Comment #	Comment ID	Commenter	Comment Excerpt	Topic Area
			- Herbicide use and changes in herbicide use patterns; - 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.	
41	APHIS-2013-0042-0046	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	
Attachment	APHIS-2013-0042-0047	Center for Food Safety	Comments to USDA APHIS on Draft Environmental Assessment and Draft Plant Pest Risk Assessment for Dupont-Pioneer's Petition (11-	

Comment #	Comment ID	Commenter	Comment Excerpt	Topic Area
			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			
Ray Gaesser	grower and First Vice President of the American Soybean Association	They [2,4-D and dicamba] 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.	Agronomic practices
		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 - cell interference) response to our own crop or our neighbor's. As the previous 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.	Herbicide use
		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.	Herbicide use
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.	N/A
		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.	Herbicide-resistant weeds

Commenter	Affiliation	Concern/Issue	
		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 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	

Commenter	Affiliation	Concern/Issue	
		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.	
		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.	

Appendix 3. Weed Management and Herbicide Use

Weed Management and Herbicide Use

Weed control programs are important aspects of corn and soybean 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 corn and soybean producers an average of 2% in yield loss per every leaf stage of delay (Knezevic, Evans 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).

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).

Table 3-1. Soybean and Corn Yield Losses Due to Weeds at Known Populations

Weed	Percent Yield Loss (%)			
	Corn		Soybean	
	(1 plant/m^2)	(5 plants/m^2)	(1 plant/m^2)	(5 plants/m^2)
Annual Broadleaves				
Giant ragweed	13	36	14	40
Lamb's-quarters	12	35	13	38
Pigweed	11	34	12	36
Cocklebur	6	22	15	41
Ragweed	5	21	10	33
Wild mustard	5	18	5	18
Velvetleaf	4	15	4	15
Lady's thumb	3	13	4	15
Wild buckwheat	2	10	4	15
Eastern black nightshade[1]	2	7	14	40
Annual Grasses				
Giant foxtail	2	10	3	12

Weed	Percent Yield Loss (%)			
	Corn		Soybean	
	(1 plant/m^2)	(5 plants/m^2)	(1 plant/m^2)	(5 plants/m^2)
Proso millet	2	10	3	12
Fall panicum	2	10	2	10
Barnyard grass	2	7	3	12
Green foxtail	2	7	2	8
Yellow foxtail	1	5	1	5
Old witch grass	1	5	1	4
Crabgrass	1	3	1	4
Volunteer corn	--	--	4	15

[1] Eastern black nightshade in soybeans reduces its quality.
Note: Crop losses assume that the weeds have emerged with the crop.
Adapted from www.wedpro75.com (Ontario Ministry of Agriculture and Food 2009)

Yield loss information on weeds at different weed and crop growth stage is available through the use of the WeedSOFT™ yield loss calculator (see http://weedsoft.unl.edu, click on "tools-calculators") (Weed Soft 2013).

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, Coble 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, IPM 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.

Chemical Control - Herbicides

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 corn 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. For pre-plant incorporated, herbicides are applied to soil and mechanically incorporated into the top 2 to 3 inches of soil before the crop is planted. In burndown, generally herbicides are used in combination such that there is no selectivity. Burndown applications in both corn 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-emergence: applied after the crop is planted, but prior to emergence of weeds. Pre-emergent herbicides are generally not effective after weeds have established. They may be used prior to or after crop emergence.
- 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. When weather complicates the timing of herbicide applications with planting, growers may plant and apply the residual herbicide in a mix with a foliar applied product (Monsanto 2010). 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, 2013). 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, 2013) :

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 3-2 provides WSSA herbicide groups with information on modes of action, chemical families, and example active ingredients and herbicides.

Table 3-2. 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
				Cyclohexanedione ("DIMs")	clethodim	Select
					sethoxydim	Poast
				Phenylpyrazoline ("DENs")	pinoxaden	Axial XL

	Site of Action Group (WSSA Group)	Site of Action	Number of Resistant Weed Species in U.S.	Chemical Family	Active Ingredient	Herbicide
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 Inhibitors	5	Photosynthesis II Inhibitors (binding sites other than 6 and 7)	24	Triazine	prometryn	Caparol
					atrazine	Aatrex
					simazine	Princep
				Triazinone	hexazinone	Velpar
					metribuzin	Sencor

	Site of Action Group (WSSA Group)	Site of Action	Number of Resistant Weed Species in U.S.	Chemical Family	Active Ingredient	Herbicide
	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 Inhibitors	8	Lipid Synthesis Inhibitors	8	Thiocarbamate	butylate	Sutan +
					EPTC	Eradicane
	15	Long-chain Fatty Acid Inhibitors	1	Chloroacetamide	acetochlor	Harness
					alachlor	Intrro
					metalochlor	Dual

	Site of Action Group (WSSA Group)	Site of Action	Number of Resistant Weed Species in U.S.	Chemical Family	Active Ingredient	Herbicide
					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, Dorrance 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 corn 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, Fjell 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, IPM 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. In general, most weeds are more easily managed in corn or soybeans than in other agronomic or horticultural crops. Good control in corn can reduce weed problems in rotational crops. 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.

Since 1991, 75% of corn planted acreage has been in some form of rotation (USDA-ERS 2010). Corn can be grown successfully in a conservation tillage system if rotated with other crops such as wheat and soybeans, which will reduce some of the problems encountered with conservation tillage (IPM 2007). Crops used in rotation with corn vary regionally and include oats, peanut, soybean, wheat, rye, and forage (USDA-APHIS 2010). Alternative rotations are an important aspect of overall management strategies, and could theoretically reduce the cycle of herbicide applications associated with corn/soybean rotations (DAS 2010). However, the impact of these rotations does not appear to have been studied in detail.

Consecutive plantings of corn frequently require at-planting or pre-plant pesticide treatments to control corn pests and pathogens as well as supplemental fertilizer treatments (IPM 2004, Erickson and Lowenberg-DeBoer 2005, Sawyer 2007, Stockton 2007). Corn-to-corn rotations also may require a change in tillage practices. Corn-to-corn cultivation may produce substantially greater quantities of field residue, requiring additional tillage prior to planting (Erickson and Lowenberg-DeBoer 2005). The increased adoption of corn-to-corn rotation, mainly in conventional and GE production systems, has been attributed to rising corn demand and prices (Hart 2006, Stockton 2007).

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 2011). 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, Owen 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, Egan et al. 2012).

A variety of strategies have been proposed to help farmers deal with glyphosate-resistant weeds (Boerboom 1999, Beckie 2006, Sammons, Heering et al. 2007, Frisvold, Hurley et al. 2009). 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, Ferrell 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.

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Appendix 4. Herbicide Use Trends and Predicted Use on Enlist™ Corn and Soybean

Herbicide Use Trends and Predicted Use on Enlist™ Corn and Soybean

In recent years, herbicide use data has generally not been publicly available. For this analysis, third party proprietary data was obtained by DAS and assumed to be "reported correctly". APHIS used this information to identify the major herbicides, herbicide sites of action, and trends in their use on soybean and corn for the past twenty years. National usage is reported using the metric treatment acres and not pounds of active ingredient used per crop. Pounds of active ingredient per crop over emphasizes herbicides that are used at high application rates (such as glyphosate, 2,4-D, and chloroacetamides) and underestimates the use of herbicides used at low application rates (such as acetolactate synthase (ALS) and acetyl-CoA carboxylase (ACCase) inhibitors). The latter herbicides may be used at rates 100 times less than the former. Treatment acres refer to the acres of land treated with a particular herbicide summed for each time the land is sprayed. For example, if one acre of land is sprayed twice with a particular herbicide, it is counted as two treatment acres for that herbicide. This metric gives a better representation of grower reliance for a particular herbicide than does pounds of active ingredient.

Corn Herbicide Use Trends

The ten most actively used herbicides used on corn, based on treatment acres and in order of use, nationwide and regionally in 2011 are shown in Table 4-1 and Table 4-2, respectively. The top 10 herbicides accounts for greater than 95% of the herbicide use on corn (Rausch, 2013). Atrazine has historically been the most widely used herbicide on corn through as late as 2007 and is still widely used. In 2007, glyphosate became the most widely used herbicide on corn and its use has continued to increase through 2011. In addition, chloroacetamide herbicides are also still widely used including acetochlor and metolachlor-S. These two chloroacetamides have largely replaced alachlor and metolachlor, which were the predominant chloroacetamides used prior to 1997. Synthetic auxins such as 2,4-D and dicamba were also commonly used prior to the adoption of RR corn. As glyphosate use increased, synthetic auxin use decreased but both dicamba and 2,4-D are now finding increased use in corn as is a third synthetic auxin, clopyralid. Presumably the increased use of synthetic auxins is in response to the increasing prevalence of glyphosate tolerant and resistant weeds. In addition, the two HPPD type inhibitors, mesotrione and isoxaflutole, are finding increased use, as is the ALS inhibitor, flumetsulam.

Also shown in Table 4-1 are the WSSA group number, chemical family name, and site of action for the ten herbicides. These ten widely used corn herbicides represent six herbicide sites of action (Group 9: EPSPS inhibitors, Group 5: Photosystem II inhibitors, Group 15: very long chain fatty acid inhibitors, Group 27: 4-HPPD inhibitors, and Group 4: synthetic auxins). For the regional data in Table 4-2, just the active ingredient and group number are shown.

Table 4-1. Top 10 Nationally Used Herbicides on Corn

Active Ingredient	WSSA Group	Chemical Family	Site of Action
glyphosate	9	Glycine	5-enolpyruvylshikimate-3-phosphate synthase
atrazine	5	Triazine	Photosystem II
acetochlor	15	Chloroacetamide	Very Long Chain Fatty Acids

Active Ingredient	WSSA Group	Chemical Family	Site of Action
metolachlor-S	15	Chloroacetamide	Very Long Chain Fatty Acids
mesotrione	27	Callistemones	4-Hydroxyphenyl-pyruvate dioxygenase
dicamba	4	Benzoic Acid	Synthetic Auxin
2,4-D	4	Phenoxy-carboxylic acid	Synthetic Auxin
clopyralid	4	Pyridine carboxylic acid	Synthetic Auxin
flumetsulam	2	Triazolopyrimidine	Acetolactate synthase
isoxaflutole	27	Isoxazole	4-Hydroxyphenyl-pyruvate dioxygenase

Source: (DAS, 2013a)

Table 4-2. Top 10 Regionally Used Herbicides on Corn

Heartland (6)		N Crescent (6)		N Great Plains (6)		Prairie Gateway (7)		Southeast (7)	
AI	**GN**	**AI**	**GN**	**AI**	**GN**	**AI**	**GN**	**AI**	**GN**
glyphosate	9	glyphosate	9	glyphosate	9	glyphosate	9	glyphosate	9
atrazine	5	atrazine	5	atrazine	5	atrazine	5	atrazine	5
acetochlor	15	metolachlor-S	15	acetochlor	15	dicamba	4	metolachlor-S	15
mesotrione	27	mesotrione	27	metolachlor-S	15	2,4-D	4	mesotrione	27
metolachlor-S	15	acetochlor	15	mesotrione	27	metaolachlor-S	15	2,4-D	4
flumetsulam	2	flumetsulam	2	isoxaflutole	27	acetochlor	15	dicamba	4
clopyralid	4	clopyralid	4	dicamba	4	mesotrione	27	rimsulfuron	2
isoxaflutole	27	dicamba	4	2,4-D	4	isoxaflutole	27	simazine	5
2,4-D	4	2,4-D	4	clopyralid	4	difluflenzopyr	19	paraquat	22
thiencarbazone-methyl	2	rimsulfuron	2	flumetsulam	2	carfentrazone-ethyl	14	nicosulfuron	2

Source: (DAS, 2013a)

Heartland: MN, IA, MO, IL, IN, KY, OH
Northern Crescent: WI, MI, PA, NJ, NY, MA, RI, CT, VT, NH, ME
Northern Great Plains: MT, ND, SD, NE
Prairie Gateway: CO, KS, OK, TX
Southeast: AS, LA, MS, AL, GA, SC, NC, TN, VA, WV, MD, DE
Numbers next to the regions represent number of sites of action in the top ten most frequently used herbicides.
AI: active ingredient
GN: WSSA group number

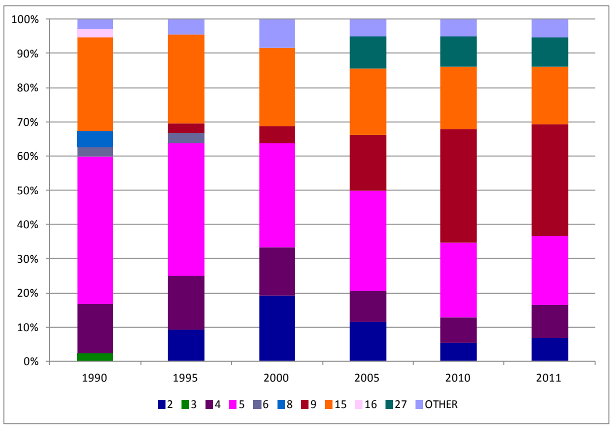
Regional herbicide use on corn largely mirrors national use. The ten most widely used herbicides represent either 6 or 7 sites of action. In all regions glyphosate and atrazine are the two most frequently used herbicides. After atrazine, chloroacetamides and then HPPD inhibitors are in most frequent use in all regions except the Prairie Gateway. In this region, synthetic auxins, dicamba and 2,4-D are the most frequently used herbicides after atrazine. There are some differences in the type of ALS inhibitor used between regions. The Prairie Gateway and Northern Great Plains seldom rely on ALS inhibitors in corn. In the other areas, flumetsulam or rimsulfuron are the most commonly used ALS inhibitors. Both the Prairie Gateway and the Southeast use 7 modes of action compared to six in the other regions. In the Prairie Gateway, the seventh site of action is the PPO inhibitor, carfentrazone-ethyl, and in the South the 7th site of action is, paraquat, a PSI inhibitor which is commonly included in burndown applications.

Trends in Herbicide Use on Corn by Site of Action (SOA)

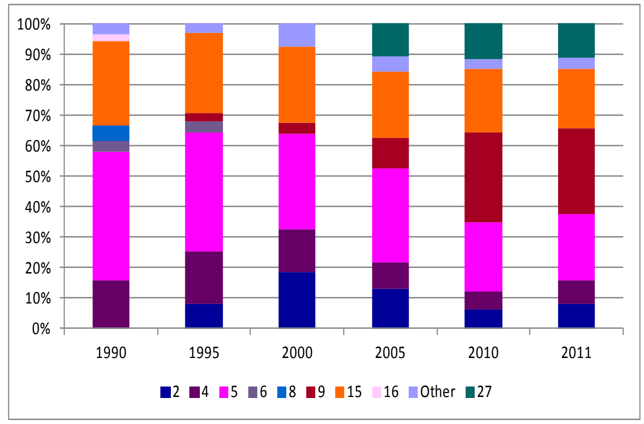
Although weed resistance may be selected against one herbicide in a group and not another (for example lambsquarters biotypes have been selected against the synthetic auxin dicamba but not 2,4-D (Heap, 2011)), there are examples where selection against one herbicide in the Group also cross selects resistance to other herbicides of that Group. For example, a biotype selected against the Group 2 herbicide imazethapyr was cross resistant to several other Group 2 herbicides including imazapic, chlorimuron, pyrithiobac, and flumetsulam (Heap, 2011). From the standpoint of managing weed resistance, it is better to rotate herbicide sites of action rather than herbicides within a site of action. Because selection of herbicide resistant weeds is a prominent issue in this EIS, the analysis of herbicide use focuses on sites of action rather than individual herbicides. Figure 4-1 shows the trends in use of herbicide sites of action on corn nationally and by region in five year increments since 1990 and in 2011. Group 9 (glyphosate) use on corn has been increasing in all regions of the country while there appear to be decreases in the use of Group 15 (chloroacetamides), Group 2 (ALS inhibitors), and Group 5 (largely atrazine) herbicides. There have been increases in Group 4 (auxin) herbicide use regionally in the Southeast and Prairie Gateway.

Corn

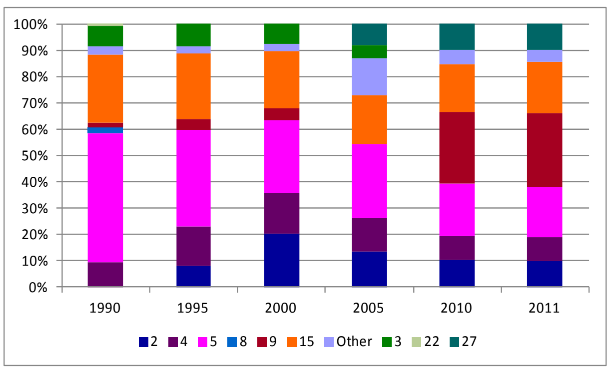
US



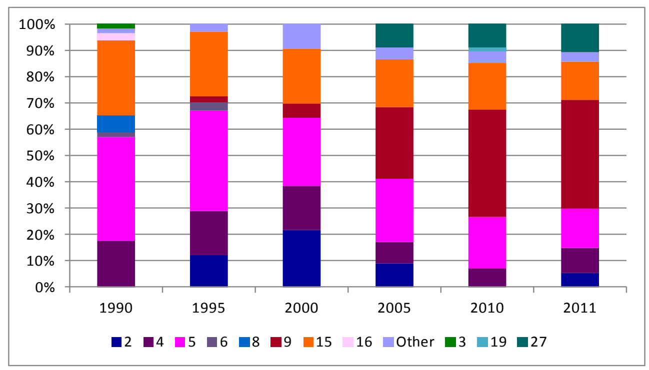
Heartland



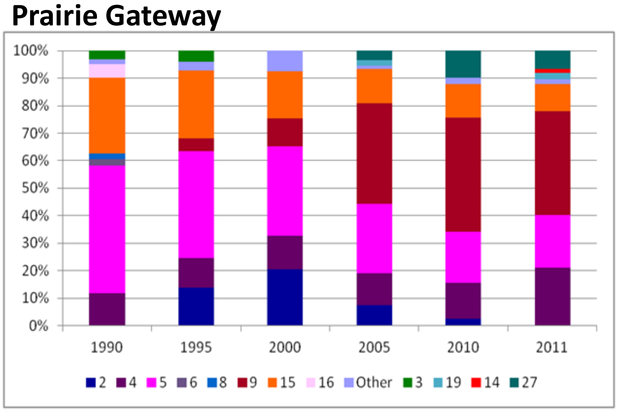
Northern Crescent



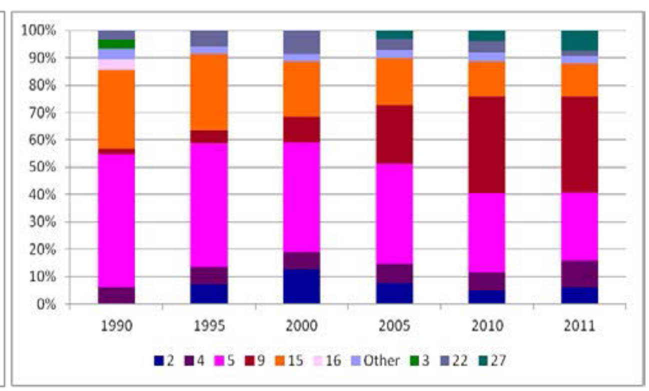
Northern Plains



Prairie Gateway



Southeast



SOA	1	2	3	4	5	6	7	8	9
Chemical Family	ACCase	ALS	Mitosis Inhib	Auxins	PS II Inhib-A1	PS II Inhib-B	PS II Inhib-A2	FALB Inhib	EPSP Inhib
SOA	**10**	**13**	**14**	**15**	**16**	**19**	**22**	**27**	**Other**
Chemical Family	GS Inhib	DOXP Inhib	PPO Inhib	VLCFA Inhib	Unknown	ATI	PS I Inhib	HPPD Inhib	

Source: (DAS, 2013d).
Classification of herbicides according to site of action.: http://www.hracglobal.com/Publications/ClassificationofHerbicideSiteofAction.aspx
Classification of Mechanism of Action http://wssa.net/weed/resistance/.

Figure 4-1. Trends in Herbicide use on corn by SOA.

Soybean Herbicide Use Trends

The trend in soybean herbicide use changed dramatically with the introduction of Roundup Ready™ (RR) soybeans in 1996. The adoption of RR soybeans allowed post emergent application of a systemic herbicide (glyphosate) that controlled most grasses and broadleaves with one product that only required an average of 1.5 applications during the course of a season. This had the added benefits of using a single rate across soil types or pH and did not require either mechanical incorporation into the soil or rainfall for activation. This proved an attractive option for farmers that allowed a simpler solution and also gave a better weed control result in many cases and at less cost. The use of glyphosate post emergent on RR soybeans worked very well because soybeans are usually planted in narrow rows which provide rapid canopy closure thereby preventing most weeds from germinating. The benefit of total post emergent weed control also supported adoption of no till practices, saving time and money for the grower while reducing soil erosion.

In 1995 prior to the introduction of glyphosate-resistant soybean, the most commonly used herbicides in soybean were: imazethapyr (44 percent of soybean acres treated), pendimethalin (26 percent), trifluralin (20 percent), glyphosate (20 percent) (for pre-plant weed control)and metolachlor (10%) (USDA-NASS, 1995). By 2001, glyphosate had become the most commonly used herbicide in soybean, used on 73 percent of soybean acres, followed by pendimethalin (10 percent), imazethapyr (9 percent), fomesafen (7 percent), and trifluralin (7 percent) (USDA-NASS, 2002). Metolachlor no longer was included in the he top 10 most commonly used herbicides on soybean.

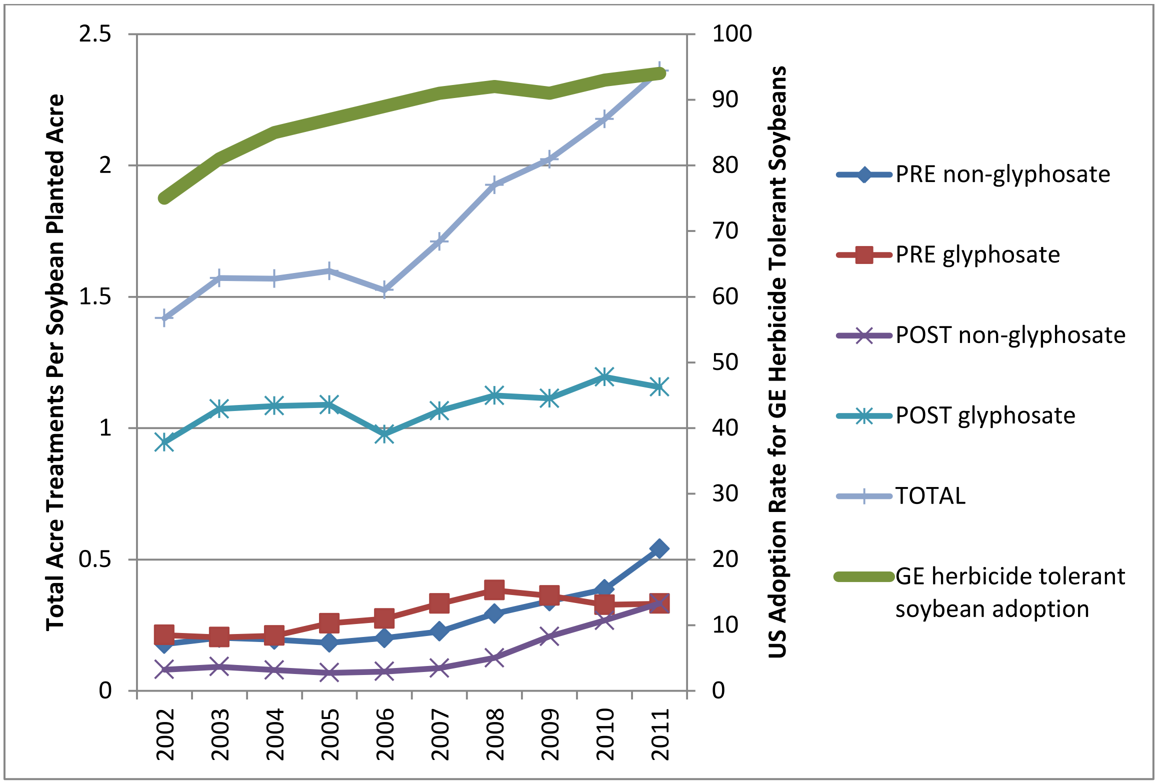
In 2006, glyphosate (all forms) continued to be the most commonly used herbicide on soybean; it was used on more than 96 percent of soybean acres and that use has largely continued to the present (Table 4-3). The next most commonly used herbicide on soybean was 2,4-D (all forms). Its use on soybean for pre-plant weed control has been steadily increasing since 2008 and in 2011 it was used on more than 12 percent of soybean acres.

Table 4-3. Estimated 2,4-D, Glyphosate, and Glufosinate Use in Soybean, 2008-2011

Year	Total Soybean Acres	2,4-D		Glyphosate		Glufosinate	
		(percent acres treated)	(lbs/acre)	(percent acres treated)	(lbs/acre)	(percent acres treated)	(lbs/acre)
2008	74,404,953	7	0.54	96	1.32		
2009	77,584,979	10	0.48	94	1.30	0.3	0.46
2010	78,725,007	10	0.53	94	1.38	1.1	0.52
2011	74,835,007	12	0.55	96	1.40	1.3	0.53
2012	75,939,995	NA	NA	NA	NA	3.9	0.51

NA– Not Available
Source: (DAS, 2012c)

Although glyphosate use on soybean has remained fairly constant, since 2006, there has been a trend to use non glyphosate herbicides for both pre- and post-emergent applications, as depicted in Figure 4-3. As noted in Table 4-3, glufosinate use has also been increasing as more growers use soybean with the LibertyLink® trait. Between 2011 and 2012, glufosinate use increased 3 fold from 1.3% to 3.9% of acres treated.



Source: Total acre treatments from (Monsanto, 2012); soybean planted acres from (USDA-NASS, 2002; USDA-NASS, 2004; USDA-NASS, 2006; USDA-NASS, 2007; USDA-NASS, 2009; USDA-NASS, 2011)

Figure 4-2. Total Acre Treatments per Soybean Planted Acre and Adoption of GE Herbicide Resistant Soybeans, 2002-2011

Table 4-4 lists the 10 most frequently used herbicides on soybean in 2011 based on treatment acres in the order of their use. The top 10 herbicides account for greater than 95% of the herbicide use on soybean (Rausch, 2013). Glyphosate remains the most widely used herbicide though its dominance has been steadily declining since 2005. After glyphosate, the nine most frequently used herbicides comprise another five sites of action. These include in order of use, Group 14 PPO inhibitors (flumioxazin and fomesafen), Group 2 ALS inhibitors (chlorimuron, imazethapyr, thifensulfuron), Group 4 synthetic auxins (2,4-D), Group 15 chloroacetamides (metolachlor-S and acetochlor), and Group 1ACCase inhibitor (clethodim) herbicides.

Table 4-4. Top 10 Most Frequently Used Herbicides on Soybean in 2011 (Nationally)

Active Ingredient	WSSA Class	Chemical Family	Site of Action
glyphosate	9	glycine	EPSP synthase
chlorimuron	2	sulfonylurea	Acetolactate synthase

Active Ingredient	WSSA Class	Chemical Family	Site of Action
flumioxazin	14	N-phenylpthalimide	Protoporphyrinogen oxidase
2,4-D	4	Phenoxy-carboxylic acid	Synthetic auxin
Fomesafen	14	Diphenylether	Protoporphyrinogen oxidase
Imazethyapyr	2	Imidazolinone	Acetolactate synthase
Metolachlor-S	15	Chloroacetamide	Very long chain fatty acids
Clethodim	1	Cyclohexandione	AcetylcoA carboxylase
Chloransulam-methyl	2	Triazolopyrimidine	Acetolactate synthase
Thifensulfuron-methyl	2	Sulfonylurea	Acetolactate synthase

Source: (DAS, 2013a)

Regional Use of Herbicides in Soybean by U.S. Cropping Region

Most of U.S. soybean production occurs in the five regions indicated in Table 4-2. Herbicide use on soybeans was examined in these five regions and the top 10 herbicides used are listed in Table 4-5 based on treatment acres in the order of their use. The Heartland region is where most soybeans are grown in the U.S. and accounts for half of all soybean herbicide treatments (data not shown). Overall, the herbicides used to control weeds in soybean are similar across regions. Glyphosate provides the principal basis for weed control in each of the regions with other actives from Group 2, Group 4, and Group 14 being used to control weeds that are not controlled satisfactorily by glyphosate alone.

Some regional differences in herbicide use are as follows:

- In the Heartland, Northern Crescent, and Northern Great Plains, Group 15 herbicides are not widely used while the Group 1 grass herbicides are.
- The Northern Crescent is the one region where Group 5 Photosystem II inhibitors are widely used. The Northern Crescent is less reliant on synthetic auxins and uses a smaller variety of PPO inhibitors and a greater variety of ALS inhibitors.
- In the Northern Great Plains and the Prairie Gateway, Group 3 (mitosis inhibitors) herbicides are widely used.
- In the Southeast, Group 22 (Photosystem I) and Group 10 (Glufosinate) are widely used.
- Overall, the Heartland, uses the fewest sites of action in the top ten herbicides (5), the Southeast the most (7), while the other three regions use (6).

Table 4-5. Top Ten Herbicides and WSSA Group Used on Soybean in the 5 Principal Growing Regions

Heartland (5)		N Crescent (6)		N Great Plains (6)		Prairie Gateway (6)		Southeast (7)	
AI	**GN**	**AI**	**GN**	**AI**	**GN**	**AI**	**GN**	**AI**	**GN**
glyphosate	9	glyphosate	9	glyphosate	9	glyphosate	9	glyphosate	9
chlorimuron	2	chlorimuron	2	imazethyapyr	2	chlorimuron	2	fomesafen	14
flumioxazin	14	imazethyapyr	2	saflufenacil	14	flumioxazin	14	flumioxazin	14
2,4-D	4	flumioxazin	14	2,4-D	4	2,4-D	4	chlorimuron	2
clethodim	1	clethodim	1	clethodim	1	metolachlor-S	15	metolachlor-S	15
sulfentrazone	14	2,4-D	4	flumioxazin	14	fomesafen	14	2,4-D	4
chloransulam-methyl	2	metribuzin	5	chlorimuron	2	sulfentrazone	14	paraquat	22
imazethyapyr	2	thifensulfuron	2	pendimethalin	3	thifensulfuron	2	thifensulfuron	2
fomesafen	14	tribenuron methyl	2	chloransulam-methyl	2	lactofen	14	glufosinate	10
thifensulfuron	2	chloransulam-methyl	2	Fluthiacet-methyl	14	pendimethalin	3	dicamba	4

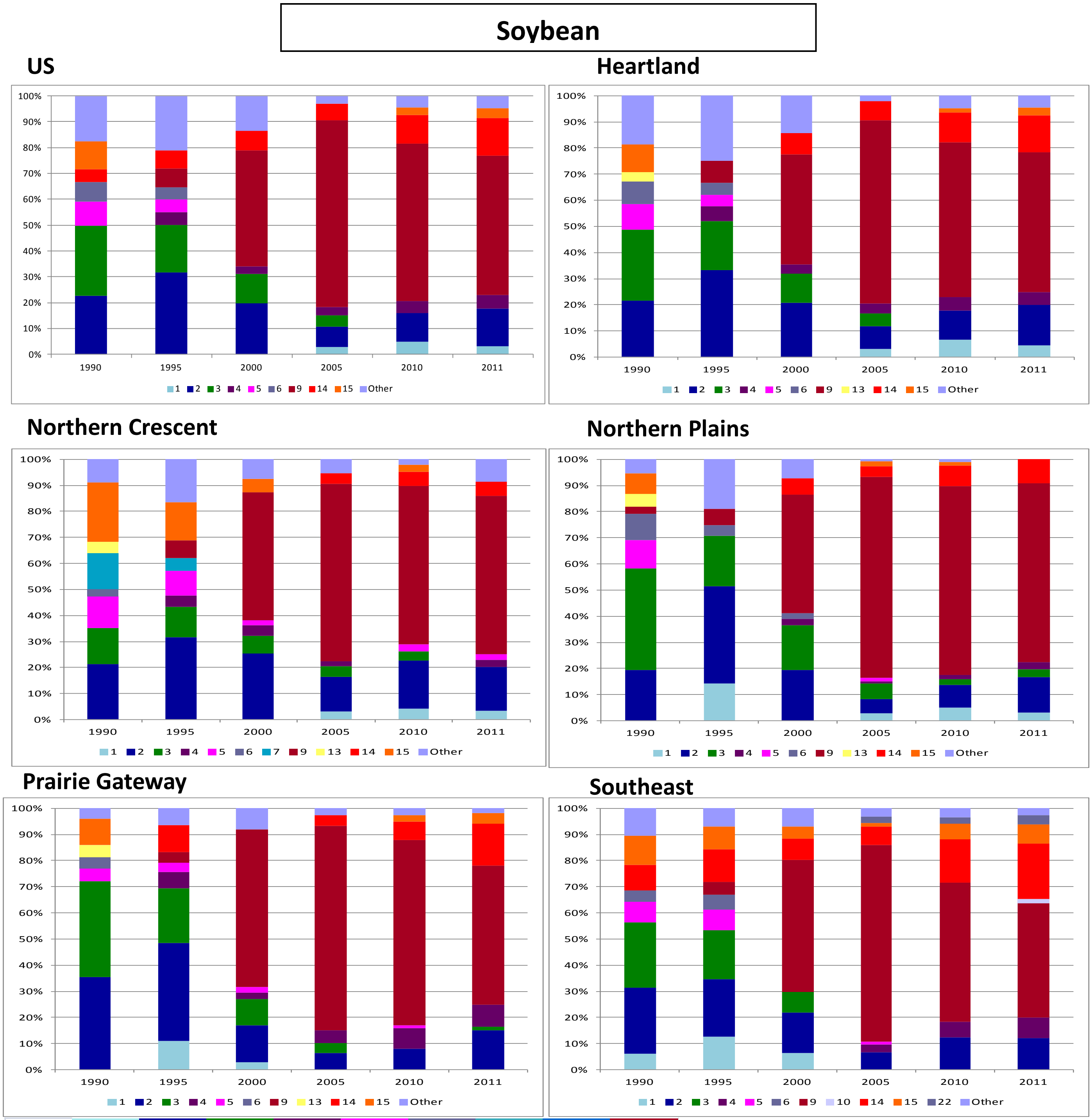
Heartland: MN, IA, MO, IL, IN, KY, OH
Northern Crescent: WI, MI, PA, NJ, NY, MA, RI, CT, VT, NH, ME
Northern Great Plains: MT, ND, SD, NE
Prairie Gateway: CO, KS, OK, TX
Southeast: AS, LA, MS, AL, GA, SC, NC, TN, VA, WV, MD, DE
Numbers next to the regions represent number of sites of action in the top ten most frequently used herbicides.
AI: active ingredient
GN: WSSA group number
Source: (DAS, 2013a)

Trends in Herbicide Use on Soybean by Site of Action (SOA)

Figure 4-3 shows trends in herbicides used on soybean from 1990-2010 in five year intervals and for 2011 alone, grouped according to Weed Science Society of America (WSSA) chemical classification for sites of action (WSSA, 2013). The analysis presents each herbicide site of action (SOA) as a percentage of the total treatment area of all actives used in that year. This approach allows a consistent comparison of herbicides used given the changes in crop area over time. The figure also breaks down usage by region. It illustrates the decreasing reliance of soybean growers on glyphosate and the utilization of additional sites of action including PPO inhibitors (Group 14), ALS inhibitors (Group 2), chloroacetamides (Group 15), and synthetic auxins (Group 4) (Figure 4-3).

In all regions there has been a similar increasing trend in the use of non-glyphosate herbicides as weed control has slipped in recent years with some weeds developing increased tolerance or resistance to glyphosate and Group 2 herbicides. In all the major soybean growing regions, the next most widely used herbicide is either a group 2 (chlorimuron and/or imazethapyr) or a Group 14 (flumioxazin, fomesan, or saflufenacil) herbicide. In all the regions 2,4-D is also widely used. There is increasing pre-emergent applications of residual herbicides such as metolachlor-S and pendimethalin in the Northern Great Plains, the Prairie Gateway, and the Southeast. These herbicides prevent weeds from germinating over a period of 4-6 weeks and help control glyphosate resistant weeds provided there is adequate rain for activation.

In the Southeast, where glyphosate resistant weeds are the most prevalent, there is a decreasing trend in glyphosate use and the greatest use of different sites of action among the various regions.



SOA	1	2	3	4	5	6	7	8	9
Chemical Family	ACCase	ALS	Mitosis Inhib	Auxins	PS II Inhib-A1	PS II Inhib-B	PS II Inhib-A2	FALB Inhib	EPSP Inhib
SOA	10	13	14	15	16	19	22	27	Other
Chemical Family	GS Inhib	DOXP Inhib	PPO Inhib	VLCFA Inhib	Unknown	ATI	PS I Inhib	HPPD Inhib	

Source: (DAS, 2013d)
Classification of herbicides according to site of action. http://www.hracglobal.com/Publications/ClassificationofHerbicideSiteofAction.aspx
Classification of Mechanism of Action http://wssa.net/weed/resistance/

Figure 4-3. Trends in Herbicide Use on Soybean by SOA

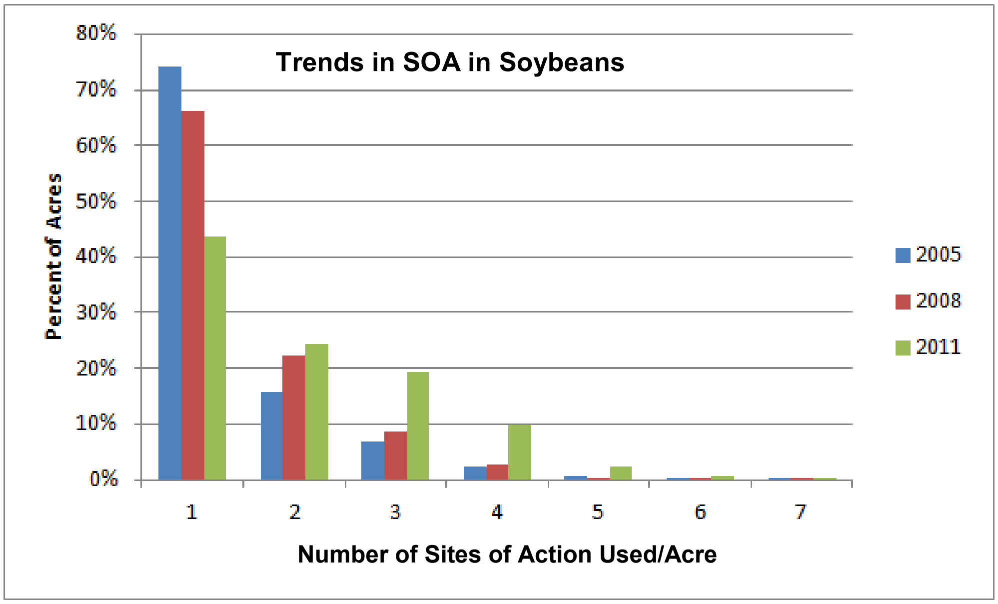
Summary of Herbicide Trends in Soybean

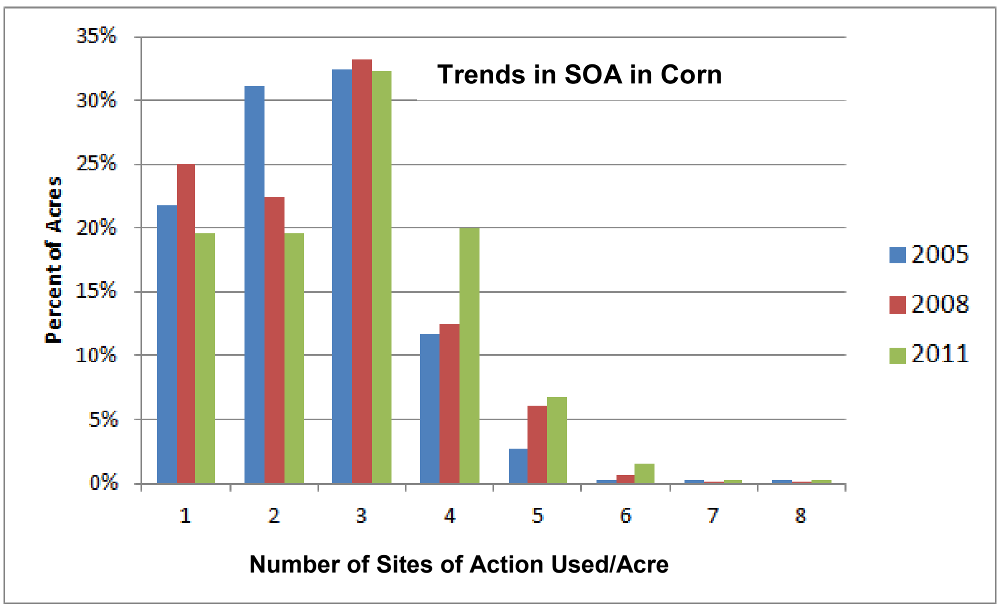
Trends in herbicide use are evident in Figure 4-3. Since the mid-2000s, at the national level, the use of glyphosate and microtubule inhibitors has been declining. The use of four other sites of action has been increasing. These are the ALS inhibitor, chlorimuron, the PPO inhibitors flumioxazin and fomesafen, the auxin 2,4-D and the chloroacetamide, metolachlor-S. The greatest decline in glyphosate use has been in the southeast. In all 5 soybean regions, chlorimuron use on soybeans appears to be increasing. In the Prairie Gateway and Southeast, 2,4-D and flumioxazin use on soybean appears to be increasing. In the Southeast, fomesafen and metolachlor-S use also appear to be increasing.

Comparison of Herbicide Use in Corn and Soybean

Herbicide use in corn differs substantially from that in soybean both in the types of herbicides used and the variety of herbicide sites of action. Corn yields are more negatively impacted by early season weed competition than soybeans. Corn is also planted in wider rows than soybeans and the resulting penetration of light allows weed germination over a longer period of time than in soybeans (Rausch, 2013). For these reasons, post emergent applications of glyphosate are not as beneficial in corn as they are in soybean. To obtain the best corn yields, growers need to manage weeds with pre-plant or pre-emergent herbicide applications. Historically they have used atrazine, and chloroacetamide herbicides such as acetochlor, metolachlor, and more recently metolachlor-S. They also relied on both dicamba and 2,4-D. Even after RR corn was widely adopted, most corn growers have continued to use residual herbicides followed by application of post emergent herbicides as needed to provide good weed control and maximize yield potential. Consequently, soybean growers have been much more reliant on glyphosate than have corn growers.

Figure 4-4 shows the number of herbicidal sites of action (SOA) corn and soybean growers used in 2005, 2008, and 2011. Whereas 3/4 of soybean growers relied exclusively on a single SOA for their weed control in 2005, less than ¼ of corn growers similarly relied on a single SOA. When only one SOA is used, in both cases the predominant herbicide is glyphosate (Figure 4-5). For soybean growers who used just one SOA, greater than 97% of the growers used exclusively glyphosate whereas in corn, this number was 75% in 2005 but increased to 90% in 2011. The alternative herbicides that are used as the only SOA on corn include atrazine, glufosinate, HPPD inhibitors, or chloroacetamides. However more commonly, several SOAs are used to raise corn. Over 30% of corn growers used at least three sites of action and this trend did not change over the period of 2005 to 2011 (Figure 4-4). In comparison, over the same period of time soybean growers using three sites of action changed from just over 5% to nearly 20%. Soybean growers using only glyphosate decreased to just over 65% in 2008 and further decreased to 44% of growers in 2011. As in soybean, the recent trend in corn has also been to use even more herbicide SOAs. For example from 2005 to 2011, the percentage of growers using 4 SOAs almost doubled from 10% to 20%. There has also been an upward trend in corn growers using herbicides representing 5 and 6 SOAs.





Source: (DAS, 2013c)

Figure 4-4. Herbicide sites of action used in soybeans and corn since 2005 based on national data.

Number of Sites of Action Used/Acre

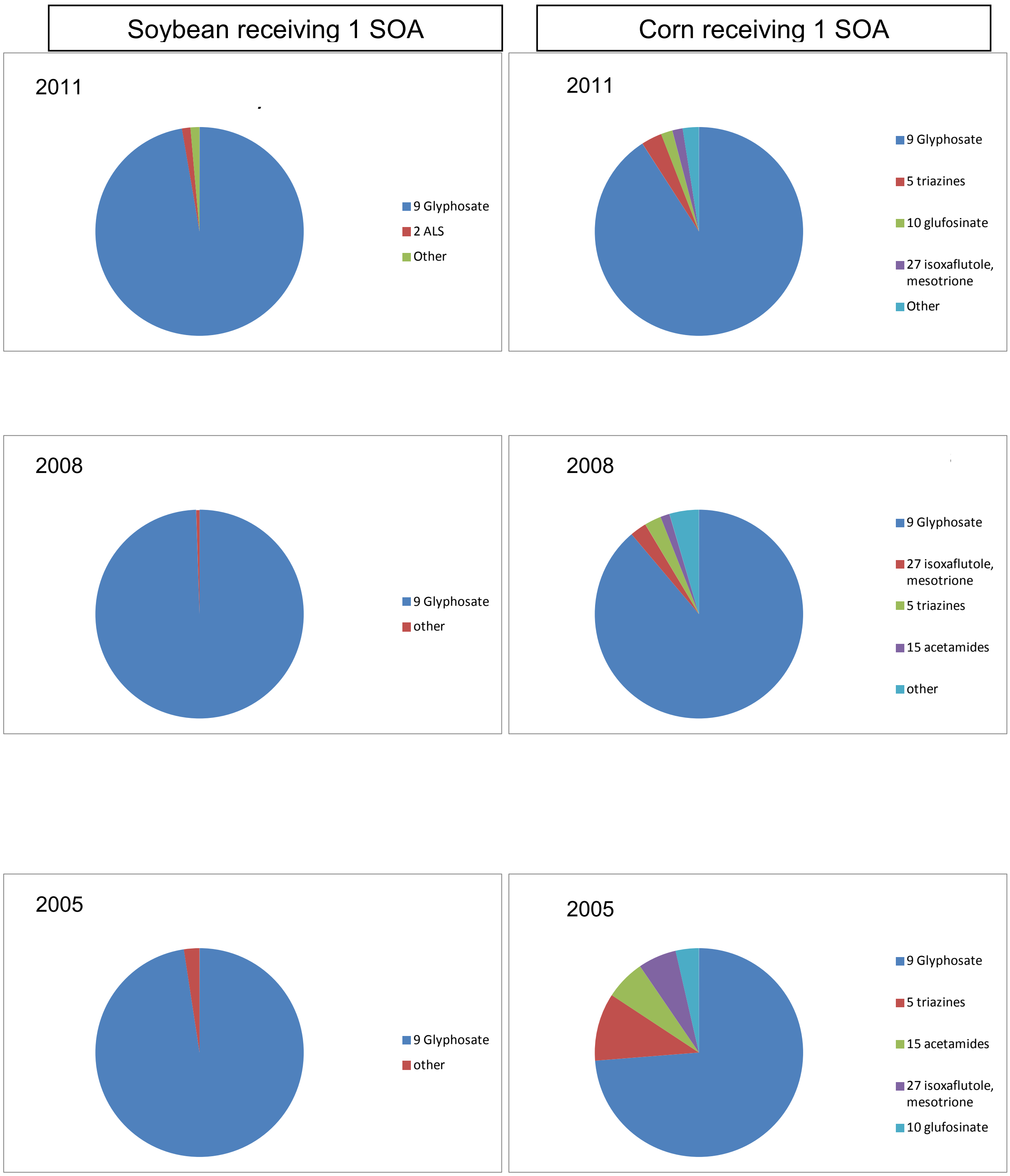


Figure 4-5. Herbicides used in Corn and Soybean when a Single Herbicide is Applied.
Source: (DAS, 2013d)

Trends in Preplant/Pre-emergent vs Post-emergent Herbicide Use in Corn and Soy

As described more fully in Appendix 3, pre-plant herbicide use refers to use of the herbicide prior to planting the crop, pre-emergent describes use of the herbicide prior to weed emergence, and postemergent describes use after the crop and weeds emerge. Figure 4-6 shows the most commonly used herbicides on corn and soybean and the percent each herbicide was used pre-plant/pre-emergent (pre) or post-emergent (post) in approximately five year increments since 1990 (DAS, 2013a). In some situations, such as the use of herbicide on perennial crops and fallow, this nomenclature is not applicable (NA) and notated accordingly. Herbicides that are primarily used in pre-emergent applications include acetachlor, metolachlor, metolachlor-S, atrazine, isoxaflutole, pendimethalin trifuralin, and paraquat. Herbicides that are used primarily post emergent include fomesafen, imazethapyr, thifensulfuron, glyphosate, and glufosinate. Some herbicides are widely used for both preplant/pre-emergent and post-emergent applications including 2,4-D, dicamba, flumetsulam, and mesotrione. One noteworthy trend is that for both 2,4-D and dicamba, pre-plant uses are increasing while post-emergent uses are declining. Presumably this use reflects increased use of these herbicides for pre-plant burndown to better manage glyphosate resistant weeds.

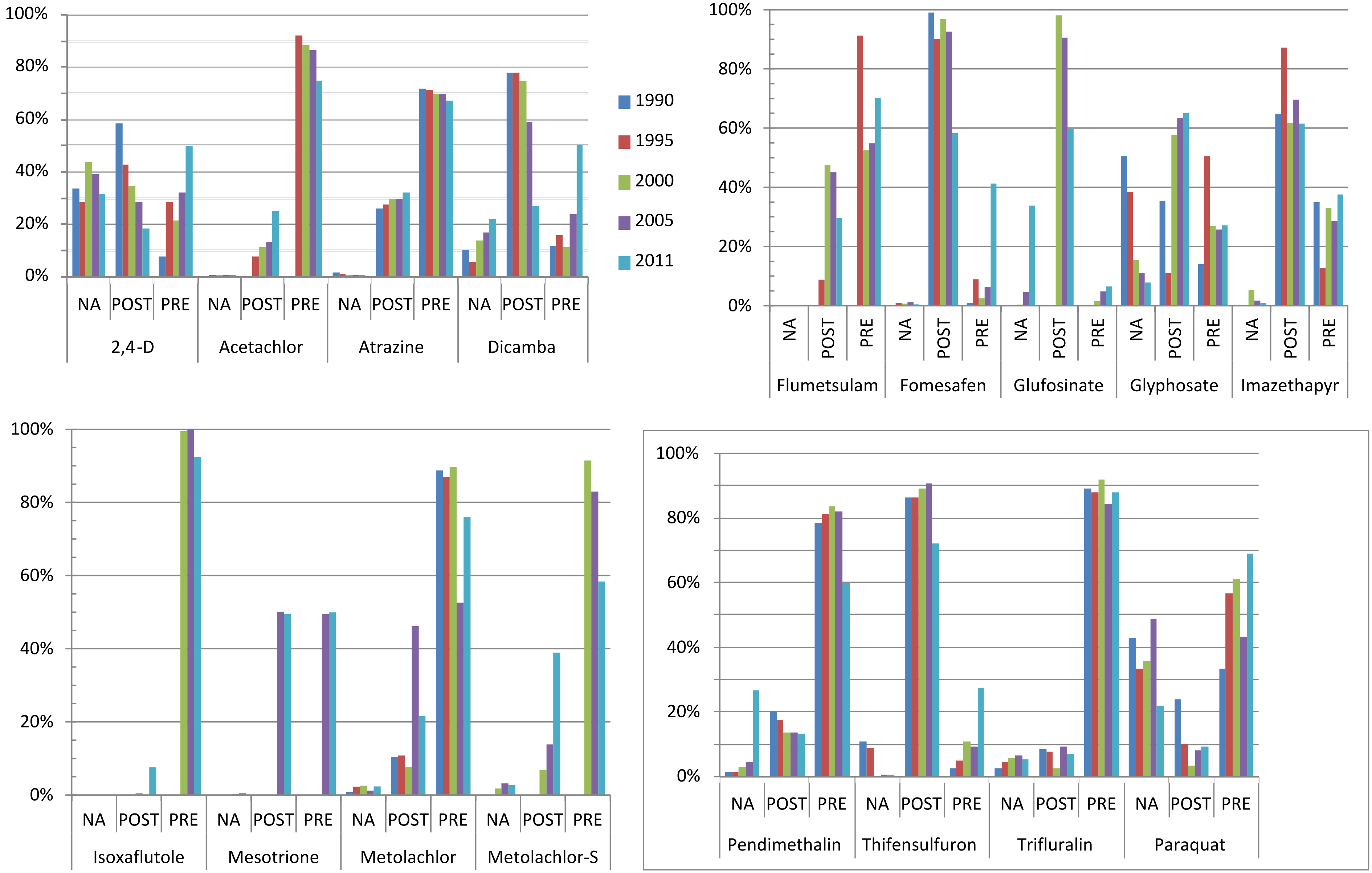


Figure 4-6. Timing of Herbicide Use.
For each herbicide, the percentage of that herbicide used either post emergent, pre-emergent, or in situations where the timing is not applicable (NA) is noted for the years indicated.
Source: (DAS, 2013a)

Common and Unique Herbicides Used in Corn and Soybean

One of the strategies to reduce the pressure of selecting herbicide resistant weeds is to diversify the herbicide sites of action that are used. As crops often are managed with different herbicides, crop rotation can facilitate the use of different herbicidal sites of action. To compare the extent to which herbicide sites of action would vary in a corn-soy rotation, the common and unique herbicides were identified from among the most widely used herbicides in the two crops. Sites of action corresponding to these herbicides were then compared. This information is presented in Table 4-6 for each of the five major corn and soybean regions. If an herbicide is used only on soybean in a particular region, the corresponding matrix square is colored blue. If the herbicide is only used on corn, the square is colored yellow. If the herbicide is used on both crops, the square is colored green. The stippled green squares represent the situation where a common SOA is used on both crops but the herbicides used differ. For the most part, Group 14 PPO inhibitors, Group 1 ACCase inhbitors, and Group 10 glufosinate herbicides are used on soy. Group 5 PSII inhibitors and Group 27 HPPD inhibitors are used on corn. The Group 15 chloroacetamides, which historically have been used primarily on corn, are now seeing increased use on soybean especially in the Prairie Gateway and the Southeast. Glyphosate and auxins, particularly 2,4-D are used on both corn and soybean. The auxins, dicamba and clopyralid, are still mostly used on corn.

Table 4-6. Common and Unique Herbicides Used in Corn and Soy[1]

Regions		Heartland	Northern Crescent	Northern Great Plains	Prairie Gateway	Southeast
Sites of Action	**WSSA**					
EPSPS	9	both	both	both	both	both
Auxin Action	4	both	both	both	both	both
PSI	22	N/A	N/A	N/A	N/A	both
ALS	2				soy	
PPO	14	soy	soy	soy		soy
ACCase	1	soy	soy	soy	N/A	N/A
Microtubule	3	N/A	N/A	soy	soy	N/A
GS	10	N/A	N/A	N/A	N/A	soy
PSII	5	corn		corn	corn	corn
HPPD	27	corn	corn	corn	corn	corn
Chloroacetamide	15	corn	corn	corn	both	both

[1]based on the 10 most widely used herbicides in a given region: Source: (DAS, 2013a).

Key

Green (both): Herbicides with the same site of action used in both soybean and corn in a given region.

Green Shaded: Herbicides with the same site of action used in both soybean and corn but differing in individual herbicides.

Blue (**soy**): Herbicides with a site of action used only on soy in a given region.

Yellow (corn): Herbicides with a site of action used only on corn in a given region.

White (N/A): Not applicable because herbicides with that site of action are not used in the region.

Herbicide Use in the Different Market Segments

Only a few of the major herbicides used in corn and soybean have a major portion of their use in non-crop markets. These herbicides are glyphosate, pendimethalin and the synthetic auxins 2,4-D, clopyralid, and dicamba (Figure 4-7). In addition to use on agricultural crops, these herbicides are applied for use on range and pasture use and non-crop uses.

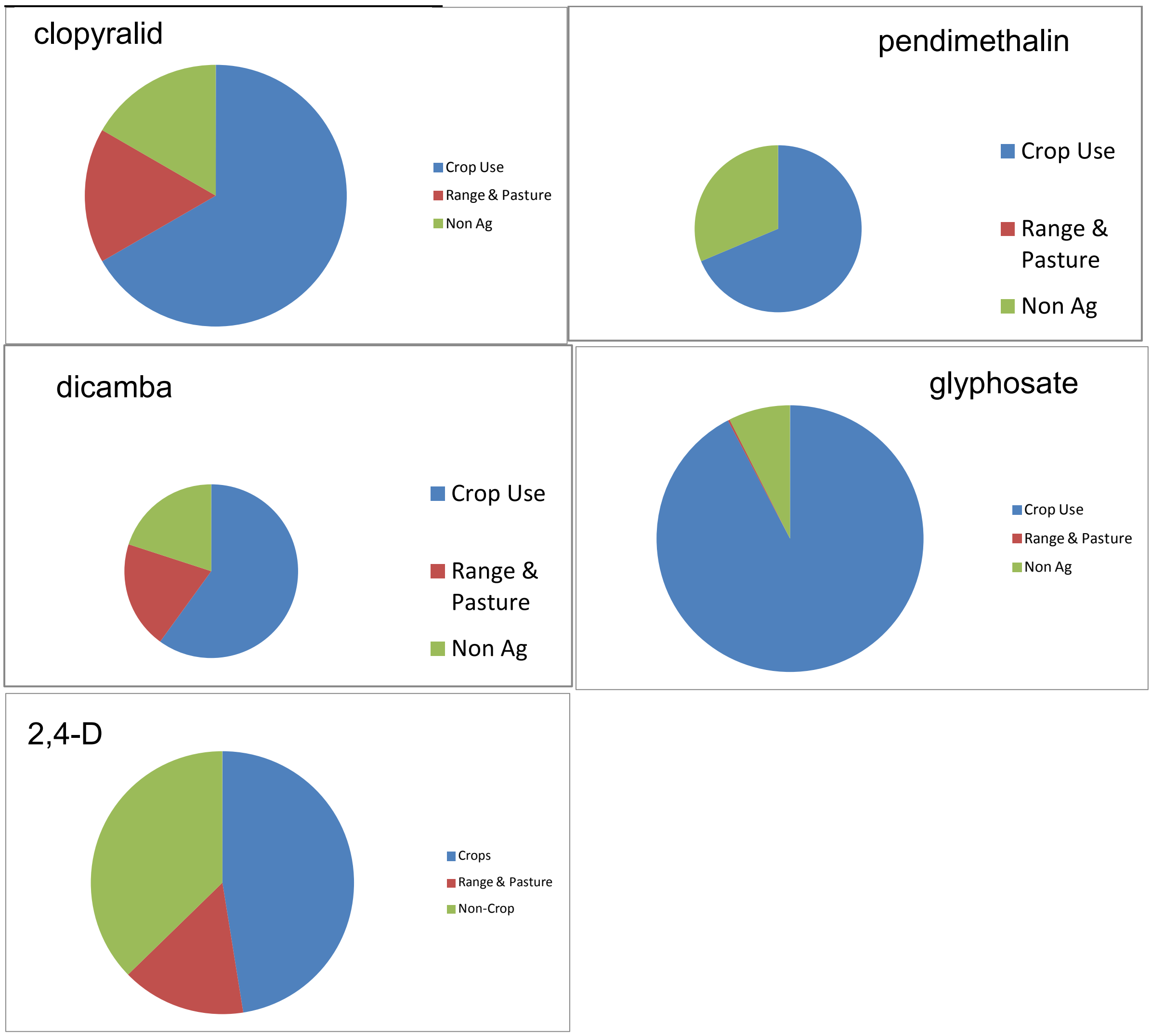
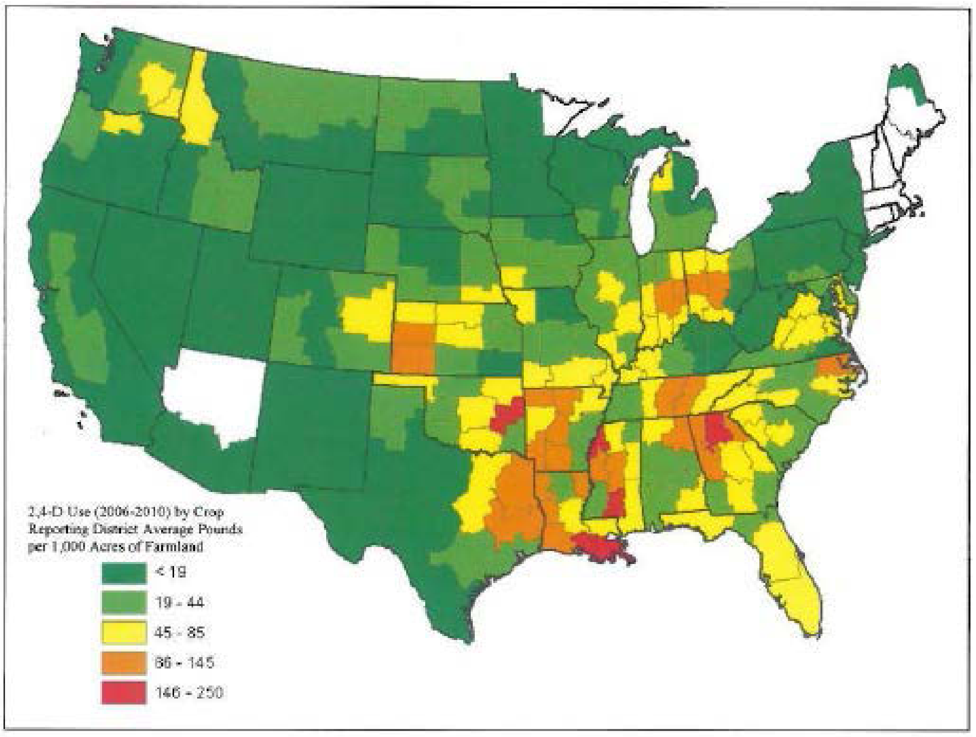


Figure 4-7. Herbicide Use by Market Segment
Source: (DAS, 2013a).

Current 2,4-D Use

The herbicide 2,4-D is a phenoxy auxin herbicide, introduced more than 60 years ago and registered and used throughout the world for the treatment of broadleaf weeds. The mode of action of 2,4-D is described as an "auxin mimic," meaning that it kills the target weed by mimicking auxin plant growth hormones like indole acetic acid (IAA) (Tu *et al.*, 2001). Auxins and synthetic auxinic herbicides regulate virtually every aspect of plant growth and development; at low doses, auxinic herbicides possess similar hormonal properties to natural auxin (Kelley and

Riechers, 2007). However, as rates increase, they can cause various growth abnormalities in sensitive dicots (Tu *et al.*, 2001). Observable plant responses to 2,4-D can include epinasty, root growth inhibition, meristematic proliferation/callusing, leaf cupping/narrowing, stem cracking, adventitious root formation, senescence, and chlorosis. This uncontrolled and disorganized plant growth eventually leads to plant death when applied at effective doses (Tu *et al.*, 2001). The agricultural segment is made up of the crop use segment and the range and pasture segment. Within the crop segment these uses are very diverse ranging from burndown application prior to planting soybeans, to use underneath tree crops and use on wheat. The range and pasture segment consists of control of annual weeds as well as control of perennial weeds, woody and invasive species. Unlike the other herbicides, less than 50% of 2,4-D is used in the crop segment (Figure 4-7).



Source: (US-EPA, 2012c).

Figure 4-8. 2,4-D Agricultural Usage by Crop Reporting District, 2006–2010

As can be seen in Figure 4-8, 2,4-D is used predominantly in the Heartland, Prairie Gateway, the Southeast, and Northwestern U.S. 2,4-D controls many broadleaf weeds including carpetweed, dandelion, cocklebur, horseweed, morning glory, pigweed sp., lambsquarters, ragweed spp., shepherd's-purse, and velvetleaf. It has little to no effective activity on grasses, including wheat, corn, and rice (Industry Task Force II, 2005). The states with the highest use in both periods from 2001–2005 and 2006–2010 were Texas, Oklahoma, Kansas and Montana, while the sites with the highest use in terms of total pounds applied in these periods were pastureland, winter wheat, and corn. The three highest use states are those with some of the highest amounts of pastureland. The share of 2,4-D use on pastureland declined considerably between 2001–2005 and 2006–2010. The most non-agricultural usage in terms of pounds applied as reported in 2003 and 2005 was by consumers for lawn use, direct application, or as a fertilizer combination (US-EPA, 2012b).

2,4-D is an ingredient in approximately 660 agricultural and home use products as a sole active ingredient or in conjunction with other active ingredients. In 2002, 2,4-D was ranked as the third most used herbicide by active ingredient in the U.S. for all purposes (~46 million pounds), behind glyphosate (~102 million pounds) and atrazine (~77 million pounds) (Gianessi and Reigner, 2006). That same report found that the use of 2,4-D remained relatively steady from 1992 to 2002; Since that time, 2,4-D use has been increasing from about 46 million pounds in 2002 to 64 million pounds in 2011 (DAS, 2013b). In 2011, about 40% of 2,4-D was used on crops, 38% was used on turf and ornamentals, and 22% was used on range and pasture and for industrial vegetation management such as to control unwanted vegetative growth on utility corridors, rights-of-way, roadsides, railroads, cemeteries, non-crop areas, and managed forest. It is also used to control aquatic and nuisance weeds, e.g., purple loosestrife (Industry Task Force II, 2005). 2,4-D is very widely used for non-agricultural use.

A major use today of 2,4-D is in combination with other herbicides because it economically enhances the weed control spectrum of many other herbicides such as glyphosate, dicamba, mecoprop, and ALS herbicides (US-EPA, 2005). Agriculturally, it is used on a variety of grass crops including pasture/hay, small grains (spring wheat, winter wheat, rice, sorghum, barley, millet, oats), corn, and sugar cane and on nut and fruit tree crops (almonds, apples, apricots, cherries, citrus, hazelnuts, nectarines, peaches, pears, pecans, pistachios, plums, and walnuts). It is also used in the production of some crops which are very sensitive to 2,4-D such as soybean, cotton, grapes where the 2,4-D is used without applying it to the crop (see Table 4-7). Table 4-7 lists the crops where at least 10% of the crop is treated with 2,4-D and includes how many pounds of 2,4-D were applied based on EPAs screening level usage analysis conducted in 2012 (US-EPA, 2012b). Although 2,4-D is labeled for use in corn as a broad-leaf weed herbicide, its use is limited beyond early seedling stages because it can produce significant malformations of corn plants when applied at late seedling stages (Wright *et al.*, 2010). When used in soybean production, 2,4-D is applied as a pre-plant burndown treatment.

Table 4-7. Agricultural Uses of 2,4-D

		Amount Used	Percent Crop Treated	
	Crop	Pounds Active Ingredient (lbs a.i.)	Average	Maximum
1	Almonds	200,000	15	20
2	Apples	80,000	20	25
3	Apricots	2,000	10	25
4	Asparagus	5,000	10	30
5	Barley	500,000	25	40
6	Cherries	30,000	15	25
7	Corn	3,200,000	5	10
8	Cotton	700,000	10	15
9	Fallow	2,300,000	25	30
10	Grapefruit	10,000	10	25
11	Grapes	50,000	5	15
12	Hazelnuts (Filberts)	20,000	25	35
13	Nectarines	5,000	15	35
14	Oats	300,000	15	20
15	Oranges	100,000	20	30
16	Pasture	10,600,000	10	15
17	Peaches	30,000	20	30
18	Peanuts	50,000	5	10
19	Pears	10,000	15	20
20	Pecans	40,000	10	15
21	Pistachios	9,000	5	20
22	Plums	5,000	15	30
23	Prunes	20,000	15	25
24	Rice	300,000	10	15
25	Sorghum	900,000	20	30
26	Soybeans	2,900,000	10	15
27	Sugarcane	400,000	40	65
28	Sunflowers +	60,000	5	10
29	Sweet Corn	7,000	5	10
30	Tangelos	1,000	30	45
31	Tangerines	2,000	10	20
32	Walnuts	40,000	10	15
33	Wheat	5,900,000	30	65

Source: (US-EPA, 2012a).

The current EPA-approved use directions for 2,4-D on corn allows a single pre-emergent (burn down) application of 0.5-1 lb acid equivalents/acre (ae/ac) of 2,4-D, a single post-emergent application of 0.5 lbs ae/ac, and a single preharvest application of up to 1.5 lbs ae/ac. Seasonal maximum use is 3 lbs ae/ac/season (DAS, 2010a).

The current EPA-approved use directions for 2,4-D on conventional soybean allows a single pre-plant (burn down) application of 0.35-1 lb acid equivalents/acre (ae/ac) of 2,4-D. There is a 7 to 30 day pre-plant restriction, depending on the application rate used during the pre-plant application (DAS, 2010b).

When 2,4-D is utilized in a burn down or pre-plant treatment (corn or soybean), it is almost always combined in a tank mix with glyphosate or other non-selective herbicide and, when tank-mixed, 2,4-D is generally recommended at the lower end of the rate range ~ 0.5 lbs ae/ac (Nice *et al.*, 2013)

In 2012, 97 million acres of corn was planted and 97.4 million acres were planted in 2013 (USDA-NASS, 2013). Based on third party proprietary data obtained by DAS, in 2011, 5.5 million pounds of 2,4-D were applied to 9.5 million acres (10% of the corn crop) for an average of 0.57 lbs ae/treated acre while in 2009, 4 million pounds were used on 7.3 million acres (8.4% of the corn crop) for an average of 0.55 lbs ae/treated acre (Table 4-8) (DAS, 2012d).

Table 4-8. 2,4-D Applied to Corn

Year	Total Acres	Acres treated with 2,4-D	Treated Acres % of Total Acres	Total Pounds 2,4-D	Pounds 2,4-D/ Acre	Total Applications / Acre
2009	86,382,000	7,300,000	8.4	4,000,000	0.55	
2011	91,936,000	9,500,000	10	5,500,000	0.57	

Source: (DAS, 2012d).

In 2012, 77 million acres of soybean was planted and 77.7 million acres were planted in 2013. 2,4-D use as a pre-plant burndown material has continued to increase between 2008 to 2011 where the percent of the crop treated has increased from 7% to 12% and total pounds used has increased from 2.7 million pounds to 4.9 million pounds (Table 4-9) (DAS, 2012c).

Table 4-9. 2,4-D Applied to Soybean

Year	Total Acres	Acres treated with 2,4-D	Treated Acres % of Total Acres	Total Pounds 2,4-D	Pounds 2,4-D/ Acre	Total Applications /Acre
2008	74,404,953	5,068,628	7	2,716,207	0.5	1.01
2009	77,584,979	7,637,880	10	3,680,330	0.4	1.01
2010	78,725,007	7,763,593	10	4,106,140	0.5	1.00
2011	74,835,007	8,832,324	12	4,893,146	0.5	1.00

Source: (DAS, 2012c).

Current Quizalofop Use

DAS-40278-9 corn is resistant to quizalofop-P-ethyl whereas conventional corn is sensitive. The "fop" herbicides (AOPP ACCase inhibitors) have been registered for crop use for more than 20 years (USDA-APHIS, 2010). The "fop" herbicides traditionally have not been used to control weed species in cornfields because, as a grass (Poaceae family) species, corn is damaged by AOPP ACCase inhibitor activity. The registration and use of "fop" herbicides has been primarily on broadleaf crops, such as soybean, to control grass weed species, although certain cereal plant varieties have a level of tolerance to some "fops" (see DuPont, 2010). According to the USDA National Agricultural Statistics Service (NASS) Agricultural Chemical Use Database, "fop" type herbicides were used for weed control on at least 23 food crop species between 1990 and 2006, totaling more than 16 million pounds of active ingredient (USDA-NASS, 2011).

The AOPP herbicides inhibit chloroplastic ACCase, which catalyzes the first committed step in fatty acid biosynthesis, causing plant death (Burton *et al.*, 1989). There are three families of ACCase inhibitors, the "fops", the "dims", and the "dens" where Quizalofpr-ethyl belongs to the "fops" family.The herbicidal activity of quizalofop-ethyl ester was first reported in 1983, and quizalofop-ethyl was first approved for use in a registered herbicide product in the U.S. in 1988 (DAS, 2010b; DuPont, 2010).[1] However, all end use product registrations were cancelled prior to 1996 and it was replaced by the more active quizalofop-P-ethyl (pure R-enantiomer of quizalofop racemic mixture), which first was approved for use in a registered product in 1990 (DuPont, 2010). Quizalofop-P-ethyl is a systemic herbicide that is absorbed from the leaf surface and translocated throughout the plant (DAS, 2010b).

Most non-graminaceous plants (dicots and sedges) are tolerant to quizalofop. Dicotyledonous plants contain a prokaryotic form of ACCase which is insensitive to "fop" herbicides. In contrast, monocotyledonous plants contain a sensitive eukaryotic form of ACCase in the plastid (DAS, 2010a). This is the primary reason that the "fop" herbicides are generally good graminicides, with little activity on dicot plants. In addition, some grass species, including some cereal crops and weeds (e.g., annual bluegrass and wild oats), are tolerant of some of these herbicides (i.e., clethodim, quizalofop, and others) due to their ability to metabolize the herbicides to inactive forms (Devine and Shukla, 2000; Powles and Preston, 2009).

Quizalofop-P-ethyl is used as a selective post-emergent herbicide for the control of annual and perennial grass weeds in 23 broadleaf food crop species. The currently registered uses of quizalofop-p-ethyl include canola, crambe, cotton, crops grown for seed, eucalyptus, dry beans (including Chickpea), dry and succulent peas, flaxseed, hybrid poplar plantings, lentils, mint (spearmint and peppermint), pineapple, ryegrass grown for seed, snap beans, soybeans, sugar beets, sunflowers, and noncrop areas. Current allowable rates for this herbicide vary from 0.0172 to 0.344 lb ai/acre, depending on crop and weed conditions (see EPA approved label for Assure II) (DAS, 2010b; DuPont, 2010).

Although quizalofop-P-ethyl is registered for use on soybean, it is not among the 10 most frequently used herbicides on this crop. It is sometimes used to eliminate volunteer corn from

[1] Reference to the DuPont Assure™ II label is for illustration only, and is not intended to infer any recommendation for the use of this product by APHIS or the USDA.

soybean fields. The most frequently used ACCase inhibitor on soybean is clethodim, an herbicide in the "dim" family and the fifth most widely used herbicide in the Heartland, the Northern Crescent, and the Northern Great Plains. The "fop" herbicides traditionally have not been used to control weed species in cornfields because, like other grasses, corn is sensitive to ACCase inhibitors. DAS-40278-9 corn, however is resistant to quizalofop.

Current Glufosinate Use

Glufosinate is a nonselective herbicide that is used to control grasses, sedges and broadleaf weeds. Since it is a nonselective herbicide it injures or kills crop plants that it contacts. 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. Bayer Crop Science has registered glufosinate for use on glufosinate-resistant crops including corn and soybean. Ignite 280 SL Herbicide (EPA Reg. No. 264-829) is a commercially available glufosinate containing herbicide with directions for use on glufosinate-resistant crops (DAS, 2012a).

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, a water soluble herbicide, is approved for use on apples, berries, canola, corn, cotton, currants, grapes, grass grown for seed, potatoes, rice, soybeans, sugar beets, and tree nuts. Non-crop areas where glufosinate is registered for use on include residential lawns and industrial and public areas. Products include Rely™, Remove™, AEH™, Derringer™, and Finale™ (US-EPA, 2008). Ignite™/Liberty™ glufosinate products are registered exclusively for selective over-the-top use on GE LibertyLink™ corn, cotton, canola, rice, and soybean.

In 2002, it was estimated that glufosinate use in the U.S. for all purposes was 982,324 lb a.i. (Gianessi and Reigner, 2006). Estimates of annual applications of glufosinate in the U.S. indicate that approximately 1,000,000 lb a.i. were applied to agricultural land with the highest percentage (90 percent) used on corn (United States Geological Survey, No Date). 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 lbs), almonds (200,000 lbs), cotton (200,000 lbs), grapes (200,000 lbs), canola (100,000 lbs) and soybeans (100,000 lbs)(US-EPA, 2012d). With the commercial availability of glufosinate-resistant LibertyLink™ soybean beginning in 2009, glufosinate use on soybeans has increased. Glufosinate-resistant soybean accounted for less than 1 percent of soybean acreage planted in the U.S. in 2009 with approximately 72,000 lb ai glufosinate applied. In 2012, the planted acreage of glufosinate-resistant soybeans increased to 3.9 percent, and glufosinate use rose to approximately 1,536,000 lb (DAS, 2012a) Table 4-3. The map in Figure 4-9 shows the use of glufosinate from 2009 prior to the use on soybean. (A more recent version is/is not available). At that time, most use of glufosinate was concentrated in the Midwest.

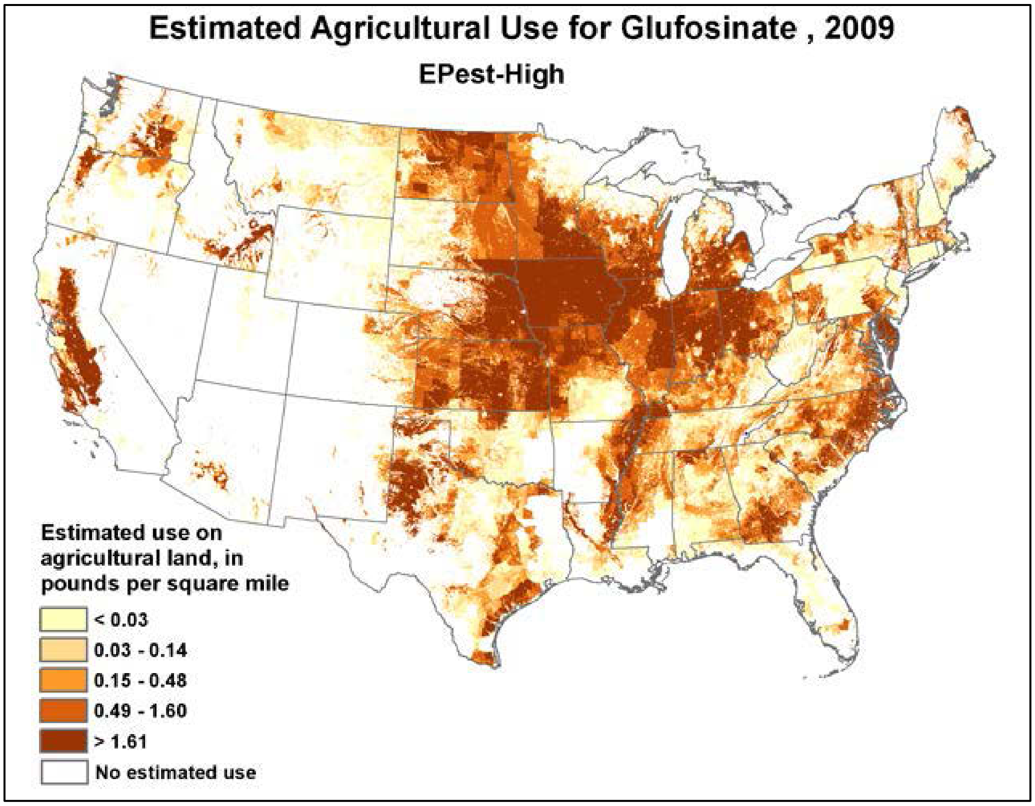


Figure 4-9. Estimated Annual Agricultural Use of Glufosinate in the U.S.
Source: (USGS, 2009)

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 resistance in Enlist™ soybean enables use of glufosinate as an herbicide on commercially grown soybeans but also provides use as a selection agent in breeding programs and seed amplification (DAS, 2010b).

Glufosinate-resistant soybeans are a more recent introduction than glyphosate-resistant soybeans. The number of acres planted to glufosinate-resistant soybeans has grown steadily but is still a very small fraction of total soybean acres. Average seasonal use rate is about a half pound per acre with just over 1 application per acre made. Glufosinate can also be used as a pre-plant (burn down) treatment on conventional and glufosinate-resistant soybean, however volume estimates for this use have a high degree of uncertainty (DAS, 2012a). For the years 2009-2011only a total of 46,000 lbs were used in a pre-plant treatment and 75% of those pounds were used in 2011.

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).

Application rates of glufosinate range significantly by use pattern, with the highest rate allowed for broadcast (ground) spray applications, at 1.5 lbs 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 lbs a.i./A. Multiple applications are allowed by most labels, although the interval is not generally specified (US-EPA, 2008). The EPA-registered use of glufosinate on LibertyLink™ (i.e., glufosinate-resistant) soybean includes an initial application of glufosinate no higher than 0.66 lb a.i./A (36 fl oz/A) with a minimum of 0.40 lb a.i./A (22 fl oz/A). A single second application of glufosinate up to 0.53 lb a.i./A (29 fl oz/A) is approved on LibertyLink™ soybeans, with a seasonal maximum rate of 1.2 lb a.i./A (65 fl oz/A) permitted. Glufosinate applications on LibertyLink™ soybean should be made from emergence up to but not including the bloom growth stage and within 70 days of harvesting soybean (Bayer CropScience, 2011).

Current Glyphosate Use

Current glyphosate use directions approved by EPA for use on glyphosate-resistant corn allow a maximum pre-emergence application amount of 3.7 lbs glyphosate ae/ac, and two post-emergent applications each at 1.125 lbs glyphosate ae/ac (total 2.25 lbs ae/ac). An additional pre-harvest application of 0.77 lbs ae/ac can be made. Total seasonal use rate is 6 lbs glyphosate ae/ac . Application of glyphosate to soybean is similar with the exception that post-emergent applications from 0.75 to 1.5 lbs glyphosate ae/ac (total 2.25 lbs ae/ac/season) can be made.

Third party proprietary market research data indicate that the percentage of glyphosate-resistant corn acres has grown over the last four years (Table 4-10). Total pounds of glyphosate applied to corn have also increased during this time where the percentage of the crop has increased from 77% treated in 2008 to 90% treated in 2011. In contrast, acres of soybean treated have remained fairly constant at 94-96% of the crop (Table 4-11). The application rate and the total applications/acre have remained fairly uniform for both crops despite the increase in glyphosate resistant weeds.

Table 4-10. Glyphosate Use on Glyphosate-Resistant Corn

Year	Total Acres	Gly-Tol Acres	Gly-Tol as % of Total Acres	Total Pounds Gly	Lbs Gly/Acre	Total Applications/ Acre
2008	86,705,017	66,854,236	77	67,760,400	1.06	1.29
2009	86,409,977	71,071,345	82	68,621,113	1.05	1.28
2010	87,230,005	75,958,684	87	75,582,434	1.11	1.31
2011	91,620,001	82,163,813	90	85,671,957	1.17	1.33

Source:(DAS, 2012d)

Table 4-11. Glyphosate Use on Glyphosate-Resistant Soybean

Year	Total Acres	Gly-Tol Acres	Gly-Tol as % of Total Acres	Total Pounds Gly	Lbs Gly/Acre	Total Applications/ Acre
2008	74,404,953	71,592,624	96	95,398,687	1.32	1.58
2009	77,584,979	73,219,835	94	96,415,627	1.30	1.55
2010	78,725,007	74,059,182	94	102,162,527	1.38	1.58
2011	74,835,007	71,734,538	96	100,121,452	1.40	1.54

Source: (DAS, 2012c)

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 4-10.

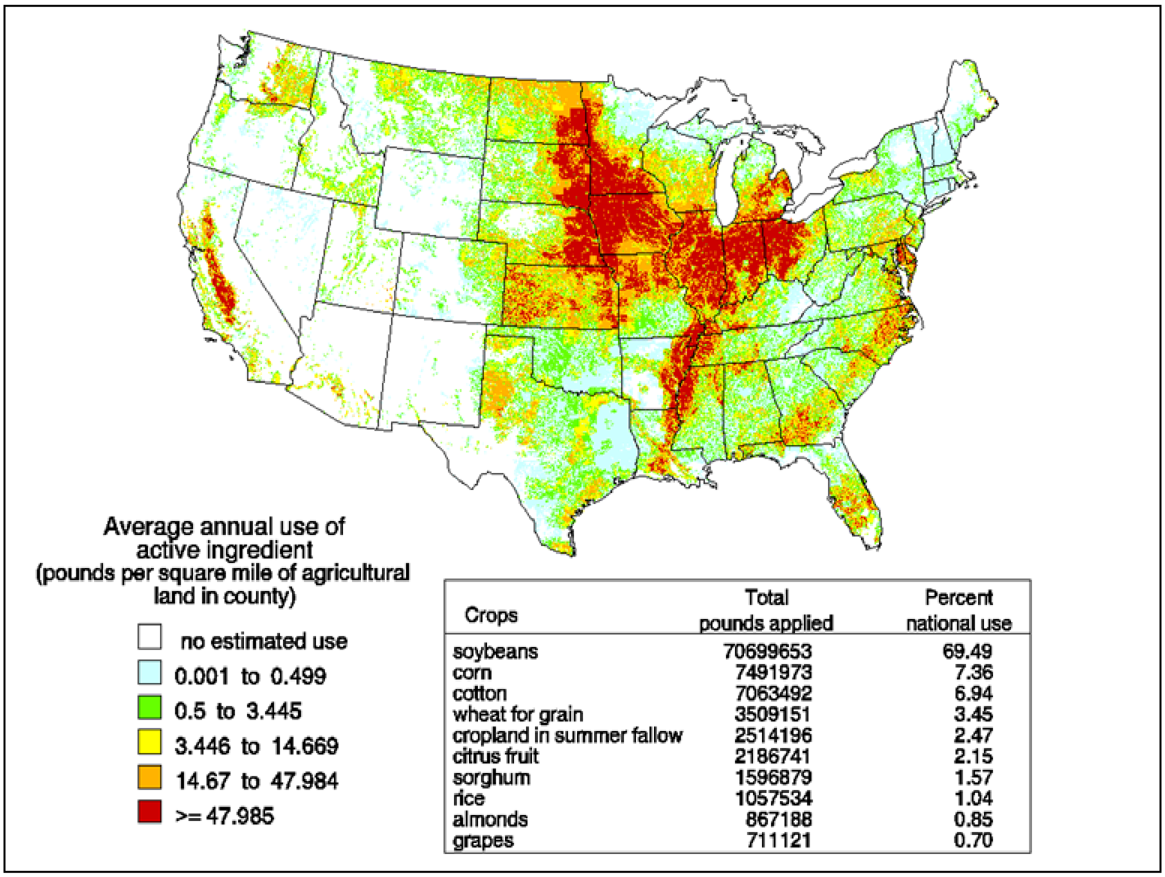


Figure 4-10. Estimated Annual Agricultural Use of Glyphosate in the U.S.

Notes: Map represents average annual pesticide use intensity expressed as average weight (in pounds) of a pesticide applied to each square mile of agricultural land and typical use patterns over the 5-year period of 1999 through 2004.
Source: (USGS, 2009; United States Geological Survey, No Date)

Changes in 2,4-D and Glyphosate Use for Enlist Duo™ Herbicide

Proposed new use rates of 2,4-D and glyphosate, the active ingredients in the new DAS Enlist Duo™ herbicide formulation, on Enlist™ corn and soybeans are detailed in Appendix 8.

Projected 2,4-D Use in Corn and Soybean under the No Action and Action Alternatives

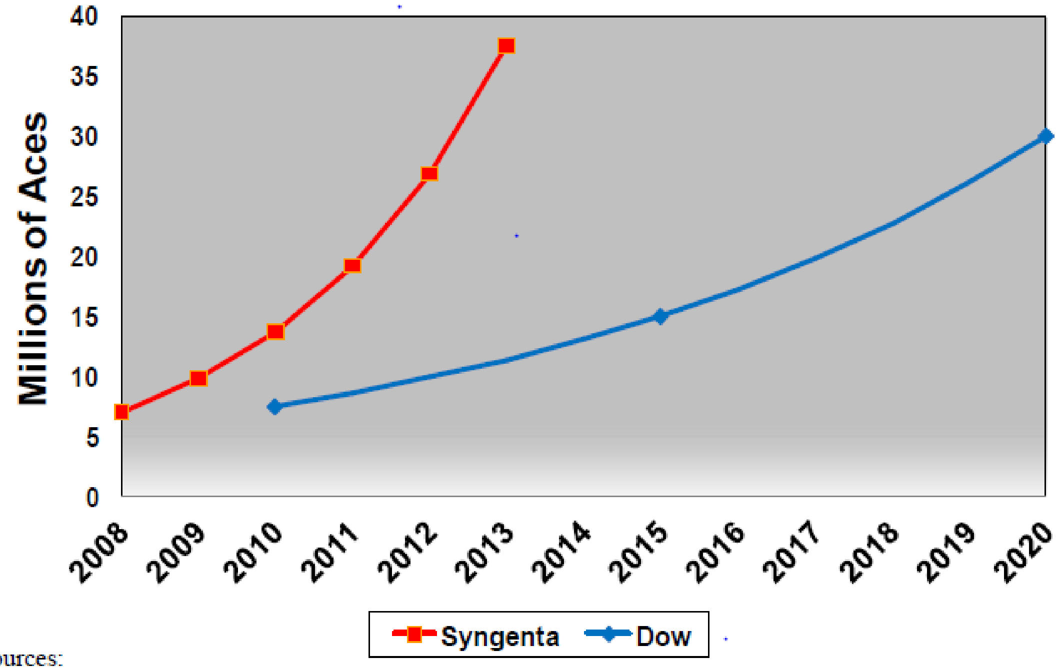
No Action Alternative

In the past 3 years, there has been a 38% increase in the amount of 2,4-D applied to corn (Table 4-8) and an 80% increase in the amount applied to soybean over the past 5 years (Table 4-9) (DAS, 2012d; DAS, 2012c). These increases are due to the increased fraction of the crops treated and the increase in acreage of both crops. Although the acreage of corn and soybean is not expected to increase substantially beyond current levels, the percentage of the crop treated is expected to continue to increase as glyphosate resistant weeds become more widespread. Thus, under the No Action Alternative, an increase in baseline use of 2,4-D on corn and soybean is expected. Historically, the highest recorded use of 2,4-D is its application to 14% of the U.S. corn acres in 1994 (USDA-NASS, 2011) which would result in a further 4% increase in 2,4-D use in corn. However, APHIS sees no reason that this share is an upper limit and 2,4-D use in either crop as a pre-plant burndown could reasonably be expected to follow the distribution of glyphosate-resistant weeds in the corn and soybean crop.

Third-party proprietary market research demonstrates that approximately 98% of glyphosate-resistant soybean acres receive at least one glyphosate application (burn down and/or post emergent). A small population of farmers (~4%) that purchase glyphosate-resistant soybeans elect not to make a post-emergent glyphosate application. The market research also indicates that 22% of planted soybean acres currently receive a burn-down (pre-plant or pre- emergence) herbicide application. For corn, ~10% of farmers that purchase glyphosate-resistant corn elect not to make a post-emergent glyphosate application. The market research also indicates that 22% of planted corn acres currently receive a burn-down (pre-plant or pre-emergence) herbicide application.

Using third party market data, DAS has estimated that 5% of U.S. corn or soybean acreage had glyphosate-resistant weeds in 2010, and that the percentage would grow to 10% of soybean/corn acreage by 2015 and to 30% by 2020 (Figure 4-13). This is consistent with but less aggressive than predictions made by other others, (Foresman, 2009; Farm Industry News, 2013).

Assuming that by 2020, 30% of corn and soybean fields will be infested with glyphosate resistant weeds, it is reasonable to assume that up to 30% of corn and soy growers will use 2,4-D on their crops for burndown applications. Currently 12% of the soy crop is treated with 2,4-D (Table 4-9). If that percentage increases to 30%, 2,4-D use on soy would be expected to increase from 5.4 to 13.5 million pounds (a factor of 30/12=2.5). Likewise, 10% of the corn crop is treated with 2,4-D (Table 4-8). If 30% were treated, the amount of 2,4-D applied would increase from 5.4 million pounds to 16.2 million pounds. Assuming 2,4-D use does not increase in other crop or non-crop applications, the total applied to crops is predicted to increase from 25.6 million pounds to 44.5 million pounds resulting in a 74% increase in crop use of 2,4-D and a 29% increase in total 2,4-D use (Table 4-14) under the No Action Alternative.



Sources:

- Foresman, C. 2009. Syngenta Resistance Fighter™ Message Board. http://blog.syngenta-us.com/blogs/ask_the_expert/archive/2009/04.aspx Accessed January 16, 2011.
- Dow AgroSciences LLC.

Source: (DAS, 2011a).

Figure 4-11. Projected corn and soybean acres infested with glyphosate resistant weeds.

Action Alternatives

There is considerable uncertainty regarding the projected use of 2,4-D on DAS-40278-9 corn, DAS-68416-4 soybean, and DAS 44406-6 soybean should all be granted non-regulated status. The adoption rate would depend on the availability of the traits in high performing varieties, the extent to which weeds are difficult to control with existing herbicides, cost of the new product relative to existing varieties, to name a few.

EPA has approved 2,4-D for use on other major agricultural crops at rates greater than those proposed for DAS-68416-4 soybean, DAS 44406-6 soybean or DAS-40278-9 corn. The proposed maximum 2,4-D application rate for soybean is the same as that currently approved for use on field corn and popcorn (US-EPA, 2005), which are typically grown in the same areas as soybeans and often in the same fields in rotation with soybean. Utilizing the historically consistent data from the current and broad use of glyphosate on DAS-40278-9 corn (Table 4-10), DAS has estimated that farmers who grow Enlist™ corn will use an average of 0.875 lbs 2,4-D ae/ac/application with an average of 1.33 applications per season. Similarly, utilizing the historically consistent data from the current and broad use of glyphosate on soybean (Table 4-11) plus field trial data on weed control with various herbicide application rates, DAS has estimated that farmers who grow Enlist™ soybean will use an average of 0.875 lbs 2,4-D ae/ac/application with an average of 1.54 applications per season (includes burn down and post emergent applications). The application rate of 0.875 lbs 2,4-D ae/ac is the midpoint between the medium and high rates allowed on the Enlist Duo™ label and is consistent with the glyphosate rate needed for weed control. As Enlist Duo™ contains an ~1:1 ratio of 2,4-D and glyphosate, nearly identical rates of 2,4-D and glyphosate will be applied.

DAS provided to APHIS three projections of 2,4-D use in corn and soybean:

***Scenario* 1** assumes growers will only apply Enlist Duo™ to DAS-40278-9 corn, DAS-68416-4 soybean, or DAS 44406-6 soybean where growers are facing or actively trying to prevent the establishment of glyphosate-resistant weeds. Additionally this scenario also assumes that all farmers with corn or soybean acres that have glyphosate resistant weeds will plant DAS-40278-9 corn or DAS-68416-4/ DAS 44406-6 soybeans and will use Enlist Duo™ herbicide. This is an overestimate of the use of 2,4-D given the fact that other weed control options are available. Assuming that minimal additional acreage would be treated to prevent glyphosate resistant weeds from becoming established, and using the assumptions set forth above regarding total corn or soybean acres, application rates and applications per season, the following formula was used to calculate total lbs of 2,4-D ae that might be used on DAS 40278-9 corn, DAS-68416-4 soybean, or DAS 44406-6 soybean:

Corn

92MM acres x 30% resistant weeds (in 2020) x .875 lbs ae/ac/application x 1.33 applications/season = 32MM lbs 2,4-D ae per year (Table 4-14). This represents an approximate six-fold increase in 2,4-D use on corn in 2020 compared to the volume of 2,4-D currently used on corn in 2011 and a 100 % increase compared to the volume predicted to be used under the No Action Alternative for 2020.

Soybean

76MM acres x 30% resistant weeds (in 2020) x .875 lbs ae/ac/application x 1.54 applications/season = 31MM lbs 2,4-D ae per year (Table 4-14). This represents an approximate six- fold increase in 2,4-D use in 2020 compared to the volume of 2,4-D currently used on soybean in 2011 and a 130 % increase compared to the volume predicted under the No Action Alternative for 2020.

Scenario Two. The second scenario assumes that all acres of DAS 40278-9 corn, DAS-68416-4 soybean, or DAS 44406-6 soybean would receive applications of Enlist Duo™, regardless of weed control need, and thus relies on estimates of what the projected market share of these two crops will be:

DAS sells corn and soybean seed through its subsidiary seed companies, i.e., Mycogen Seeds, Renze Seeds, Dairyland Seed, Pfister Seeds, Brodbeck Seeds, Triumph Seed, Prairie Brand Seed and Hyland Seeds. Through these subsidiaries, DAS currently has <5% of the market share for field corn and silage corn and <3% of the market share for soybean. At this time, DAS is not planning to breed DAS-40278-9 corn into all of its corn hybrids, so DAS-40278-9 corn would occupy considerably less than DAS's current ≤5% of the market. Similarly, DAS is not planning to breed DAS-68416-4 soybean into all of its soybean varieties, so Enlist™ soybean would occupy less than DAS's current ≤3% of the market. However, for purposes of this estimate, 5% and 3% will be used as a minimum potential for DAS-40278-9 corn and Enlist™ soybean acreage, respectively.

DAS is interested in and is pursuing licensing agreements with additional corn and soybean seed companies to breed DAS-40278-9 corn and DAS-68416-4 or DAS-44406-6 soybean into a licensee's corn and soybean germplasm, respectively. To date, two licensing agreement have been made representing ~35% of the soybean market but no agreements have been made for corn. Through natural growth and these licensing arrangements it is reasonably possible that, at maturity, approximately 45% of the corn and soybean germplasm could have the Enlist™ trait and these corn and soybean varieties could be planted on up to 45% of the total corn and soybean acreage. Due to the technical aspects of corn and soybean seed breeding, rapid improvement of germplasm and stacking with other traits, this level of adoption of DAS-40278-9 corn, DAS-68416-4 soybean, or DAS-44406-6 soybean is estimated to take 5-10 years to reach maturity (maturity in 2018-2023).

Corn:

Assuming application rates of 2,4-D are as described above: an average of 0.875 lbs ae/ac/application with 1.33 applications per year and 90% of acres estimated (based on current glyphosate application information from proprietary third party data that only 90% of glyphosate resistant corn is sprayed with glyphosate) :

At present market share of 5%, 2,4-D use on corn is expected to double compared to 2011:

92MM acres x 5% market share x 90% DAS-40278-9 corn acres treated x 0.875 lbs ae/ac/application x 1.33 applications per DAS-40278-9 corn acre = 4,709,250 additional lbs 2,4-D ae per year compared to 5.4 million pounds in 2011.

At a market share of 45%, 2,4-D use on corn might increase 8 fold compared to 2011 levels.

92MM acres x 45% market share x 90% DAS-40278-9 corn acres treated x 0.875 lbs ae/ac/application x 1.33 estimated applications per DAS-4078-9 corn acre = 43,361,325 lbs 2,4-D ae per year.

Soybean:

Assuming application rates of 2,4-D are as described above: an average of 0.875 lbs ae/ac/application with 1.54 applications per year and 100% of acres are treated:

At a market share of 45%, 2,4-D use on soybean is expected to increase approximately nine-fold compared to 2011 levels.

76MM acres x 45% market share x 100% DAS-68416-4 soybean acres treated x 0.875 lbs ae/ac/application x 1.54 estimated applications per Enlist™ soybean acre = 46,084,500 lbs 2,4-D ae per year.

***Scenario Three*:** The third scenario assumes that all current glyphosate-resistant corn and soybean acres would be planted to hybrids that also contain the DAS-40278-9 corn, DAS-68416-

4 soybean, or DAS44406-6 soybean traits. This is an unrealistically high estimation but provides an upper confidence level on 2,4-D volume. It is unrealistic to assume that all glyphosate resistant corn and soybean will be replaced by the Enlist™ products. First, not all growers will be faced with glyphosate resistant weeds and such growers may have little economic incentive to adopt Enlist™ corn or soybean. Second, other herbicide resistant soybean varieties are on or expected to appear on the market, such as glufosinate, dicamba, isoxaflutole, and mesotrione resistant varieties so competition is expected to reduce market share. Third, corn is already resistant to 2,4-D and dicamba for at least part of its growth cycle, and thus some growers may not value this trait in corn. Even with this extreme assumption, the estimated 2,4-D volume is only a 17-fold increase in 2,4-D use on corn and a fourteen fold increase on soybean compared to the current use of 2,4-D on existing varieties, calculated as follows:

From Table 4-10, 82MM acres of the 92 MM total corn acres are planted to glyphosate-resistnat corn. Using the same application information and other assumptions used in the previous two scenarios, the 2,4-D volume can be estimated as follows:

82MM glyphosate-resistant acres x 90% DAS-40278-9 corn acres treated x 0.875 lbs ae/ac/application x 1.33 estimated applications per DAS-4078-9 corn acre = 85,884,750 lbs 2,4-D per year.

For soybean, at least 32% of the market (24MM acres) will not contain the DAS-68416-4 or DAS-44406-6 soybean traits, due to one developing technology that will be a direct competitor to the Enlist™ Weed Control System. Correcting for this market share, the maximum acreage that might be planted to DAS-68416-4 or DAS 44406-6 soybean traits is 52MM acres (76MM-24MM). Using the previously applied assumptions for soybean, 2,4-D volume is estimated as follows:

52MM glyphosate-resistant acres x 100% DAS-68416-4/DAS 44406-6 soybean acres treated x 0.875 lbs ae/ac/application x 1.54 estimated applications per DAS-68416-4/DAS-44406-6 soybean acre = 70,070,000 lbs 2,4-D per year**.**

Other Estimates of 2,4-D Use on Enlist™ Corn and Soybean.

Benbrook (Benbrook, 2012) projected much higher 2,4-D use rates on DAS-40278-9 corn (30 fold) than any of the scenarios noted above. One major discrepancy is his assumption that 2,4-D use on corn may increase to 55% of planted corn acres by 2019. This is a much larger estimate than DAS made (30-45%) based on its potential for licensing of its technology to corn seed breeders. He also assumes a much higher use rate. Both Benbrook and DAS estimate a comparable application rate of 0.84 and 0.875 lbs/acre, respectively. However Benbrook projects that the frequency of applications will increase to 2.3 applications/year, while DAS estimates the average number of applications to be 1.33 per year. Historically, corn growers have used 3-4 different herbicide chemistries even after the introduction of Roundup Ready corn. If growers continue to use other modes of action, it is unlikely that 2,4-D applications will rise to 2.3 applications/year. Therefore, USDA considers the Benbrook projection to be an overestimate.

Summary of Projected 2,4-D Use

The information from the calculations described above are summarized in Table 4-14. Under the No Action Alternative, 2,4-D use is expected to increase to 82.8 million pounds for all uses of 2,4-D where 44.5 million pounds are applied to crops. The predicted 2020 crop usage constitutes an increase of nearly 75% compared to the volume of 2,4-D used on crops in 2011 (44.5 million pounds vs25.6 million pounds).

Under the Action Alternatives, three scenarios were considered (I, II, and III). Under Scenario I, a six fold increase in 2,4-D use is estimated for both corn and soybean compared to current levels. Under Scenario II, an 8 fold increase is estimated for corn and a 9 fold increase is estimated for soybean. Under Scenario III, a 17 fold increase is estimated for corn and a 14 fold increase is estimated for soybean. These calculations are summarized in Table 4-14. Total crop 2,4-D use is predicted to range from 98.6 million pounds to 214.5 million pounds, depending on the scenario and Alternative.

Compared to levels of 2,4-D used in 2011, the predicted increase in crop 2,4-D use under the Preferred Alternative would be approximately 204% to 588%. However compared to the No Action Alternative estimation for 2020, the increase on crop use is estimated to range from 75%-296%.

Under Alternative 3 where only corn would be deregulated, the increase of crop 2,4-D use predicted under the three scenarios ranges from an increase of 136% 370% compared to the current situation. Relative to the No Action Alternative estimation for 2020, the increase ranges from 36% to 169%.

Under Alternative 4, where only soy would be granted non-regulated status, the increase of crop 2,4-D use predicted under the three scenarios ranges from an increase of 201% 316% compared to the current situation. Relative to the No Action Alternative estimation for 2020, the increase ranges from 39% to 139%.

Note that even under Scenario I which predicts the smallest fold increase in 2,4-D use, USDA considers the estimate to be high because it assumes an unrealistically high market share. Thus while 2,4-D use is expected to increase under the Action Alternatives, the difference from the predicted No Action is expected to be less than the 75% increase noted in Table 4-14.

Currently, 2,4-D is the third most frequently used herbicide in the U.S (an estimated 64 million pounds were used in 2011) after glyphosate (an estimated 225 million pounds were used in 2011) and atrazine (an estimated 77 million pounds were used in 2011) (Table 4-15). Levels of atrazine use have stayed fairly constant over the past decade but use of glyphosate and 2,4-D have continued to increase. Based on the assumptions made, it is estimated that 2,4-D use will surpass atrazine use by 2020 under both the No Action and Action Alternatives.

Table 4-12. Projected 2,4-D Use Under Four Alternatives.

Alternative 2 (Enlist™ corn + soybean)					
	actual 2,4-D (millions of pounds)	projected 2,4-D use in 2020 under No Action (NA) Alternative	Projected 2,4-D use based on DOW estimates for 2,4-D use on 2,4-D corn and soybean (millions of pounds)		
	2011	increased burndown[1]	Scenario I[2]	Scenario II[3]	Scenario III[4]
crops	25.6	44.5	77.8	104.1	176.2
turf and ornamental	24.3	24.3	24.3	24.3	24.3
range/pasture/industrial management	14.0	14.0	14.0	14.0	14.0
corn	5.4	16.2	32.0	43.3	85.9
soybean	5.4	13.5	31.0	46.0	70.1
total 2,4-D	64.0	82.8	116.1	142.4	214.5
% increase in crop 2,4-D relative to No Action 2020			75%	134%	296%
% increase in total 2,4-D relative to No Action 2020			40%	72%	159%

Alternative 3 (Enlist™ corn only)					
	2011	increased burndown[1]	Scenario I[2]	Scenario II[3]	Scenario III[4]
crops	25.6	44.5	60.3	71.6	119.6
Turf and ornamental	24.3	24.3	24.3	24.3	24.3
range/pasture/industrial management	14.0	14.0	14.0	14.0	14.0
corn	5.4	16.2	32.0	43.3	85.9
soybean	5.4	13.5	13.5	13.5	13.5
total 2,4-D	64.0	82.8	98.6	109.9	157.9
% increase in crop 2,4-D relative to NA 2020			36%	61%	169%
% increase in total 2,4-D relative to NA 2020.			19%	33%	91%

Alternative 4 Enlist™ (soybean only)					
	2011	increased burndown[1]	Scenario I[2]	Scenario II[3]	Scenario III[4]
crops	25.6	44.5	62.0	77.0	106.5
Turf and ornamental	24.3	24.3	24.3	24.3	24.3
range/pasture/industrial management	14.0	14.0	14.0	14.0	14.0
corn	5.4	16.2	16.2	16.2	16.2
soybean	5.4	13.5	31.0	46.0	70.1
total 2,4-D	64.0	82.8	100.3	115.3	144.8
% increase in crop 2,4-D relative to NA 2020			39%	73%	139%
% increase in total 2,4-D relative to NA 2020.			21%	39%	75%

[1]Assumes 2,4-D applied to 30% of corn and soybean crop as preplant burndown.

[2]I estimate (30% glyphosate resistant weeds)= 6X current soy and corn use.

[3]II estimate (DAS 45% market share corn and soy)= 9x current soy and 8X current corn

[4]III estimate (all corn and soy less competitor market share)=14X current soy and 17X current corn

Source: (DAS, 2013d).

Table 4-13. Top Three Herbicides-Total Crop Use in 2002, 2011 and Estimated Use Under Alternatives (millions of lbs)

	2002	2011	2020 (No Action)	2020 (Preferred)	2020 (Alt 3)	2020 (Alt 4)
glyphosate	102	225	225	225	225	225
atrazine	77	77	77	77	77	77
2,4-D	40	64	83	116-215	99-160	100-145

Source: (DAS, 2013d).

Projected use of Quizalofop on DAS 40278-9 Corn

Changes in Quizalofop Use Directions with Enlist™ Weed Control System

Quizalofop is currently registered for use on soybean and no changes in the use of quizalofop on soybean are projected.

Quizalofop is not yet registered for use on corn. It's use as a post-emergent herbicide on corn is a proposed new use[2] (DAS, 2010b). The petitioner has indicated that "fop" herbicides could be used to maintain seed purity in DAS-40278-9 corn breeding nurseries, hybrid production fields, and generally for the control of grass weeds in corn. Table 4-16 provides a summary of the current labeled uses of quizalofop in comparison with proposed application rates and directions for use on DAS-40278-9 corn.

In current registered uses of quizalofop, the EPA has approved single application rates ranging from 0.034 to 0.082 lbs ai/acre (38 g ai/ha to 92 g ai/ha), depending on the weed species, with the highest maximum seasonal application rate being 0.206 pounds ai/acre (231 g ai/ha) for weed control in mint (DAS, 2011b). Upon EPA approval of the herbicide registration amendment, a quizalofop herbicide (e.g., Assure II) would be available for use on DAS-40278-9 corn. Whether used as a selection agent or as an herbicide, the proposed use directions would essentially be the same. The proposed directions for use of quizalofop on DAS-40278-9 corn would allow up to two post emergent applications from the V2 to V6 growth stage (Figure 4-14). Application rates are 0.034-0.082 lbs ai/ac. The total amount that could be applied in a season is 0.082 lbs ai/ac (DAS, 2011b). The maximum seasonal rate for quizalofop on DAS-40278-9 corn would be less than or equal to the maximum seasonal rate on the label for all other crops. DAS-40278-9 corn has proven tolerant to quizalofop post-emergent application rates of up to 184 g ai/ha (0.164 lbs ai/acre) in field trials (DAS, 2011c). The proposed maximum application rate is also the seasonal maximum application rate (DAS, 2011c). This maximum application rate is less than that currently approved for use of quizalofop for control of grassy weeds in soybeans and cotton, where a seasonal maximum application rate of 139 g ai/ha (0.124 lb ai/acre) is approved (DAS, 2011c).

Table 4-14. Comparison of Current and Proposed Application Rates for Quizalofop

Crop Stage	Current Use Pattern for Quizalofop on Soybeans and Cotton		Proposed New Use on DAS-40278-9 Corn	
	Maximum Application Rate (lb/acre)[1,2]	Directions and Timing	Maximum Application Rate (lb/acre)[1,2]	Directions and Timing
Post-emergence	0.082	Apply 0.034 to 0.082 lb/acre per application. Do not exceed a total of 0.124 lb/acre per	0.034 to 0.082	Apply 0.034 to 0.082 lb/acre per application from V2 – V6 Growth stages. Do not make more than 2 applications. Do not exceed a total of

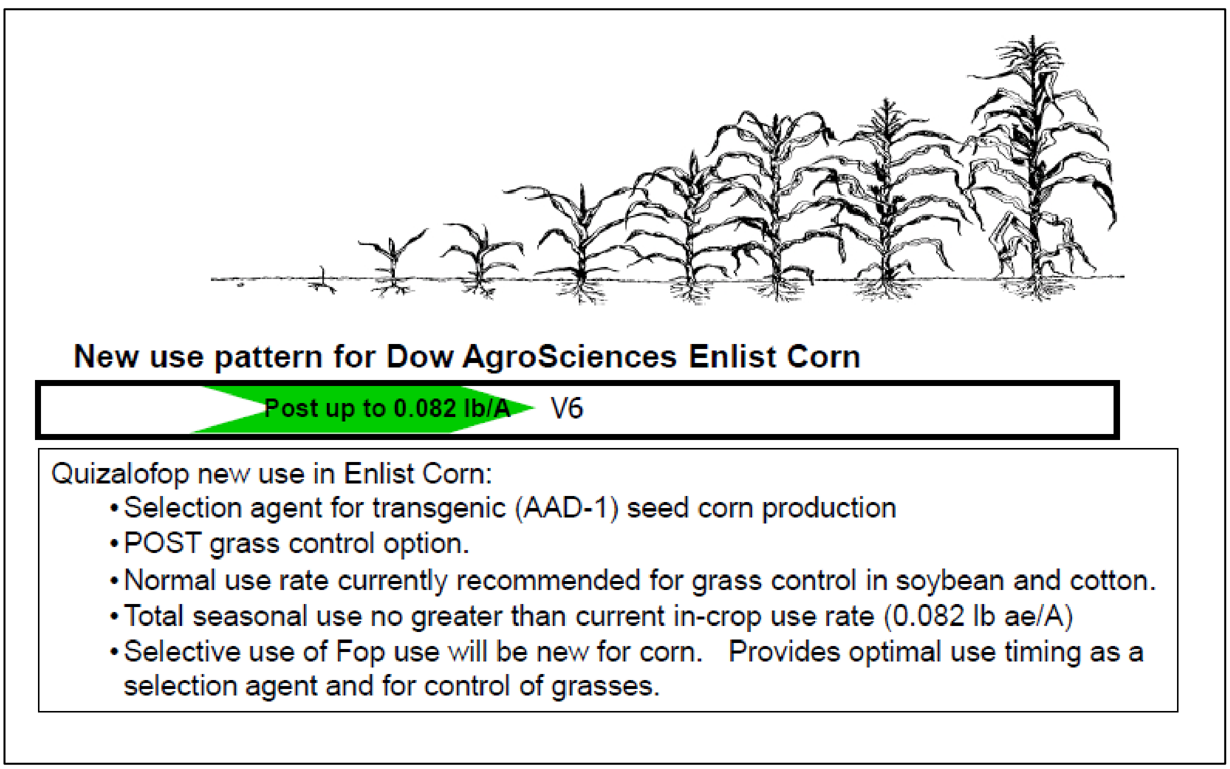
[2]As required under FIFRA, metabolism and residue data, along with proposed labeling changes, will be submitted to the EPA for the use of "fop"-type herbicides (specifically quizalofop) in DAS-40278-9 Cornfields (page 18 of the Petition). Under FIFRA, it is unlawful to use an herbicide "in a manner inconsistent with its labeling" without an experimental use permit issued (7 U.S.C. 136j). Quizalofop is currently under registration review (http://www.epa.gov/oppsrrd1/registration_review/) by the EPA with a Final Decision expected in 2013 (EPA-HQ-OPP-2007-1089 at http://www.regulations.gov, accessed 3/2011).

Crop Stage	Current Use Pattern for Quizalofop on Soybeans and Cotton		Proposed New Use on DAS-40278-9 Corn	
	Maximum Application Rate (lb/acre)[1,2]	Directions and Timing	Maximum Application Rate (lb/acre)[1,2]	Directions and Timing
		season.		0.082 lb/acre per season. Do not apply later than V6 growth stage.
Total Annual Maximum Application	0.124	---	0.082	---

Source: (DAS, 2010a).

Notes:

1. Active ingredient.
2. 1 lb/acre is the equivalent of 1,120 g/hectare.



Source: (DAS, 2012b).

Figure 4-12. Proposed Use Pattern of Quizalofop on DAS 40278-9 Corn

Under the No Action Alternative and Alternative 4, Enlist™ corn would not be deregulated and quizalofop could not be used on currently available corn varieties due to its inherent sensitivity. No changes are anticipated in the use of quizalofop on soybean.

Under the Preferred Alternative and Alternative 3, DAS-40278-9 corn would be deregulated. Because, unlike all other corn, DAS-40278-9 corn is resistant to quizalofop, new uses for quizalofop may arise including the control of glyphosate resistant grasses in corn. A determination of nonregulated status of DAS-40278-9 corn, with EPA-approved use of quizalofop on corn, has the potential to result in an increase in the annual amount of quizalofop use. Although six grass species have developed resistance to glyphosate in the US (Jungle rice, Goosegrass, Italian Ryegrass, Rigid Ryegrass, Annual Ryegrass and Johnson grass), glyphosate remains an effective grass herbicide because the acreage of the affected area is still small. Hence, in the near future it is not expected that quizalofop will be used to control grass weeds in corn. One of the major uses of quizalofop is to control volunteer corn in soybean. It is expected that this use of quizalofop to control volunteer corn will decrease on farms that have adopted DAS-40278-9 corn, under the Preferred Alternative and Alternative 3.

DAS anticipates that the primary use of quizalofop will be to enhance the purity of lines bred with the DAS 40278-9 trait. The expected primary use is as a selection agent, to remove (kill) any corn plants in the seed propagation nursery that do not contain the DAS 40278-9 trait. It could find more widespread use to control grassy weeds in corn if other herbicide control options prove to be unsatisfactory. E.I. DuPont Company (DuPont) has submitted a label amendment (Assure II, EPA Reg. No.352-541, active ingredient quizalofop) to provide new directions for quizalofop use as a selection agent in growing seed corn and as a grass herbicide for use in corn.

There are two applications considered in predicting the use of quizalofop on DAS 40278-9 corn: Use as a selection agent in producing hybrid seed corn, and use as an herbicide to control glyphosate-resistant grasses. In the foreseeable future, the latter is not considered likely given the effectiveness of glyphosate in controlling grass weeds. Hence projections are only considered for the use of quizalofop in seed corn production.

Seed Corn Production: The production of hybrid seed corn requires approximately 1 acre of nursery to produce sufficient hybrid seed to plant 125 acres the following season. Two scenarios are presented to bound the range. The first scenario, the lower bound, uses DAS current 5% market share for field and silage corn. The second, upper bound, assumes DAS market share will expand to 45%.

Scenario 1: 5% market share for field and silage corn.

92MM acres /125 acres nursery/acre of field corn x 5% market share x 0.082 lbs ai/ac/application x 1 application = 3018 lbs quizalofop.

Scenario two: 45% market share for field and silage corn.

92MM acres /125 acres nursery/acre of field corn x 45% market share x 0.082 lbs ai/ac/application x 1 application = 27,158 lbs quizalofop.

Note that if just one percent of the adopters had previously used quizalofop to manage volunteer corn in soybean, either increase will be offset by a corresponding decrease in quizalofop that will no longer be used to manage corn volunteers. For example if 1% of the soybean growers no longer use quizalofop to control volunteer corn and assuming a 5% market share of DAS-40278-9 corn is grown in rotation with soybean, the decrease in quizalofop is calculated as follows:

76MM acres soybean x 5% market share of DAS-40278-9 corn adopters x 1% no longer using quizalofop for volunteer control x 0.082 lbs ai/ac/application x 1 application=3116 pounds.

Thus the small increase in quizalofop use that is expected for corn seed production under the Preferred Alternative 2 and 3 is likely to be offset by a corresponding or larger decrease in quizalofop use by soybean growers who had previously used quizalofop to manage corn volunteers. Accordingly, it is expected that quizalofop use will decrease overall under the Preferred Alternative and Alternative 3.

Glufosinate Proposed Use on DAS-68416-4 Soybean

Under the No Action Alternative, glufosinate resistant lines of corn and soybean will still be available (Liberty Link™). As noted earlier, the planting of glufosinate resistant soybean increased three fold between 2011-2012 and further increases can be anticipated under the No Action Alternative. The Action Alternatives will not impact the availability of glufosinate resistant corn and soybean varieties. In all likelihood, glufosinate and glyphosate resistance traits will be stacked with resistance to 2,4-D and growers will have the flexibility to use glufosinate, glyphosate, and 2,4-D as appropriate. Most likely, the use of glufosinate would not increase under the Action Alternatives relative to the No Action Alternative. Possibly, glufosinate use will decrease relative to the No Action Alternative if 2,4-D is considered a more favorable option for glyphosate resistant weed control compared to glufosinate.

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Appendix 5. Common Weeds in Corn and Soybean

Common Weeds in Corn 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 corn 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, Stachler 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. These weeds tend to be the most problematic weeds in corn and soybeans, as they share a similar life cycle.

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 morning glory. 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, Creech 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. These weed species have root systems that store large amounts of food reserves, making them difficult to control. Winter perennials are particularly competitive and difficult to control because these weeds re-grow every year from rhizomes or root systems (DAS 2010). Canada thistle, bermudagrass, common milkweed, common pokeweed, dandelion, johnsongrass are examples of perennial weeds (Penn State University 2009, Mock, Creech et al. 2011).

Generally, annual grass and broadleaf weeds are considered the most common weed problems in corn and soybean (Krausz, Young et al. 2001, DAS 2010).

Weed Seed Bank

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, Renner et al. 2005, May and Wilson 2006, Buhler, Hartzler 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). Estimates of weed seeds in Corn Belt soils range from 56 to 14,864 seeds per square foot (Renner 2000). 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, Hartzler et al. 1997).

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, Hartzler 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, Hartzler 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, Sprague 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

[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.

and Norsworthy 2010, Weller, Owen 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 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, Lanini 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, Lingenfelter 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, Hartzler et al. 2008, Baucom and Holt 2009, Curran, Lingenfelter et al. 2009).

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[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 (≥30 percent), reduced (15-30 percent), or intensive (0-15 percent) CTIC (2008). 2008 Amendment to the National Crop Residue Management Survey Summary, Conservation Technology Information Center.

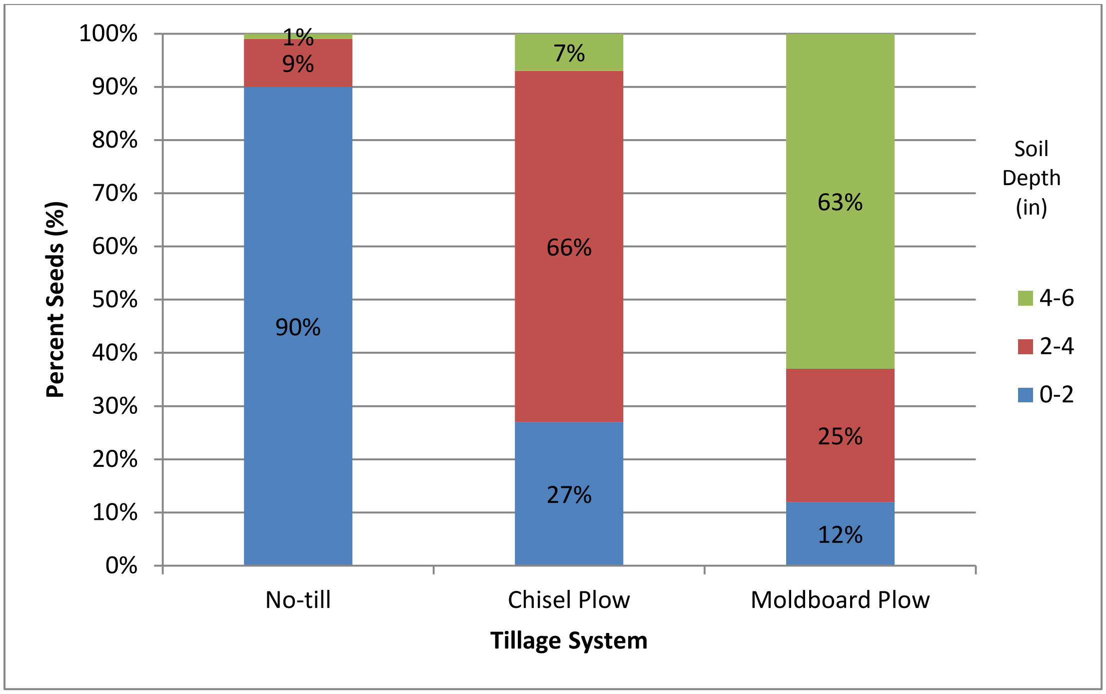

Figure 5-1. Vertical Distribution of Weed Seeds in the Soil Profile at Depths of 0 to 2 inches, 2 to 4 inches, and 4 to 6 inches Affected by Different Tillage Regimes
Source: (Shrestha, Lanini et al. 2006)

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 corn 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).

Corn is more vulnerable to early competition by weeds than soybean, especially when weed density is high, when corn is under stress from environmental conditions (e.g., drought, extreme wet conditions, cold soils), or when the crop is slow to establish (Monsanto 2012). Weed control is most critical during the first three to five weeks after emergence of corn seedlings (Sikkema and Hamill 2005, ANR 2009). Weed costs in corn begin almost as soon as the corn emerges. Weeds that are about 3 to 4 inches tall when corn is at the V-3 to V-4 growth stage[3] are going to present the most competition. If the weeds are taller than corn, they will shade the crop. Control should be begin four to five days (one to two leaves) prior to the beginning of the CPWC (Knezevic 2007). If weeds are controlled early, after several weeks when the corn canopy closes, corn can compete with later emerging weeds by shading them out. Narrow row spacing and adequate plant populations promote early corn canopy closure (Rosenberg 2013).

Although weeds do not impact corn yield nearly as much later in the corn growing season, those weeds can harbor destructive insect pests, such as thrips, which can carry Fusarium ear rot, and armyworms, which can defoliate corn. Additionally, weeds in corn can also reduce silage and feed quality, slow harvesters by causing wheel slippage or clogging, raise grain moisture content, and reduce future corn harvests by adding to the seed bank (ANR 2009).

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, Young 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, Reberg-Horton 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, Norsworthy et al. 2013).

Common Weeds in Corn and Soybean

To assist growers in managing weeds, individual states, typically through their state agricultural extension service, list the prevalent weeds in crops in their area and the most effective means for their control (see, e.g., IPM 2004, IPM 2007, University of California 2009). Some of the key weed species found in corn and soybean fields are described in the following sections.

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 corn and soybean. Weed emergence timing can dictate which weeds will be the most problematic for or be more easily controlled by a specific

[3] Corn at the V3 is approximately 2 weeks after emergence and is ~8 inches tall and at the V4 growth stage is near or at 12 inches tall.

crop production or weed management practice (Buhler, Hartzler et al. 2008). Weed management is discussed in Appendix 3.

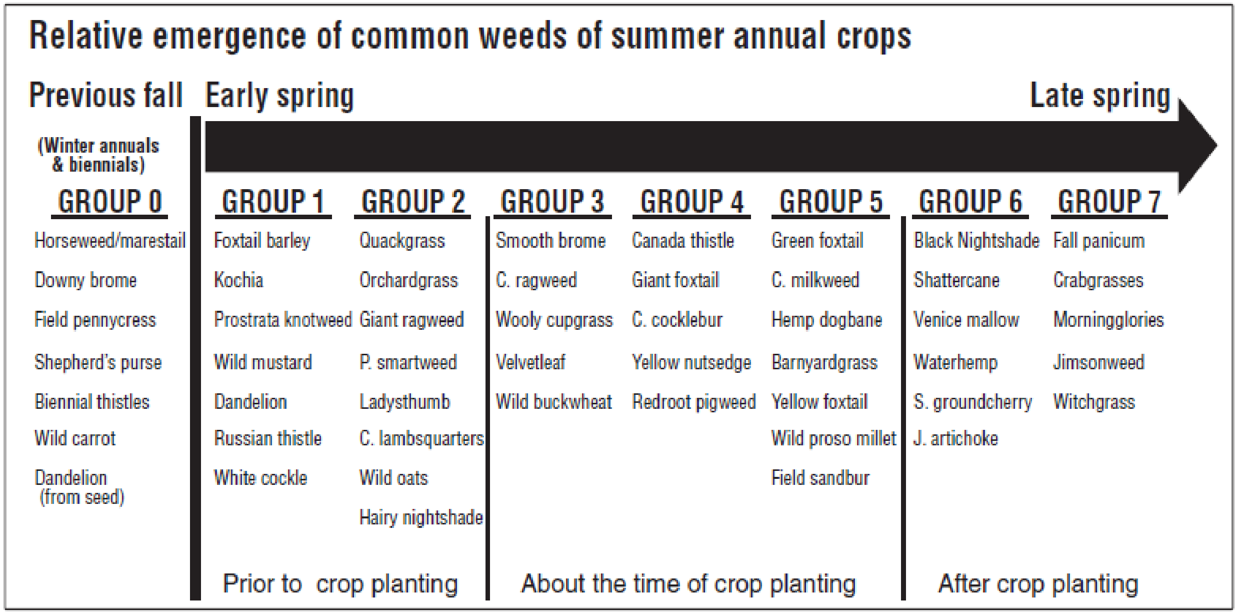

Figure 5-2. Relative Emergence of Common Weeds of Summer Annual Crops.
Source: (Buhler, Hartzler et al. 2008).

Problem Weeds in Corn and Soybean

Based on a survey of growers in 2011, Table 5-1 lists the 10 broadleaf or grass weeds found in corn and soybean that growers indicated they most often had to manage in their fields (DAS 2013). The first column lists those weeds on a national basis and the remaining columns list the weeds that are most problematic in each region. Regions that produce very little corn or soybean were not included. The Southeast region produces very little corn, but significant amounts of soybean; so information for the region was included for soybean but not for corn. Likewise the Prairie Gateway produces considerable corn but little soybean and was included in the section for corn but not soybean. Many of the problem weeds are present in multiple regions.

Table 5-1. National and Regional List of Top Ten Troublesome Broadleaf and Grass Weeds in Corn and Soybean in 2011.

US Corn	Heartland	Northern Crescent	Northern Great Plains	Prairie Gateway
Broadleaf Weeds most treated for				
VELVETLEAF	VELVETLEAF	LAMBSQUARTERS	VELVETLEAF	PIGWEED, REDROOT
PIGWEED, REDROOT	WATERHEMP, COMMON	PIGWEED, REDROOT	PIGWEED, REDROOT	KOCHIA
LAMBSQUARTERS	LAMBSQUARTERS	VELVETLEAF	WATERHEMP, COMMON	THISTLE
WATERHEMP, COMMON	RAGWEED, GIANT	RAGWEED	SUNFLOWER	VELVETLEAF
COCKLEBUR	COCKLEBUR	RAGWEED, GIANT	COCKLEBUR	MORNINGGLORY
RAGWEED, GIANT	PIGWEED, REDROOT	DANDELION	KOCHIA	THISTLE, RUSSIAN
KOCHIA	RAGWEED	THISTLE, CANADA	LAMBSQUARTERS	BINDWEED, FIELD
MARESTAIL	MARESTAIL	MORNINGGLORY	MARESTAIL	COCKLEBUR
RAGWEED	MORNINGGLORY	COCKLEBUR	THISTLE, CANADA	THISTLE, MUSK
MORNINGGLORY	HORSEWEED	THISTLE	SUNFLOWER	SUNFLOWER
Grass weeds most treated for				
FOXTAIL	FOXTAIL	FOXTAIL	FOXTAIL, YELLOW	JOHNSONGRASS
FOXTAIL, GIANT	FOXTAIL, GIANT	QUACKGRASS	FOXTAIL	SANDBUR
FOXTAIL, YELLOW	FOXTAIL, YELLOW	FOXTAIL, GIANT	FOXTAIL, GREEN	WHEAT, VOLUNTEER
FOXTAIL, GREEN	FOXTAIL, GREEN	FOXTAIL, YELLOW	FOXTAIL, GIANT	PANICUM, TEXAS
JOHNSONGRASS	JOHNSONGRASS	CRABGRASS	SANDBUR	BARNYARDGRASS
CRABGRASS	PANICUM, FALL	FOXTAIL, GREEN	WHEAT, VOLUNTEER	SICKLEGRASS
WHEAT, VOLUNTEER	CUPGRASS, WOOLLY	PANICUM, FALL	OAT, WILD	
QUACKGRASS	BARNYARDGRASS	GRASSES, ALL	BARNYARDGRASS	
PANICUM, FALL	QUACKGRASS	MILLET, WILD-PROSO	CHEAT	
BARNYARDGRASS	CRABGRASS	CUPGRASS, WOOLLY	CRABGRASS	

US Soybeans	Heartland	Northern Crescent	Northern Great Plains	SouthEast
Broadleaf Weeds most treated for				
REDROOT PIGWEED	WATERHEMP, COMMON	LAMBSQUARTERS	VELVETLEAF	PIGWEED, REDROOT
COMMON WATERHEMP	VELVETLEAF	VELVETLEAF	WATERHEMP, COMMON	MORNINGGLORY
VELVETLEAF	RAGWEED, GIANT	PIGWEED, REDROOT	COCKLEBUR	MARESTAIL
COCKLEBUR	LAMBSQUARTERS	RAGWEED	MARESTAIL	COCKLEBUR
MARESTAIL	COCKLEBUR	RAGWEED, GIANT	PIGWEED, REDROOT	AMARANTH, PALMER'S
LAMBSQUARTERS	PIGWEED, REDROOT	DANDELION	MUSTARD, WILD	SICKLEPOD
GIANT RAGWEED	MARESTAIL	NIGHTSHADE, BLACK	BUCKWHEAT, WILD	SIDA, PRICKLY
MORNINGGLORY	RAGWEED	CHICKWEED, MOUSEEAR	LAMBSQUARTERS	LAMBSQUARTERS
RAGWEED	MORNINGGLORY	MORNINGGLORY	SUNFLOWER	SESBANIA, HEMP
SUNFLOWER	WATERHEMP, TALL	WATERHEMP, COMMON	KOCHIA	HENBIT
Grass weeds most treated for				
FOXTAIL	FOXTAIL	FOXTAIL	FOXTAIL	JOHNSONGRASS
FOXTAIL, GIANT	FOXTAIL, GIANT	QUACKGRASS	FOXTAIL, YELLOW	BARNYARDGRASS
JOHNSONGRASS	FOXTAIL, YELLOW	FOXTAIL, GIANT	OAT, WILD	CRABGRASS
FOXTAIL, YELLOW	JOHNSONGRASS	FOXTAIL, YELLOW	FOXTAIL, GIANT	SIGNALGRASS, BROADLEAF
BARNYARDGRASS	CORN, VOLUNTEER	CORN, VOLUNTEER	FOXTAIL, GREEN	RYEGRASS
FOXTAIL, GREEN	FOXTAIL, GREEN	CRABGRASS	BROME, DOWNY	WATERGRASS
CRABGRASS	QUACKGRASS	FOXTAIL, GREEN	BROME, JAPANESE	BLUEGRASS, ANNUAL

Source: (DAS 2013)

Based on the information in Table 5-1, a list of the unique problem weeds in corn and soybean are presented in Table 5-2. In some cases the same weed species are listed under two different common names in Table 5-1. In Table 5-2, common waterhemp and tall waterhemp are listed as waterhemp. Marestail and horseweed are listed as horseweed. Moringglory and field bindweed are listed as field bindweed. Thistle is listed as Canada, Russian, or Musk thistle. Foxtail is listed as giant, yellow, or green foxtail.

In summary, there are 25 broadleaf and 22 grass weed species noted from the top ten lists, respectively, that required control measures in the major growing regions of soybean and corn. Some species such as redroot pigweed were problematic in all regions in both corn and soybean fields (marked in green in Table 5-2). Other species such as sicklepod, prickly sida, and wild buckwheat were more regional problems. Combining the lists of corn and soybean, there are a total of thirteen broadleaf and nine grass weeds, respectively, that are a problem in both corn and soybean, four broadleaf and seven grass weeds that are mostly problematic in corn (marked in yellow in Table 5-2), and eight broadleaf and six grass weeds that are mostly problematic in soybean (marked in blue in Table 5-2).

Table 5-2. Summary of Problem Weeds Affecting Corn and Soybean.

Broadleaf Weeds			Grass Weeds		
Corn + Soybean	**Corn**	**Soybean**	**Corn + Soybean**	**Corn**	**Soybean**
redroot pigweed	henbit	wild mustard	giant foxtail	woolly cupgrass	downy brome
lambsquarters	Pennsylvania smartweed	black nightshade	yellow foxtail	wild-proso millet	Japanese brome
waterhemp	Russian thistle	mousear chickweed	green foxtail	sandbur	broadleaf signalgrass
cocklebur	musk thistle	hemp sesbania	johnsongrass	fall panicum	ryegrass
giant ragweed		palmer's amaranth	crabgrass	cheat	watergrass
kochia		sicklepod	wheat, volunteer	Texas panicum	annual bluegrass
horseweed		prickly sida	quackgrass	sicklegrass	
common ragweed		wild buckwheat	barnyardgrass		
field bindweed			wild oat		
sunflower					
Canada thistle					
velvetleaf					
dandelion					

Based on the data in Table 3-1 (DAS 2013) .
Notes:
Green: Weeds managed in both corn and soybean
Yellow: Weeds primarily managed in corn
Blue: Weeds primarily managed in soybean

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> The species composition and density of weed seed in the soil vary greatly and are closely linked to the cropping history of the land. Altering tillage practices changes weed seed depth in the soil, which plays a role in weed species shifts and affects efficacy of control practices. Crop rotation and weed control practices also affect the weed seedbank. Information on the influence of cropping practices on the weed seedbank should be a useful tool for integrated weed management. Decision aid models use information on the weed seedbank to estimate weed populations, crop yield loss, and recommend weed control tactics. Understanding the light requirements of weed seed may provide new approaches to weed management. Improving and applying our understanding of weed seedbank dynamics is essential to developing improved weed management systems. The principles of plant ecology must be integrated with the science of weed management to develop strategies that take advantage of basic plant responses in weed management systems for agronomic crops.

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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)) and then in field bindweed (*Convolvulus arvensis)* in Kansas cropland in 1964 (Heap, 2013a).

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 (International, 2012).

ALS inhibitors or Group 2 herbicides were introduced in the mid-1980s and became extensively used in both corn and 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 (Owen, 2008; Duke and Powles, 2009) (Duke and Powles, 2008).

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 I 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, 2013a). 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 (see also Figures 4-1, 4-3. 4-4, and 4-5). 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. In 2005, surveyed growers in multiple states rotating soybean and corn indicated they chose glyphosate 22% of the time for spring burndown, versus 9% 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), and growers rotating between corn and soybean, used glyphosate two or more times 50% of the time on soybean. When growers used non-glyphosate herbicides, continuous soybean growers used these herbicides in post-emergence applications 67% of the time, and corn/soybean growers applied the herbicides on soybean post-emergence 35% of the time (Table 6-2). 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, and because the most common rotation crop for corn is soybean, exposure of weeds to selecting doses of glyphosate occurs in consecutive seasons. Prince et al. (2012) document that in 2005, glyphosate tolerant corn/glyphosate tolerant soybean rotations, only 9% of soybean acreage received non-glyphosate herbicides, although 45% of corn acreage received non-glyphosate treatment.

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/corn rotation	22%	9%

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

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

	Herbicide Application					
Crop	**Glyphosate**			**Non-glyphosate**		
Frequency	1X	2X	3X	1X	2X	3X
Continuous soybean	23	62	12	27	7	67
Soybean in soybean/corn rotation	48	47	3	53	12	35

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 (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 (Burnet et al., 1994). 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 corn, 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). A decline in corn pre-emergent herbicide use also occurred, from nearly 80% to around 60%. Post-emergent herbicides were applied to about 80% of soybean in 1996, then steadily increased to nearly 100% in 2010; in corn, post emergent herbicide use increased from 60% to 75%. These reflect increased use of glyphosate with its utility as an over the top and POST herbicide on soybean, but also a decline in reliance on pre-emergent non glyphosate herbicides. 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 numbers of herbicides used in soybean and corn. 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). Corn growers chose to rotate pesticides to avoid resistance development from a high of 45% in 1998 to about 30% in 2010. Total applications of all herbicides have also declined from nearly 3 per year in soybean in 1996 to about 2 in 2006 (USDA-ERS, 2010). Although this survey does not tabulate different sites of action applied in these years, it is clear that fewer SOAs were likely employed since overall application rates indicate limited actual use of non-glyphosate herbicides on soybean.

Weeds Resistant to the Herbicides Commonly Used on Corn and Soybean.

As of March 21, 2013, internationally, there were 397 cases of herbicide resistant weeds in 217 species (Heap, 2013a). 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 21 of the 25 known herbicide sites of action has been identified throughout the world (Heap, 2013a). Of the 25 known herbicide sites of action, 11 of these sites of action are commonly used on corn and soy (See Appendix 4, Table 6-3). These sites of action and the particular herbicides commonly used to manage weeds in corn and soybean are listed on the top and bottom, respectively of Table 6-3. While there are hundreds of cases of herbicide resistant weeds, most of these weeds are not actively managed in corn and soybean. The analysis below focuses on weeds that are actively managed in corn and soybean fields and addresses which of these have developed herbicide resistance to the major herbicides used in corn and soybean.

Table 6-3, below, lists the problem weeds of corn and soybean, derived from survey data noted in Tables 5-1 and 5-2 in Appendix 5, and indicates whether validated herbicide resistance has been reported for these species as noted in the International Survey of Herbicide Resistant Weeds (Heap, 2013a). Each column represents a different site of action and the WSSA number associated with that site of action is also listed on the top of each column. The major herbicides used on corn and soybean are listed below the table and color coded green if used on both corn and soybean, blue if used only on soybean, and yellow if only used on corn. If a particular weed has been reported to be resistant to any of the herbicides listed below the chart, the herbicide is so indicated for that combination and colored as just described. In cases where herbicide resistance has been noted only outside the U.S., the herbicide is marked with an asterisk. Quizalofop-p-ethyl is not among the top ten herbicides used in corn or soybean, but nevertheless is indicated where corn/soybean weeds are resistant. Cells are marked NR, for "not reported," in cases where resistant weeds against the listed herbicides are not reported on International Survey of Herbicide Resistant Weeds site (Heap, 2013a).The last column lists those cases where weeds have been selected for resistance against more than one herbicide site of action corresponding to the listed herbicides. In those cases, the WSSA Herbicide Group # for the site of action is listed. For example, two types of multiply resistant kochia biotypes have been noted. One is multiply resistant to both ALS (#2) and PSII inhibitors (#5), the other is multiply resistant to ALS inhibitors (#2) and glyphosate (#9).

Table 6-3. Herbicide Resistant Biotypes of Problem Weeds in Corn and Soybean.

WSSA herbicide #	2	5	1	4	22	9	3	14	15	27	10	
major weeds in corn and soybean	**ALS**	**PSII**	**ACCase**	**Auxin**	**Bipyridiliums**	**EPSPS**	**Dintro-anilines**	**PPO**	**Chloroacetamides**	**4-HPPD**	**GS**	**multiple**
BROADLEAF												
PIGWEED,REDROOT	imazethapyr Chlorimuron-ethyl chloransulam-methyl thifensulfuron-methyl tribenuron methyl [1] nicosulfuron[1]	metribuzin[1] atrazine simzine[1]	N/A	NR	NR	NR	NR	NR	NR	NR	NR	2+5 2+7
LAMBSQUARTERS	thifensulfuron-methyl tribenuron methyl [1]	metribuzin atrazine simzine	N/A	dicamba[1]	NR	NR	NR	NR	NR	NR	NR	NR
WATERHEMP	Chlorimuron-ethyl imazethypyr chloransulam-methyl thifensulfuron-methyl flumetsulam nicosulfuron rimsulfuron	atrazine	N/A	2,4-D	NR	Glyphosate	NR	fomesafen lactofen	NR	mesotrione isoxaflutole	NR	2+5 2+[1]4 2+9 2+27 2+5+9 2+5+[1]4 2+9+[1]4 2+5+27 2+9+27 2+5+[1]4+27 2+5+9+[1]4 2+5+9+27 2+5+9+[1]4+27
COCKLEBUR	imazethypyr Chlorimuron-ethyl chloransulam-	NR	N/A	NR	NR	NR	NR	NR	NR	NR	NR	NR

WSSA herbicide #	2	5	1	4	22	9	3	14	15	27	10	
major weeds in corn and soybean	ALS	PSII	ACCase	Auxin	Bipyridiliums	EPSPS	Dintro-anilines	PPO	Chloroacetamides	4-HPPD	GS	multiple
	methyl											
RAGWEED, GIANT	chloransulam-methyl imazethypyr Chlorimuron-ethyl	NR	N/A	NR	NR	Glyphosate	NR	NR	NR	NR	NR	2+9
KOCHIA	imazethypyr thifensulfuron-methyl tribenuron methyl rimsulfuron nicosulfuron	atrazine	N/A	dicamba	NR	Glyphosate	NR	NR	NR	NR	NR	2+5 2+9
Horseweed	Chlorimuron-ethyl chloransulam-methyl thifensulfuron-methyl tribenuron methyl	atrazine simzine	N/A	NR	paraquat	Glyphosate	NR	NR	NR	NR	NR	2+9 9+22 5+7[1] 2+5[1]
RAGWEED	Chlorimuron-ethyl chloransulam-methyl imazethypyr	atrazine simzine	N/A	NR	NR	Glyphosate	NR	flumioxazin fomesafen lactofen	NR	NR	NR	2+[1]4 2+9
Field Bindweed	NR	NR	N/A	2,4-D	NR	NR	NR	NR	NR	NR	NR	NR
SUNFLOWER	Chlorimuron-ethyl imazethypyr chloransulam-methyl flumetsulam	NR	N/A	NR	NR	NR	NR	NR	NR	NR	NR	NR
THISTLE, CANADA	NR	NR	N/A	2,4-D[1]	NR	NR	NR	NR	NR	NR	NR	NR
velvetleaf	NR	atrazine	N/A	NR	NR	NR	NR	NR	NR	NR	NR	NR

WSSA herbicide #	2	5	1	4	22	9	3	14	15	27	10	
major weeds in corn and soybean	ALS	PSII	ACCase	Auxin	Bipyridiliums	EPSPS	Dintro-anilines	PPO	Chloroacetamides	4-HPPD	GS	multiple
dandelion	NR	NR	N/A	NR	NR	NR	NR	NR	NR	NR	NR	NR
HENBIT	NR	NR	N/A	N/A	NR	NR	NR	NR	NR	NR	NR	NR
Pennsylvania SMARTWEED	NR	atrazine	N/A	NR	NR	NR	NR	NR	NR	NR	NR	NR
Russian thistle	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
Musk thistle				2,4-D								
wild mustard	chloransulam-methyl imazethypyr thifensulfuron-methyl tribenuron methyl[1]	atrazine[1] metribuzin[1]	N/A	dicamba[1] 2,4-D[1]	NR	NR	NR	NR	NR	NR	NR	NR
black nightshade	NR	atrazine simazine	NR		paraquat	NR	NR	NR	NR	NR	NR	NR
mousear chickweed	NR	NR	N/A	NR	NR	NR	NR	NR	NR	NR	NR	NR
hemp sesbania	NR	NR	N/A	NR	NR	NR	NR	NR	NR	NR	NR	NR
palmer's amaranth	imazethypyr Chlorimuron-ethyl thifensulfuron-methyl	atrazine				Glyphosate				mesotrione		2+9 2+5+27
sicklepod	NR	NR	N/A	NR	NR	NR	NR	NR	NR	NR	NR	NR
prickly sida	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
wild buckwheat	thifensulfuron-methyl tribenuron methyl[1]	NR	N/A	NR	NR	NR	NR	NR	NR	NR	NR	NR
Grasses												
foxtail, giant	imazethypyr nicosulfuron rimsulfuron	atrazine	clethodim quizalofop-p-ethyl[2]	N/A	NR	NR	NR	NR	NR	NR	NR	NR
foxtail, yellow	imazethypyr	atrazine simzine	NR	N/A	NR	NR	NR	NR	NR	NR	NR	NR
foxtail, green	imazethypyr[1]	atrazine[1]	NR	N/A	NR	NR	NR	NR	NR	NR	NR	NR

WSSA herbicide #	2	5	1	4	22	9	3	14	15	27	10	
major weeds in corn and soybean	**ALS**	**PSII**	**ACCase**	**Auxin**	**Bipyridiliums**	**EPSPS**	**Dintro-anilines**	**PPO**	**Chloroacetamides**	**4-HPPD**	**GS**	**multiple**
johnsongrass	nicosulfuron rimsulfuron[1] imazethypyr	NR	quizalofop-p-ethyl[2] clethodim	N/A	NR	Glyphosate	NR	NR	NR	NR	NR	NR
crabgrass	imazethypyr[1] nicosulfuron[1]	atrazine[1]	clethodim[1] quizalofop-p-ethyl[1]([2])	N/A	NR	NR	NR	NR	NR	NR	NR	NR
wheat, volunteer[3]	NR	NR	N/A	N/A	NR	NR	NR	NR	NR	NR	NR	NR
quackgrass	NR	NR	N/A	N/A	NR	NR	NR	NR	NR	NR	NR	NR
barnyardgrass	imazethypyr[1] nicosulfuron[1]	atrazine simzine	quizalofop-pethyl[1]([2])									
oat, wild	rimsulfuron[1]	NR	clethodim[1] quizalofop-p-ethyl[2]	N/A	NR	NR	NR	NR	NR	NR	NR	NR
cupgrass, woolly	NR	NR	N/A	N/A	NR	NR	NR	NR	NR	NR	NR	NR
millet, wild-proso	NR	NR	N/A	N/A	NR	NR	NR	NR	NR	NR	NR	NR
sandbur	NR	NR	N/A	N/A	NR	NR	NR	NR	NR	NR	NR	NR
panicum, fall	NR	atrazine[1]	NR	N/A	NR	NR	NR	NR	NR	NR	NR	NR
cheat[4]	NR	NR	N/A	N/A	NR	NR	NR	NR	NR	NR	NR	NR
panicum, texas	NR	NR	N/A	N/A	NR	NR	NR	NR	NR	NR	NR	NR
sicklegrass	NR	NR	N/A	N/A	NR	NR	NR	NR	NR	NR	NR	NR
brome, downy	NR	atrazine[1] simzine[1]	clethodim quizalofop-p-ethyl[2]	N/A	NR	NR	NR	NR	NR	NR	NR	NR
brome, japanese[4]	NR	NR	N/A	N/A	NR	NR	NR	NR	NR	NR	NR	NR
signalgrass, broadleaf	NR	NR	N/A	N/A	NR	NR	NR	NR	NR	NR	NR	NR
ryegrass (italian?)	NR	NR	clethodim[1] quizalofop-p-ethyl[2]	N/A	NR	Glyphosate	NR	NR	NR	NR	glufosinate	NR
watergrass[4]	NR	NR	N/A	N/A	NR	NR	NR	NR	NR	NR	NR	NR
bluegrass, annual	NR	simzine atrazine	NR	N/A	NR	Glyphosate	NR	NR	NR	NR	NR	NR

WSSA herbicide #	2	5	1	4	22	9	3	14	15	27	10	
major weeds in corn and soybean	ALS	PSII	ACCase	Auxin	Bipyridiliums	EPSPS	Dintro-anilines	PPO	Chloroacetamides	4-HPPD	GS	multiple

Key: Commonly used herbicides on corn and soybean

2	5	1	4	22	9	3	14	15	27	10
ALS	**PSII**	**ACCase**	**Auxin**	**Bipyridiliums**	**EPSPS**	**Dintroanilines**	**PPO**	**Chloroacetamides**	**4-HPPD**	**GS**
Chlorimuron	metribuzin	clethodim	2,4-D	paraquat	Glyphosate	pendimethalin	flumioxazin	metolachlor-S	mesotrione	glufosinate
imazethypyr	atrazine	quizalofop-p-ethyl[2]	dicamba				fomesafen	acetochlor	isoxaflutole	
chloransulam-methyl	simzine		clopyralid				sulfentrazone			
thifensulfuron-methyl							saflufenacil			
tribenuron methyl							flutiacet-methyl			
flumetsulam							lactofen			
thiencarbazone-methyl										
rimsulfuron										
nicosulfuron										

[1]outside US only

[2]not a top 10 herbicide in either soy or corn

[3]ALS resistant varieties through conventional breeding; glyphosate resistant variety identified as volunteers in a single Oregon field though never deregulated.

[4]Not resistant to herbicides commonly used on corn and soybean

Source: (DAS, 2013; Heap, 2013b)

The most widespread resistance is observed for the ALS inhibitors. Five different ALS inhibitors are commonly used on soybean and four are used on corn but none of these herbicides are commonly used on both crops. For this site of action, 12 of the 25 problem broadleaf weeds and 7 of the 22 grasses include ALS resistant biotypes. We are not aware if these biotypes exhibit cross reactivity to other ALS herbicides listed or otherwise. From limited survey data, it has been inferred that ALS resistant weeds are present in all soybean fields in the Heartland (Tranel *et al.*, 2011).

Also widespread are biotypes resistant to PSII inhibitors which include 11 of the problem broadleaf weed species and eight of the grasses. Most of these cases involve biotypes that have been selected against atrazine in corn or metribuzin in soybean.

ACCase inhibitors are grass specific herbicides and so have not been used on corn. They have been used on soybean and other crops. Clethodim is one of the more commonly used herbicides on soybean. Quizalofop-p-ethyl, is not commonly used on soybean but is considered here because Enlist™ corn would also be resistant to that herbicide. Seven of the problem grasses have developed resistance to quizalofop-p-ethyl and a subset of six biotypes are also reported to be resistant to clethodim, though for two of these cases, crabgrass, and barnyard grass, resistant biotypes have only been reported outside the U.S.

Glyphosate, 2,4-D, and dicamba are the three herbicides that are commonly used on both soybean and corn. Of the three, only glyphosate is effective on most grass weeds. Relatively few grass weeds have resistant biotypes so glyphosate remains a very effective herbicide to control grasses. Of the problem weeds in corn and soybean, three: johnsongrass, Italian ryegrass, and annual bluegrass have been selected for glyphosate resistance. Glyphosate resistant broadleaf weeds have been more problematic. In this case, resistant biotypes have been selected in five broadleaf species and these resistant biotypes are more widely disseminated especially in the Southeast. The prevalence of such weeds is increasing and becoming more problematic in the Northern Crescent, Heartland, and Great Plains. Corn/soybean weeds that now have glyphosate resistance include waterhemp, giant ragweed, kochia, horseweed, and common ragweed.

Resistance to glufosinate offers an alternative mode of action to glyphosate for the broad-spectrum control of weeds in soybean. To date, only Italian Ryegrass has been reported as resistant to glufosinate in the U.S. and this biotype is located in Oregon. However, this population of Italian Ryegrass also appears tolerant to glyphosate. Three problem corn/soybean weeds, lambsquarters, kochia, and wild mustard have dicamba resistant biotypes (though wild mustard is not reported to be resistant in the U.S.). Four problem corn/soybean weeds, waterhemp, field bindweed, canada thistle, and wild mustard, are reported to be resistant to 2,4-D (though the Canada thistle and wild mustard biotypes are not reported to be resistant in the U.S.). Resistance to clopyralid, the other auxin commonly used in corn, has not been reported.

For the other commonly used herbicides on corn and soybean, resistant biotypes have generally not been selected in the problem weeds. The exceptions include horseweed and black nightshade resistant to paraquat, waterhemp and ragweed resistant to PPO inhibitors, Italian ryegrass resistant to glufosinate, and waterhemp and Palmer's amaranth resistant to the 4-HPPD inhibitors mesotrione and isoxaflutole. There are two sites of action for which we are not aware of any resistant biotypes in the problem weeds. These include the dinitroanilines, such as pendamethalin, and the chloroacetamides such as metolachlor-S and acetochlor.

A number of the problem weeds have biotypes that are resistant to herbicides corresponding to more than one site of action. The most problematic is waterhemp which is resistant to six of the eleven sites of action commonly used in corn and soybean. Biotypes multiply resistant to 13 combinations of these sites of action have been reported including one biotype that is resistant to five sites of action (Owen, 2012). Ragweed, kochia, and horseweed are each reported to have biotypes resistant to four sites of action including biotypes that are multiply resistant to two herbicides. Horseweed has four such biotypes, kochia and ragweed each have two. Multiply resistant biotypes have also been selected in redroot pigweed and giant ragweed. In total, 7 of the 47 problem weeds include biotypes resistant to more than one herbicide.

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Appendix 7. Off-Target Pesticide Movement

Off-Target Pesticide Movement

Once applied, pesticides (which include herbicides) 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 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.

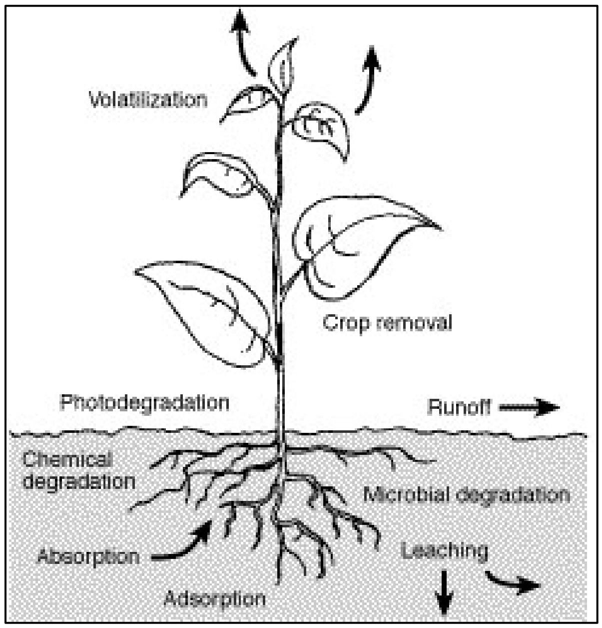

Figure 7-1. Environmental fate of herbicides in the environment.

Pesticide use has the potential to affect soil quality due to the impact to the soil microbial community. 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, 2012c). 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. Currently, EPA-OPP is evaluating new regulations for pesticide drift labeling and the identification of BMPs to control such drift (US-EPA, 2009), 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, 2009).

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 2,4-D and quizalofop, 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).

In the comments to the EA on 2,4-D resistant corn and soybean, the issue was raised whether the increase in 2,4-D use expected from the adoption of Enlist™ corn and soybean would result in greater off-target effects to neighboring crops and thereby increase adverse socioeconomic impacts to these farmers. A group, Save Our Crops Coalition (SOCC), comprised of fruit and vegetable growers in the Heartland, petitioned the USDA to conduct an EIS regarding the deregulation of Enlist™ corn and soybean, because of their concern that off target movement of 2,4-D would damage their crops. In this appendix, we consider the EPA's regulation of off-target pesticide movement, the recorded cases of 2,4-D damages to neighboring farms, and the changes requested by DAS for the registration of Enlist™ products aimed at mitigating off-target pesticide movement.

2,4-D and off-target movement

Since it was introduced in 1948, there have been reports of 2,4-D adversely affecting non-target broadleaf food and feed crops, such as cotton, grapes and tomatoes, growing in the vicinity of target crops (Schultz *et al.*, 1956). Such incidents have been linked to drift of spray droplets (especially through aerial spraying) or drift of vapors formed by volatilization of the 2,4-D itself (Dexter, 1993).

Increased control of drift and volatilization across pesticides has been achieved with proper equipment setup and attention paid to climatic conditions at the time of application. University extension agencies have been especially prominent in developing and disseminating "Good Application Practices" to minimize drift. Additionally, pesticide label restrictions, state pesticide regulations, nozzle technology and manufacturer stewardship programs have helped to develop and establish application practices that minimize the potential for off-target exposure.

The herbicide 2,4-D is currently available in several formulations, including 2,4-D acid, 2,4-D sodium salt, 2,4-D diethyl amine, 2,4-D dimethylamine salt, 2,4-D isopropyl acid, 2,4-D triisopropyl acid, 2,4-D butoxyethyl ester), 2,4-D ethylhexyl ester, and 2,4-D isopropyl ester (US-EPA, 2005c). In 2011, EPA approved the first new use of the 2,4-D choline salt formulation on crops, including corn and soybean (US-EPA, 2011). The 2,4-D mode of action as a synthetic auxin is not changed by these formulations, but the chemical and physical properties of each formulation influence the selection of equipment, mitigation measures adopted in the field to minimize off-target impacts, and formulation-specific safety measures. 2,4-D is formulated primarily as an amine salt in an aqueous solution or as an ester in an emulsifiable concentrate (US-EPA, 2005c). For a majority of uses, 2,4-D is combined with other herbicides because it economically enhances the weed control spectrum of many other herbicides such as glyphosate, dicamba, mecoprop, and acetolactate synthase (ALS)-inhibitor herbicides (US-EPA, 2005c).

Attributions of volatility to 2,4-D have largely been associated with the esters, particularly short chain esters. Early forms of 2,4-D included short chain esters that were favored due to rapid herbicidal activity, but these were relatively volatile (Nice *et al.*, 2004). A desire to reduce risk of off-target injury to sensitive crops, such as cotton, tomatoes or grapes, led to the development of longer chain esters that were notably less volatile, and to development of various amine salts that EPA considers to be essentially non- volatile. The volatility of the salt forms approaches two orders of magnitude reduction compared to the short chain esters (US-EPA, 2013). In the last two decades, longer chain esters have replaced the shorter chain esters and reduced volatility issues. In addition, the new 2,4-D choline salt further reduces the potential for volatility.

Federal and State Regulation of Off-target Pesticide Movement (DAS, 2013)

EPA is the federal agency vested with the authority and responsibility for regulating the sale, distribution and use of pesticides, including herbicides such as 2,4-D. EPA registers or approves a pesticide for one or more uses only after determining that the product will not cause unreasonable adverse effects on the environment – the statutory test for registration under FIFRA. When EPA approves the registration of a pesticide, it approves a particular product for a particular use or uses under specified conditions (including composition, application methods, usage rates, and protective measures) and specifies the language that must appear on the label of the pesticide product that sets forth those conditions and limitations. If a pesticide product is used in a manner that is inconsistent with its labeling, the user is subject to federal and state enforcement action. When making its registration decision, EPA specifies the data and information it needs to support that registration. Among the data EPA requires are those relating to off-target pesticide movement including, e.g., spray drift and volatilization (40 CFR part 158, Subparts L and N).

Federal law requires EPA to periodically review existing pesticide registrations to ensure that they meet the FIFRA standard for registration (the "no unreasonable adverse effects" criteria of FIFRA) under current scientific standards. EPA specifically addressed issues regarding off-site pesticide movement of 2,4-D in EPA's 2005 Reregistration Eligibility Decision (RED) for 2,4-D (US-EPA, 2005c), which incorporated major label revisions to products containing 2,4-D. These revisions included:

- lower limits for spray droplet size;
- prohibitions on spraying at wind speeds greater than 15 mph,
- spraying with a wind direction that is not favorable to on-target deposition, or spraying with sensitive non-target crops within 250 feet downwind;
- a prohibition on spraying at wind speeds of less than 3 mph if there are temperature inversion conditions, or stable atmospheric conditions at or below nozzle height;
- a prohibition on spraying where sensitive crops might otherwise be susceptible to drift;
- restrictions on boom length and spray release height for aerial applications, and nozzle height for ground boom applications;
- lower limits on application rates and total applications per year for specific crops
- compliance with any state and local laws that are more stringent (e.g., California, areas of which have seasonal limitations on use of 2,4-D) (US-EPA, 2005c)

EPA determined the use of the then-existing formulations of 2,4-D to be eligible for reregistration with those label restrictions. States also regulate the use of pesticides, including herbicides.   A number of states have passed laws to specifically address spray drift (Feitshans, 1999). These laws may include penalties and/or restrict application methods, require prior notification, impose buffer zones, etc., as each state has deemed appropriate.

In addition to registering individual pesticides, EPA also regularly assesses the safety of pesticide use more broadly, and has repeatedly addressed issues associated with off-target pesticide movement.   As stated on their web site (http://www.epa.gov/pesticides/factsheets/spraydrift.htm.) some of these efforts include:

- In 2009, EPA developed and issued for public comment a draft guidance document (PR Notice) on Pesticide Drift Labeling to provide guidance to pesticide manufacturers on labeling statements concerning pesticide drift, and to inform the public of EPA's policies with regard to pesticide drift. EPA continues to work with stakeholders to finalize this guidance.

- For many years EPA has contributed funding to support education and training programs on drift management. EPA provides annual funds to states to support pesticide applicator training programs, many of which include educational material on drift management, and EPA has contributed to other educational programs, such as the National Coalition on Drift Minimization educational video and CD-Rom, the National Pesticide Applicator Certification Core Manual, and the National Agricultural Aviation Association's Professional Aerial Applicator Support System (PAASS) to support their training and education programs to reduce drift incidents.

- EPA encourages pesticide applicators to use all feasible means available to them to minimize off-target drift. To support this goal, EPA has stated its intent to work with applicators, agricultural extension agents, registrants, environmental groups, and other interested stakeholders to collect and develop information on best management practices (BMPs) to reduce off-target drift for specific application methods and crop sector combinations. These guidance documents will be consolidated by EPA and made available online.

- OPP and the 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, 2012a).

- EPA has also taken action to address issues around pesticide volatility. In December 2009, EPA convened the FIFRA Scientific Advisory Panel (SAP) to examine scientific issues associated with field volatilization of conventional pesticides, focusing on methodologies by which bystander inhalation could be measured.

Existing precautions against off-target exposure (DAS, 2013)

Despite federal and state controls and the best efforts of applicators, off-target pesticide movement occasionally damages neighboring crops. Crops may be exposed to pesticide volatility or drift from a variety of sources, including public right of way uses for road maintenance and utilities, and agricultural uses. Crops that have the potential for damage due to exposure to a particular pesticide are considered sensitive crops. Sensitive crops to 2,4-D include cotton, grapes, and many fruits and vegetables.

Growers use a number of approaches to protect their crops from off-target exposure. Location of where the crop is grown is a key consideration; sensitive crop growers may choose to plant in fields that are sheltered or protected from potential exposure, and are not immediately adjacent to conventional crops(Mohr). Buffer zones and vegetative barriers are often used as a no spray zone between a sensitive area and a crop being sprayed. A buffer zone may be a vegetative barrier consisting of groves, hedge rows, wind breaks, pastures, or even the grower's own conventional crops. Vegetation planted in strategic lines can reduce the extent of spray drift of agricultural chemicals by filtering out spray droplets in air passing through their foliage (Department of Primary Industries). In some cases, growers are able to select a sensitive crop variety that is less sensitive to pesticides that are commonly applied to neighboring areas. Modified cultural practices, including timing of operations, are another approach that can be used to protect against off-target exposure (Maynard *et al.*, 2012).

Sensitive crop growers may help to avoid exposure in right of way areas by posting signs and making arrangements with government road crews or utility companies to do their own maintenance of easements and road ways near their sensitive crops. Similarly, neighboring farms can be notified of the presence of sensitive crops that require protection from herbicide spray drift and volatility. Since applications of herbicides are increasingly being made by custom applicators, signage placed near field entrances alerting operators to the presence of sensitive crops and that no sprays are allowed, are also used. Alternatively, sensitive crop growers may notify the local coops and applicators directly.

Some states have a pesticide sensitive crop registry and locator. Driftwatch (Driftwatch) is a national online tool for identifying specialty crop sites and to further enhance communications between producers of specialty crops and pesticide applicators that promote awareness and stewardship activities to help prevent and manage drift effects that sometime occur from spray operations. It currently includes the states of Colorado, Illinois, Indiana, Michigan, Minnesota, Missouri, Montana, Nebraska, and Wisconsin. This site features an easy-to-use Google Maps™ interface that clearly shows applicators the locations of registered areas so they can utilize the information in their ongoing stewardship activities before they spray. Other states, such as Maryland maintain their own, voluntary, pesticide-sensitive crop registry (http://mda.maryland.gov/Pages/homepage.aspx).

If crop damage occurs, affected growers can seek compensation by a variety of mechanisms. The pesticide applicator may have insurance to cover such losses. In many cases, growers work out an equitable settlement. Where this is not possible, state pesticide enforcement bureaus are notified to view and document the damage. EPA obtains reports of pesticide incidents from private citizens, poison control centers, states, and other government and non-governmental organizations. In some states, the applicator may be subject to fines or other penalties (Feitshans, 1999). The crop damage may also give rise to claims for legal damages in private lawsuits.

<u>Recorded Cases of Damages from Off-target Exposure to 2,4-D (DAS, 2013)</u>

USDA is not aware of a comprehensive, national database of offsite incidents from pesticide use. Incidents involving alleged pesticide spray drift may be reported by various sources to the grower, applicator, retailer, state or federal agency and/or the product manufacturer (US-EPA, 2007). Information associated with the alleged incidents and investigations is managed by each respective party or entity.

Pesticide product registrants are required under FIFRA Section 6(a)(2) to submit certain types of factual information to the U.S. Environmental Protection Agency (EPA) regarding adverse effects on human health or the environment from the use of their registered products. If the incidents are "minor" they are included in the Aggregate Incidents Database and are not included in the Ecological Incident Information system (EIIS) (US-EPA, 2007). EIIS includes information on all ecological incidents reported to the agency prior to 1998 and all major incidents reported since. For plants, a major effect is one that is alleged to have occurred on more than 45% of the acreage exposed to the pesticide (US-EPA, 2005b). EIIS also includes information on incident reports submitted through other sources, such as the States, regardless if they are "major" incidents or not. Incidents of adverse effects on lawns and other ornamentals caused by direct application of pesticide products are not entered into EIIS. When available, EIIS includes date and location of incident, type and magnitude of effects observed in various species, use(s) of pesticides known or suspected of contributing to the incident. However, the database contains a limited number of reported incidents and is not readily available to the public.

Registrants routinely submit reports on alleged incidents that have not been independently verified. Thus, due to the nature of incidents and how they are typically reported through the FIFRA 6(a)(2) process, the authenticity, validity, and/or accuracy of information contained in the reports cannot be guaranteed by the registrants and may not accurately reflect actual incidents and products involved. In many cases there is not enough information to determine if the alleged adverse effects noted were in fact the result of pesticide spray drift and not another contributing factor. Thus, spray drift allegations may be reported as plant damage which may, in fact, have been caused by diseases, insects, nutrient deficiencies, herbicide residue (carryover) and growing conditions. For its part, EPA does not require reporting of adverse effects to non-target plants at the use site when the pesticide label provides adequate notice. As a result, some incidents may not be reported because EPA is already aware of the potential for those effects to occur under certain conditions. It should be noted that none of the reports includes 2,4-D formulated with choline, a formulation designed to be less susceptible to drift, as the registration of this formulation was only recently approved by the EPA.

While accurate, comprehensive, and reliable national data on offsite incidents from pesticide use is not readily available, EPA's Office of Pesticide Programs may publish incident data as part of its periodic review of all pesticides to ensure that their registrations continue to meet current scientific standards. Recently, EPA published a scoping document for 2,4-D acid, salts, and esters to support registration review that includes the results of a search of the EIIS and the Aggregate Incident Reports databases for ecological incidents involving 2,4-D acid and its forms (US-EPA, 2012a). They reported that, for all years, there were 422 incidents involving plants in the EIIS and 13,798 incident reports for all forms of 2,4-D in the Aggregate Incident Report database. From the details provided in the EPA summary of the EIIS reports, many of the plant incidents appeared to result from over-application of 2,4-D products to lawns or application of 2,4-D products to types of plants that are sensitive to 2,4-D. Other plant incidents were the result of spray drift in agricultural settings. Detailed information was not provided for the Aggregate Incident reports.

2,4-D use restrictions

EPA's registration for 2,4-D under section 3 of FIFRA includes certain restrictions on use that appear on the product's label, but EPA has not classified 2,4-D as a "restricted use pesticide" (RUP). The most frequent means by which EPA addresses potential adverse effects is through warnings, prohibitions, restrictions and directions for use on the product label (40 CFR Part 156). When registering a product, the EPA also has the ability to classify a pesticide as a RUP should it deem that the product needs additional restrictions to decrease the risk of adverse effects (40 CFR subpart I, 152.160). RUPs can only be applied by or under the direct supervision of an applicator certified by the state or EPA (DAS, 2013).

After a pesticide is registered by EPA, states can register pesticides under specific state pesticide registration laws. State lead agencies have primary authority for pesticides used within the state. In some cases, states may enact additional restrictions for use of a product to meet the uses and needs of their state. For example in Northeast Arkansas, rice, a crop where 2,4-D was used for weed control, and cotton, a 2,4-D sensitive crop, are grown in proximity. In 2006, the Arkansas State Plant Board (ASPB) received more than 100 complaints about 2,4-D drift (Bennett, 2006). The greater than usual drift was attributed in part to a very wet spring (USDA-NASS, 2006) which resulted in many applications of 2,4-D being conducted aerially and done in a short period of time. The ASPB created a 2,4-D task force and a glyphosate task force in 2006 charged with the mission of developing proposed regulations for the board to consider (Bennett, 2007). After conducting public meetings and taking testimony from representatives from various agriculture sectors, the task forces submitted recommendations to the ASPB at the end of 2006. The final rule, adopted in February 2007, called for a ban on most aerial and ground spray applications of 2,4-D in ten northeastern counties (area known as Crowley's Ridge) between April 15 and September 15 and buffers of 2,4-D applications from susceptible crops in the remaining counties (Arkansas State Plant Board, 2007). Applications of glyphosate were limited to wind speeds no higher than 10 mph or 15 mph if using a commercially available hooded sprayer (Arkansas State Plant Board, 2007).

Currently, there are 18 states with some type of restriction on the use of 2,4-D (Figure 7-2 and Table 7-1). Types of use restrictions on registered products include general restricted use pesticide (RUP) regulations, formulation-specific restrictions, time-specific restrictions and/or location-specific restrictions.

Types of State Restrictions

2,4-D products designated as a RUP – Four states, Massachusetts, New Jersey, New Mexico and Vermont have designated 2,4-D products a RUP. The RUP designation means that applicators must be certified to use the RUP product or have a licensed applicator within the vicinity of the person making the application. The applicator must also keep spray records.

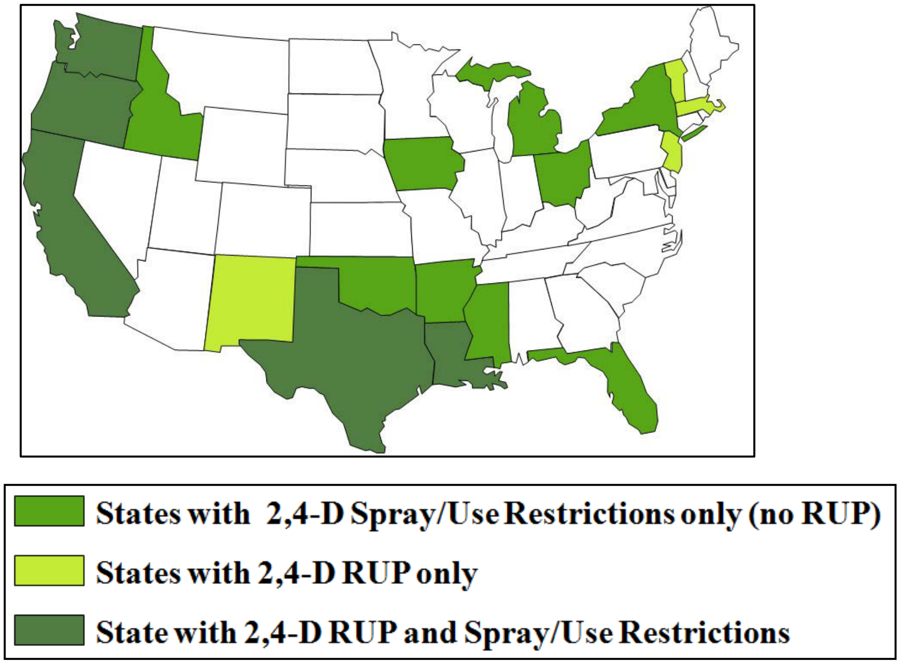

Figure 7-2. States with restrictions on the use of 2,4-D
Source: (DAS, 2013).

Table 7-1. State 2,4-D Restrictions*

TYPE OF RESTRICTION	STATE
State RUP designation, but with no spray/userestrictions (*e.g. licensed applicators, permitting, record keeping, etc*.)	MA, NJ, NM, VT
State RUP designation and spray/use restrictions	CA, LA, TX, WA
No state RUP designation but spray/use restrictions	AR, FL, ID, IA, MI, MS, NY, OH, OK, OR
Total number of states	**18**

**State regulations subject to change.*
Source: (DAS, 2013)

2,4-D products designated as a RUP along with spray use restrictions – Four states, California, Louisiana, Texas and Washington designate 2,4-D as a RUP and in addition impose spray use restrictions which vary by state. In these states, applications are restricted or prohibited during certain times of the year (e.g. April through September) in designated counties. For the remaining counties in Louisiana and Texas, buffers from sensitive or susceptible crops are established.

2,4-D products are subject to specific spray use restrictions – Ten states, Arkansas, Idaho, Iowa, Florida, Michigan, Mississippi, New York, Ohio, Oklahoma and Oregon impose spray use restrictions though they do not designate 2,4-D as a RUP. The restrictions range from buffers to aerial versus ground spray applications to the type of 2,4-D formulations which can be applied. For example, New York has spray use restrictions in only three counties. In these counties, no 2,4-D can be applied within 100 feet of any grape vineyard and there is a 2-mile buffer for all ester formulations. In Mississippi, 2,4-D is limited to ground spray applications only from April 1 to September 30. In Iowa, ester formulations only are prohibited in five counties. The specific state restrictions of 2,4-D use are summarized in Table 7-2.

Table 7-2. Summary of State Restrictions on the Use of 2,4-D

STATE	RUP	RESTRICTIONS
Arkansas	No	All 2,4-D herbicides are in Class F with use restrictions. From Apr. 15 - Sept. 15: 2,4-D use is not allowed in Clay, Greene, Craighead, Poinsett, Cross, Crittenden, St. Francis, Lee, Phillips, and Mississippi Counties. Permits may be obtained to allow exemption with key requirements recording application details. Buffer zone/wind speed requirements. Buffer zones set: e.g. 4 mile aerial; 1 mile ground. *AR Regulations on Pesticide Classification - Final Rule (Rev. 06/07):*
California	Yes	RUP for products 1 gal or greater containing over 15% active ingredient. Permits are needed to spray 2,4-D in defined areas of Sacramento, Madera, Fresno, Kings, Tulare, Kern, and San Joaquin Counties. Restrictions are based on dates, formulation type, wind speed, set-back from commercial vineyard or cotton planting. 2,4-D use restrictions exist to protect the California Red Legged Frog (buffer zones in 33 counties); 2,4-D salts and esters are designated as toxic air contaminants. *Title 3, CCR 3, Sec. 6400*
Florida	No	Sale and use of highly volatile[1] forms of organo-auxin herbicides is prohibited except for those products labeled as plant growth regulators on citrus. Minimum set-back distances from susceptible crops are specified based on wind speed. Max wind speed = 10 mph. Applicator record keeping requirements are in effect. Aerial application by fixed-wing aircraft is prohibited Jan 1 until May 1 in Hendry, Palm Beach, Glades, Martin counties.*Florida Administrative Code Chapter 5E-2.033*
Idaho	No	2,4-D ester restrictions exist in Latah, Nez Perce, and Clearwater Counties. Restrictions are based on aerial or ground application, formulation type, set-back from susceptible crop, and wind speed. Buffers from hazard areas required for 2,4-D amines and acids, MCPA, MCPB, and dicamba. *IDAPA 02.03.03 Sec. 550*
Iowa	No	The use of high volatile esters[2] formulations of 2,4-D and 2,4,5-T, the alcohol fraction of which contains five or fewer carbons, is prohibited in the counties of Harrison, Mills, Lee, Muscatine and that part of Pottawattamie county west of Range 41 West of the 5th P.M. *21—45.27(206)*
Louisiana	Yes	2,4-D is designated an RUP for agricultural uses. Restrictions for commercial and private applicators are based on timing, location, and wind speed. 32 parishes have restrictions. *LA Title 7, Part XXIII, § 1103*

STATE	RUP	RESTRICTIONS
Massachusetts	Yes	If product contains >20% 2,4-D, it is a State RUP -- application must be made by certified applicators and there are reporting requirements. *333 CMR 1.00*
Michigan	No	No use of volatile ester forms of 2,4-D and MCPA are allowed within specified regions from May 1 to Oct. 1 in parts of Berrien, Cass, Kalamazoo and Van Buren counties. There are sprayer specifications for amine forms. *MDA Reg 285.637*
Mississippi	No	For hormone-type herbicides,[3] restrictions apply for aerial application. Restrictions are based on date and type of aircraft and include no use of ester formulations, a 0.5 mile set-back from cotton and susceptible crops, applications at wind speed < 5 mph. There are applicator and licensing requirements. *Miss. Code Ann. § 69-21-109 (Part 3-Ch 10-Sub 01)*
New Jersey	Yes	Concentrated 2,4-D (>20%) may only be purchased and used by certified applicators *N.J.A.C. 7:30-2.10*
New Mexico	Yes	State restrictions apply to all 2,4-D products used in agriculture. Spray restrictions in Curry and Roosevelt counties are based on timing, application method, and must be applied at windspreeds < 10 mph and only by certified applicators. Permits are required for applications of low volatile formulations. Esters and aerial applications are not permitted in these 2 counties from Apr.15 to Oct. 1. *21.17.56 NMAC*
New York	No	For 2,4-D, 2,4-5T, and MCP spray restrictions and set-backs of 100 ft from grape vineyards in portions of Chautauqua, Erie, Niagara counties are in effect. *NY ECL Art. 33 § 321-324*
Ohio	No	Restriction from use of ester formulation in Madison township of Lake County is in effect. *ORC Title IX, Ch. 921*
Oklahoma	No	Applications of products containing 2,4-D esters or dicamba to agricultural lands are prohibited in Greer, Harmon, and Kiowa counties May 1-October 15; Applications of products containing 2,4-D, dicamba, picloram, triclopyr, or clopyralid are prohibited in Jackson and Tillman counties May 1 - October. Notification and reporting procedures are required for 2,4-D applications. *2 O.S. § 3-84 (35:30-17-24.1)*
Oregon	No	Use of high volatile esters of 2,4-D in areas of Morrow and Umatilla counties are prohibited Apr 1 - Sept 1 except by permit. *OAR 603-057-0301 to 0320*

STATE	RUP	RESTRICTIONS
Texas	Yes	Use of 2,4-D, MCPA, dicamba, quinclorac is prohibited within 4 miles of a susceptible crop in 53 "Pesticide Regulated Herbicide Counties". No applications are permitted when wind speeds exceed 10 mph. Additional provisions are set county-by-county. *TAC 4-1-7-E §7.50, 53*
Vermont	Yes	Class A restricted use, application requirements, and reporting requirments are in effect. *6 V.S.A. Ch 87*
Washington	Yes	All phenoxy hormone-type herbicides are restricted throughout eastern Washington with additional restrictions in 14 counties: Adams, Benton, Columbia, Douglas/Chelan, Franklin, Garfield, Grant, Kittitas, Klickitat, Lincoln, Okanogan, Spokane, Walla Walla, Whitman, and Yakima. Specific restrictions are determined by county pertaining to boundaries; formulation type, application parameters, dates, and aerial or ground, set-backs. *16 WAC 16-228,232*

Source: (DAS, 2013)

[1]*All pesticides registered for sale in Arkansas are assigned to a Class. Each Class carries with it one or more restrictions that must be complied with by the user, applicator, or dealer. The classification system ranges from Class A which presumably all pesticides are registered as initially, until a problem develops. The only use-restrictions assigned to Class A products are those on the product label. If problems develop with a product, the Plant Board, after a public hearing, can move a product from the Class A designation to another designation (B, C, D, E or F) which has more restrictions. Each classification carries with it all the restriction(s) that are specified for that class plus all that came before it.*

[2]*Note: High volatility esters of 2,4-D are those that have five or fewer carbons on the alcohol side chain. Currently there are no high volatility esters registered for use in the United States.*

[3]*Hormone-type herbicides include 2,4-D, 2,4-DB, aminopyralid, clopyralid, dicamba, dichlorprop, fluroxypyr, MCPA, MCPB, mecoprop, picloram, quinclorac and triclopyr.*

New technologies for controlling drift and volatility (DAS, 2013)

DAS conducted an extensive evaluation of various salts under conditions inducing high volatility to identify candidates that had significantly reduced volatility and thus lowered potential for injury to susceptible plants. The results led to the development of 2,4-D choline salt. This novel form of 2,4-D has been tested in the laboratory and subsequently in field studies. Quantification of volatilized 2,4-D from soybean and bare soil fields demonstrated that 2,4-D ethylhexylester was the most volatile, with calculated loss rates of the 2,4-D ethylhexylester as much as two orders of magnitude greater than the 2,4-D dimethylamine (DMA) form, which is considered to be much less volatile than ester formulations (National Pesticide Information Center). The choline form of 2,4-D measured as much as 50X less volatility than the DMA form and had dramatically less injury to a variety of crops known to be sensitive to auxin herbicides under confined conditions as compared to ester and amine forms of 2,4-D (US-EPA, 2013).

DAS's new product containing 2,4-D choline and glyphosate DMA (Enlist Duo™ herbicide) will make the herbicide spray droplets larger and more uniform in size compared to a standard 2,4-D and glyphosate tank mix application. DAS has measured a 3X improvement (reduction) in driftable fines (<150 µ) for both 2,4-D choline and glyphosate under field conditions using commercial application equipment. This validates observations made under controlled laboratory and wind tunnel conditions. Coupled with using the latest in drift reduction nozzles, as much as a 10X reduction in drift was achieved compared to a standard tank mix application of the same active ingredients using conventional nozzles.

Pending registration by EPA, DAS intends to market Enlist Duo™ Herbicide with Colex-D Technology, a pre-mix of the new 2,4-D choline salt and glyphosate dimethylamine with reduced drift and volatility characteristics, for use with Enlist™ corn and soybean. Via a Technology Use Agreement, DAS will require growers of Enlist™ corn and soybean who choose to use 2,4-D in post-plant applications to purchase the 2,4-D formulation in Enlist Duo™ to provide this added protection against off-target exposure. A combination of EPA-required label restrictions, contractual obligations and grower education and outreach are expected to minimize off-target effects to neighboring crops when applications of Enlist Duo™ is made to Enlist™ corn and soybeans.

In addition to the technology innovations, the herbicide product label and product use guide do not allow applications into areas where temperature inversions are present, do not allow applications when winds exceed 15 mph, do not allow aerial applications, and require use of only spray nozzles that produce a coarse or coarser spray droplet size. Such stewardship and responsible use requirements are expected to further minimize the potential for off-target herbicide movement.

In addition to the reduction of particle drift or volatilization due to physical properties of the herbicide formulation, other precautions have been included in conjunction with the Enlist™ Weed Control System to minimize the potential for off-target movement. Specifically, DAS will request an amendment to its pending herbicide label submitted to EPA to include language regarding sensitive crops under a new "Susceptible Plants" heading on the label and label language requiring buffer zones between areas of 2,4-D choline use and sensitive plants (Coalition, 2012). The proposed label for Enlist Duo™ Herbicide with Colex-D Technology™ label does not allow herbicide application through any type of irrigation equipment and prohibits aerial application (DAS, 2011). Individual state regulations for use of 2,4-D, such as the widespread prohibition of aerial application and restricted seasonal application, will also remain in effect. For instance, Texas has limited the application of "regulated herbicides" (such as 2,4-D) by county with the aerial application of 2,4-D being prohibited in many counties between March 10 and September 15 or outright prohibited within a given distance of any susceptible crop (4 Tex. Admin. Code §7.53). Iowa state law prohibits the use of some 2,4-D esters in some counties (21 IAC 45.27 [2013]). Mississippi prohibits the aerial application of 2,4-D by fixed wing aircraft between April 1 and September 30 (CMSR 02-001-310). However, Mississippi allows 2,4-D to be applied by helicopter between April 1 and September 30 as long as certain application criteria are met, such as the use of precision spray systems, the use of booms no longer than rotor diameter, a flight speed of no more than 30 mph during application, and wind speed of 5 mph or less at the time of application (CMSR 02-001-310).

Use of the innovative choline salt of 2,4-D, the new formulation technologies, and Dow AgroSciences' Stewardship Program is expected to help reduce the potential for off-target impacts on sensitive crops and non-crop plants/organisms.

Proposed Herbicide Label Language for Enlist Duo™ (DAS, 2013)

DAS has submitted to EPA for approval a proposed label for its Enlist Duo™ herbicide with Colex-D Technology™, a pre-mix of the new 2,4-D choline salt and glyphosate DMA. DAS's proposed label contains the instructions for use directly addressing the potential for spray drift and volatility. The same label instructions will be submitted for use on Enlist™ soybeans.

DAS has submitted for EPA approval the following proposed Enlist Duo™ label language specifically addressing spray drift management. During its label approval process, EPA may impose additional use restrictions or other protective measures for corn and/or soybean.

Spray Drift Management

Avoid drift. Use extreme care when applying this product to prevent injury to desirable plants and crops.

Do not allow GF-2726 to mist, drip, drift or splash onto desirable vegetation since minute quantities of this product can cause severe damage or destruction to the crop, plants or other areas on which treatment was not intended. The likelihood of injury occurring from the use of this product increases when winds are gusty, as wind velocity increases, when wind direction is constantly changing or when there are other meteorological conditions that favor spray drift. When spraying, avoid combinations of pressure and nozzle type that will result in fine particles (mist) which are likely to drift. **Do not apply at excessive speed or pressure**. Use of this product in any manner not consistent with this label may result in injury to persons, animals or crops, or other unintended consequences.

Avoiding spray drift at the application site is the responsibility of the applicator. The interaction of many equipment- and-weather-related factors determines the potential for spray drift. The applicator and the grower are responsible for considering all these factors when making decisions.

Do not aerially apply this product.

Droplet Size

Apply as a coarse or very coarse spray (ASABE S-572 Standard). Use drift reducing nozzle tips in accordance with manufacturer directions that produce a droplet classification of coarse or very coarse to significantly reduce the potential for drift.

Groundboom Application

Use the minimum boom height based upon the nozzle manufacturer's directions. Spray drift potential increases as boom height increases. Spray drift can be minimized if nozzle height is not greater than the maximum height specified by the nozzle manufacturer for the nozzle selected.

Wind

Drift potential is lowest at wind speeds of 10 mph or less. However, many factors, including droplet size and equipment type, determine drift potential at any given speed. Do not apply at wind speeds greater than 15 mph. **Note**: Local terrain can influence wind patterns. The applicator should be familiar with local wind patterns and how they affect drift.

Temperature and Humidity

When making applications in low relative humidity, set up equipment to produce larger droplets to compensate for evaporation. Droplet evaporation is most severe when conditions are both hot and dry.

Temperature Inversions

If applying at wind speeds less than 3 mph, the applicator must determine if: a) conditions of temperature inversion exist, or b) stable atmospheric conditions exist at or below nozzle height. Do not make applications during a temperature inversion or stable atmospheric conditions. Temperature inversions restrict vertical air mixing, which causes small suspended droplets to remain in a concentrated cloud. This cloud can move in unpredictable directions due to the light variable winds common during inversions. Temperature inversions are characterized by increasing temperatures with altitude and are common on nights with limited cloud cover and light to no wind. They begin to form as the sun sets and often continue into the morning. Their presence can be indicated by ground fog; however, if fog is not present, the presence of an inversion can also be identified by the movement of smoke from a ground source. Smoke that layers and moves laterally in a connected cloud (under low wind conditions) indicates an inversion, while smoke that moves upwards and rapidly dissipates indicates good vertical air mixing.

Drift Setbacks from Sensitive Areas

Allow setbacks (buffer zones) upwind of sensitive area (e.g., residential areas, bodies of water, known habitat for threatened or endangered species, sensitive non-target crops other than those listed above).

If a coarse or very coarse droplet classification cannot be maintained, an upwind setback of 250 feet from sensitive areas must be observed.

Applicators will not exceed a spray volume of 15 gallons (water) per acre.

In addition, when sensitive areas are nearby, applicators will use recommended drift setbacks based on wind speed and spray boom height above canopy (see below).

Table 7-3. Drift Setback Distances (feet)

Wind Speed (mph)	Spray Boom ≤24 inches above Canopy	Spray Boom >24 inches above Canopy
<5	15	`30
5 – 10	40	80
10 – 15	80	150

Susceptible Plants

Do not apply under circumstances where spray drift may occur to food, forage, or other plantings that might be damaged or crops thereof rendered unfit for sale, use or consumption. Avoid contact of herbicide with foliage, green stems, exposed non-woody roots of crops, desirable plants and trees because severe injury or destruction may result. Small amounts of spray drift that may not be visible may injure susceptible broadleaf plants. Before making an application, please refer to your state's sensitive crop registry (if available) to identify any commercial specialty or certified organic crops that may be located nearby.

Commercially grown tomatoes and other fruiting vegetables (EPA crop group 8), cucurbits (EPA crop group 9), and grapes are particularly sensitive to drift from this product. Do not apply when wind direction favors off-target movement onto these crops.

State and Local Requirements

Applicators must follow all state and local pesticide drift requirements regarding application of 2,4-D herbicides. Where states have more stringent regulations, they must be observed.

The submitted Enlist Duo™ label language also requires additional measures to avoid off- target movement and crop injury, including detailed instructions for clean-out of sprayer equipment, use of drift control additives, and boom and nozzle height instructions.

Additional DAS measures to address spray drift and volatility

As noted above, DAS will contractually require growers of Enlist™ corn and soybean who wish to use 2,4-D as an in-crop herbicide to use only Enlist Duo™. This new 2,4-D technology will provide substantially lower volatility than any other form of 2,4-D, as well as improved drift control, low odor, and improved handling characteristics.

Through its Technology Use Agreement, DAS will impose a legal and contractual obligation that will require all growers of Enlist™ corn and soybean to:

Use only EPA accepted and DAS authorized 2,4-D formulations containing Colex-D Technology™, such as Enlist Duo™, for in-crop applications to Enlist™ corn and soybean.

Read and follow FIFRA Pesticide Product Label directions.

Read and follow the Enlist™ Weed Control System Product Use Guide.

Use properly maintained and calibrated ground application equipment for Enlist Duo™ with Colex-D Technology™ with minimum boom heights.

Use nozzles that reduce the potential for physical drift of Enlist Duo™ with Colex-D Technology™.

Follow instructions for equipment clean-out after product use.

DAS will provide comprehensive training on its technology and portfolio of products to growers, dealers and distributors through a variety of formats. Education and training, reinforced through product profiles, technical bulletins, sales literature, direct mailing and websites will also be presented in multiple formats to enhance learning and mastery of core concepts related to stewardship to be employed around Enlist™ corn and soybean. A variety of educational formats will be used to promote concept learning. This training will include education on spray technology and herbicide application, including spray quality basics, as well as spray quality of Enlist Duo™, as well as how to minimize the potential for off-target movement of Enlist Duo™.

Producers who do not comply with the requirements of the stewardship program risk losing access to the Enlist™ Weed Control System. Legal penalties may also be imposed by state regulatory agencies when label instructions are not followed.

<u>Potential Off-target Pesticide Impacts on Organic Crops (DAS, 2013)</u>

Growers of organic crops may also face economic damages from off-target pesticide movement, even if their crops are not damaged. If a certifying agent tests a crop grown under organic production and the test reveals the presence of residues from a pesticide not approved for use under the National Organic Program (NOP), the crop may not be sold as organic if the residue is present at a level greater than five percent of the EPA tolerance for the detected prohibited residue (7 CFR 205.671). A grower whose organic crops were subject to off-target pesticide movement that resulted in residue levels greater than five percent of the EPA tolerance could then lose the organic premium he may otherwise have obtained for his crop. While some certifying agents have refused to allow organic production on fields that have been the objects of spray drift, a recent court decision found this three year ban on organic production following spray drift to be inconsistent with the NOP (Anonymous, 2012).

In finalizing the NOP, USDA described the following in regards to grower's responsibilities to protect against chemical drift (65 FR 80556):

Drift has been a difficult issue for organic producers from the beginning. Organic operations have always had to worry about the potential for drift from neighboring operations, particularly drift of synthetic chemical pesticides. As the number of organic farms increases, so does the potential for conflict between organic and nonorganic operations.

It has always been the responsibility of organic operations to manage potential contact of organic products with other substances not approved for use in organic production systems, whether from the nonorganic portion of a split operation or from neighboring farms. The organic system plan must outline steps that an organic operation will take to avoid this kind of unintentional contact.

When we are considering drift issues, it is particularly important to remember that organic standards are process based. Certifying agents attest to the ability of organic operations to follow a set of production standards and practices that meet the requirements of the Act and the regulations.

All of the preventions discussed above are available to organic growers and many are required by the NOP as part of their organic production plan. Similarly, insurance and legal recourse may be available to organic growers who lose premiums as a result of spray drift.

2,4-D has an extensive history of safe and effective use. It has been thoroughly reviewed and reregistered by all major regulatory agencies in the world within the last ten years. Recently (April 2012), the EPA denied a petition to cancel the tolerances and registrations for 2,4-D based on toxicological hazard. The Agency issued a denial of that petition, affirming that 2,4-D posed no unreasonable risk when used as directed (US-EPA, 2012b). Therefore the impacts to the physical environment are expected to be similar under the No Action and Action Alternatives.

<u>Other potential sources of off-target movement (DAS, 2012b)</u>

Soil Leaching

2,4-D has a relatively short half-life and is rather immobile in the soil. In 35 recent field dissipation studies across the U.S., less than 5% of applied 2,4-D moved downward more than 15 cm (6 inches). The average lowest depth detected ranged from 6 to 12 inches in soils of the southern United States, and 16 to 24 inches in low organic soils where greater movement would be expected ((Industry Task Force, 2006) cited in (DAS, 2012a)). Groundwater detections of 2,4-D, which are very rare, are largely attributed to direct introduction by misuse or spills at well sites ((Industry Task Force II, 2013)cited in (DAS, 2012a)). Proper application and avoiding filling spray equipment near well heads are standard good farming practices that minimize the potential for leaching and work effectively for 2,4-D.

Runoff

The environmental risks of pesticide use are assessed by EPA in the pesticide registration process and are regularly reevaluated by EPA for each pesticide to maintain its registered status under FIFRA. EPA's process ensures that each registered pesticide continues to meet the highest standards of safety to protect human health and the environment (DAS, 2012a).

Both field crop and aquatic application for weed control are registered uses of 2,4-D (US-EPA, 2005c). Glyphosate is registered for use on many food and non-food field crops as well as non-crop areas where total vegetation control is desired (US-EPA, 1993). Although the registered use of glufosinate is primarily terrestrial (US-EPA, 2008; Bayer CropScience, 2011), it may be applied to certain confined waters for irrigated crops, such as rice (US-EPA, 2002).

As described in (DAS, 2012a), as part of an ecological risk assessment, EPA recently evaluated monitoring data from the USGS NAWQA program to assess the current trend of 2,4-D concentrations in surface water and groundwater (US-EPA, 2013)). 2,4-D was detected in 47 percent of surface water samples (i.e., 434 samples from a total national dataset of 931 samples). The maximum concentrations of 2,4-D ranged from 0.008 µg/l to 8.7 µg/L. 2,4-D was detected in only 1 percent of the groundwater samples (i.e., 12 samples from a total national dataset of 1,184 samples). The maximum concentrations of 2,4-D ranged from 0.008 µg/L to 1.4 µg/L. The reported concentrations for both surface water and groundwater are lower than in the previously reported drinking water memorandum (US-EPA, 2004).

As described in (DAS, 2012a), 2,4-D is currently approved by EPA for aquatic applications to control aquatic weeds in food use areas (i.e., rice and fish farms) as well as industrial areas (i.e., drainage systems) (US-EPA, 2005c). When used for aquatic treatments (direct application to water for aquatic vegetation control), 2,4-D has a half-life of between 3.2 days and 27.8 days (US-EPA, 2005c); the half-life of 2,4-D in aerobic aquatic environments is approximately 45 days, and the half-life of 2,4-D esters in normal agricultural soil and natural waters is less than 3 days (US-EPA, 2005a; US-EPA, 2009). EPA has stated that the 2,4-D acid and amine salts are practically non-toxic to freshwater or marine fish (US-EPA, 2005c).

Environmental Loading of Herbicides Used on Corn (DAS, 2012b)

DAS has conducted an analysis to determine the anticipated impact on environmental loading of herbicides resulting from the use of 2,4-D choline on herbicide tolerant DAS-40278-9 corn, DAS-68416-4, soybean, and DAS 44406-6 soybean. Specifically, this analysis looked at the environmental load of herbicides applied on glyphosate tolerant corn and soybeans to control glyphosate resistant and hard-to-control weed biotypes (DAS, 2012a). The top currently available herbicide programs (excluding just increasing the rate of glyphosate alone) that are currently being recommended to control glyphosate resistant weeds in corn under scenarios representative of different key corn-growing regions were compared to projected use of Enlist Duo™. While the range of rates of these currently available alternate programs and the ones for Enlist Duo™ programs overlapped, when the average of the Enlist Duo™ program rates were compared to the average of all of these top alternates, the analysis indicated that the use of 2,4-D on herbicide tolerant DAS-40278-9 corn would reduce the per acre environmental load of herbicides compared to these top, currently available, non-glyphosate alternative programs. Reductions on corn ranged by 0.15 to 0.74 lb ai/ac, within the individual scenarios, with an overall average reduction of 0.49 lb ai/ac across all scenarios (DAS, 2012a).

Herbicide use may increase to meet the need for additional integrated weed management tactics to mitigate herbicide-resistant weeds in different cropping systems (Culpepper *et al.*, 2008; Owen, 2008; Heap, 2011; Owen *et al.*, 2011). Some of these adjustments may have the potential to impact surface water quality through increased sedimentation and agricultural chemical loading derived from exposed soils (Towery and Werblow, 2010; Owen *et al.*, 2011). Some of these adjustments have the potential to impact air quality by increased emissions from tillage equipment and release of particulate matter generated from soil disturbance during tillage operations (Madden *et al.*, 2009). Increases in herbicide resistant weeds potentially could lead to a decline in no-till and conservation tillage. Declines in such practices are expected to reduce air quality from greater use of heavy field equipment and greater release of airborne particles. Implementation of BMP to slow soil erosion and filter pollutants from surface runoff, such as vegetated strips, control of spray drift, and adherence to label restrictions governing safe application and equipment cleanup, minimize the potential for pesticide impacts to surface and groundwater.

The environmental risks of pesticide use are assessed by EPA in the pesticide registration process and are regularly reevaluated by EPA for each pesticide to maintain its registered status under FIFRA. In this process, steps to reduce pesticide drift and volatilization are included on a pesticide's label approved by EPA. EPA's process ensures that each registered pesticide continues to meet the highest standards of safety to protect human health and the environment. Use of the herbicides glyphosate 2,4-D, and glufosinate would be contingent upon periodic reevaluation and continued approval by EPA.

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Appendix 8. Herbicides used on DAS Corn and Soybean

Herbicides Used on DAS Corn and Soybean

Three petitions submitted by DAS to APHIS seek determinations of nonregulated status for GE maize and soybean cultivars engineered for resistance to herbicides. The three petitions are as follows:

APHIS Petition 09-233-01p (DAS, 2010a) is for GE maize (*Zea mays*) designated as event DAS-40278-9 corn. It is engineered for increased resistance to certain broadleaf herbicides in the phenoxy auxin group such as 2,4-D (2,4-dichlorophenoxyacetic acid). DAS-40278-9 corn is also resistant to grass herbicides classified as aryloxyphenoxypropionate (AOPP) acetyl coenzyme A carboxylase (ACCase) inhibitors, such as quizalofop-p-ethyl (quizalofop), that are referred to as fop herbicides.

APHIS Petition 09-349-01p (DAS, 2010b) is for a GE soybean (*Glycine max*) variety designated DAS-68416-4 soybean. The *aad-12* gene in DAS-68416-4 soybean expresses the AAD-12 protein, which degrades 2,4-D into herbicidally inactive 2,4-dichlorophenol. DAS-68416-4 soybean also contains the PAT protein, conferring resistance to the herbicide glufosinate.

APHIS Petition Number 11-234-01p (DAS, 2011d) is for non-regulatory status determination of event DAS-44406-6 soybean, which is genetically engineered for increased resistance to certain broadleaf herbicides, including the nonselective herbicides glufosinate, glyphosate, and 2,4-D. The only difference between these two soybean events is that resistance to glyphosate in DAS-68416-4 soybean will be achieved by traditional breeding with another soybean containing the *2mEPSPS* gene, while DAS-44406-6 soybean has been genetically engineered with this gene.

A brief overview of the four herbicides (glyphosate, 2,4-D, quizalofop, and glufosinate) that are intended to be used on the three DAS events are presented in the following sections. The proposed uses of these herbicides on DAS-40278-9 corn and DAS-68416-4 soybean (which would also include DAS-44406-6 soybean) and any EPA assessments performed assessing the potential effects from the new uses are summarized.

2,4-D

Background and Current Uses

2,4-D is in the phenoxy or phenoxyacetic acid family and is listed as an herbicide, a plant growth regulator, and has been reported to elicit fungicidal properties at concentrations in ex cess of approved application rates. Its main use is as a selective post-emergence herbicide for controlling broadleaf weed species. The herbicide is approved for use on a wide variety of crops and has more than 600 registered end-use products for use on more than 300 distinct agricultural and residential sites, including terrestrial and aquatic settings (US-EPA, 2005b). Agriculturally, it is used on a variety of crops including corn, rice, sorghum, sugar cane, wheat, rangeland, and pasture. In addition, 2,4-D is used to control unwanted vegetative growth on utility corridors, rights-of-way, roadsides, non-crop areas, managed forest, and lawn and turf areas. It is also used to control aquatic and nuisance weeds, e.g., purple loosestrife (Industry Task Force II, 2005). 2,4-D controls many broadleaf weeds including carpetweed, dandelion, cocklebur, horseweed, morning glory, pigweed sp., lambsquarters, ragweed spp., shepherd's-purse, and velvetleaf. It causes some plant damage to grasses at early growth stages in corn, and little to no plant damage in other grasses such as wheat and rice (Industry Task Force II, 2005).

The herbicide 2,4-D is currently available in ten molecular forms: 2,4-dichlorophenoxyacetic acid, dimethylamine salt of 2,4-D, 2-ethylhexyl ester of 2,4-D, butoxyethyl ester of 2,4-D, triisopropanolamine salt of 2,4-D, isopropylamine salt of 2,4-D, diethanolamine salt of 2,4-D, sodium salt of 2,4-D, isopropyl ester of 2,4-D, and choline salt of 2,4-D (US-EPA, 2013b). 2,4-D is formulated primarily as an amine salt in an aqueous solution or as an ester in an emulsifiable concentrate (US-EPA, 2005b).

The mode of action of 2,4-D is described as an "auxin mimic," meaning that it kills the target weed by mimicking auxin plant growth hormones, such as indole acetic acid (IAA) (Tu *et al.*, 2001). Auxins and synthetic auxinic herbicides regulate virtually every aspect of plant growth and development; at low doses, auxinic herbicides possess similar hormonal properties to natural auxin (Kelley and Riechers, 2007). However, as rates increase, they can cause various plant growth abnormalities in sensitive dicots (Tu *et al.*, 2001). Observable plant responses to 2,4-D can include epinasty, root growth inhibition, meristematic proliferation/callusing, leaf cupping/narrowing, stem cracking, adventitious root formation, senescence, and chlorosis. This uncontrolled and disorganized plant growth eventually leads to plant death when applied at effective doses (Tu *et al.*, 2001). 2,4-D controls many broadleaf weeds including carpetweed, dandelion, cocklebur, horseweed, morning glory, pigweed sp., lambsquarters, ragweed spp., shepherd's-purse, and velvetleaf (Industry Task Force II, 2005).

The 2,4-D mode of action as a synthetic auxin is not changed by the formulations, but the chemical and physical properties of each formulation influence the selection of equipment, mitigation measures adopted in the field to minimize off-target impacts, and formulation-specific safety measures. For a majority of uses, 2,4-D is combined with other herbicides because it economically enhances the weed control spectrum of many other herbicides, such as glyphosate, dicamba, mecoprop, and ALS herbicides (US-EPA, 2005b).

The degradation products of 2,4-D are 1,2,4-benzenetriol, 2,4-DCP, 2,4-dichloroanisole (2,4-DCA), 4-chlorophenol, chlorohydroquinone (CHQ), volatile organics, bound residues, and carbon dioxide. The EPA has determined that residues other than 2,4-D and 2,4-DCP are not of risk concern due to low occurrence under environmental conditions, comparatively low toxicity, or a combination thereof (US-EPA, 2013b).

Using pesticide usage data from the USDA-NASS and Private Pesticide Market Research, EPA estimated that an average of nearly 29 million pounds of all forms of 2,4-D were applied to agricultural crops in the U.S. annually between 2006 and 2010 (US-EPA, 2012a). Based on average treated fraction of acreage, the crops with the highest uses of 2,4-D were: almond (15%), apples (20%), barley (25%), cherries (15%), fallow (25%), hazelnuts (25%), nectarines (15%), oats (15%), oranges (20%), peaches (20%), pears (15%), plums (15%), prunes (15%), sorghum (20%), sugarcane (40%), tangelos (30%), wheat (30%). All other treated crops averaged 10% or less of the total acreage grown (US-EPA, 2012a). Average annual use on lawns, turf, nurseries, etc. in commercial settings decreased from 5 million to 4 million pounds per year (2002, 2004, 2006). Homeowner and aquatic weed control uses have remained fairly constant with average annual uses of 9 to 9.5 million pounds per year (2003, 2005) (US-EPA, 2013b) .

For 2,4-D, the current maximum approved usage rate is 4.0 lbs ae/A per year for asparagus, pome fruits, sugarcane, stone fruites, forestry uses, and non-cropland uses, among others. The maximum rate for aquatic uses is 10.8 lbs ae/acre foot for submerged aquatic plants. Typically, one to three applications are made per growing season. 2,4-D is currently registered in the U.S. for use on corn. The currently approved application rates for field corn and popcorn are a maximum per-year application rate of 3 lbs/acre and a maximum single application rate of 1.5 lbs/acre (US-EPA, 2013b).

2,4-D is approved for use on soybean only for pre-plant burndown application. Application rates on soybean are 0.5 or 1.0 lbs ae/A per application or 1.0 lbs ae/A per crop per year. The herbicide may not be applied any later than 7 to 15 days (0.5–1.0 lb ae/A of ester formulations) or 15 to 30 days (0.5–1.0 lb ae/A of amine formulations) prior to planting due to the potential for crop injury (DAS, 2011a).

Under Section 408 of FFDCA, EPA regulates the levels of pesticide residues that can remain on food or food commodities from pesticide applications (US-EPA, 2010b). The tolerance level is the maximum residue level of a pesticide that can legally be present in food or feed, and if pesticide residues are found to exceed the tolerance value, the food is considered adulterated and may be seized. The EPA establishes tolerances to regulate the amount of pesticide residues that can remain on food or feed commodities as the result of pesticide applications. Table 8-1 shows the current tolerances for residues of 2,4-D established for corn and soybean commodities (US-EPA, 2011a).

Table 8-1. 2,4-D Tolerances for Corn and Soybean Commodities

Commodity	Residue (parts per million)
Corn, field, forage	6.0
Corn, field, grain	0.05
Corn, field, stover	50
Soybean, forage	0.02
Soybean, hay	2.0
Soybean, seed	0.02

Source: (US-EPA, 2011b)

EPA is currently conducting a registration review of 2,4-D which was begun in 2012 and is currently scheduled to be completed in 2017 (US-EPA, 2013a). According to EPA, as part of their review, a comprehensive ecological risk assessment, including an endangered species assessment, will be prepared for all uses of 2,4-D. Additionally, EPA will conduct revised dietary, residential, and occupational risk assessments, incorporating any new toxicological or other relevant data (US-EPA, 2013a). All documents related to the 2,4-D registration review can be viewed at the registration review docket:

http://www.regulations.gov/#!docketDetail;D=EPA-HQ-OPP-2012-0330

New 2,4-D Choline Salt Formulation and Uses

DAS has developed a new herbicide formulation containing 2,4-D choline salt (DAS, 2010b; DAS, 2010a; DAS, 2011a) for additional pre- and post-emergence use with DAS-40278-9 corn, DAS-68416-4 soybean, and DAS-44406-6 soybean. The 2,4-D-resistance traits allow for a later application of the herbicide in both soybean (R2 stage) and corn (V8 stage). The new formulation is reported to be chemically more stable, making it less volatile, than the currently used amine or ester formulations of 2,4-D. In addition, the new formulation is reported to have minimized potential for physical drift in comparison to the currently used 2,4-D ester and 2,4-D dimethylamine (DMA) formulations, as well as decreased odor and improved handling (DAS, 2011a; DAS, 2011e).

2,4-D choline salt is a quaternary ammonium salt that rapidly dissociates into a 2,4-D anion and a choline cation. 2,4-D choline salt is currently registered on a number of crops including: sugarcane, rice, pome fruits, stone fruits, conventional corn and soybeans, fallow land, turf, and tree and brush control. Dow Agrosciences LLC, the manufacturer and registrant of 2,4-D choline salt, has submitted applications to EPA to add the following uses to the current 2,4-D choline salt labels: 1) DAS-40278-9 corn, 2) DAS-68416-4 soybean, 3) Enlist™ corn (DAS-40278-9 corn stacked with a glyphosate-resistance trait), and Enlist™ soybean (DAS-68416-4 soybean stacked with a glyphosate-resistance trait).

Two of the proposed registrations contain only 2,4-D choline salt as the active ingredient, whereas the other two labels are for a 2,4-D-choline salt/glyphosate mixture which DAS plans to market under the name Enlist Duo™. The latter would allow applications to GE herbicide-resistant corn and soybean with resistance to both 2,4-D and glyphosate. The 2,4-D choline formulation GF-2654 TS would be used on DAS 68416-4 soybean and the 2,4-D choline formulation GF-2654 TC used on DAS-40278-9 corn. The Enlist Duo™ formulations GF-2726 and GF-2727, containing both 2,4-D choline salt and glyphosate, would be applied on Enlist™ corn and Enlist™ soybean, respectively.

Proposed New 2,4-D Use on Corn

Although 2,4-D is already used on corn, its use is limited beyond early seedling stages (Wright *et al.*, 2010). Applications of 2,4-D as a post-emergent herbicide at later growth stages in conventional corn can cause significant malformations (Wright *et al.*, 2010). The proposed new use of 2,4-D choline on DAS-40278-9 corn includes a pre-emergent and up to two post-emergent applications (DAS, 2011b). Table 8-2 compares the current the use patterns for 2,4-D on field corn with the proposed use patterns for 2,4-D on DAS-40278-9 corn. The comparison is also shown graphically in Figure 8-1.

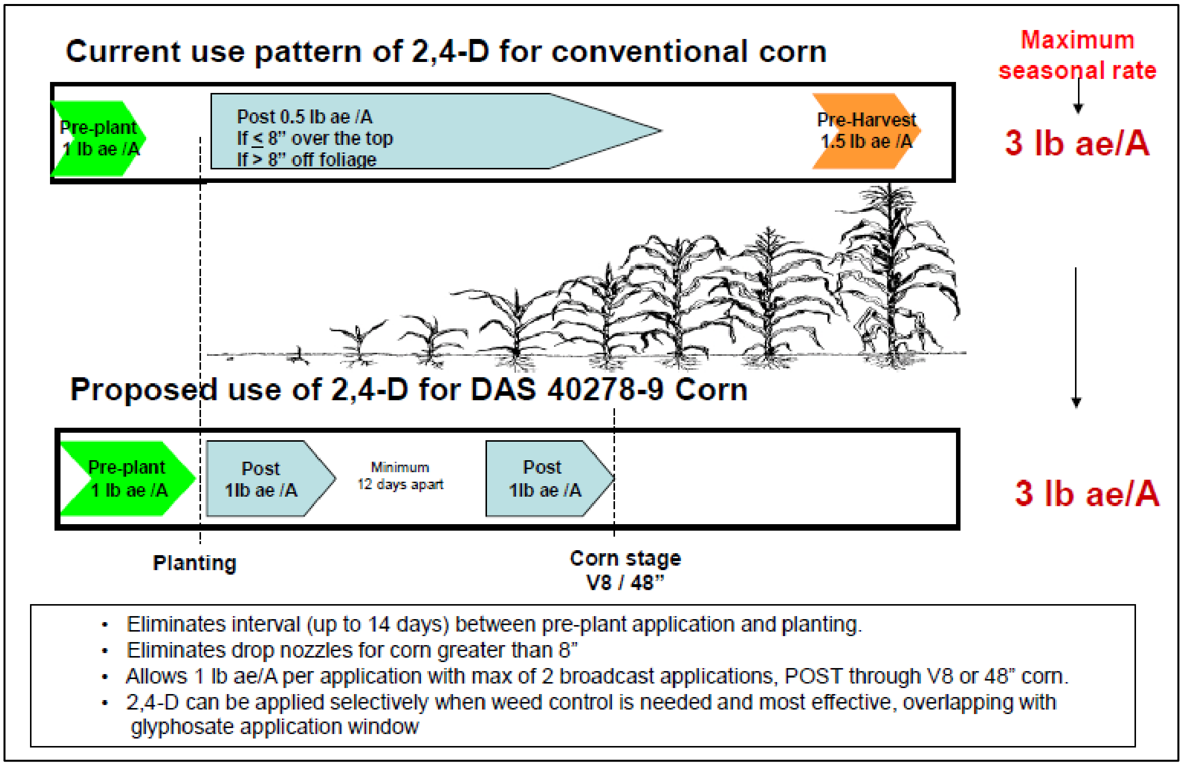
The label directions indicate no more than one pre-emergence application and no more than two post-emergence applications per use season. Proposed application rates for this new use of 2,4-D on DAS-40278-9 corn are up to 1 lb acid equivalent (ae)/acre (1,120 g ae/ha) as a pre-emergent herbicide and up to two applications between 0.5 to 1.0 lbs ae/acre (560 and 1,120 g ae/ha) for post-emergence. The post-emergence applications must be at a minimum of 12-days apart during the first 3-5 weeks before the corn reaches 6-8 inches in height and again up to the V8 [48-inch] stage of corn. These application rates are based on the currently approved rates for field corn and popcorn, which establish a maximum-per-year application rate of 3 lbs/acre, and a maximum single application rate of 1.5 lbs/acre (DAS, 2011f). Post-emergence application of 2,4-D, as specified on the draft label, could not occur within 30 days of forage harvest. The proposed preharvest interval (PHI) for corn is 30 days. Applications are to be made using groundboom equipment. Aerial application and chemigation are prohibited. The new use pattern and draft label are subject to regulatory approval by EPA.

Table 8-2: Comparison of Current and Proposed Application Rates for 2,4-D on Corn

Crop Stage	Conventional Field Corn		Proposed New Use on DAS-40278-9 Corn	
	Maximum Application Rate (lb/acre)[1,2]	Directions and Timing	Maximum Application Rate (lb/acre)[1,2]	Directions and Timing
Pre-plant or Pre-emergence	1.0	Apply before corn emerges to control emerged broadleaf weed seedlings or existing cover crops	1.0	Apply before corn emerges to control emerged broadleaf weed seedlings or existing cover crops
Post-emergence	0.5	Apply when weeds are small and corn is less than 8 inches tall (to top of canopy). When corn is over 8 inches tall, use drop nozzles and keep spray off foliage.	0.5 to 1.0	Apply after crop and weed emergence but before corn exceeds growth stage V8 or 48” in height, whichever occurs first. Make 1 to 2 applications with a minimum of 12 days between applications.
Pre-harvest	1.5	Apply after hard dough (or at denting) stage.	---	---
Total Annual Maximum Application	3.0	---	3.0	---

Source: (DAS, 2011f)

1. All values expressed as acid equivalents.
2. 1 lb/acre is the equivalent of 1,120 g/hectare.



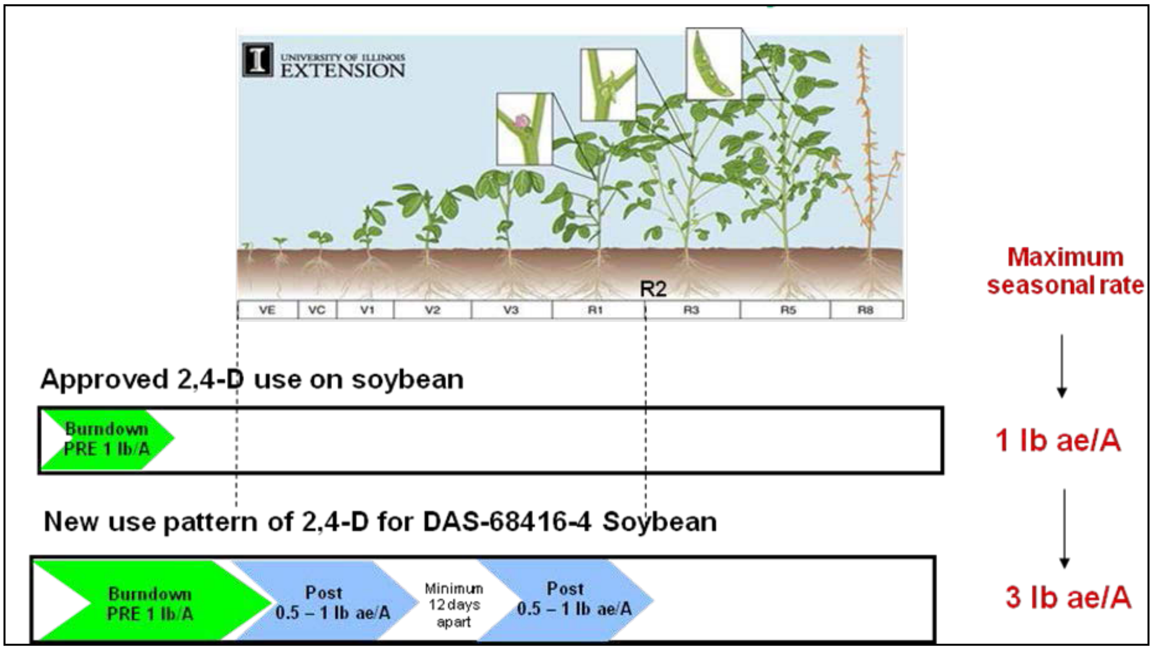
Source: (DAS, 2012b).

Figure 8-1. Current use pattern of 2,4-D on conventional corn and proposed new use of 2,4-D choline salt on DAS-40278-9 corn.

New 2,4-D Use on Soybean

Currently, 2,4-D is approved for use on soybean only for pre-plant burndown application. Application rates on soybean are 0.5 or 1.0 lbs ae/A per application or 1.0 lbs ae/A per crop per year (US-EPA, 2005b). It may not be applied any later than 7 to 15 days (0.5–1.0 lb ae/A of ester formulations) or 15 to 30 days (0.5–1.0 lb ae/A of amine formulations) prior to planting due to the potential for crop injury (DAS, 2010b).

The proposed new use of 2,4-D choline on DAS-68416-4 soybean (or DAS-44406-6 soybean) includes a single pre-plant or pre-emergent application and up to two post-emergent applications (DAS, 2011b). Specifically, an application of 2,4-D at pre-plant/burndown or pre-emergence (1.0 lb ae/A) without plant back restrictions would be allowed and/or one or two over-the-top post-emergence applications (0.5 - 1.0 lb ae/A) at least 12 days apart up to the R2 stage (full flower) of development (see Figure 8-2) (DAS, 2010b). Thus, the proposed maximum total seasonal application rate of 2,4-D on DAS-68416-4 soybean (or DAS-44406-6 soybean) would increase from 1.0 lb ae/A (current) to 3.0 lb ae/A per year. (This proposed new seasonal rate is the same current EPA-approved maximum annual use rate of 2,4-D for popcorn and field corn). Post-emergence application of 2,4-D, as specified on the draft label, could not occur within a PHI of 30 days (DAS, 2011a; DAS, 2011c). The new use pattern and draft label are subject to regulatory approval by EPA. Table 8-3 presents a comparison of the current and proposed application rates of 2,4-D on soybean and DAS-68416-4 (or DAS-44406-6 soybean) (DAS, 2010b).



Source: (DAS, 2010b).
Note: the new 2,4-D use pattern would be the same for DAS-44406-6 soybean.

Figure 8-2. Proposed 2,4-D Application Rates on DAS-68416-4 Soybean Compared to Current Application Rates Permitted for Conventional Soybean

Table 8-3. Comparison of Current and Proposed Application Rates of 2,4-D on Soybean

	Current Use Pattern - Conventional Soybean		Proposed New Use Pattern – DAS-68416-4 Soybean (or DAS-44406-6 Soybean)	
Crop Stage	**Maximum Application Rate (lb/acre)[1]**	**Directions and Timing**	**Maximum Application Rate (lb/acre)[1]**	**Directions and Timing**
Pre-plant (burndown) or Pre-emergence	0.5 -1.0	**Pre-plant:** Apply before soybean emerges to control emerged broadleaf weed seedlings or existing cover crops	1.0	**Pre-plant:** Apply any time prior to and up through soybean planting but before soybean emerges to control emerged broadleaf weed seedlings or existing cover crops. **Pre-emergence:** Apply any time after planting but before soybean emerges to control broadleaf weed seedlings or existing cover crops.

Crop Stage	Current Use Pattern - Conventional Soybean		Proposed New Use Pattern – DAS-68416-4 Soybean (or DAS-44406-6 Soybean)	
	Maximum Application Rate (lb/acre)[1]	Directions and Timing	Maximum Application Rate (lb/acre)[1]	Directions and Timing
Post-emergence	--[2]	--	0.5-1.0	Apply when weeds are small and soybean growth stage is no later than R2 (full flowering stage). Make one to two applications with a minimum of 12 days between applications.
Total Annual Maximum Application	1.0	--	3.0	--

[1] All values expressed as acid equivalents

[2] Not applicable

Source: (DAS, 2011c).

EPA Assessments of Proposed New 2,4-D Choline Salt Formulation and Uses on 2,4-D-Resistant Corn and Soybean

Under FIFRA, EPA regulates the use of herbicides, requiring registration of a pesticide for a specific use prior to distribution or sale of the pesticide for a proposed use pattern. The process of registering a pesticide is a scientific, legal, and administrative procedure through which EPA examines the ingredients of the pesticide; the particular site or crop on which it is to be used; the amount, frequency, and timing of its use; and storage and disposal practices. In evaluating a pesticide registration application, EPA assesses a wide variety of potential human health and environmental effects associated with use of the product. Prior to registration for a new use for a new or previously registered pesticide, the producer of the pesticide must provide data from tests done according to EPA guidelines. EPA must determine through this submitted test data that the pesticide will not cause unreasonable adverse effects on the environment and non-target species when used in accordance with label instructions and will result in a reasonable certainty of no harm to humans.

EPA must also approve the language used on the pesticide label in accordance with 40 CFR part 158. The EPA pesticide registration process involves the design of use restrictions that, if followed, have been determined to be protective of worker health. Growers are required to use pesticides consistent with the application instructions provided on the EPA-approved pesticide labels. The overall intent of the label is to provide clear directions for effective product performance while minimizing risks to human health and the environment (US-EPA, 2010c).

Based on the studies submitted on 2,4-D choline salt formulation by DAS, EPA has conducted draft assessments on the potential environmental fate, ecological effects, and human health effects of the proposed new uses of 2,4-D choline 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.

Environmental Fate and Ecological Risks

EPA Environmental Fate and Effects Division (EFED) assessed the ecological risks to listed and non-listed species associated with the proposed new uses of 2,4-D choline salt on 2,4-D-resistant corn and soybean. The assessment examined the effects of 2,4-D choline salt (and 2,4-DCP, when relevant) on aquatic and terrestrial environments primarily through the routes of spray drift, volatile (vapor) drift, and runoff. Modeled application rates represent the maximum use patterns of the proposed labels for use on 2,4-D-resistant corn and soybean.

The results are summarized as follows:

No potential direct risks from the proposed applications of 2,4-D choline salt to herbicide-tolerant corn and soybeans were identified for the following:

- Birds (chronic),
- Aquatic plants,
- Freshwater fish (acute and chronic),
- Estuarine/marine fish (acute and chronic),
- Freshwater invertebrates (acute and chronic),
- Estuarine/marine invertebrates (acute and chronic),
- Aquatic plants, and
- Terrestrial insects.

The screening level risk assessment for non-listed species identified these groups as being potentially at direct risks from exposures from the proposed new uses of 2,4-D choline salt:

- Mammals (acute and chronic),
- Birds, reptiles, terrestrial-phase amphibians (acute), and
- Terrestrial plants.

In addition, the screening level risk assessment identified all non-listed taxa as potentially at indirect risks from the proposed uses of 2,4-D choline salt because of potential dependencies (e.g., food, shelter, habitat) on species that are directly affected. Information, such as biological distribution, species biology, spray drift properties specific to the 2,4-D choline formulations, and mitigation efforts in regions where the pesticide is used, could be used to reduce the uncertainty regarding potential direct and indirect effects.

An assessment of the direct and indirect risks to listed species for which a potential for risk was identified in the screening level assessment is under development by EPA. This assessment will address the specific geographical and biological characteristics of each species potentially at risks from exposures to 2,4-D. When this refined, species-specific assessment is completed, EPA will be able to identify which species are at direct and indirect risks from exposures to 2,4-D.

A spray drift analysis using the GF2726 formulation indicated that buffers could reduce risk quotients for birds (acute), mammals (acute and chronic), and terrestrial plants below the Agency's levels of concern. The results of the buffer analysis indicated that riskes below levels of concern can only be achieved through the combination of the AIXR 11004 nozzle and GF-2726 formulation. Final species-specific buffer distances remain uncer review and refinement. The locations of the buffers would be dependent on species distribution, species biology, and any mitigation efforts proposed by the registrant.

EPA will be publishing these complete draft analyses in the Federal Register for public comment.

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 2,4-D choline salt on 2,4-D-resistant corn and soybean. Based on their draft human health risk assessment, EPA HED recommends for a registration for the use of 2,4-D choline on 2,4-D-resistant corn and soybean. EPA identified additional data needed, specific tolerance recommendations, and label modifications. 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.

Hazard Characterization: Based on its review of hazard data, EPA concluded that 2,4-D's principal toxic effects are changes in the kidney, thyroid, liver, adrenal, eye, and ovaries/testes in the rat following exposure *via* the oral route at dose levels above the threshold of saturation of renal clearance. No systemic toxicity was observed in rabbits following repeated exposure *via* the dermal route at dose levels up to the limit dose. Neurotoxicity was observed in the acute neurotoxicity study in rats at the high dose. In an extended 1-generation reproductive toxicity study in rats, reproductive toxicity, developmental neurotoxicity, and immunotoxicity were not observed, and the thyroid effects observed at dose levels up to/approaching renal saturation were considered treatment-related, although not adverse. Maternal and developmental toxicity were observed at high dose levels exceeding the threshold of saturation of renal clearance. There are no residual uncertainties for pre- and/or postnatal toxicity. 2,4-D is not acutely (lethal) toxic via the oral, dermal, and inhalation routes, is not a dermal irritant or a dermal sensitizer, but it is a severe eye irritant. 2,4-D has been classified as a Category D chemical, i.e., not classifiable as to human carcinogenicity.

Dietary Exposure and Risk Assessment: Acute and chronic aggregate (food + dietary drinking water) exposure and risk assessments were conducted for the new proposed use of 2,4-D choline salt. EPA HED determined that the resulting acute food plus drinking water risk estimates are not of concern to (≤100% of the acute population adjusted dose (aPAD)) at the 95^{th} percentile of the exposure distribution for the general population and all population subgroups. The resulting acute risk estimate for children 1 to 2 years old (the subgroup with the greatest exposure) was

14% of the aPAD at the 95th percentile of the exposure. The resulting chronic risk estimates are not of concern to EPA HED for the general population and all population subgroups. The most highly exposed population was children 1 to 2 years old, utilizing 15% of the chronic PAD (cPAD).

Residential (Non-Occupational) Exposure and Risk Assessment: There is no potential hazard *via* the dermal route for 2,4-D, therefore the handler assessment included only the inhalation route of exposure and the post-application assessment included only the inhalation and incidental oral route of exposure. The residential handler and post-application risk estimates are not of concern for 2,4-D for all scenarios and all routes of exposure.

Exposure to drift and volatilization, and the appropriate available data, were considered in this assessment due to the anticipated market expansion. Concerning spray drift, the residential post-application exposure assessment for registered use as direct application to turf is protective of potential deposition on turf from spray drift for the proposed use of 2,4-D choline on herbicide-tolerant corn and soybean. The potential exposure to vapor phase 2,4-D residues emitted from treated fields for the proposed uses of 2,4-D choline has been evaluated in this assessment. The results indicate that volatilization of 2,4-D from treated crops does occur and could result in bystander exposure to vapor phase 2,4-D. Modeling results, however, indicate that airborne concentrations, even at the edge of the treated fields, are not of concern.

Aggregate Risk Estimates: The acute aggregate risk assessment include only food and water exposure. The resulting acute food plus drinking water risk estimates are not of concern to EPA HED (≤100% aPAD) at the 95th percentile of the exposure distribution for the general population and all population subgroups.

The short-term aggregate risk assessment includes food, water, and residential exposure. According to EPA HED, the resulting short-term aggregate risks are not of concern (margins of exposure (MOEs) > level of concern (LOC) of 100) for adults and children.

There are no intermediate-term residential exposure to 2,4-D; therefore the intermediate-term aggregate risk assessment include only food and drinking water exposure. Furthermore, the chronic aggregate risk assessment includes only food and water exposure. The chronic food plus drinking water risk estimates are not of concern to EPA HED for the general population and all populations subgroups.

Occupational Exposure and Risk Assessment: Occupational handlers may apply 2,4-D choline with groundboom equipment. There is no potential hazard *via* the dermal route for 2,4-D, therefore the occupational handler assessment included only the inhalation route of exposure. Occupational handler inhalation risk estimates are not of concern (i.e., MOEs > LOC of 300) for all scenarios for use of 2,4-D choline on herbicide-tolerant corn and soybean. At baseline personal protective equipment (PPE) (i.e., no respirator), the occupational handler inhalation MOE is 4,900 for mixer/loaders and 3,200 for applicators using groundboom equipment.

There is no potential hazard via the dermal route for 2,4-D; therefore, a quantitative occupational post-application dermal risk assessment was not completed. Furthermore, a quantitative post-application inhalation risk assessment was not performed for workers at this time; although the assessment was not performed, other exposure scenarios are expected to be protective of potential worker post-application inhalation exposure. The minimum Worker Protection Standard (WPS) restricted entry interval (REI) of 48 hours is adequate to protect agricultural workers from post-application exposures to 2,4-D.

Glyphosate

Background and Current Uses

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 and soybean.

Glyphosate was first introduced under the trade name of Roundup™ by Monsanto in 1974. Glyphosate salts serve as the source of the active ingredient (ai) *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, 2009c). 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, 2009c). Glyphosate is absorbed across the leaves and stems of plants and moves throughout the plant, concentrating in the meristem tissue (Henderson, 2010).

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, 2012e).

The CP4 EPSPS protein confers resistance to glyphosate and has been used in many Roundup Ready™ crops (e.g., canola, corn, cotton, soybean, and sugar beet). Glyphosate may be used premergent, preplant incorporated, or postemergent with Roundup Ready™ crops. As listed on the Roundup™ herbicide labels, Roundup Original MAX™, Roundup WeatherMAX™, and Roundup PowerMAX™ products contain 48.8 percent of the potassium salt of glyphosate, equivalent to 4.5 lb of glyphosate ae per gallon (540 g glyphosate per liter (L)). Glyphosate is also commonly used in conjunction with many other herbicides as a tank mix for both pre-plant/pre-emergence weed control up through the 12-leaf stage or until the corn reaches a height of 30 inches (see, e.g., Loux *et al.*, 2011).

The current approved maximum pre-emergence application of glyphosate on glyphosate-resistant corn or soybeans is 3.7 lbs ae/acre. A glyphosate post-emergence application from 0.75 to 1.5 lbs ae/acre (total 2.25 lbs/acre/season post-emergence) and an additional pre-harvest application of 0.77 lbs/ae/acre are permitted. The current maximum total seasonal use rate for glyphosate on glyphosate-resistant corn and soybean is 6 lbs ae/acre (DAS, 2012c).

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, 2010a). Table 8-4 shows the current tolerances for residues of glyphosate established for corn and soybean commodities.

Table 8-4. Glyphosate Tolerances for Corn and Soybean Commodities

Commodity	Residue (parts per million)
Corn, field, forage	13
Corn, field, grain	5
Corn, field, stover	100
Soybean, forage	100
Soybean, hay	200
Soybean, hulls	120
Soybean, seed	20

Source: (US-EPA, 2010a).

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, 2009b). 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, 2009b)."

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

Glyphosate Use on DAS-40278-9 Corn, DAS-68416-4 Soybean, and DAS-44406-6 Soybean

DAS' new pre-mix of 2,4-D choline and glyphosate DMA, the Enlist™ Duo formulations GF-2726 and GF-2727, will be formulated as an approximate 1:1 ratio of 2,4-D choline to glyphosate DMA. If approved by EPA, glyphosate could be applied to Enlist™ Corn and Enlist™ Soybean (DAS-40278-9 corn and DAS-68416-4 soybean stacked with a glyphosate-resistance trait (or DAS-44406-6 soybean) at pre-plant/burndown at 0.5 to 1.0 lb ae/acre and up to two post-emergence applications at 0.5 to 1.0 lb ae/, for a maximum total seasonal application rate of 3.0 lb ae/acre. This compares to current glyphosate use on glyphosate-resistant corn and soybeans of a maximum pre-emergence application of 3.7 lbs ae/acre and post-emergence applications from 0.75 to 1.5 lbs ae/acre (total 2.25 lbs/acre/season post-emergence) and an additional pre-harvest application of 0.77 lbs/ae/acre. The current maximum total seasonal use rate for glyphosate on glyphosate-resistant corn and soybeans is 6 lbs ae/acre (DAS, 2011f; DAS, 2012a).

Quizalofop

Background and Current Uses

Quizalofop-p-ethyl is a selective, systemic post-emergence phenoxy herbicide that is toxic to many annual and perennial grasses. It belongs to a subclass of phenoxy compounds known as aryloxyphenoxys ("fops"). Quizalofop-p-ethyl is absorbed from the leaf surface and is moved throughout the plant. It accumulates in the active growing regions of stems and roots. Most non-graminaceous plants (dicots and sedges) are tolerant to quizalofop. Dicotyledonous (or dicot) plants contain a prokaryotic form of ACCase (an enzyme found in chloroplasts) which is insensitive to "fop" herbicides. In contrast, monocotyledonous (or monocot) plants contain a sensitive eukaryotic form of ACCase in the plastid (DAS, 2010a). This is the primary reason that the "fop" herbicides are generally good graminicides[1], with little activity on dicot plants. In addition, some grass species, including some cereal crops and weeds (e.g., annual bluegrass and wild oats), are tolerant of some of these herbicides (i.e., clethodim, quizalofop, and others) due to their ability to metabolize the herbicides to inactive forms (Devine and Shukla, 2000; Powles and Preston, 2009).

The aryloxyphenoxypropionates (AOPP) herbicides inhibit chloroplastic ACCase, which catalyzes the first committed step in fatty acid biosynthesis, causing plant death (Burton *et al.*, 1989). The herbicidal activity of quizalofop-ethyl ester was first reported in 1983, and quizalofop-ethyl was first approved for use in a registered herbicide product in the U.S. in 1988 (DAS, 2010a; DuPont, 2010).[2] However, all end use product registrations were cancelled prior to 1996 and it was replaced by the more active quizalofop-P-ethyl (pure R-enatiomer of quizalofop racemic mixture), which first was approved for use in a registered product in 1990 (DuPont, 2010).

[1] A graminicide is an herbicide used for the control of grass weeds (of the former family "Gramineae').'

[2] Reference to the DuPont Assure® II label is for illustration only, and is not intended to infer any recommendation for the use of this product by APHIS or the USDA.

The “fop” herbicides (AOPP ACCase inhibitors) have been registered for crop use for more than 20 years (USDA-APHIS, 2010). The “fop” herbicides traditionally have not been used to control weed species in cornfields because, as a grass (Poaceae family) species, corn is damaged by AOPP ACCase inhibitor activity. The registration and use of “fop” herbicides has been primarily on broadleaf crops, such as soybean, to control grass weed species, although certain cereal plant varieties have a level of tolerance to some “fops” (see DuPont, 2010). According to the USDA-NASS Agricultural Chemical Use Database, “fop” type herbicides were used for weed control on at least 23 food crop species between 1990 and 2006, totaling more than 16 million pounds of active ingredient (USDA-NASS, 2011).

The currently registered uses include canola, crambe, cotton, crops grown for seed, eucalyptus, dry beans (including Chickpea), dry and succulent peas, flaxseed, hybrid poplar plantings, lentils, mint (spearmint and peppermint), pineapple, ryegrass grown for seed, snap beans, soybeans, sugar beets, sunflowers, and noncrop areas. Current allowable rates for this herbicide vary from 0.0172 to 0.344 lb ai/acre, depending on crop and weed conditions (see EPA approved label for Assure II) (DAS, 2010a; DuPont, 2010).

Pesticide residue tolerances for quizalofop are listed in 40 CFR Part 180.441. As quizalofop is not currently approved by EPA for use on corn, only residue limits for soybean commodities are shown in Table 8-5, representing combined residues of combined residues of quizalofop ethyl, quizalofop, and quizalofop methyl (US-EPA, 2012b).

Table 8-5. Quizalofop Tolerances for Soybean Commodities

Commodity	Residue (parts per million)
Soybean, flour	0.5
Soybean, hulls	0.02
Soybean, meal	0.5
Soybean, seed	0.05
Soybean, soapstock	1.0

Source: (US-EPA, 2012b)
Note: quizalofop is not currently approved for uses on corn.

The Registration Review for quizalofop was begun in 2007 and a final workplan was completed in June of 2008. EPA has not published a proposed decision schedule for quizalofop as of this assessment:
http://www.epa.gov/oppsrrd1/registration_review/schedule.htm

Documents related to the EPA review are posted as part of the Registration Review of Quizalofop-ethyl (128711) and quizalofop-p-ethyl (128709) docket (EPA-HQ-OPP-2007-1089):

http://www.regulations.gov/#!docketDetail;D=EPA-HQ-OPP-2007-1089

New Use of Quizalofop on DAS-40278-9 Corn

DAS-40278-9 corn is a GE corn line that has increased resistance to treatment with phenoxy auxin herbicides (e.g., 2,4-D) and resistance to AOPP ACCase inhibitor (“fop”) herbicides (DAS, 2010a). DAS has indicated that “fop” herbicides could be used to maintain seed purity in DAS-40278-9 corn breeding nurseries, hybrid production fields, and generally for the control of grass weeds in corn. As quizalofop is not currently registered for use as a post-emergent herbicide on corn, this is a proposed new use (DAS, 2010a).

Quizalofop-P ethyl is the active ingredient in DuPont Assure II™ herbicide (EPA Reg. No. 352-541). DuPont has submitted petitions to EPA to add the new use of quizalofop on DAS-40278-9 corn. Since most grass crops, including corn, are highly sensitive to the herbicide, quizalofop could only be used on field corn that has been GE to be resistant to the herbicide, such as DAS-40278-9 corn.

DuPont proposes a maximum single application rate of 0.082 lb ai/acre corn (DAS, 2011f). The proposed maximum application rate also is the seasonal maximum application rate (DAS, 2011f). The proposed PHI is 30 days for forage; a PHI for corn grain or stover is not specified (US-EPA, 2011). This maximum application rate is less than that currently approved by EPA for use of quizalofop for the control of grassy weeds in soybeans and cotton, where a seasonal maximum application rate of 139 g ai/ha (0.124 lb ai/acre) is approved (DAS, 2011f). Applications of quizalofop would be made by broadcast foliar application by ground; aerial applications would be prohibited. EPA currently is reviewing the proposed label change for quizalofop and has not granted the registration yet. Table 8-6 provides a summary of the proposed application rates and directions for use on DAS-40278-9 corn.

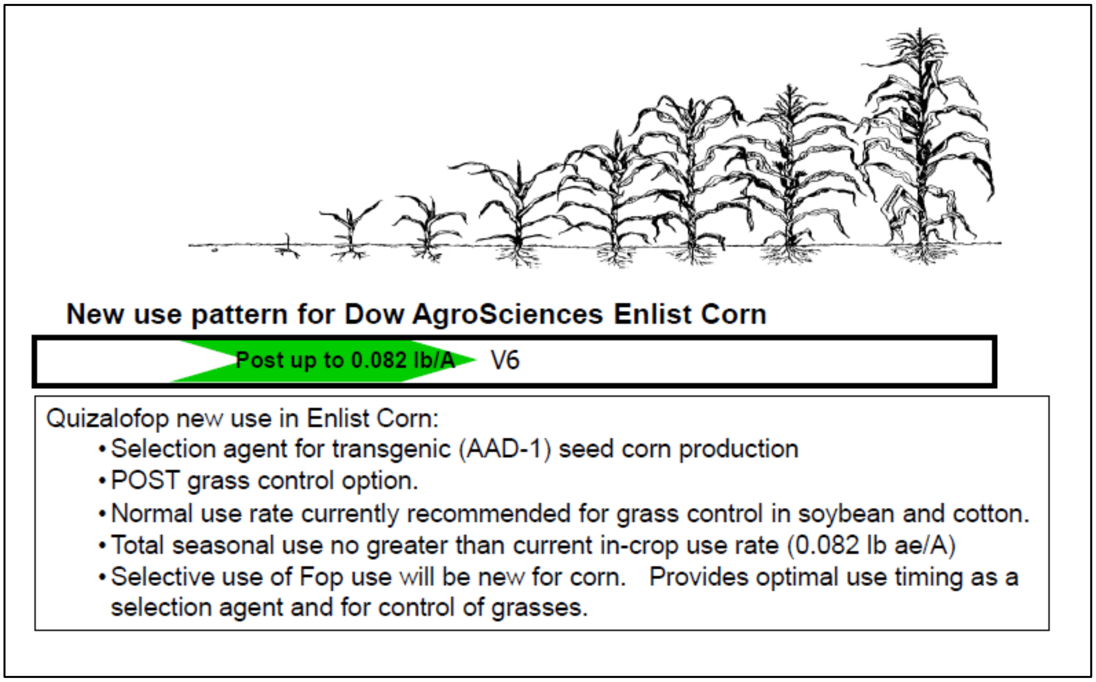
Table 8-6. Comparison of Current and Proposed Application Rates for Quizalofop

Crop Stage	Current Use Pattern for Quizalofop on Soybeans and Cotton		Proposed New Use on DAS-40278-9 Corn	
	Maximum Application Rate (lb/acre)[1,2]	Directions and Timing	Maximum Application Rate (lb/acre)[1,2]	Directions and Timing
Post-emergence	0.082	Apply 0.034 to 0.082 lb/acre per application. Do not exceed a total of 0.124 lb/acre per season.	0.034 to 0.082	Apply 0.034 to 0.082 lb/acre per application from V2 – V6 Growth stages. Do not make more than 2 applications. Do not exceed a total of 0.082 lb/acre per season. Do not apply later than V6 growth stage.
Total Annual Maximum Application	0.124	---	0.082	---

Source: (DAS, 2011f).

Notes:

1. Active ingredient.
2. 1 lb/acre is the equivalent of 1,120 g/hectare.



Source: (DAS, 2010b).

Figure 8-3. Proposed Quizalofop Application Rate on DAS-40278-9 Corn.

EPA Assessments of Proposed New Use of Quizalofop on DAS-40278-9 Corn

Environmental Fate and Ecological Risks

As part of the approval process, EPA EFED performed a screening level ecological risk assessment for listed and non-listed species for the proposed label for quizalofop. The screening-level analysis for quizalofop-p-ethyl concluded that the proposed new agricultural use for quizalofop shows the possibility for direct effects to mammals (chronic dose-based risk), and terrestrial monocots. Direct risks were also assumed for aquatic vascular plants, and estuarine/marine fish (acute) because of an absence of data. Chronic risks were assumed for terrestrial birds because of nondefinitive toxicity endpoints. Since birds serve as surrogates for terrestrial-phase amphibians and reptiles, these taxa may also be at direct risk from the new uses of quizalofop-p-ethyl. Indirect effects were determined by assessing the potential for reduction of prey base or habitat modification of listed taxa. Given that monocots are at risk, there is the potential for habitat modification to indirectly affect all listed taxa.

The draft assessment will be published by EPA in the Federal Register for public review and comment.

Human Health Risk Assessment

EPA HED evaluated hazard and exposure data, as well as dietary, residential (non-occupational), occupational, and aggregate exposures to estimate the risk to human health that could potentially result from the proposed new use of quizalofop on DAS-40278-9 corn. Based on their draft human health risk assessment, EPA HED recommends for a registration for the use of quizaolfop on DAS-40278-9 corn. EPA identified additional data needed, specific tolerance recommendations, and label modifications. 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.

Hazard Characterization: Quizalofop ethyl has low acute toxicities via the oral, dermal, and inhalation routes. It is not an eye or dermal irritant nor a skin sensitizer. Following oral administration, quizalofop ethyl is rapidly absorbed and excreted via urine and feces. Liver is the target organ as evidenced by increased liver weight and histopathological changes in the liver.

There were no effects observed in oral toxicity studies that could be attributable to a single-dose exposure. Hence, a dose and endpoint have not been selected for assessment of acute exposure. Similarly, there was no observed toxicity in a dermal subchronic study at the highest dose tested (above the limit dose) so no dermal risk assessment is needed. Inhalation toxicity studies for occupational exposure assessment are waived based on the low exposure expected by the current and proposed use patterns. A chronic reference dose (cRfD) was established based on a combined chronic toxicity/carcinogenicity study in rats. Mutagenicity studies conducted on quizalofop ethyl did not demonstrate evidence of mutagenic potential. The Cancer Peer Review Committee determined that quizalofop ethyl should be classified as Category D (not classifiable as to human carcinogenicity). As such, a cancer risk assessment was not conducted.

Developmental studies in rats and rabbits and a two-generation reproduction study in rats showed no evidence (qualitative or quantitative) for increased susceptibility following *in utero* and/or pre/post-natal exposure to quizalofop ethyl.

Dietary Exposure and Risk Assessment: An acute dietary risk assessment was not performed, as an acute endpoint was not identified in the hazard assessment. Similarly no cancer risk assessment was needed, as quizalofop ethyl was not classifiable with regard to carcinogenicity.

A chronic dietary exposure assessment was conducted using the maximum application rate per season for quizalofop ethyl on dry peas in Michigan. Under this scenario, children (1-2 years) were found to have the maximum chronic dietary risk at 29% of the chronic population adjusted dose (cPAD). This is well below HED's level of concern of 100% of cPAD.

Residential Risk: Quizalofop ethyl has no registered homeowner or ornamental uses and none are being proposed.

Aggregate Risk Estimates: Aggregate risk estimates take into account dietary and non-dietary residential sources of exposure. As there are no registered or proposed uses of quizalofop that would result in non-dietary residential exposure, the aggregate risk estimates are equivalent to the chronic dietary risk estimates discussed above and are below HED's level of concern.

Occupational Exposure and Risk Assessment: No doses or endpoints for dermal or inhalation exposure were selected or needed. Therefore, a quantitative estimate of occupational risk was not determined. The acute toxicity categories are IV for both routes of exposure, and a 12-hour re-entry interval (REI) was established under the worker protection standard (WPS).

Glufosinate Ammonium

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 is manufactured and labeled by Bayer Cropscience for pre-plant burndown on conventional or GE soybean, corn, cotton, canola, or sugar beet and post-emergence use on crops designated as LibertyLink™ (soybean, corn, cotton, canola, and rice). The PAT protein expressed in DAS 68416-4 and DAS 44406-6 soybean soybean is similar to PAT found in other commercially-grown glufosinate-resistant crops (e.g., LibertyLink™ soybeans, corn, cotton, canola, rice). Since the PAT protein has been included as an herbicide tolerance marker in products containing plant incorporated protectants (PIPs), it has been reviewed by EPA as a PIP inert ingredient (US-EPA, 2005a). Based on their environmental risk assessment, EPA determined that the PAT protein presents a low probability of risk to human health and the environment and granted an exemption from the requirement of a tolerance for this PIP inert ingredient (40 CFR 180.1151; 62 FR 17719, Aug. 11, 1997).

Based on pesticide usage data from USDA-NASS, private pesticide market research, and California Department of Pesticide Regulation (DPR), EPA estimated glufosinate usage from 2003 through 2010. The crops with the highest glyphosate uses (based on average treated fraction of acreage) were: almond (15%), canola (25%), grapes (15%), and pistachios (20%). All other treated crops averaged less than 15% of the total acreage grown (US-EPA, 2012d).

DAS has indicated that the proposed glufosinate application rate for use on DAS-68416-4 soybean and DAS 44406-6 soybean will be consistent with the current use pattern of glufosinate on other glufosinate-resistant soybean (i.e., LibertyLink™ soybean) (DAS, 2010b). As there is no change from the current EPA-approved labeled use pattern, no petition has been submitted to EPA for a change in the glufosinate label. The EPA-approved label for Liberty™ (i.e., glufosinate ammonium) use on glufosinate-resistant soybean can be viewed here:

http://www.bayercropscience.us/products/herbicides/liberty/labels-msds

The EPA-registered use of glufosinate on LibertyLink™ soybean includes an initial burndown application of glufosinate no higher than 0.66 lb a.i./A (36 fl oz/A) with a minimum of 0.53 lb a.i./A (29 fl oz/A). A single second in-season application of glufosinate up to 0.53 lb a.i./A (29 fl oz/A) is approved on LibertyLink™ soybeans, with a seasonal maximum rate of 1.2 lb a.i./A (65 fl oz/A) permitted. Glufosinate applications on LibertyLink™ soybean should be made from emergence up to but not including the bloom growth stage and within 70 days of harvesting.

Pesticide residue tolerances for quizalofop are listed in 40 CFR Part 180.473 (US-EPA, 2012c). As quizalofop is not currently approved by EPA for use on corn, only residue limits for soybean commodities are shown in Table 8-7, representing combined residues of combined residues of quizalofop ethyl, quizalofop, and quizalofop methyl.

Table 8-7. 2,4-D Tolerances for Corn and Soybean Commodities

Commodity	Residue (parts per million)
Corn, field, forage	4.0
Corn, field, grain	0.20
Corn, field, stover	6.0
Soybean	2.0
Soybean, hulls	0.02

Source: §180.473 Glufosinate ammonium; tolerances for residues (US-EPA, 2012c).

Currently, glufosinate is undergoing registration review by EPA. The registration review began in 2008 and a decision is expected in 2013 (US-EPA, 2009a). EPAs website for the glufosinate ammonium registration review case can be found here:

http://www.epa.gov/oppsrrd1/registration_review/glufosinate_ammonium/index.htm

The docket containing documents related to EPAs review can be viewed here:

http://www.regulations.gov/#!docketDetail;D=EPA-HQ-OPP-2008-0190

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