October 10, 2014

Regulatory Analysis and Development, PPD, APHIS
Station 3A-03.8
4700 River Road, Unit 118
Riverdale, MD 20737- 1238

RE: Docket No. APHIS-2013-0043

Comments to USDA's Animal and Plant Health Inspection Service on the Agency's draft Environmental Impact Statement on Monsanto Petitions (10-188-01p and 12-185-01p) for Determinations of Nonregulated Status for Dicamba-Resistant Soybean and Cotton Varieties

Center for Food Safety, Science Comments I

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Notes on science comments

These comments submitted by Center for Food Safety are one of three sets of comments from our organization. Legal comments and a second set of science comments are also being submitted separately. The references cited have been uploaded as supporting materials. The filenames for these documents match the citations in the text (e.g. Benbrook 2009a). A references section is included at the end.

CFS has addressed many issues of relevance to this draft EIS in comments to the Environmental Protection Agency on the proposed registration of dicamba for use on these dicamba-resistant crops. We also submitted scoping comments for the draft EIS. These documents are being submitted as appendices, and will be referenced to in these comments as follows:

Appendix A: CFS Science Comments to EPA on registration of dicamba for new use on MON 88701, dicamba- and glufosinate-resistant cotton, 1/18/2013

Appendix B: CFS Science Comments to EPA on registration of dicamba for new use on MON 87708, dicamba-resistant soybean, 9/21/2012

Appendix C: CFS Comments to USDA on petitions for deregulation of MON 87708 soybean (9/11/2012) and MON 88701 cotton (4/29/2013)

Appendix D: CFS Scoping Comments to USDA on Notice of Intent to Prepare an Environmental Impact Statement on MON 87708 soybean and MON 88701 cotton, 7/17/2013

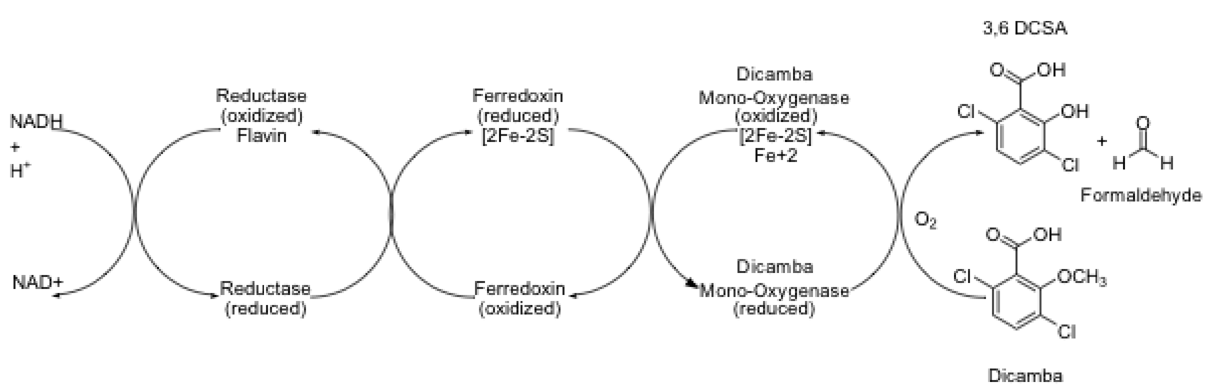
Appendix E: CFS Legal Comments to EPA on registration of dicamba for new use on MON 88701 cotton, 1/13/2013

Appendix F: CFS Legal Comments to EPA on registration of dicamba for new use on MON 87708 soybean, 9/12/2012

Appendix G: CFS Science Comments I to USDA on the Draft Environmental Impact Statement for 2,4-D Resistant Corn and Soybeans, 3/11/14

Introduction

The Monsanto Company has petitioned APHIS for determinations of nonregulated status for dicamba-resistant soybean (MON 87708) and dicamba- and glufosinate-resistant cotton (MON 88701). Both varieties are genetically engineered to withstand direct application of high rates of dicamba herbicide (3,6-dichloro-2-methoxybenzoic acid). Dicamba resistance is conferred by an enzyme, dicamba mono-oxygenase (DMO), that demethylates dicamba to form the non-phytotoxic 3,6-dichlorosalicylic acid (DCSA) as well as formaldehyde, as depicted below.



DMO was initially purified from strain DI-6 of *Stenotrophomonas maltophilia*, found in soil and water samples obtained from storm water retention ponds at a dicamba manufacturing plant in Beaumont, Texas (Krueger et al 1989[1]). In this paper, Krueger and colleagues envisioned the use of this *S. maltophilia* strain as follows:

"Organisms capable of degrading dicamba and/or its 3,5-isomer … may be useful for facilitating the rapid dissipation of both isomers from the environment" (p. 534).

In the presence of this organism: "…dicamba is metabolized to compounds that are less of an environmental concern. Complete mineralization of dicamba would result in reduced environmental exposure to degradation products and reduced potential for leaching of dicamba or its metabolites to groundwater" (p. 538).

Chakraborty et al (2005), who isolated and purified DMO from this same organism,[2] also make passing reference to the function of such bacteria as "useful in the bioremediation of harmful pollutants" (p. 20). Paradoxically, in the same paper, they note that DMO "has recently been utilized to develop transgenic plants that are tolerant to dicamba levels that are 10 to 20 times higher than the typical field application rate" (p. 27).

This discussion highlights a general phenomenon. There was a spate of research undertaken in the 1980s and 1990s to isolate or engineer microorganisms for bioremediation of pesticides and other toxic compounds in soils and water (e.g. at toxic waste dumps). Much of this research was funded by the public sector with the goal of reducing human and environmental exposure to pesticides, for instance by the Swiss government (Zipper et al 1999) and the EPA (Short et al 1991). To the best of our knowledge, none of these well-intentioned research efforts bore fruit in terms of successful bioremediation applications.

However, knowledge gained in this research has more recently been applied by pesticide companies and their university collaborators for the precisely contrary purpose of fostering greater use of herbicides, which of course leads to greater human and environmental exposure. In addition to the dicamba-demethylating DMO enzyme from *S. maltophilia*, Monsanto derived the EPSPS gene/enzyme utilized in most glyphosate-resistant crops from the CP4 strain of *Agrobacterium* originally isolated from the grounds of its Louisiana glyphosate manufacturing plant (Charles 2001, pp. 68-69). *Sphingobium herbicidovorans*, originally researched as a potential candidate for bioremediation of phenoxyalkanoic acid herbicides (Kohler 1999), has been utilized by Dow Chemical Co. to genetically engineer corn, soybean and cotton varieties resistant to phenoxy auxin broadleaf herbicides such as 2,4-D (Wright et al 2010).

In fact, the major focus of pesticide industry R&D efforts is to exploit the herbicide resistance that has evolved in soil bacteria from past use of their products to facilitate many-fold higher rates of application to plants engineered with the resistance-conferring

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[1] Krueger et al (1989) identified the source bacterium as a Pseudomonas species. In 1993, it was reclassified as S. maltophilia. See http://www.uptodate.com/contents/stenotrophomonas-maltophilia.

[2] Which they incorrectly named *Pseudomonas maltophilia*, apparently unaware of the 1993 reclassification to *S. maltophilia* noted in the previous footnote.

microbial genes. Table 1 below shows 10 such herbicide-resistant crops that have either been recently deregulated or are pending deregulation by APHIS (including dicamba-resistant crops), representing crops developed by each of the world's major pesticide companies.

Table 1: GE Herbicide-Resistant Crops Approved or Pending Approval by USDA

Petition No.	Company	Crop	Herbicides	Status
13-262-01p	Dow	Cotton	2,4-D, glufosinate, ***glyphosate***	Pending approval
12-251-01p	Syngenta	Soybeans	HPPD inhibitors, glufosinate, ***glyphosate***	Pending approval
12-185-01p	Monsanto	Cotton	Dicamba, glufosinate, ***glyphosate***	Pending approval
11-234-01p	Dow	Soybean	2,4-D, glufosinate, glyphosate	Approved 2014
10-188-01p	Monsanto	Soybean	Dicamba, ***glyphosate***	Pending approval
09-349-01p	Dow	Soybean	2,4-D, glufosinate, ***glyphosate***	Approved 2014
09-328-01p	Bayer	Soybean	Isoxaflutole, glyphosate	Approved 2013
09-233-01p	Dow	Corn	2,4-D, ACCase inhibitors, ***glyphosate***	Approved 2014
09-015-01p	BASF	Soybean	Imidazolinones	Approved 2014
07-152-01p	DuPont-Pioneer	Corn	Imidazolinones, glyphosate	Approved 2009

Table 1. Partial list of genetically engineered, herbicide-resistant crops recently approved or pending approval by USDA. Source: USDA's Petitions for Determination of Nonregulated Status, http://www.aphis.usda.gov/biotechnology/petitions_table_pending.shtml. Where glyphosate is bolded and italicized, the company has not genetically engineered glyphosate resistance into the GE crop for its review by USDA, but has announced plans to breed a glyphosate resistance trait into commercial cultivars to be sold to farmers.

DuPont-Pioneer scientists have sketched out the industry-wide strategy of engineering multiple herbicide-resistant crops to be utilized in combination with premix formulations of the corresponding herbicides (Green et al 2007). This same paper compiles a list of transgenes that await deployment in herbicide-resistant crops, most derived from microbes, presumably soil microbes (see table below).

Table 1. Non-glyphosate resistant transgenes that are not currently commercial (adapted from Reference 48)

Herbicide/herbicide class	Characteristics	Reference
2,4-D	Microbial degradation enzyme	49
Aryloxyphenoxyoxypropionate ACCase inhibitor	Microbial aryloxyalkanoate dioxygenase	50
Asulam	Microbial dihydropteroate synthase	51
Dalapon	Microbial degradation enzyme	52
Dicamba	*Pseudomonas maltophilia*, O-demethylase	45
Hydroxyphenylpyruvate dioxidase (HPPD) inhibitors	Overexpression, alternate pathway, and increasing flux of pathway	53
Phenylurea	*Helianthus tuberosus*, P450	54
Paraquat	Chloroplast superoxide dismutase	55
Phenmedipham	Microbial degradation enzyme	56
Phenoxy acid (auxin)	Microbial, aryloxyalkanoate dioxygenase	50
Phytoene desaturase (PDS) inhibitors	Resistant microbial and Hydrilla PDS	57
Protoporphyrinogen oxidase (PPO) inhibitors	Resistant microbial and *Arabidopsis thaliana* PPO	58

From: Green et al (2007).

In short, government and university-funded research originally undertaken to ameliorate pesticide pollution has been "repurposed" by industry to greatly increase it. The pesticide industry is guiding American agriculture into an era of much increased use of and dependence on pesticides, contrary to widespread misconceptions on this point.

The impact of dicamba-resistant crops on herbicide use

Summary of herbicide use

Monsanto's MON 87708 soybean and MON 88701 cotton are genetically engineered to withstand direct application of high rates of dicamba without risk of crop injury. At present, dicamba is little used in American agriculture, and is applied to just 1% of soybean and 8-10% of cotton acres. The two major constraints on wider use are dicamba's toxicity to soybeans and cotton, which restricts its use to early in the season, and its propensity to drift and hence cause injury to other crops. By alleviating crop injury concerns, deregulation of these varieties would lead to a huge increase in dicamba use in American agriculture. CFS estimates an over 100-fold increase on soybeans, a 19-fold increase on cotton, and a 3-fold increase on corn. Overall dicamba use in agriculture would increase more than 11-fold, from 3.8 to 43.2 million lbs. per year. Because glyphosate would continue to be used at current rates, no change is expected. Glufosinate use on cotton would triple to about 1.5 million lbs/year, as growers take advantage of MON 88701's resistance to this herbicide. Overall herbicide use on soybeans is projected to increase, conservatively, by 20 million lbs./year, or 14%.

Dicamba a little used herbicide

Dicamba is used very little in American agriculture. According to proprietary pesticide use data reported by Monsanto, just 3.8 million lbs. were applied to 25.3 million acres in 2011 (DEIS, Table 8-1, p. 8-6). For perspective, this represents just 0.9% of total agricultural herbicide use of 442 million lbs. in 2007 (EPA Pesticide Use 2011, Table 3.4), and 6.5% of total cropland area of 390 million acres in 2012 (USDA Census 2012).

Registered uses of dicamba include asparagus, barley, corn, cotton, fallow cropland, hay, oats, proso millet, pasture, rangeland, sorghum, soybean, sugarcane and wheat (BASF 2010). The top five uses, by both pounds applied and acres treated, are corn, fallow, pastureland, wheat and cotton (DEIS, Table 8-1, 8-6).

Current dicamba use in soybeans

Soybeans are extremely sensitive to dicamba, and the risk of crop injury has greatly limited its use. When used in soybean production, dicamba must be applied before planting (pre-plant), at rates of 0.125 to 0.5 lb. acre (BASF 2010). Because dicamba is moderately persistent, it must be applied long enough before crop emergence (i.e. when seedlings sprout) to allow sufficient time for it to degrade to levels that will not injure the emerging soybean seedling: at least 28 days with 0.5 lb./acre and 14 days for 0.25 lb/acre or less. At least 1" of rainfall before planting is also needed to facilitate degradation. The need for waiting intervals and rainfall to avoid crop injury likely explains why so little dicamba has been used in soybean production (see DEIS, Figure 8-1, 8-5).

Soybean growers have used somewhat more dicamba since 2008 (DEIS, Figure 8-1, 8-5), but as late as 2011 and 2012 it was applied to just 0.6 to 1.4% of U.S. soybean acres (USDA NASS AgChem 2013; DEIS, Table 8-1, 8-6; Monsanto Weed 2014, Table 4).[3] This increase is likely a response to glyphosate-resistant weeds, though the constraints described above appear to have made other alternatives to glyphosate more attractive to most growers.

Dicamba use with deregulation of MON 87708

Monsanto projects that 20.5 million lbs. of dicamba would be applied to MON 87708 at an estimated peak adoption rate of 40% of U.S. soybean acreage (DEIS, Table 4-9, 4-17), or 88 times more than was used in 2011, given dicamba's sparing use at present (DEIS, 147). However, even this is likely a substantial underestimate, for two basic reasons. Monsanto underestimates the number of soybean acres infested with glyphosate- and multiple herbicide-resistant weeds that would be treated with dicamba two or three times per season, and makes no allowance for rising dicamba rates in response to the emergence of dicamba-tolerant and –resistant weeds.

Monsanto assumes that MON 87708 growers will make 1, 2 or 3 applications of dicamba per season depending on whether they employ conventional tillage or no-till production methods, and whether their fields are infested with glyphosate- or multiple herbicide-resistant weeds of the *Amaranthus* genus (see top panel of Table 2). Growers with resistant weeds make an additional dicamba application: two rather than one in conventionally tilled fields, and three rather than two in no-till fields.

Monsanto's projection assumes that only growers with resistant weeds of the *Amaranthus* genus would make the additional dicamba application, and that only 5 million acres of MON 87708 soybeans would be infested with resistant *Amaranthus* weeds. Neither assumption is legitimate. First, as discussed further below, several GR and multiple HR non-*Amaranthus* weeds are prevalent and would likely be troublesome enough to trigger an additional dicamba application. Second, resistant *Amaranthus* weeds alone are much more prevalent than Monsanto assumes. CFS has adjusted Monsanto's dicamba projection to account only for the latter factor. Scenario 1 is based on 15 million acres and Scenario 2 on 20 million MON 87708 acres infested with resistant *Amaranthus* weeds (see bottom two panels of Table 2). Scenario 1 yields dicamba use of 26.7 million lbs., while 29.8 million lbs. of dicamba are used in Scenario 2.

There are three *Amaranthus* genus weeds (Palmer amaranth, waterhemp, and spiny amaranth) that have evolved glyphosate resistance, sometimes in combination with resistance to other herbicides such as ALS inhibitors, triazines and PPO inhibitors. The International Survey of Herbicide-Resistant Weeds (ISHRW) shows 136 glyphosate-resistant weed biotypes; 50 of them, or 37%, are *Amarathanus* biotypes (30 Palmer amaranth, 19 waterhemp and 1 spiny amaranth) (ISHRW GR Weeds 10-9-14). Until 2012,

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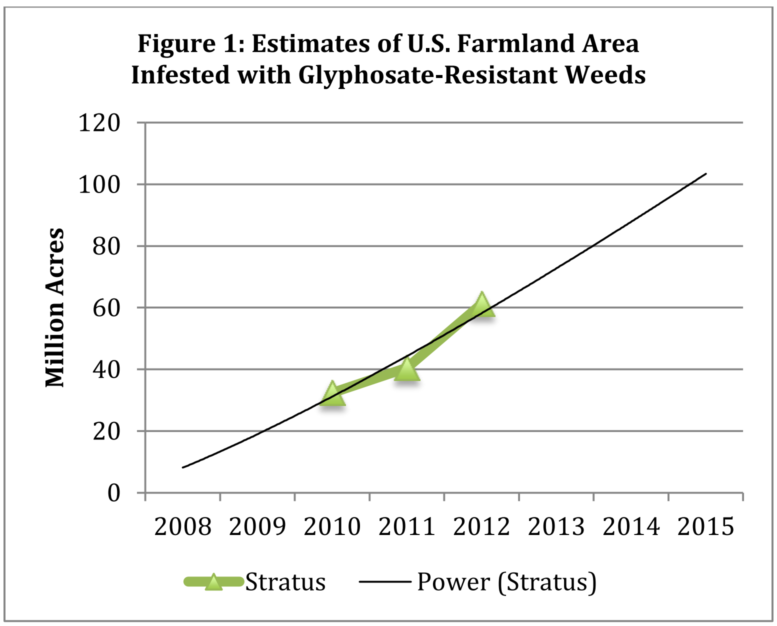
[3] Calculations based on USDA NASS agricultural chemical use data show roughly 470,000 soybean acres treated in 2012, or 0.6% of national soybean acreage. Proprietary data from BASF indicate 1.06 million dicamba-treated soybean acres in 2012 (Monsanto Weed 2014, Table 4, p. 15), or 1.4% of national soybean acreage. Monsanto reports 1.2% of soybean acres treated with dicamba in 2011 (DEIS, Table 8-1, 8-6).

ISHRW provided estimates of acreage infested for most herbicide-resistant weed biotypes, including glyphosate-resistant (GR) weeds. As of 2012, GR *Amaranthus* weeds infested 8.2 of the 18.7 million acres reported to be infested with GR weeds overall, or 44% (CFS GR Weed List 9/20/12). It is now widely acknowledged that ISHRW, a passive reporting system, vastly underestimated the true extent of GR weeds. Many GR weeds were never reported to ISHRW; reports once submitted were often not updated as populations expanded. APHIS notes that 61 million acres were infested with glyphosate-resistant weeds in 2012 (DEIS, 124, 179), over three times the acreage reported to ISHRW by that year. APHIS's source for this estimate also reported GR weed-infested acreage in 2010 and 2011, revealing a sharply increasing trend (Stratus 2013, see Figure 1) that suggests (conservatively) 80 million GR weed infested acres by 2014.



Source: Stratus 2013

Based on these data showing that GR *Amaranthus* weeds comprise roughly 40% of overall GR weeds, a total of 60-80 million acres infested with GR weeds, and the likelihood that all or nearly all farmers who choose to grow MON 87708 would be those with GR weed-infested fields, it appears evident that 5 million acres is far too small an estimate of MON 87708 growers with GR *Amaranthus*-infested fields. Monsanto does not appear to provide any explanation or documentation for its estimate of 5 million acres.[4] Scenario 1 is based on the assumption that GR *Amaranthus* weeds in soybeans comprise just one-fifth of total GR weed acreage; while Scenario 2 assumes they make up about one-fourth of total GR weed acreage, both reasonable assumptions. We conclude that dicamba use with introduction of MON 87708 would rise, conservatively, to 25-30 million lbs./year at the peak adoption rate of 40% posited by Monsanto. This estimate is conservative in that it does not account for increased dicamba application frequency and rates in response to

[4] See DEIS, Table 4-9, 4-17, where the 5 million acre figure appears without explanation or documentation. We find no discussion by Monsanto anywhere in the DEIS or its supporting documents of GR weed infested acreage, which is absolutely critical

other problematic resistant weeds, such as GR horseweed, kochia, and giant ragweed, or those resistant to other herbicides. It is also conservative in not making allowance for the near-certain emergence of dicamba-tolerant and –resistant weeds, which would likely lead to an increasing number of applications and rising rates, the trend clearly seen with glyphosate applications and rates with emergence of glyphosate-resistant weeds (Benbrook 2009a, NRC 2010).

Table 2: Dicamba Use At Peak Adoption of MON 87708 Soybeans

Dicamba applications per season	Acres MON 87708 (millions)	Percent planted soybean acres	No. of PRE applications	PRE application rate (lb/acre)	No. of POST applications	POST application rate (lb/acre)	Lbs. dicamba (millions)
Monsanto's Projection of Dicamba Use on MON 87708							
1 - tillage	15.5	21%	0		1	0.38	5.89
2 - tillage GR weeds	2.5	3%	0		2	0.5	2.5
2 - no-till	9.5	13%	1	0.5	1	0.38	8.36
3 - no-till GR weeds	2.5	3%	1	0.5	2	0.5	3.75
TOTALS	**30.0**	**40%**					**20.5**
Monsanto's Projection Adjusted for Greater Prevalence of Resistant Amaranthus spp. Weeds - Scenario I							
1 - tillage	10.5	14%	0		1	0.38	3.99
2 - tillage GR weeds	7.5	10%	0		2	0.5	7.5
2 - no-till	4.5	6%	1	0.5	1	0.38	3.96
3 - no-till GR weeds	7.5	10%	1	0.5	2	0.5	11.25
TOTALS	**30.0**	**40%**					**26.7**
Monsanto's Projection Adjusted for Greater Prevalence of Resistant Amaranthus spp. Weeds - Scenario II							
1 - tillage	8.0	11%	0		1	0.38	3.04
2 - tillage GR weeds	10.0	13%	0		2	0.5	10
2 - no-till	2.0	3%	1	0.5	1	0.38	1.76
3 - no-till GR weeds	10.0	13%	1	0.5	2	0.5	15
TOTALS	**30.0**	**40%**					**29.8**

Source: DEIS, Table 4-9, 4-17

Current dicamba use in cotton

As with soybeans, the potential for dicamba to injure cotton has greatly restricted its use to pre-emergence applications, with a waiting interval of sufficient length to permit degradation to levels that do not injure emerging cotton seedlings. Dicamba is used somewhat more in cotton than in soybeans, with generally larger amounts applied beginning in 2007 (DEIS, Figure 8-1, 8-5). USDA NASS AgChem (2011) shows 199,000 lbs. dicamba were applied to 8% of cotton acres in 2010, while Monsanto's figures show 364,000 lbs. applied to 9.6% of cotton in 2011 (DEIS, Table 8-1, 8-6); both estimates of pounds applied roughly match USGS data (DEIS, Figure 8-1, 8-5), which shows a more than two-fold increase from 2010 to 2011. As with soybeans, increasing dicamba use with cotton is generally regarded as a response to epidemic emergence of glyphosate-resistant weeds, which have been particularly damaging in cotton.

Dicamba use with deregulation of MON 88701 cotton

Monsanto projects that 5.225 million lbs. of dicamba would be applied to MON 88701 cotton at its peak adoption of 50% of U.S. cotton acres (DEIS, Table 4-12, 4-26), or 14.3 times the current (2011) usage of 364 million lbs. (DEIS, 147). However, this is likely an underestimate because Monsanto makes unreasonably low projections for dicamba use in the cotton-growing region where glyphosate-resistant weeds are most widespread and damaging, and where one would expect the most intensive dicamba use in response. When the number of applications and application rates are adjusted upward in this region to account for increased use, CFS projects conservatively that 6.763 million lbs. of dicamba would be applied to MON 88701 cotton at peak adoption on 50% of U.S. cotton acres (see Table 3).

Monsanto projects dicamba use in three cotton-growing regions (see Table 3):

1) Delta, Southeast and East Texas: Alabama, Arkansas, Florida, Georgia, Louisiana, Mississippi, Missouri, North Carolina, South Carolina, Tennessee, eastern Texas and Virginia;
2) California; and
3) Arizona, Kansas, New Mexico, Oklahoma and western Texas

The majority of cotton in the Delta and Southeast is infested with GR weeds, particularly the most problematic one, Palmer amaranth. Monsanto projected an additional application of dicamba for soybean acres infested with resistant *Amaranthus*, but fails to make the corresponding projection for infested cotton acres. In fact, Monsanto assumes that MON 88701 cotton growers in the Delta/Southeast region, where the country's most extensive and damaging outbreaks of glyphosate-resistant weeds have occurred on millions of acres (see Resistant Weed section below), would make the same sparing use of dicamba as MON 88701 cotton growers in California, where only one glyphosate-resistant weed biotype has been detected in cotton, GR junglerice[5] (DEIS, Table 4-10, 4-23).

This assumption is unwarranted, particularly given the fact that GR Palmer amaranth is not well-controlled by a single dicamba application (Merchant et al 2013). Thus, CFS has adjusted Monsanto's projection by adding one additional dicamba application for this region: 2 rather than 1 for conventionally tilled acres, and 3 rather than 2 for no-till acreage, in line with Monsanto's projection for dicamba use on MON 87708 soybeans. We have also adjusted the preplant rate upward, from 0.375 to 0.5 lb/acre, also in line with Monsanto's soybean projections (second panel of Table 3, adjustments in boldface, compare to Table 2). Monsanto justifies its unreasonably low dicamba application frequency by assuming growers will make extensive use of residual herbicides as well as glufosinate to complement dicamba (DEIS, Table 4-10, 4-23). Extensive residual use is highly unlikely. As discussed further in the Resistant Weed section below, history shows clearly that

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[5] See http://www.weedscience.com/Details/Case.aspx?ResistID=5545, last visited 9/22/14.

herbicide-resistant crop growers rely on the associated herbicide(s) until the emergence of resistant weeds force use of additional herbicides. Because MON 88701 is glufosinate-resistant, glufosinate use is more plausible, but Monsanto fails to project additional glufosinate use (DEIS, 4-21).

Table 3: Dicamba Use at Peak Adoption of MON 88701 Cotton

Cotton Growing Region	Dicamba appl's per season	Acres MON 88701 (millions)	Percent planted cotton acres	No. of PRE appl's	PRE appl. rate (lb/acre)	No. of POST applications	POST application rate (lb/acre)	Lbs. dicamba (millions)
Monsanto's Projection of Dicamba Use on MON 88701								
SE, Delta, E. Texas	1 - tillage	2.310	18.3%	0		1	0.5	1.155
	2 - no-till	0.614	4.9%	1	0.375	1	0.5	0.537
	SUBTOTAL	2.924	23.1%					1.692
CA	1 - tillage	0.214	1.7%	0		1	0.5	0.107
	2 - no-till	0.057	0.5%	1	0.375	1	0.5	0.050
	SUBTOTAL	0.271	2.1%					0.157
W. TX, AZ, OK, NM, KS	2 - tillage	2.472	19.5%	0		2	0.5	2.472
	3 - no-till	0.657	5.2%	1	0.375	2	0.5	0.903
	SUBTOTAL	3.129	24.7%					3.375
US TOTALS		**6.324**	**50.0%**					**5.225**
Monsanto's Projection Adjusted for Greater Dicamba Use in SE, Delta, E. TX								
SE, Delta, E. Texas	2 - tillage	2.310	18.3%	0		**2**	0.5	**2.310**
	3 - no-till	0.614	4.9%	1	**0.5**	**2**	0.5	**0.921**
	SUBTOTAL	2.924	23.1%					**3.231**
CA	1 - tillage	0.214	1.7%	0		1	0.5	0.107
	2 - no-till	0.057	0.5%	1	0.375	1	0.5	0.050
	SUBTOTAL	0.271	2.1%					0.157
W. TX, AZ, OK, NM, KS	2 - tillage	2.472	19.5%	0		2	0.5	2.472
	3 - no-till	0.657	5.2%	1	0.375	2	0.5	0.903
	SUBTOTAL	3.129	24.7%					3.375
US TOTALS		**6.324**	**50.0%**					**6.763**

Source: DEIS, Table 4-12, 4-26

Dicamba use on corn

Neither APHIS nor Monsanto considered the impact that dicamba-resistant soybeans and cotton would have on increasing dicamba use in corn. Dicamba is both an effective and inexpensive[6] broadleaf herbicide, and was once a major corn herbicide. (Like other cereal or monocot crops, corn has considerable tolerance to dicamba.) However, its use has declined sharply since the mid-1990s (DEIS, Figure 8-1, 8-5), replaced by newer broadleaf herbicides (Monsanto 2010, 197). One important reason for dicamba's declining use is its propensity to drift and volatilize, causing injury to neighboring crops dicot crops like soybeans, cotton, vegetables and fruits that are extremely sensitive to it (Doohan and Mohseni-Moghadam 2014; AAPCO 1999, 2005). As newer, less drift-prone herbicides became available, corn farmers abandoned dicamba to avoid causing injury to their own and their neighbors' dicamba-sensitive crops.

Widespread adoption of dicamba-resistant soybeans and cotton would erode corn growers' reservations about using dicamba, and lead to a resurgence of dicamba use on corn. Steve Smith, the Director of Agriculture at Red Gold, an Indiana-based tomato processor which sources tomatoes from family farmers in Indiana, Ohio and Michigan, explains the situation well:

> Dicamba has proven itself to move off-target and cause injury and yield reductions to soybeans and so in a large sense, it is rarely used. Farmers respect their neighbors and know they are at risk of causing injury if they use dicamba, so it is not widely and routinely used in corn production. However, when soybeans become tolerant to dicamba, it is very likely that the amount of dicamba used in corn production will skyrocket when the fear of soybean injury is eliminated. As an example, when glyphosate soybeans were first introduced, there was significant injury due to drift on corn the first few years. It didn't take long for applicators and farmers to gain a higher degree of respect for the injury that could occur. But once the widespread use of glyphosate resistant corn became common, that level of caution began to erode because it didn't really matter if you drifted onto your neighbor, because their crop was also glyphosate resistant. I also predict a similar fate for dicamba use once soybeans are made tolerant. With no fear of soybean injury, the use of dicamba on corn acreage will dramatically increase, raising the overall exposure of sensitive crops to injury. Because dicamba is deadly to weeds and cheap to use, it is a sure prediction that dicamba use will increase dramatically, followed by escalating crop losses."
> (Smith 2010)

Another important factor to consider is that most soybean farmers also grow corn. Those who become accustomed to using dicamba on MON 87708 soybeans may well decide to apply it to their corn acres as well, especially since they would no longer have to fear drift injury to their own soybeans. The same would hold true of MON 88701 cotton farmers who also grow corn. With 40% and 50% adoption of dicamba-resistant soybeans and cotton, respectively, the potential for rising dicamba use on corn is quite high. While this is difficult to project, historical use patterns provide some guidance.

[6] Based on price data for Banvel and Clarity in U. of Tenn (2011). However, to our knowledge Monsanto has not released pricing information on its Roundup Xtend premix formulation of dicamba+glyphosate, which will likely be considerably more expensive than existing dicamba formulations.

Dicamba was applied to 21% to 29% of corn acres from 1993 to 1997 (USDA NASS AgChem 1993-1997), and 7% to 10% of U.S. corn acres in 2010 and 2011 (USDA NASS AgChem 2011; DEIS, Table 8-1, 8-6; DEIS, Figure 8-1, 8-5). If one conservatively assumes a tripling of the current proportion of corn treated with dicamba to 1990s levels, then dicamba use on corn would rise from 1.531 million lbs. to 4.593 million lbs. per year.

Dicamba-resistant soybeans and cotton might similarly promote increased dicamba use on wheat, sorghum, fallow land, pastureland by alleviating drift-related crop injury concerns, but there is not sufficient information to project such potential increases.

Overall increase in dicamba use

Table 4 provides an estimate of the overall increase in dicamba use in U.S. agriculture, based on the projections made above and existing uses. According to Monsanto's figures, 3.837 million lbs. of dicamba were used in U.S. agriculture in 2011 (DEIS, Table 8-1, 8-6). Dicamba use would rise to 29.8 million lbs. on MON 87708 soybeans (128-fold rise, Scenario II), to 6.753 million lbs. on MON 88701 cotton (18.6-fold increase), and to 4.593 million lbs. in corn (3-fold more). Overall agricultural dicamba use would rise more than 11-fold, to 43.2 million lbs. For perspective, this would launch dicamba from a decidedly minor herbicide to America's third most heavily used weed-killer, behind only glyphosate and atrazine.[7]

Table 4: Projected Increase in Dicamba Use

Crop	**Current Use** (2011, mill. lbs)	**Projected Use** (peak adoption, mill. lbs)	**Increase** (X-fold over current)
Soybeans	0.233	29.8	128
Cotton	0.364	6.763	18.6
Corn	1.531	4.593	3.0
Other uses	1.710	2.032	
TOTAL	3.838	43.188	11.3

Notes: Current use based on DEIS, Table 8-1, 8-6. Projected use for soybeans and cotton refer only to MON 87708 and MON 88701 based on CFS projections above (Scenario II for soybeans). The "other uses" figure under Projected Use includes continued use of dicamba at present levels on the 60% of soybeans and 50% of cotton that are projected to remain non-dicamba-resistant.

Glufosinate use

APHIS follows Monsanto in claiming that "glufosinate use may decline" under the Preferred Alternative, "based on comparative efficacy data and the observation that dicamba is considered a more effective option for GR weed control compared to glufosinate" (DEIS at 147). Unfortunately, APHIS provides no independent assessment of Monsanto's claim. There are several reasons to expect a considerable increase in glufosinate use with approval of dicamba-resistant soybeans and cotton. First, Monsanto has in fact genetically

[7] Or perhaps fourth, as the use of 2,4-D skyrockets to about 100 million lbs/year or more with the anticipated introduction next year of Dow AgroSciences Enlist, 2,4-D-resistant corn and soybeans.

engineered MON 88701 cotton to be glufosinate-resistant, which would make little sense if it did not expect farmers to use the herbicide. Second, Monsanto does in fact plan to recommend glufosinate use with MON 88701 cotton. Third, weed scientists find that dicamba alone is often inefficacious on problematic weeds, and recommend that dicamba be used in combination with glufosinate.

Monsanto recommends that cotton growers in the 12 states of the Delta and Southeast, and those in California, use glufosinate for control of glyphosate-resistant weeds (DEIS, Table 4-10, 4-23). These 13 states – Alabama, Arkansas, California, Florida, Georgia, Louisiana, Mississippi, Missouri, North Carolina, South Carolina, Tennessee, eastern Texas and Virginia – represent over one-half of U.S. cotton acreage (DEIS, Table 4-12, 4-26). These are also among the states (excepting California) where glyphosate-resistant weeds have been most widespread and damaging; for instance, 92% of Georgia farmers reported that they had glyphosate-resistant weeds (DEIS, 182; Stratus 2013). APHIS states that: "All acres in this region where glyphosate-resistant weeds are present, regardless of tillage, are expected to receive a single in-crop application of glufosinate at 0.53 lbs a.i. per acre" (DEIS, 4-22). Several million acres of cotton in the south are infested with glyphosate-resistant weeds, hence the increase in glufosinate use could be quite substantial if growers follow Monsanto's recommendations. In 2010, USDA figures show that just 7% of U.S. cotton acres were treated with 394,000 lbs. of glufosinate (USDA NASS AgChem 2011). If just 2 million acres of MON 88701 cotton are treated with glufosinate at the recommended rate, then glufosinate use would rise by over 1 million lbs. Finally, southern weed scientists have found that dicamba alone does not provide good control of GR Palmer amaranth, cotton farmers' worst weed, but that combining it with glufosinate improves control considerably (Merchant et al 2013). APHIS likewise (and inconsistently) acknowledges that: "When combined, dicamba and glufosinate provide control of HR weeds that include GR [glyphosate-resistant] biotypes of Palmer amaranth (*Amaranthus palmeri*), marestail (*Conyza canadensis*), common ragweed (*Ambrosia artemisiifolia*), giant ragweed (*Ambrosia trifida*) and waterhemp (*Amaranthus tuberculatus*)" (DEIS, 5). These facts point clearly to considerably ***increased*** use of glufosinate on MON 88701, not a reduction as APHIS speculates. APHIS declined to analyze this issue, preferring to speculate ("***may*** decline") (DEIS, 4-21).

Overall herbicide use

Glyphosate use is likely to continue unchanged at current historically high levels given that:

1) Both MON 87708 soybeans and MON 88701 cotton will come stacked with glyphosate resistance;
2) Glyphosate controls grass and some other non-glyphosate-resistant weeds better than dicamba, and will continue to be used to control those weeds;
3) Monsanto will market a premix formulation of dicamba + glyphosate (Roundup Xtend) that will likely be used by many growers of these crops; and
4) Glyphosate is often recommended for use in combination or sequence with dicamba for both crops.

APHIS states several times that approval of MON 88078 soybeans and MON 88701 cotton is not expected to increase glyphosate use (DEIS, 147), and nowhere indicates that these crops would lead to any reduction, consistent with the points made above. Thus, additional use of dicamba with MON 87708 could only displace non-glyphosate herbicides (DEIS, 146). However, there is relatively little non-glyphosate herbicide to displace. Gold standard USDA pesticide usage data shows that in 2012, glyphosate comprised an astounding 82% of herbicide active ingredient (by weight) applied to U.S. soybeans in that year (USDA NASS AgChem 2013). Even if one assumes that MON 87708 growers rely entirely on dicamba and glyphosate (i.e. completely eliminate other herbicides currently used on soybeans), there would still be a considerable 14% increase in overall soybean herbicide use over 2012 usage with the projected 40% adoption of MON 87708 soybeans: from 138.5 to 158.5 million lbs (Table 5). Because a minority of MON 87708 soybean growers would likely make some limited use of herbicides other than glyphosate and dicamba, as also assumed by APHIS (DEIS, 146), this is a very conservative estimate, and the overall increase in herbicide use on soybeans would be greater than 14%. Overall herbicide use on cotton would similarly increase with deregulation of MON 87701 cotton.

Hence, APHIS's various guesstimates that overall herbicide use would decline under the Preferred Alternative (e.g. DEIS 19-20) or, alternately, remain the same (DEIS, 22) are entirely unfounded.

Table 5: Herbicide Use on Soybeans With and Without MON 87708

	Herbicide Use in 2012 (lbs)	Herbicide Use at Peak Adoption of MON 87708 (lbs/year)		
		MON 88078 (40%)	Other Soybeans (60%)	Total
Glyphosate	113,891,667	45,556,667	68,335,000	113,891,667
Non-Glyphosate	24,628,125	0	14,776,875	14,776,875
Dicamba		29,800,000		29,800,000
Total Herbicide Use	**138,519,792**	75,356,667	83,111,875	**158,468,542**

Sources: USDA NASS AgChem (2013) for 2012 soybean use, which provides herbicide use data for soybeans in the Program States, which represented 96% of national soybean acreage; figures divided by 0.96 for national use. Glyphosate use at peak adoption of MON 87708 assumed to remain at 2012 levels (40% on MON 87708, 60% on other soybeans); "Non-Glyphosate" use for 2012 and for "Other Soybeans" includes dicamba; "Non-Glyphosate" use for "Other Soybeans" = 60% of 2012 "Non-Glyphosate" use. Dicamba use for MON 87708 from Scenario II projection in Table 2 above.

The impact of dicamba-resistant crops on weed resistance

CFS has provided EPA with extensive discussion of the herbicide-resistant weed threats posed by herbicide-resistant crop systems in general, and by MON 87708 soybean and MON 88701 cotton in particular, in Appendices A and B. We have also provided APHIS with comments on the petitions for nonregulated status for these crops (Appendix C), and with scoping comments outlining issues to consider in drafting the EIS (Appendix D). We will not repeat those discussions here, but rather summarize key issues, introduce new material and respond to APHIS's assessment in the draft EIS.

The discussion of herbicide use in the preceding section focused mainly on assessing the magnitude of increased dicamba and overall herbicide use to be expected if APHIS chooses to deregulate MON 87708 and MON 88701 under the Preferred Alternative. However, the likelihood and rapidity of resistant weed evolution is not a simple function of how much of an herbicide is used. It also involves the frequency, exclusivity, timing and extent of use. Each of these factors contributes to the "selection pressure" by which initially rare, mutant weeds with the genetic capacity to survive exposure to an herbicide become more numerous, and over a few short years come to dominate the local weed population. In brief, a weed population is more likely to evolve resistance to an herbicide if that herbicide is used several times per season rather than once, and/or consistently on the same fields over years without break; as the sole or primary weed management technique to the exclusion of other tactics; later in the season to larger weeds rather than earlier to smaller ones; and on large expanses of cropland rather than to limited areas. Herbicide-resistant crops foster just such resistance-promoting herbicide use, as clearly demonstrated by experience with Roundup Ready crops and glyphosate-resistant weeds (for documented discussion, see Appendix B, 17-23).

Factors promoting dicamba-resistant weeds with MON 87708 and MON 88701

APHIS concedes that the Preferred Alternative would lead to increased selection pressure for dicamba-resistant weeds (DEIS, 173). Below we discuss how the four resistance-promoting factors outlined above apply to dicamba-resistant crops and weeds.

<u>Increasing extent of dicamba use</u>

Dicamba would be applied to far more acres of cropland than ever before under the Preferred Alternative. Monsanto estimates that at its peak usage in 1994, 36.3 million acres were treated with dicamba (Monsanto 2010, Table VIII-11, p. 198), falling to 25.3 million acres by 2011 (DEIS, Table 8-1, p. 8-6). Under the Preferred Alternative, usage would expand by roughly 36 million acres (Tables 6 and 7) on soybeans and cotton; and by 12 million acres on corn, from the current 11 million acres (DEIS, Table 8-1, p. 8-6) to roughly 23 million acres (assuming 25% of corn is treated with dicamba, as discussed above). Thus, one can anticipate a total of roughly 48 million dicamba-treated acres, nearly double the 2011 area and well above peak historical usage in 1994. This means that correspondingly more individual weeds and thus resistant mutants would be exposed to this herbicide, increasing the probability that dicamba-resistant weed populations would be selected.

Increasing frequency of dicamba use

It is clear that dicamba would be used quite frequently on substantial acreage planted to MON 87708 soybeans and MON 88701 cotton, dramatically increasing selection pressure for resistant weeds. Table 6 shows the projected frequency of dicamba use on dicamba-resistant soybeans based on Monsanto's and CFS's two scenarios, as discussed above (see Table 2 and associated discussion). Table 7 shows the corresponding projections for MON 88701 cotton.

Dicamba has historically been applied just once per season in corn, soybean and cotton production (DEIS, p. 187[8]). In contrast, dicamba would be applied twice or three times per season to 14.5 to 22.0 million acres of soybeans,[9] representing from 19% to 29% of national soybean acreage. From 3.8 to 6.2 million acres of cotton would likewise receive multiple applications of dicamba, representing 30% to over 48% of U.S. cotton acreage.[10] ***Overall, 16 million combined soybean/cotton acres would receive 2 applications and roughly 10 million acres 3 applications of dicamba per season.***

For perspective, consider that glyphosate-resistant weeds have evolved to infest over 60 million acres of cropland as average seasonal glyphosate application frequencies rose from just 1.1 to 1.7 (soybeans, 1996 to 2006) and 1.0 to 2.4 (cotton, 1996 to 2007) over the period of Roundup Ready crop adoption for each crop (USDA NASS 1997, 2007, 2008). In contrast, ***a substantial portion of dicamba-resistant crop area will be treated twice to three times per season with dicamba from the very start***. There can be little doubt whatsoever that such intensive selection pressure over such a broad area would rapidly select for substantial populations of dicamba-resistant weeds.

Table 6: Dicamba Applications Per Season With MON 87708 Soybeans

No. of Applications	Monsanto Projection		CFS Scenario I		CFS Scenario II	
	Acres (mill.)	% Soy Acres	Acres (mill.)	% Soy Acres	Acres (mill.)	% Soy Acres
1	15.5	21%	10.5	14%	8.0	11%
2	12.0	16%	12.0	16%	12.0	16%
3	2.5	3%	7.5	10%	10.0	13%
TOTALS	30.0	40%	30.0	40%	30.0	40%

Source: See Table 2.

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[8] APHIS commits several errors on p. 187 of the DEIS in reporting these data, based on misreading of a table in Monsanto's petition that cites USDA NASS pesticide usage data. The sentence should read: "The frequency of annual use of dicamba was 1.00 for ~~corn~~ soybean (2006) 1.00 for cotton (~~2008~~ 2007) and 1.02 for corn (~~2006~~ 2005)."

[9] APHIS incorrectly assumes that MON 87708 soybeans would receive only 1 or 2 dicamba applications (DEIS, 146, 147), missing Monsanto's projection of 3 applications to no-till MON 87708 soybean acres infested with resistant Amaranthus weeds, perhaps due to Monsanto's confusing presentation (DEIS, Table 4-9, 4-17).

[10] APHIS states that half of MON 88701 cotton would receive two dicamba applications and the other half 3 dicamba treatments (DEIS, 146), a greater proportion of cotton receiving three applications of dicamba than CFS calculated based on DEIS, Table 4-12, 4-26. CFS was unable to find the source APHIS listed for Table 4-12 (ER Table A-41 (Monsanto 2013)) to explore this discrepancy further. If APHIS is correct, the selection pressure for dicamba-resistant weeds with MON 88701 would be still greater than we have projected.

Table 7: Dicamba Applications Per Season With MON 88701

Monsanto Projection			Monsanto Projection Adjusted		
No. App's per Season	MON 88701 Acres (mill.)	% National Cotton Acres	No. App's per Season	MON 88701 Acres (mill.)	% National Cotton Acres
1	2.524	20.0%	1	0.214	1.7%
2	**3.143**	**24.8%**	**2**	**4.839**	**38.3%**
3	**0.657**	**5.2%**	**3**	**1.271**	**10.0%**
TOTALS	6.324	50.0%		6.324	50.0%

Source: See Table 3.

Of course, it is possible that Xtend crops would be adopted on more acres and dicamba used more frequently than projected by Monsanto, which would lead to still greater emergence of dicamba-resistant weeds.

Near total reliance on dicamba and glyphosate

This outcome becomes still more assured when one considers other aspects of the proposed herbicide regimes. With respect to MON 87708 soybeans, APHIS states that: "…significant PRE non-glyphosate applications will likely be eliminated, as may more than half of POST non-glyphosate applications" (DEIS, 146), with similar reductions in non-glyphosate herbicide applications anticipated for MON 88701 cotton (DEIS, 147). What this means is that dicamba will replace most non-glyphosate herbicides (particularly in dicamba-resistant soybeans, somewhat less so with dicamba-resistant cotton). Hence, most acres of dicamba-resistant soybeans and cotton will treated only with dicamba and glyphosate, with perhaps minimal use of other herbicides on some of those acres. Because most growers of dicamba-resistant crops will be those who have glyphosate-resistant weeds, and those resistant weeds will be immune to glyphosate, they will be exposed to only one effective mode of action. For the glyphosate-resistant weed, it is as if only a single herbicide is being used, the perfect recipe for resistance. These GR weeds will then be under intense selection pressure to evolve additional resistance to dicamba, particularly since dicamba will often be applied twice or three times per season. As APHIS concedes, under this scenario "resistance might be selected quickly" (DEIS, p. 181). As noted above, Monsanto intends to market a dicamba-only formulation with MON 87708 (XtendiMax) as well as a dicamba+glyphosate premix (Roundup Xtend). Thus, some portion of dicamba-resistant soybean and cotton acres may be treated with dicamba alone, which could also give rise to dicamba resistance in weeds that are not already immune to glyphosate.

That one can expect near total reliance on dicamba and glyphosate is also suggested by experience with the only other major GE HR crop system other than the Roundup Ready system. LibertyLink crops (cotton, soybeans, corn and canola) are engineered for resistance to glufosinate herbicides. Tennessee weed scientist Larry Steckel recently reported that in his state, a survey showed that "60 percent of our Liberty Link soybeans got nothing but Liberty on them," while Arkansas weed scientist Jason Norsworthy reported a similar trend in his state: "Folks, we're going to run Liberty [glufosinate] into the ground if that's the case. We've got to use other modes of action if we're going to protect it and keep it around for any length of time" (Bennett 2014). The implications are clear. Dicamba-resistant crop systems would similarly "run dicamba into the ground" by generating dicamba-resistant weeds under the Preferred Alternative.

Timing of dicamba applications

Dicamba-resistant crops facilitate post-emergence applications of dicamba to the growing crop, and most dicamba applications are projected to be made post-emergence (POST) rather than pre-emergence or pre-plant (see Tables 2 and 3 above). Roundup Ready crop farmers have shown a strong predilection for POST use of glyphosate, and it is highly likely that those who adopt Monsanto's new crops will also make primarily POST applications of dicamba or dicamba+glyphosate, probably to an even greater extent than indicated in the recommended herbicide regimes portrayed in Tables 2 and 3. POST applications of glyphosate to Roundup Ready crops carry a much higher risk of fostering glyphosate-resistant weed evolution than pre-emergence applications to conventional crops (Neve 2008), as evidenced by the virtual absence of glyphosate-resistant weeds prior to Roundup Ready crops, and the epidemic that has emerged since their widespread adoption. Preferential post-emergence use of dicamba to MON 87708 soybeans and 88701 cotton will likewise be still another factor fostering rapid evolution of dicamba-resistant weeds.

Additional factors promoting weed resistance

The marketing and pricing of herbicide-resistant (HR) crop seed and associated herbicides can also strongly promote resistant weed evolution. A consistent feature of every major GE HR crop to date is that they are marketed as crop systems: for instance, the Roundup Ready crop system, and the Enlist Weed Control System (Dow's 2,4-D-resistant crops). System is defined as "a set or arrangement of things so related or connected as to form a unity or organic whole," and clearly signals to prospective buyers that the HR seed-herbicide package offers a complete weed control solution, which fosters exclusive use of the herbicide(s) to which the crop is resistant.

Monsanto is now pre-marketing the "Roundup Ready® Xtend Crop System," which consists of "Roundup Ready 2 Xtend™" soybean seed or "Bollgard II® XtendFlex™" cotton seed and a "Roundup Xtend™" premix of dicamba and glyphosate or an "XtendiMax™" dicamba formulation (Monsanto Xtend 2014). The branding of seed and herbicide with the same name – Xtend – reinforces the notion that they offer a complete and self-sufficient weed control system.

The price premium – technology fee – for the HR crop trait constitutes a strong financial incentive to the grower to fully exploit the resistance trait through reliance on the associated herbicide(s) (Orloff et al 2009); and a disincentive to pay still more for any additional (non-system) herbicides (e.g. residuals) that might be recommended. Weed scientists have seldom appreciated the importance of this financial incentive, perhaps because they are not farmers themselves and so do not face the daunting prospect of laying out many thousands of dollars on seeds, pesticides (including herbicides) and other inputs each year, perhaps on credit, in hopes of good weather and a thriving crop in the risky business of farming. These same scientists regularly blame farmers for weed resistance, calling it a "behavioral problem" (e.g. David Shaw, as quoted in Hopkinson 2014), while only rarely daring to challenge the marketers of these HR crop systems to change their practices.

Response to Monsanto's arguments that dicamba-resistant weeds are unlikely

Monsanto presents several specious arguments to the effect that dicamba-resistant weeds will be unlikely to develop with dicamba-resistant crops, or be small and unproblematic to the extent that they do emerge. CFS responded fully to these arguments in comments to EPA (for documented discussion, see Appendix B, pp. 23-25). Monsanto presents additional arguments, equally specious, in its weed resistance supplement. For instance, Monsanto refers to market research data indicating that because dicamba is ***currently*** seldom used alone, but most often in combination with other herbicides, that use of these additional modes of action will forestall evolution of resistance to dicamba (Monsanto Weed 2014, pp. 13, 17). This argument is specious because dicamba use patterns will alter dramatically with MON88708 soybeans and MON88701 cotton. As discussed above, APHIS finds that use of herbicides ***other than*** dicamba and glyphosate that are ***currently*** being used on soybeans and cotton will decline dramatically under the Preferred Alternative. Dicamba will be used almost entirely in combination only with glyphosate (Roundup Xtend), or perhaps in some cases alone (XtendiMax). In either case, dicamba resistance is quite likely to develop, most often in weeds already resistant to glyphosate and other herbicides.

Synthetic auxin-resistant crops and weeds

Dicamba resistance must be considered in the broader context of resistance to synthetic auxin herbicides as a class, for several reasons. First, weeds have evolved cross-resistance to multiple members of this herbicide family, including dicamba and 2,4-D, and the mechanisms of resistance to these two herbicides are likely similar (DEIS, pp. 187, 188). Second, MON 88708 soybeans have low-level resistance to 2,4-D, which further suggests that weeds have the potential for cross-resistance to these two auxin herbicides (DEIS, p. 187). Third, USDA has already approved Dow's 2,4-D resistant corn and soybeans, which will lead to a two- to seven-fold increase in the use of 2,4-D. In addition, Monsanto has obtained a license to deploy Dow's 2,4-D resistance trait in its own corn varieties (Farm Industry News 2013), which will dramatically increase the acres of corn sprayed with 2,4-D, and Dow is seeking approval of 2,4-D-resistant cotton. Finally, in 2010 Monsanto was already in Phase 2 development of corn resistant to both dicamba and glufosinate (Monsanto Pipeline 2010). We note that if Monsanto successfully commercializes this corn, its license from Dow for the 2,4-D resistance trait in corn would allow it to combine dicamba, 2,4-D and glufosinate resistance in its corn varieties.

Thus, both dicamba- and 2,4-D-resistant (collectively, "auxin-resistant") varieties of three major crops will likely become available in the near future. It is quite possible that a large percentage of corn, soybeans and cotton will soon be heavily treated, multiple times per season and every year, with one or more auxin herbicides. Mortensen et al. (2012) project that combined adoption of 2,4-D- and dicamba-resistant soybeans will reach the 90% level by 2024, based on adoption trends for Roundup Ready soybeans and the huge and growing populations of glyphosate-resistant weeds these crops are meant to counter. A similar scenario would likely unfold in cotton. Given the frequent rotation of these three crops on the same fields (especially corn and soybeans), this would dramatically expand the acreage treated with an auxin herbicide every year, and make generation of weeds with resistance to one or both of these herbicides much more likely. While APHIS recognizes the potential for this to occur, its only response is wishful thinking: "…because of the potential for cross-resistance, growers will likely be cautioned not to plant 2,4-D-resistant and dicamba-resistant crops in successive years on the same field" (DEIS, p. 186).

Finally, Monsanto has in the past few years conducted field trials of wheat resistant to dicamba, glufosinate and glyphosate (Monsanto DR wheat 2013) and dicamba-resistant canola (Monsanto DR canola 2012), which if commercially introduced would expand auxin use and selection pressure for auxin-resistant weed populations still more. APHIS does not mention these developments or assess the additional impacts they would have.

APHIS continues to perpetuate the illusion fostered by Dow (Wright et al. 2010) and Monsanto that the number of auxin-resistant weeds is small compared to those resistant to other herbicide groups, and to use this as justification for projecting limited emergence of auxin-resistant weeds under the Preferred Alternative (DEIS, p. 187). APHIS is wrong on both counts. First, the number of auxin-resistant weed species is ***high***, not low, relative to other modes of action. Of the 22 herbicide groups, synthetic auxins rank fourth in terms of the number of resistant weed species, with 31, in the upper quintile (ISHRW HR Weeds by Group 10-9-14, see also DEIS, pp. 183-185). Egan et al. (2011) have made precisely the same point. APHIS suggests that the number is low in light of the long period of use of synthetic auxins (DEIS, p. 187), but other herbicide groups that have also been used for many decades have much lower numbers of weed species resistant to them, for instance microtubule inhibitors (K1 group) such as trifluralin, for which only 12 weed species have evolved resistance (ISHRW HR Weeds by Group 10-9-24). The high number of weed species with auxin resistance provides evidence that auxin resistance mechanisms are relatively common in weed populations. That auxin-resistant weeds do not infest a larger acreage than they do at present is simply a function of low selection pressure, for instance "a relatively low frequency of repeated exposures both historically and in current usage," in fact just one application per year for soybeans, corn and cotton (DEIS, p. 187). As detailed above, this selection pressure will increase dramatically with Xtend crops, with many millions of acres treated two and even three times each season, and many of those acres likely treated with auxins in consecutive years.

APHIS's assessment is filled with internal contradictions. To take just one example, APHIS acknowledges that "[t]he primary purpose of MON 87708 soybean and MON 88701 cotton is to provide growers with an additional in-crop weed management option to mange GR [glyphosate-resistant] broadleaf weeds" (DEIS, p. iii), but then warns that "use of Xtend crops in areas with such glyphosate-resistant weeds is inadvisable" because it would hasten the evolution of weed resistance to dicamba (DEIS, p. 181). APHIS never resolves the contradiction of the "inadvisability" of using Xtend crops for their "primary purpose."

Weeds with especially high risk of evolving resistance to dicamba

It should be emphasized that dicamba used as part of the "Roundup Ready® Xtend Crop System" poses a high risk of fostering dicamba resistance in any species of broadleaf weed for the reasons discussed above. However, it is useful to explore which weed species might be more likely to evolve dicamba resistance, and if so have particularly adverse agronomic, environmental and economic impacts.

Roberto Crespo, formerly a Masters student in agronomy at the University of Nebraska-Lincoln, conducted a risk assessment of the potential for dicamba use with dicamba-resistant soybeans to foster evolution of dicamba-resistant weeds (Crespo 2011). This work subsequently formed the basis for a published paper co-authored by several weed scientists, some of whom served as Crespo's advisers for his Master's thesis (Crespo et al. 2014).

Crespo first surveyed weed scientists to estimate the likelihood of ten weed species evolving resistance to dicamba following commercialization of dicamba-resistant soybeans. The ten weed species were selected based on several criteria: 1) Species with prior resistance to dicamba or other synthetic auxins; 2) Species with known resistance to two or more modes of action; and 3) Frequency of appearance in soybean producing areas of the western Midwest.

Relative risk of dicamba resistance	**Weed species**
High	Kochia, waterhemp, Palmer amaranth, horseweed
Moderate	Common lambsquarters, giant ragweed
Low	Canada thistle, field bindweed, velvetleaf, prickly lettuce

The survey results, based on the expert opinions of 25 weed scientists, indicated that four weed species posed a particularly high risk of dicamba resistance: kochia, horseweed, waterhemp and Palmer amaranth. In response to other survey questions, scientists found that these same weeds would have the greatest potential economic and environmental impacts (Crespo 2011).

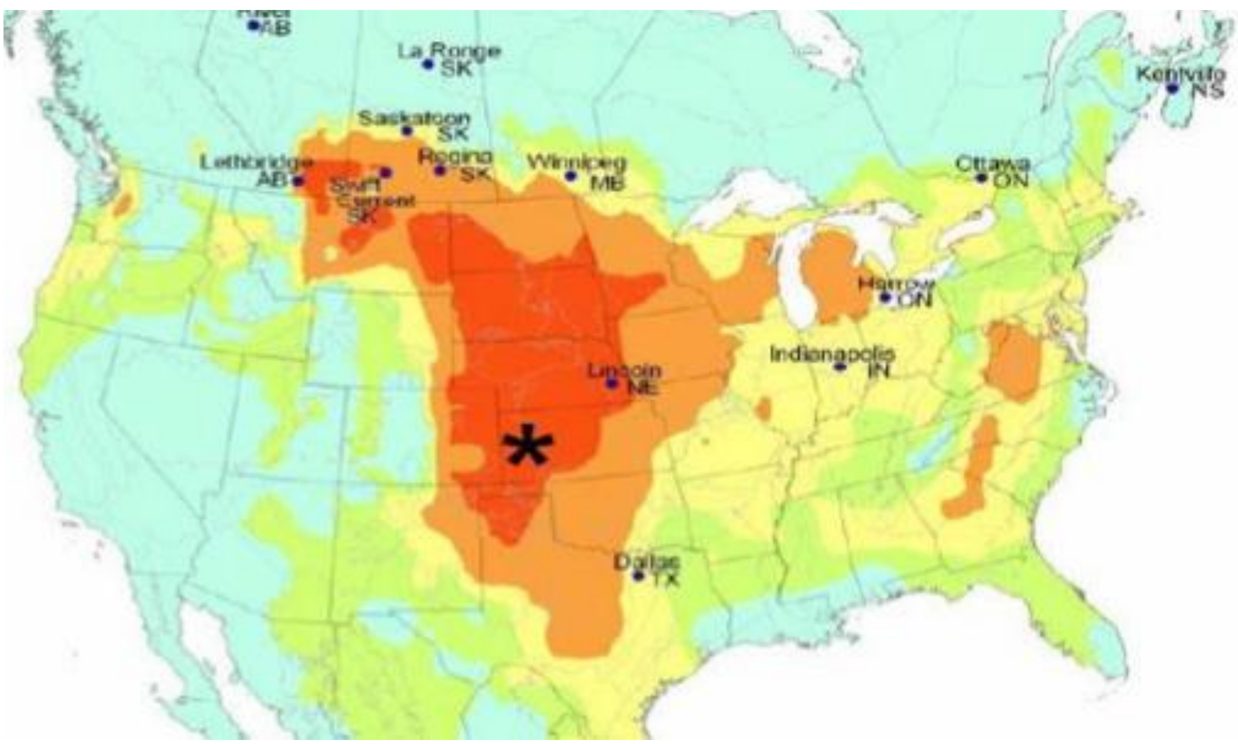
The survey of weed scientists was followed by dicamba dose-response studies on populations of kochia (73), waterhemp (41) and horseweed (10) collected throughout much of Nebraska.

<u>Kochia</u>

One of the kochia populations was found to be "highly resistant" to dicamba, requiring an 18-fold higher rate to control than the most susceptible population tested. This represents the fifth dicamba-resistant kochia biotype that has been reported, the others all occurring in the U.S. (Montana, North Dakota, Idaho and Colorado). Based on their results as well as the history of dicamba resistance in other kochia populations, it was concluded that without aggressive stewardship of dicamba-resistant soybeans, there was "a very high probability for dicamba-resistant kochia populations to be selected," and that "they will likely spread widely because of kochia's 'tumbleweed' seed dispersal" (Crespo 2011, p. 105).

The very likely emergence of additional dicamba-resistant kochia populations under the Preferred Alternative is troubling for several reasons. First, kochia is an increasingly problematic weed of soybeans and is also found in cotton. Second, dicamba resistance would likely evolve in kochia already resistant to glyphosate and other herbicides, making it extremely difficult, expensive and environmentally damaging to control. Third, there is evidence that the preferred resistance prevention and management strategy of using multiple herbicides is likely to fail. We address each of these points below.

Kochia a troublesome weed in soybeans and cotton
Monsanto claims that "[k]ochia is not a common or problematic weed species in most of the soybean producing states," and on this basis has not conducted any field studies to evaluate the efficacy of dicamba in controlling glyphosate-resistant kochia (Monsanto Enviro Report 2013, p. 563). Monsanto is simply wrong on this point. In fact, kochia is widely distributed and abundant in regions where both soybeans and to a lesser extent cotton are grown (see map below); and it is regarded as among the top ten troublesome weeds in soybeans (Soybean Weeds 2012).



Source: Westra et al (2013). "Kochia distribution and abundance in North America"

Crespo notes that although historically kochia has been less common in soybean regions, as soybean cultivation “continues to expand west and north more soybean acres will be infested with kochia” (Crespo 2011). USDA figures bear this out, showing a substantial increase in soybean acres in the Great Plains states (Kansas, Nebraska, North and South Dakota) – where kochia is most prevalent – from just 12.9 to 19.8 million acres from 2007 to 2013 (USDA NASS 2014).

Pre-existing resistance to other herbicides make dicamba resistance more threatening
Forty-five kochia populations have evolved resistance to one or more herbicides from four different herbicide families, all but one in the U.S. (39) or Canada (5) (ISHRW Kochia 10-7-14). Kochia’s proclivity to evolve resistance to many herbicides (including dicamba), and the prevalence of these HR biotypes, has made it one of the world’s ten worst herbicide-resistant weeds (ISHRW Worst HR Weeds). Pre-existing resistance makes the prospect of additional resistance to dicamba all the more threatening.

Kochia was one of the first weeds to evolve widespread resistance to triazines and ALS inhibitors (Crespo 2011; ISHRW Kochia 10-7-14). Limited populations of glyphosate-resistant (GR) kochia first emerged in Kansas in 2007, and rapidly spread throughout the western third of the state (Stahlman et al. 2011). Subsequent populations were quickly confirmed in South Dakota (2009), Nebraska (2011), North Dakota (2012), Colorado (2012), Montana (2012 and 2013) and Oklahoma (2013), as well as in the Canadian Provinces of Alberta and Saksatchewan (2012). Kansas researchers found that: “Glyphosate-resistant kochia spread rapidly throughout the central U.S. Great Plains within 4 years of discovery” (Stahlman et al. 2013). Virtually all of the glyphosate-resistant kochia in Canada is also resistant to ALS inhibitors (Beckie 2013), and many U.S. populations are likely to be resistant to ALS inhibitors and/or triazines as well.

Stahlman et al (2013): "Tumble weed moved long distances by wind"

At least 4 of the 10 glyphosate-resistant kochia biotypes have emerged in soybeans, and in most cases corn as well, with one biotype found in cotton as well as corn and soybeans, almost certainly Roundup Ready varieties (ISHRW Kochia 10-7-14). This shows once again the resistance promoting effects of using an herbicide with an herbicide-resistant crop. The area infested with GR kochia is expanding rapidly, and increasing use of glyphosate in response will likely select for higher levels of resistance (Westra et al. 2013).

Soybean and to a lesser extent cotton growers plagued by resistant kochia would be likely candidates for dicamba-resistant versions of these crops. Monsanto concedes that it has not tested the efficacy of dicamba on glyphosate-resistant kochia (Monsanto Enviro Report 2013, p. 563), but a survey of Kansas farmers found that using a mix of dicamba and glyphosate to control kochia in fallow fields was only marginally more effective than applying glyphosate alone (Stahlman et al. 2013). This could well indicate that there is already growing tolerance to dicamba in these kochia populations, and thus increased likelihood of selecting for full-blown dicamba resistance under the Preferred Alternative. Dicamba resistance would often evolve in kochia already resistant to glyphosate, ALS inhibitors and/or triazines, turning a troublesome weed into a noxious one that is extremely difficult to control.

Multiple herbicides are no solution

The primary recommendation to forestall or manage herbicide resistance ("best management practice") is to use multiple herbicides or "modes of action," each of which kill the weed in different ways. However, there is increasing evidence that such an approach is often ineffective and counterproductive, even if one ignores the human health and environmental impacts of increased use of herbicides.

The field where the most recent dicamba-resistant kochia population was found in Nebraska had been planted continuously to corn for the previous 10 years, and "dicamba had frequently been applied in tank-mixtures with glyphosate or atrazine to 2.5 cm kochia" (Crespo et al. 2014). Thus, the grower used herbicides representing three distinct modes of action – dicamba, glyphosate and atrazine – that are all rated as highly effective in controlling kochia. Glyphosate and dicamba are each rated 8 (85-90% control) and atrazine 9 (90-95% control) on a ten-point scale where 10 indicates the highest possible efficacy (96-100% control) (NE Weed Guide 2014, p. 66). We note further that these herbicide pairs were used together in mixtures, which is considered more effective in forestalling resistance than using the same herbicide pairs sequentially, "in rotation." Moreover, the kochia was treated when it was quite small (2.5 cm = 1" tall), which is considered much more effective and less likely to foster resistance than when larger weeds are treated. In short, the grower was following at least three of the primary "best management practices" that are recommended to forestall resistance, but this kochia population nevertheless evolved resistance to dicamba. How can one explain this outcome? Crespo et al. (2014) conclude as follows:

"First, dicamba must not be the ***only effective herbicide*** used to control kochia accessions ***already resistant to triazine, glyphosate, or acetolactate synthase–inhibiting herbicides***. If that ***dicamba-only*** approach is used, it is highly likely that more accessions like accession 11[11] will be selected." (emphasis added)

While not stated directly, the authors are clearly implying that this kochia population had pre-existing resistance to the other named herbicides, at least two of which (the triazine herbicide atrazine, and glyphosate) were demonstrably ineffective. Despite use of three different types of herbicide, then, the "only effective herbicide" applied was dicamba. That the authors then perversely refer to this as a "dicamba-only approach" is unfortunate, because it obscures the central fallacy of the mainstream weed science community's approach to resistant weeds – namely, that they can be forestalled by simply using more herbicides. We return to this point more generally below, but first address several other weeds regarded as posing a high risk of dicamba and more generally synthetic auxin resistance.

<u>Waterhemp</u>

As noted above, waterhemp is a second weed regarded as both likely to evolve dicamba resistance with the introduction of dicamba-resistant crops, and to be extremely damaging when it does, based on Crespo's three criteria: 1) At least one biotype has evolved resistance to a synthetic auxin herbicide (2,4-D) of the same class as dicamba; 2) Biotypes with resistance to multiple herbicides are known and prevalent; and 3) Waterhemp is an extremely prevalent and competitive weed in soybean growing areas. For a documented

[11] "Accession 11" is the kochia population under discussion, with 18-fold increased resistance to dicamba.

discussion of the likelihood and impacts of dicamba and auxin resistance in waterhemp, see Appendix B (pp. 23-26 and 29-31). We summarize and update this discussion below.

Waterhemp is regarded as one of the worst weeds of soybeans and corn, with the potential to cause huge yield reductions. Forty-six biotypes of herbicide-resistant waterhemp have been found worldwide, all in the U.S. (44) and Canada (2) (ISHRW Waterhemp 10-8-14). Waterhemp has an astounding ability to defy herbicides, having evolved resistance to six different modes of action: PS II inhibitors (e.g. atrazine), ALS inhibitors, PPO inhibitors, glyphosate, HPPD inhibitors and synthetic auxins (Rosenbaum & Bradley 2013). Biotypes resistant to one to four herbicide families each infest millions of acres of cropland and expanding in the Midwest, Plain States and the South. In Iowa, a recent survey found

In 2011, Bernards et al. (2012) discovered a waterhemp population that has 19.2-fold increased resistance to 2,4-D and 4.5-fold increased resistance to dicamba (DEIS, p. 188). This illustrates the common phenomenon of cross-resistance among herbicides of the same class, here synthetic auxins, and the likelihood that dicamba- and 2,4-D-resistant crops (collectively, "auxin-resistant crops") will lead to rapid evolution of auxin-resistant waterhemp:

> New technologies that confer resistance to 2,4-D and dicamba (both synthetic auxins) are being developed to provide additional herbicide options for postemergence weed control in soybean and cotton. The development of 2,4-D resistant waterhemp in this field is a reminder and a caution that these new technologies, if used as the primary tool to manage weeds already resistant to other herbicides such as glyphosate, atrazine or ALS-inhibitors, will eventually result in new herbicide resistant populations evolving. (UNL 2011)

The authors further call for ***mandatory*** weed resistance management measures:

> ***The commercialization of soybean, cotton and corn resistant to 2,4-D and dicamba should be accompanied by mandatory stewardship practices*** that will minimize the selection pressure imposed on other waterhemp populations to evolve resistance to the synthetic auxin herbicides. (Bernards et al. 2012, emphasis added)

A recent news article in the journal *Science* reports on a survey of herbicide-resistant waterhemp in Iowa. An astounding 89% of waterhemp populations in the state had evolved resistance to two or more classes of herbicide; 25% were resistant to were resistant to three; and 10% resistant to five separate classes of herbicide (Service 2013). The same article notes that weed control costs to control resistant weeds has risen by six-fold in Illinois soybeans and an equivalent amount in southern cotton fields, and that the high cost of controlling resistant weeds in cotton is driving a steep reduction in cotton acres planted in Tennessee and Arkansas.

Multiple herbicides are no solution
As with the kochia example discussed above, here too the field where the auxin-resistant waterhemp emerged had for many years been treated with multiple herbicides. "Since 1996, atrazine, metolachlor, and 2,4-D were applied annually to control annual grasses and broadleaf weeds" (Bernards et al. 2012).

Metolachlor, now sold primarily as S-metolachlor under the brand names Dual II Magnum, Cinch and Parallel, is sometimes referred to as a grass herbicide, but both it and 2,4-D are rated highly (8 of 10) for control of waterhemp, while atrazine is even more effective (rated 9 of 10) (NE Weed Guide, pp. 64, 66). Despite the application of three distinct and effective modes of action, this waterhemp population somehow evolved high-level resistance to 2,4-D and lower-level resistance to dicamba. The scientists are presently conducting research to "determine whether this waterhemp population has developed resistance to additional herbicide mechanisms-of-action." (UNL 2011). Atrazine-resistant waterhemp populations have been reported in many states, often in combination resistance to two to three additional modes of action (ISHRW Waterhemp 10-8-14). However, there is only one report of a confirmed metolachlor-resistant weed population in the entire world, rigid ryegrass in Australia, and just seven reports of resistance to the chloracetamide class of herbicides to which it belongs.[12] Because S-metolachlor is the third most heavily used herbicide in the U.S. (EPA Pesticide Use 2011), the evolution of weeds resistant to it would pose major problems for corn growers, the crop on which it is most heavily used.

<u>Palmer amaranth</u>
Palmer amaranth is also regarded as at high risk of evolving dicamba and auxin resistance. Closely related to waterhemp (both are in the *Amaranthus* genus), Palmer amaranth is perhaps the most destructive and feared weed in all of U.S. agriculture, primarily because of its extremely rapid growth; ability to dramatically reduce crop yields, and its resistance to multiple herbicide, especially glyphosate (see Benbrook 2009a, Chapter 4; see also Appendix B, pp. 31-32). Forty-eight biotypes of Palmer amaranth have evolved resistance to five different modes of action, all but one in the United States (ISHRW Palmer amaranth 10-8-14, Ward et al 2013). Herbicide-resistant Palmer amaranth on millions of acres of U.S. cropland has cut yields, forced farmers to resort to hand-weeding on hundreds of thousands of acres, and even occasioned abandonment of cropland in some cases. Glyphosate-resistant Palmer amaranth in particular is regarded and being treated as a noxious weed in many states where it has spread or is at risk of spreading, though it has not been officially designated as such by the USDA. In Indiana, Palmer amaranth was identified in 51 fields across five northwestern counties in 2012, and in many fields survived multiple applications of both glyphosate and PPO-inhibiting herbicides (Legleiter and Johnson 2013). Most GR Palmer amaranth is also resistant to ALS inhibitors, which is thought to be due to pre-existing ALS inhibitor-resistant populations being selected for additional resistance to glyphosate; or to cross-pollination between glyphosate-resistant and ALS inhibitor-resistant individuals (Ward et al 2013). Palmer amaranth populations have evolved resistance to five different classes of herbicide: dinitroanilines, triazines (e.g.

[12] Go to www.weedscience.com. Select Resistant Weeds, then By Herbicide Site of Action, then K3 (Long chain fatty acid inhibitors).

atrazine) and HPPD inhibitors as well as glyphosate and ALS inhibitors (ISHRW Palmer amaranth 10-8-14). In Nebraska, scientists recently discovered a population of Palmer amaranth resistant to both atrazine and HPPD inhibitors, and with reduced sensitivity to ALS inhibitors, bromoxynil and a PPO inhibiting herbicide (Jhala et al 2014).

The demonstrated ability of waterhemp to evolve resistance to auxin herbicides suggests that a similar potential likely exists in it close cousin, Palmer amaranth. Resistant biotypes of this weed are particularly widespread and problematic in cotton and soybeans, growers of which would be prime candidates to adopt dicamba-resistant soybeans and cotton. Because pre-emergence dicamba applications are being used increasingly to battle this weed in both soybeans and cotton, dicamba-resistant biotypes fostered by multiple post-emergence dicamba applications to MON 88708 soybeans and MON 88701 cotton would remove an important tool in preventing the continued spread and emergence of HR biotypes of this weed; and generate dicamba resistance in weeds already resistant to other herbicides, making them still more difficult and expensive to control.

Horseweed

Horseweed is the fourth weed judged to have the highest risk of evolving dicamba resistance with commercialization of MON88708 soybeans, and is discussed more fully in Appendix B, pp. 26-29. Fifty-nine biotypes of horseweed have evolved resistance to various herbicides of five different families, most in the United States (ISHRW Horseweed 10-8-14). Glyphosate-resistant (GR) horseweed is the most prevalent GR weed, in part due to the ability of its wind-dispersed seeds to travel extremely long distances to colonize new areas (Dauer et al 2009). Herbicide-resistant horseweed is often controlled with tillage, leading to abandonment of no-till / conservation tillage practices and increased soil erosion.

The many soybean and cotton farmers with herbicide-resistant horseweed would be prime candidates for dicamba-resistant versions of these crops. Yet Purdue University weed scientists have already founded increased tolerance to dicamba and 2,4-D in several horseweed populations, demonstrating the high potential for horseweed to evolve additional resistance to dicamba and other auxin herbicides with commercialization of dicamba-resistant crops:

> “Population 66 expressed almost twofold greater tolerance to 2,4-D ester and approximately three- to fourfold greater tolerance to diglycolamine salt of dicamba than populations 3 and 34 (Table 1). Population 43 was more sensitive to growth regulators than population 66 but expressed slightly higher levels of tolerance to 2,4-D ester and diglycolamine salt of dicamba than populations 3 and 34 based on dry weight measurements.” (Kruger et al 2010b)

It is significant that these two populations each exhibit increased tolerance to both dicamba and 2,4-D, indicating the potential for evolution of resistance to both herbicides if either one is used. In addition, the increased tolerance to dicamba of both populations was found only with the diglycolamine, but not the dimethylamine salt of dicamba. Because the versions of dicamba proposed for use on Monsanto's dicamba-resistant crops are the diglycolamine salt, they might more readily lead to dicamba-resistant horseweed than would other forms of dicamba.

Kruger and colleagues also predict that auxin herbicides will be applied later to larger horseweed plants in the context of auxin-resistant crop systems (Kruger et al 2010a). In follow-up research, they found that larger plants are much more difficult to control with auxin herbicides:

> ***While it is realistic to expect growers to spray horseweed plants after they start to bolt,*** the results show that timely applications to [small] horseweed rosettes are the best approach for controlling these weeds with growth regulator herbicides [dicamba and 2,4-D]. ***Growers should be advised to control horseweed plants before they reach 30 cm in height because after that the plants became much more difficult to control***. (Kruger et al. 2010b, emphasis added)

As discussed elsewhere, increased survival of larger weeds means a greater likelihood of resistant individuals among them surviving to propagate resistance via cross-pollination or seed production. And as the authors acknowledge, it is "realistic" to expect late application of dicamba with MON 87708, because that is precisely how growers use these crop systems, as demonstrated with the history of Roundup Ready crops.

This tendency to delay application to kill larger weeds will be greatly facilitated by the high-level dicamba resistance of MON 87708, since larger weeds require higher rates to control. The proposed label permits 2 post-emergence applications of up to 0.5 lb./acre each, up through the time when soybeans are in full bloom (R2). However, much higher rates could be used without risk of crop injury. In fact, the developers of dicamba-resistant soybeans report resistance to dicamba at rates 5 to 10-fold higher than the maximum proposed single application rate (2.5 to 5 lbs./acre):

> "Most transgenic soybean events showed resistance to treatment with dicamba at 2.8 kg/ha and 5.6 kg/ ha under greenhouse conditions (fig. S9) and complete resistance to dicamba at 2.8 kg/ha (the highest level tested in field trials) (Fig. 3)" (Behrens et al 2007).

As discussed above in relation to RR crops, farmers delay application in order to avoid the trouble and expense of a second application, whether this is a wise tactic or not. Thus, advising growers to spray weeds when they are small will likely not be any more effective with MON 87708 soybeans than were similar recommendations made for glyphosate with Roundup Ready crops.

Cultivation of MON 87708 and MON 88701 under the Preferred Alternative is thus quite likely to promote rapid evolution of horseweed resistant to dicamba and perhaps 2,4-D as well, often in combination with resistance to glyphosate and other herbicides. As noted above, tillage is a frequent response to glyphosate-resistant horseweed, and will be a still more frequent response to dicamba/glyphosate-resistant horseweed, since dicamba will be eliminated as an alternative control option. This would lead to further reductions in conservation tillage and increased soil erosion.

Common lambsquarters

Common lambsquarters (*Chenopodium album* L.) is regarded as being at moderate risk of evolving resistance to dicamba (Crespo 2011) based on the emergence in New Zealand of a dicamba-resistant biotype in 2005 (ISHRW Lambsquarters 10-9-14). New Zealand researchers recently reported that almost all common lambsquarters in their country is resistant to atrazine, and that "[f]requent use of dicamba since then, due to its low cost and high efficacy, has led to the development of resistance also to this herbicide" (Rahman et al. 2013). The authors do not report on the prevalence of this biotype, but regard it with great concern.

Dicamba-resistant lambsquarters would be likely to emerge under the Preferred Alternative, which is of great concern because it is one of the most troublesome weeds of soybeans (Soybean Weeds 2012). Because corn and soybeans are often rotated and grown in close proximity, dicamba-resistant lambsquarters resulting from cultivation of MON 87708 soybeans poses a clear risk of infesting corn fields as well. Lambsquarters resistant to atrazine and related herbicides has been reported in over 20 states (ISHRW Lambsquarters 10-9-14), thus dicamba resistance could well emerge in weeds already resistant to atrazine, as has occurred in New Zealand, creating serious weed control issues for U.S. corn growers.

Noxious weed risks posed by dicamba-resistant crops

Acting under the noxious weed provisions of the Plant Protection Act, APHIS prohibits and/or regulates introduction from overseas of seed from plants that are ***not*** noxious weeds if such seed is potentially admixed with noxious weed seed. The seed thus prohibited or regulated is regarded as a potential "pathway" for introduction of noxious weeds into the United States. APHIS has the authority and the duty to regulate herbicide-resistant crops as potential pathways for emergence of noxious, herbicide-resistant weeds.

The discussion above makes clear that some glyphosate- and multiple-herbicide resistant weeds have already

APHIS's criteria for noxious weeds

In 2008, APHIS issued a proposed rule to implement its authority under the Plant Protection Act of 2000 to regulate the noxious weed risks that may be posed by GE crops. APHIS described various impacts of noxious weeds, which include:

> "Lost productivity of crop fields: Noxious weeds may directly compete with crop plants for limited resources, dramatically reducing yields." (Federal Register Vol. 73, No. 179, pp. 60008-60048 at 60013).

One example of a federally listed noxious weed in this category is Benghal dayflower (*Commelina benghalensis*)." (Ibid)

Difficulty of control is a key attribute of noxious weeds:

> "In general, federally listed noxious weeds are plants that are likely to be aggressively invasive, have significant negative impacts, and are ***extremely difficult to manage or control once established.***" (Ibid, emphasis added)

And herbicides are major control options. While only certain problematic weeds "are considered to be so invasive, so harmful and so difficult to control" as to rate designation as noxious, "significant negative consequences" of all weeds, including noxious ones, include "lost yields, ***changes in management practices, altered herbicide use***, etc." (Ibid, emphasis added)

Appendix G (pp. 22-28) provides a documented discussion of how auxin-resistant crops (Dow's Enlist corn and soybeans) threaten to transform troublesome weeds into noxious ones, and exacerbate the noxious character of weeds – such as those discussed above – whose impacts already merit the designation of noxious. Very similar considerations apply to Monsanto's dicamba-resistant soybeans and cotton. APHIS should expeditiously apply its noxious weed authority under the Plant Protection Act to properly regulate Xtend crops to forestall the noxious weed threats they pose.

Spread of weed resistance and tragedy of the commons

Weeds evolve resistance through strong selection pressure from frequent and late application as well as overreliance on particular herbicides, as fostered especially by HR crop systems. However, once resistant populations of out-crossing weeds emerge, even small ones, they can propagate resistance via cross-pollinating their susceptible counterparts (Webster & Sosnoskie 2010). It is estimated that common waterhemp pollen can travel for one-half mile in windy conditions, and so spread resistance to neighbors' fields via cross-pollination (Nordby et al. 2007). A recent study was undertaken to measure waterhemp pollen flow because "[p]ollen dispersal in annual weed species may pose a considerable threat to weed management, especially for out-crossing species, because it efficiently spreads herbicide resistance genes long distances," because the "severe infestations and frequent incidence [of waterhemp] arise from its rapid evolution of resistance to many herbicides," and because "there is high potential that resistance genes can be transferred among populations [of waterhemp] at a landscape scale through pollen migration" (Liu et al. (2012). The study found that ALS inhibitor-resistant waterhemp pollen could travel 800 meters (the greatest distance tested) to successfully pollinate susceptible waterhemp; and that waterhemp pollen can remain viable for up to 120 hours, increasing the potential for spread of resistance traits.

A second recent study made similar findings with respect to pollen flow from glyphosate-resistant to glyphosate-susceptible Palmer amaranth (Sosnoskie et al. 2012). In this study, susceptible sentinel plants were planted at distances up to 250-300 meters from GR Palmer amaranth. From 20-40% of the progeny of the sentinel plants at the furthest distances proved resistant to glyphosate, demonstrating that glyphosate resistance can be spread considerable distances by pollen flow in Palmer amaranth.

Whether out-crossing or inbreeding, those resistant individuals with lightweight seeds can disperse at great distances. Dauer et al. (2009) found that the lightweight, airborne seeds of horseweed, the most prevalent GR weed (CFS GR Weed List 2012), can travel for tens to hundreds of kilometers in the wind, which is likely an important factor in its prevalence. Hybridization among related weeds is another potential means by which resistance could be spread, for instance by weeds in the problematic *Amaranthus* genus (Gaines et al. 2012). Movement of resistant seed via waterways when excessive rainfall leads to flooding has been suggested as one explanation for the epidemic spread of glyphosate-resistant and multiple herbicide-resistant waterhemp[13] in the sugarbeet production region of Minnesota and North Dakota (Stachler et al 2012).

Thus, even farmers who employ sound practices to prevent emergence of herbicide-resistant weeds themselves can have their fields infested with resistant weeds from those of other farmers. With reference to GR weeds, Webster & Sosnoskie (2010) present this as a tragedy of the commons dilemma, in which weed susceptibility to glyphosate is the common resource being squandered. Since responsible practices by individual farmers to prevent evolution of weed resistance in their fields cannot prevent weed resistance from spreading to their fields as indicated above, there is less incentive for any farmer to even try to undertake such prevention measures.

The weed science community as a whole has only begun to grapple with the implications of the ***spread*** of resistance, particularly as it relates to the efficacy of weed resistance management recommendations based solely on individual farmers reducing selection pressure. It may not be effective or rational for farmers to commit resources to resistance management in the absence some assurance that other farmers in their area will do likewise. This suggests the need for a wholly different approach that is capable of ensuring a high degree of area-wide adoption of sound weed resistance management practices. This represents still another reason to implement mandatory stewardship practices to forestall emergence of dicamba -resistant weeds in the context of MON 87708 soybean and similar auxin-resistant crops.

Stewardship

APHIS presumes that EPA will put in place a weed resistance management program for dicamba use on dicamba-resistant crops that is similar to the one the Agency has proposed (but not finalized) for application of Enlist Duo (a mix of 2,4-D and glyphosate) to Dow's 2,4-D-resistant (Enlist) crops (DEIS, pp. 140, 174-75, 180). An EPA official was recently quoted as saying that the proposed Enlist Duo program would serve as the model for future

[13] For the recent confirmation of multiple HR waterhemp, see http://www.ag.ndsu.edu/homemoisture/cpr/weeds/herbicide-resistance-in-waterhemp-in-mn-and-nd-and-management-in-sugarbeet-corn-and-soybean-5-24-12.

herbicide-resistant crop systems (Hopkinson 2014). In the discussion below, we refer to "auxin-resistant crops" and "auxins" to encompass both Enlist and Xtend crop systems.

The major flaw in EPA's Enlist Duo plan, which would apply equally to dicamba resistant crop systems, is that the Agency has entirely failed to mandate any effective measures to ***prevent*** evolution of auxin resistance in weeds, but rather proposed only ***monitoring*** to detect them after they have already emerged. An approach based solely on monitoring is doomed to failure, because the emergence of a resistant weed population is a slow, incremental process. In most cases it will begin with a ***single plant*** with the rare mutation that confers resistance to the herbicide, which then over the course of years of exposure to the herbicide gradually multiplies until it becomes an at all noticeable ***population*** of resistant weeds. Busy farmers may well fail to notice a few weeds that survive treatment with an herbicide; or if noticed, assume that they are simple "escapes" that were missed during a spraying operation. Crespo (2011) notes that resistance often escapes detection until at least 25% of the individual weeds in a particular population carry the resistance mutation. By that time, it may well be too late to effectively control the resistant weeds, especially in the case of outcrossing weeds able to disperse the resistance trait long distances via cross-pollination, or weeds with the ability (like horseweed) to disperse their resistant seeds even greater distances to infest neighboring or distant fields.

It is also perverse that the EPA would propose such an ineffectual monitoring plan in light of the Agency's long experience with managing insect resistance to the Bt toxins in GE, insect-resistant corn and cotton, so-called Bt crops. EPA has had great success in ***preventing*** resistance to the first generation of Bt crops, which carry toxins that kill above-ground pests like the European corn borer and cotton bollworms. But this success was only realized because EPA established strict "refuge" requirements under which growers had to plant (in most cases) 20% of their field to a non-Bt variety to prevent resistant pests from evolving in the first place. This "spatial refuge" approach is appropriate for mobile insects, while for sessile weeds a "temporal refuge" would accomplish the same purpose. This would involve imposing restrictions on the frequency with which an auxin herbicide could be applied to a particular field during a single season and over years. This is precisely the approach that many weed scientists have proposed. Frustrated by the rapid increase in glyphosate- and multiple-resistant weed populations, six weed scientists recently stated that: "The time has come to consider herbicide-frequency reduction targets in our major field crops" (Harker et al. 2012). Shaner and Beckie (2014) likewise recognize the need for "reasonable [herbicide-]frequency use intervals" to forestall evolution of weed resistance.

That EPA would propose only monitoring is also disappointing in light of the Agency's failure to prevent insect resistance from evolving to the second-generation of Bt corn, which targets the soilborne pest, corn rootworm. This failure is directly attributable to a dramatic weakening of refuge requirements – the resistance prevention component – in favor of a monitoring-based approach that is quite similar to the Enlist Duo plan (CFS Corn Rootworm 2013).

Even to the limited extent that monitoring for resistance after it has emerged would be useful, the proposed plan is undermined by EPA's delegation of virtually all responsibilities to Dow. Dow is put in charge of developing diagnostic tests used to evaluate potential resistance; investigating farmer reports of potential resistant weeds; collecting material for testing; eradicating weeds that Dow judges to be "likely resistant" based on its diagnostic tests; and informing growers and other stakeholders of likely and confirmed resistance. Dow is also required to report periodically to EPA on any findings of resistant weeds.

While this might look good on paper, delegation of these responsibilities to Dow represents a clear conflict of interest. Dow's financial interests militate directly against any finding of resistance, for several reasons. First, 2,4-D resistant weeds would represent a failure of the Enlist system, which Dow is naturally motivated to sell to growers; sales would not be promoted, but could well suffer, if Dow were to determine that weeds are resistant to 2,4-D. This is all the more true since Dow is obligated to publicize local or widespread failure of the Enlist system to growers and other stakeholders. Second, a finding of resistance could lead to EPA modification or cancellation of Enlist Duo registration. While EPA would be extremely unlikely to undertake such an action, the possibility would further incentivize Dow to avoid finding resistant weeds in the first place, to avoid loss of Enlist Duo herbicide and/or Enlist crop seed sales.

The Dow-led implementation of the monitoring program would open up many possibilities for avoiding a 2,4-D resistance determination. For instance, Dow-developed diagnostic tests could be made intentionally insensitive; Dow could drag its feet in responding to grower reports of non-compliance; reports to EPA could be incomplete or doctored; to name just a few of the possibilities. These are not idle speculations. EPA has already had experience of such machinations in the context of insect resistance management (IRM) for the Bt corn targeting corn rootworm, discussed above. Here too, EPA delegates all responsibilities for IRM to the crop developer, which happens to be Monsanto. Rootworm resistance to Monsanto's Bt corn has emerged rapidly from at least 2008, but Monsanto – in charge of investigating grower complaints of potential resistance – delayed investigations, submitted incomplete reports to EPA, and set an inappropriately "high bar" for what exactly constituted "resistance." Bt-resistant rootworm were only confirmed in 2011, at least three years after their emergence, by public sector entomologists, not Monsanto. Monsanto then first denied the resistance finding, then when it became undeniable, downplayed its significance (Philpott 2011, Gustin 2011).

There is no reason to think that Monsanto would do a better job of stewarding its dicamba-resistant crops to prevent dicamba-resistant weeds if EPA establishes a weed resistance monitoring program similar to that proposed for the Enlist system.

Neither does Monsanto's past conduct with its Roundup Ready crops give any reason for confidence. Monsanto insisted that weeds would not evolve glyphosate resistance to any serious extent when RR crops were first being introduced, based mostly on assumptions concerning the presumed rarity of glyphosate-resistance mutations, the lack of glyphosate-resistant weed evolution up to that time, and nuances of the herbicide's mode of action (Bradshaw et al. 1997). (Interestingly, Monsanto is now presenting quite similar and equally species arguments regarding the supposedly low risk of dicamba-resistant weeds with Xtend crops – specious because they leave out the all-important factor of selection pressure (Monsanto Weed 2014, p. 12)). Many weed scientists were not convinced, and called for serious measures to forestall evolution of GR weeds, which were never implemented (Freese 2010, question 1). Even several years after GR weeds first emerged in RR soybeans and then RR cotton, Monsanto promoted "glyphosate-only" weed control programs in farm press advertisements dating to 2003 and 2004, ads that leading weed scientists castigated as irresponsible for promoting weed resistance (Hartzler et al. 2004). Interestingly, this ad campaign was designed to encourage farmers to adopt Roundup Ready corn, in which they had shown little interest up to that time, in contrast to Roundup Ready soybeans and cotton, which had been readily adopted. The effect of Monsanto's ad campaign was to promote glyphosate-only weed control programs in RR corn/RR soybean rotations. Until then, most corn/soybean farmers had rotated RR soybeans with conventional corn, utilizing primarily non-glyphosate herbicides with the latter, which effectively prevented GR weeds from evolving. The subsequent rapid rise of RR corn in combination with existing RR soybeans led directly to emergence of GR weeds in Midwest and Northern Plains states beginning in earnest in 2005 (ISHRW GR Weeds 10-8-14). Thus, Monsanto not only failed to promote proper stewardship practices to forestall GR weed emergence; it actively promoted practices that led directly to the expanding GR weed epidemic in corn/soybean country. We can expect no better from the company today with respect to stewardship of dicamba-resistant crops.

It is interesting to note that just as Monsanto was encouraging farmers to rely completely on glyphosate every year in "all Roundup Ready" crop rotations – the perfect recipe for GR weed emergence – it also acquired the rights to the dicamba resistance trait from the University of Nebraska, where it was developed (Miller 2005). This report coyly noted that dicamba-resistant crops would be useful for farmers with "hard to control" weeds. Of course, no farmer would have any interest in dicamba-resistant crops if the Roundup Ready crop system were still effective – that is, if hard to control glyphosate-resistant weeds were not prevalent. Finally, it is perhaps relevant to note that Monsanto's original patent on the Roundup Ready trait in RR soybeans expires this year, in 2014, and that it will no longer collect royalties on the sale of seed that bears it (Pollack 2009).

Just to be clear, CFS is not suggesting that Monsanto set out in some nefarious way to intentionally foster glyphosate-resistant weeds. Rather, we are suggesting only that the most profitable path for the company was to maximize sales of Roundup Ready crop seed and Roundup herbicide, which it indisputably did, and that this also happened to be the path most conducive to emergence of GR weeds, which have in turn now created a new market opportunity for the company in the form of dicamba-resistant crops.

In contrast, serious weed resistance management would require restrictions on the frequency with which dicamba resistant seeds are planted and dicamba herbicide applied to them. Because this would reduce sales and profits, one can never expect Monsanto or any other company to promote or acquiesce to such constraints. That is why the USDA and/or EPA would have to impose such restrictions.

Volunteer MON 87708 soybean

Volunteer soybeans are not normally considered problematic weeds, but with the advent of RR soybeans there are some reports that glyphosate-resistance makes them more difficult to control. For instance, York et al. (2005) report that volunteer glyphosate-resistant soybean can be a problematic weed in glyphosate-resistant cotton planted the next season. They note in general that: "Volunteer crop plants are considered to be weeds because they can reduce crop yield and quality and reduce harvesting efficiency." York and colleagues tested several herbicidal options to control GR soybean volunteers, including pyrithiobac, trifloxysulfuron, and each herbicide mixed with MSMA, an arsenic-based herbicide that EPA is in the process of phasing out due to its toxicity, though an exemption has been made for continued use in cotton to control GR Palmer amaranth (EPA 2009). They also note that paraquat can be used to control GR soybean volunteers prior to emergence of cotton. Some farmers have also reported problematic volunteer RR soybean in the following year's corn, and sought advice from extension agents on how to deal with it (Gunsolus 2010). Recommendations include use of 2,4-D, dicamba, atrazine and/or other herbicides. In both cases, it is glyphosate-resistance that has made volunteer soybean a control problem for farmers, and necessitated the use of more toxic herbicides for control.

MON 87708 soybean volunteers would possess resistance to dicamba as well glyphosate, eliminating dicamba and glyphosate and reducing the efficacy of 2,4-D as herbicidal control options. These volunteer soybeans weeds would thus be still more of a management challenge than RR soybean volunteers, and lead to use of more toxic herbicides (e.g. MSMA, paraquat, atrazine) or tillage to control.

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).

In addition to MON 87708, several other HR soybean events have recently been deregulated and will likely soon be commercialized: Dow's 2,4-D/glufosinate/glyphosate-resistant soybeans, isoxaflutole/glyphosate-resistant soybeans from Bayer/M.S. Technologies, BASF's imidazolinone-resistant soybean, and finally soybeans with dual resistance to HPPD inhibitors and glufosinate developed jointly by Bayer and Syngenta.[14] While multiple HR soybean volunteers via cross-pollination would likely be an infrequent occurrence, it could trigger serious weed management challenges where it does occur.

As a general matter, such "resistance stacking" speeds evolution to those herbicides that remain effective. It limits chemical options for managing weeds, and "where weed management depends primarily on chemical weed control, results in additional selection pressure for the evolution of resistance to the few herbicides that are still effective" (Bernards et al. 2012). While this statement was made with reference to HR waterhemp, it applies more generally to multiple HR weeds, including HR soybean volunteers.

[14] See entries at http://www.aphis.usda.gov/biotechnology/not_reg.html, last visited 8/22/12.

Plant pest risks posed by dicamba-resistant cotton

MON 88701 cotton may well pose a serious plant pest risk by undermining boll weevil eradication efforts. Volunteer cotton in both follow-on cotton and rotational crops can harbor boll weevils. Cotton stalks left standing after harvest can also host boll weevils. Thus, in Texas, Tennessee and perhaps other states, cotton growers are required by law to eliminate all volunteer cotton and also destroy cotton stalks after harvest as part of boll weevil eradication efforts. Roundup Ready and glufosinate-resistant LibertyLink cotton have already made such control efforts more difficult by eliminating glyphosate and glufosinate as control options. Texas agronomists are very concerned that the introduction of auxin-resistant cotton varieties (MON 88701 and 2,4-D-resistant cotton) will make both volunteer cotton and cotton stalk destruction still more difficult. This is because dicamba and 2,4-D are the preferred herbicides for accomplishing these tasks, and one or both will be rendered ineffective with the introduction of MON 88701. For a documented discussion of this problem, refer to Appendix A, pp. 38-42. CFS explicitly requested that APHIS address this issue in our scoping comments on the draft EIS (see Appendix D), but we find no discussion of it in either the draft EIS or the MON 88701 Plant Pest Risk Assessment.

Crop injury from increased dicamba use with dicamba-resistant crops

CFS provides a documented discussion of the greatly increased crop injury from dicamba drift that is expected to occur under the Preferred Alternative in Appendix A, pp. 44-46. Here, we present additional information on this topic.

Herbicide drift comes in several forms. Spray drift refers to the movement of an herbicide off the field as it is being applied, and is affected by wind speed, direction, application method and droplet size, among other factors. Some volatile herbicides can drift days to months after application (USGS 2003), a phenomenon known as vapor drift. This occurs when an herbicide previously deposited on plant surfaces and the ground during the spray operation "volatilizes" (evaporates) and moves offsite, and is favored by hot conditions and temperature inversions (Johnson and VanGessel 2012). Drift can also occur when herbicide-laden dust is carried by the wind.

Two surveys of state pesticide regulatory agencies found that on average over 2,100 pesticide drift complaints were received annually in the six years from 1996 to 1998 and 2002-2004, most involving herbicides and crop damage (AAPCO 1999, 2005). However, the true number of drift episodes is certainly much higher, because many go unreported. According to EPA scientists who have studied pesticide drift for many years, farmers often settle drift cases without reporting them; and when lawsuits are filed, the majority are settled out of court, with confidentiality clauses that prevent disclosure even to the government (Olszyk et al. 2004, p. 225). It is often difficult to determine the source of damaging drift (Bennett 2006), which may discourage farmers who would otherwise report in hope of obtaining compensation. All of these factors suggest that the true scope of herbicide drift is far greater than implied by the number of reported cases, which in any case is substantial. Experience with Roundup Ready crops shows clearly that drift becomes more frequent and damaging when an herbicide is used in the context of an herbicide-resistant crop system.

Glyphosate drift injury in the Roundup Ready crop era

Glyphosate has low volatility, and thus is not a drift-prone weedkiller (Lee et al. 2005, p. 135). Nevertheless, it has become one of the top two herbicides (along with 2,4-D) implicated in herbicide drift complaints nationwide since the Roundup Ready era began (AAPCO 1999, 2005). Glyphosate drifting from application to Roundup Ready crops has repeatedly caused extensive damage to wheat (Baldwin 2011) and especially rice (Scott 2009) in Arkansas; to rice (Wagner 2011) and corn (Dodds et al. 2007) in Mississippi; to rice in Louisiana (Bennett 2008); and to tomatoes in Indiana and adjacent states (Smith 2010); to cite just a few of many examples.[15] Such episodes sometimes give rise to lawsuits, as when farmers won compensation for onions damaged by glyphosate applied to Roundup Ready soybeans in Ontario, Canada (Lockery vs. Hayter 2006).

Glyphosate drift injury has been extensive, damaging 30,000 to 50,000 acres of rice in Mississippi in 2006, for example (Wagner 2011). Glyphosate drift damage to wheat has prompted suggestions that it simply not be grown in Arkansas (Baldwin 2011). Tomato growers in Indiana, Michigan and Ohio suffered over $1 million in glyphosate drift damage over four years (Smith 2010). Arkansas corn growers felt so threatened that they switched to Roundup Ready varieties out of “self-defense” against glyphosate drifting from Roundup Ready soybean and cotton fields (Baldwin 2010). While most drift damage occurs near treated fields, weed consultant Ford L. Baldwin has documented glyphosate drifting 0.5 to over 2 miles to damage rice in Arkansas (Baldwin 2008).

The high incidence of glyphosate drift injury is partly attributable to the expanded acreage and increased volume of use with Roundup Ready (RR) crops. However, the late application period – mid-season with RR crops versus early season with conventional varieties – is another contributing factor. In a comprehensive study of the potential for herbicide drift to injure crops in Fresno, CA, EPA scientists found that:

> Increased use of herbicide-resistant technology by producers creates the possibility of off-site movement onto adjacent conventional crops. … Postemergence application of a herbicide to a genetically-modified (GM) crop often occurs when non-GM plants are in the early reproductive growth stage and are most susceptible to damage from herbicide drift. Consequently, most drift complaints occur in spring and summer as the use of postemergence herbicide applications increases (Lee et al. 2005, p. 15, internal citations omitted).

[15] A search of the online farm publication Delta Farm Press using the search term “glyphosate drift” turned up 128 articles (search conducted 9/11/14, www.deltafarmpress.com).

It is because Roundup Ready crops have enabled "large quantities" of glyphosate to be used "throughout the season" that it poses a greater threat than more damaging but lesser used herbicides like 2,4-D and dicamba: "Glyphosate may be applied as a preplant or postplant postemergent herbicide. It is not as damaging to sensitive crops as 2,4-D and dicamba and other high potential risk herbicides but has greater potential to damage sensitive crops because it is applied throughout the year in large quantities." (Lee et al. 2005, p. 47)

Dicamba drift injury will increase dramatically under the Preferred Alternative

Dicamba has been a frequently cited culprit in drift-related crop injury episodes, generally ranking third behind only glyphosate and 2,4-D (AAPCO 1999, 2005). The frequency of dicamba drift damage is all the more remarkable given its limited use in comparison to 2,4-D and glyphosate. In 2007, 27 million lbs. of 2,4-D and 183 million lbs. of glyphosate were used agriculturally (EPA Pesticide Use 2011), 10-fold and 67-fold greater use, respectively, than dicamba. Under the Preferred Alternative, dicamba would be applied in much larger quantities through much of the growing season. It would be applied later in the season when higher temperatures increase the frequency of volatilization and vapor drift. Because it is more damaging to sensitive crops, and at lower levels, than glyphosate, it can be expected to cause considerable damage to neighboring crops.

Dicamba in the atmosphere and in rainfall

In the Canadian Prairies, where auxin herbicide use is common on wheat fields, measurable levels of dicamba and other herbicides are frequently found in the air and in rain (Tuduri et al. 2006). At the high end of concentrations detected in rainfall in Alberta, Canada, a mixture of four herbicides (2,4-D, dicamba, MCPA and bromoxynil) was found to negatively impact test plants, leading the researchers to conclude that: "…based on our bioassay results and those of Kudsk et al. (1998), it is our opinion that the occasional high levels of herbicides detected in southern Alberta rainfall could adversely affect dry beans and tomatoes grown in the area." (Hill et al. 2002). Extensive monitoring in Washington State has shown that 2,4-D injury to grapes occurs "from regional nonpoint sources estimated to be as far as 10 to 50 miles away," and correlates with airborne 2,4-D concentrations rather than local pesticide use (Hebert 2004).

Monsanto and BASF have developed lower-volatility formulations of dicamba which they claim will mitigate drift damage to crops. However, whatever improvements have been made will be swamped by the massively increased use projected with introduction of dicamba-resistant crops, and the shift to later-season application under hotter conditions that promote volatilization. Even if many growers use these formulations,[16] dicamba would drift more, and become much more prevalent in the air and the rain. Whether from local drift, regional transport, or toxic rainfall, dicamba use under the Preferred Alternative will sharply increase injury to sensitive crops.

[16] Many farmers would likely use cheaper, more volatile formulations.

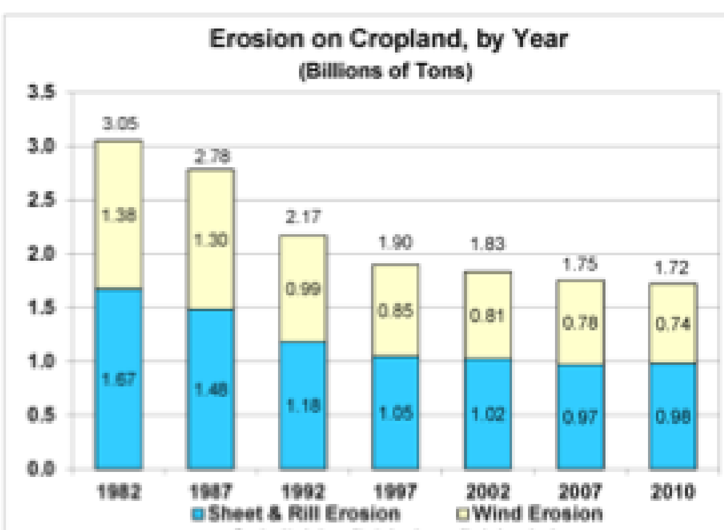
Dicamba-resistant resistant crops, soil erosion and tillage

Throughout the draft EIS (e.g. DEIS, pp. x, 21), APHIS repeatedly asserts that under the Preferred Alternative, Xtend crops would enable farmers to utilize post-emergence applications of dicamba to control glyphosate-resistant weeds, and thereby avoid soil-eroding tillage operations that would otherwise, under the No Action Alternative, become necessary to control them. APHIS accordingly credits Xtend crops with reductions in soil erosion, and a whole host of benefits commonly associated with it, including improved air, water and soil quality; and claims as well that soil erosion and the associated impacts would increase under the No Action Alternative (e.g. DEIS, p. 21).

These assertions, in turn, are based on the assumption that Roundup Ready crops have driven a reduction in soil erosion by facilitating less soil-eroding tillage practices, known collectively as "conservation tillage." APHIS argues by analogy that Xtend crops would preserve and further the benefits of reduced soil erosion purportedly conferred by Roundup Ready crops.

CFS provides a fully documented discussion that debunks the purported linkage between herbicide-resistant crops, adoption of conservation tillage practices, and reduced soil erosion in Appendix B, pp. 43-54. In brief, the large reductions in soil erosion over the last three to four decades occurred almost entirely before the Roundup Ready crop era, and are largely attributable to the 1985 Farm Bill, which provided farmers with strong financial incentives to take erodible farmland out of production by enrolling it in the Conservation Reserve Program, and to adopt conservation tillage practices on land they continued to farm. We present new information that further supports our position below.

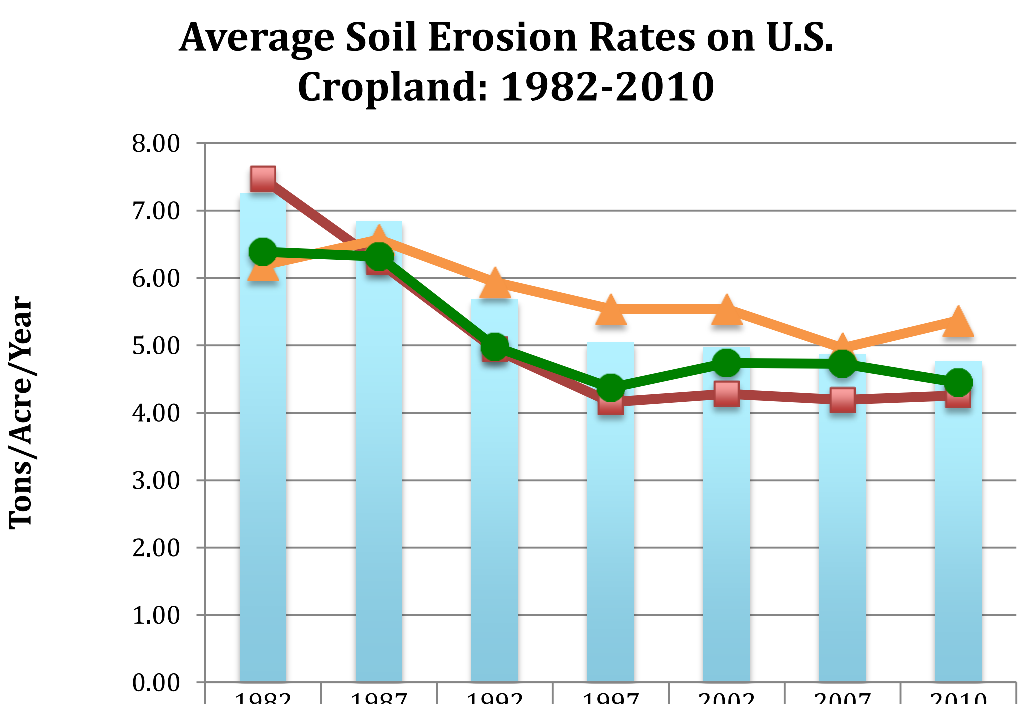
The most recent data from USDA's experts at the National Resources Conservation Service (formerly the Soil Conservation Service) show that the massive reductions in soil erosion that occurred in the 15 years before Roundup Ready crops came to a virtual halt in the Roundup Ready crop era (see figure below).



Source: USDA NRCS (2013). Summary Report: 2010 National Resources Inventory. National Resources Conservation Service, USDA, September 2013, p. 7. NRCS notes that "[t]he estimate of the change in erosion from 2007 to 2010 was not statistically different from zero."

On a national level, total soil erosion per year declined by 38% from 1982 to 1997, but by just 9% from 1997 to 2010. Roundup Ready crops were introduced in 1996, and RR varieties now comprise the overwhelming majority of corn, soybeans and cotton in America, planted on over 150 million acres. If Roundup Ready crops planted on such a massive scale truly reduced soil erosion, it would be certainly be reflected in greater reductions in soil erosion post 1997 than have in fact occurred.

However, data on soil erosion rates at the regional level are still more revealing. USDA NASS data show that the majority (over 80%) of American corn and soybeans are grown in three Farm Production regions: the Corn Belt (Iowa, Missouri, Illinois, Indiana and Ohio); the Lake States (Wisconsin, Minnesota and Michigan); and the Northern Plains states (North and South Dakota, Nebraska and Kansas), as illustrated by the map below. ***Soil erosion rates were entirely flat in corn and soybean country over the period of massive Roundup Ready crop adoption post 1997*** (see graph below).



	1982	1987	1992	1997	2002	2007	2010
NATIONAL	7.26	6.85	5.68	5.05	4.97	4.87	4.77
Corn Belt	7.47	6.24	4.94	4.16	4.28	4.19	4.26
Lake States	6.19	6.57	5.94	5.54	5.54	4.96	5.37
Northern Plains	6.39	6.32	4.98	4.37	4.74	4.73	4.45

NATIONAL Corn Belt Lake States Northern Plains

Source: USDA NRCS (2013) dataset. Data represent combined sheet/rill and wind erosion. Data not yet compiled in the report cited above. Kindly provided to CFS by Patrick Flanagan, National Statistician, NRCS, on 2/27/14.

Soil erosion rates on cropland actually increased a bit over this period in the Corn Belt and the Northern Plains states. It is simply impossible to reconcile no reduction in soil erosion with massive adoption of Roundup Ready crops that supposedly save soil. Either NRCS is wrong or RR crops have not saved soil (and Xtend crops would not). APHIS does not question these NRCS soil erosion figures, and in fact makes no reference to NRCS soil erosion data anywhere in the draft EIS. APHIS's only attempts to support the supposed linkage of RR/Xtend crops to reduced soil erosion are entirely bogus or unreliable.

APHIS cites an organization called Field to Market, an agribusiness front group whose members include all of the Big Six herbicide-resistant crop developers as well as their trade groups (e.g. CropLife)[17] for the following statement: "From 1980-2011, the reported total soil erosion in U.S. cotton production areas decreased by 42%, and decreased in soybean production areas by 28% (Field to Market, 2012)." (DEIS, p. 40). Whether this is true or not is open to dispute, especially given the financially conflicted source, but to the extent that there has been a reduction in soil erosion in cotton and soybeans over this period, the gold standard USDA-NRCS data shown above show clearly that it came in the era before Roundup Ready crops were introduced.

APHIS further states: "Increases in total acres dedicated to conservation tillage were facilitated in part by an increased use of herbicide-resistant GE crops, reducing the need for mechanical weed control (USDA-NRCS, 2006b; Towery and Werblow, 2010; USDA-NRCS, 2010b)." (DEIS, p. 73).

USDA-NRCS (2006b) is a publication entitled "Soil Quality" that discusses the value of organic matter in soil in very broad terms, and presents data on soil erosion reductions in the period from 1982 to 1997 – that is, almost entirely before Roundup Ready crops were first introduced in 1996. It makes not a single mention of herbicide-resistant crops, and provides not one shred of support for APHIS's statement.

USDA-NRCS (2010b) is entitled "Conservation Crop Rotation," and presents various criteria for choosing crop rotation sequences that best reduce soil erosion, improve soil quality, provide cover for wildlife, and otherwise meet the NRCS Conservation Practice Standard. It too makes not a single reference to herbicide-resistant GE crops, and provides absolutely no support for APHIS's statement.

The final source cited by APHIS (Towery and Werblow 2010) is an undocumented, two-page executive summary of a report by the Conservation Tillage Information Center, another agribusiness-funded organization.[18] It makes numerous breathless claims about the putative benefits of biotechnology, including the entirely false claim that they have

[17] See https://www.fieldtomarket.org/members/.
[18] See http://www.ctic.org/CTIC%20HOME/MEMBERS/Members/Corporate%20Members/

reduced herbicide use. USDA NASS data show clearly that herbicide use has skyrocketed with adoption of Roundup Ready soybeans and cotton, as we have repeatedly informed APHIS over the years. With such blatant misrepresentation of a well-known and fundamental fact about GE crops, nothing in this report can be trusted.

CFS urges APHIS to make the appropriate corrections to the draft EIS, and eliminate all reference to Towery and Werblow (2010) as completely unreliable.

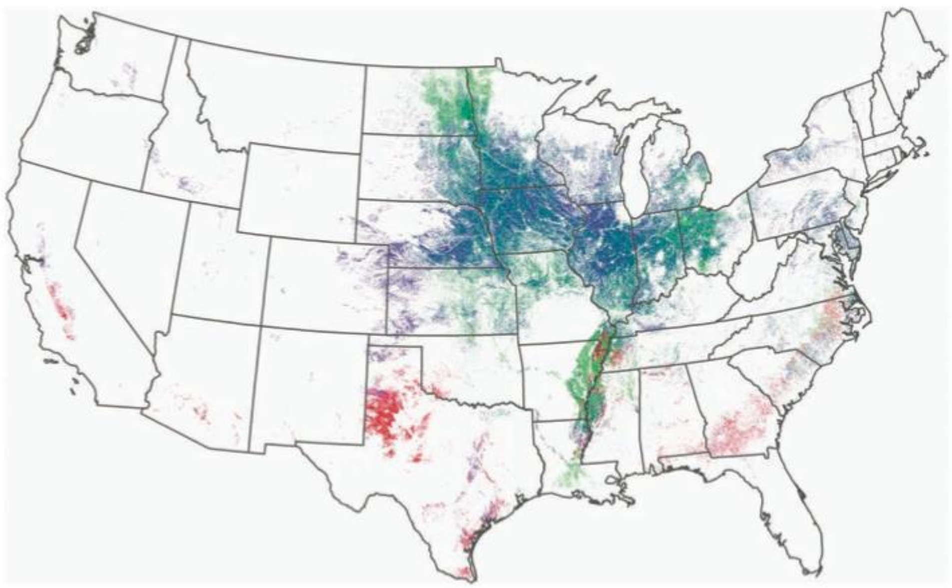


Figure 1. In 2011, approximately 26% of the land surface (558,000 square kilometers) in 12 Midwestern states (Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota, and Wisconsin) was planted almost exclusively with two plant species: corn and soybean, both of which are genetically modified for weed and insect pest management. In the map, red marks cotton fields, green is corn, and blue is soybean. The data, from 2011, were generated using the US Department of Agriculture National Agriculture Statistics Service's Cropland Data Layer Program data set.

USDA NASS CropScape map showing where corn (green), soybeans (blue) and cotton (red) are grown. The majority of corn and soybeans acres are in the 12 states of the Corn Belt, Northern Plains and Lake States, as described in text.

It is extremely important to note that ***this purported but illusory reduction in soil erosion is the sole pretext for Xtend crops, a pretext that APHIS repeats*** **ad nauseum** ***throughout he EIS to make the enormous increase in dicamba and overall herbicide use and increased weed resistance that would occur under the Preferred Alternative more palatable, and to create the false negative impression of increased soil erosion under the No Action Alternative.***

In fact, it is indisputable that tillage has sharply increased in response to glyphosate-resistant weeds generated by glyphosate use with Roundup Ready crops.

In conclusion, it should be noted that reducing soil erosion has for three decades and longer been a leading goal of U.S. agricultural policy - deservedly so, for rich topsoil is one of the most important factors that makes American agriculture so productive; and its loss through soil erosion was the major cause of one of our country's worst agricultural and human disasters – the Great Dust Bowl of the 1930s. Topsoil once lost is not readily restored, and thus preservation of this invaluable resource is of crucial importance to America's long-term well-being. Thus, the misconception that HR crop systems serve this laudable goal represents much more than deceptive pleading for deregulation of Xtend crops. It also obfuscates the true causes of soil erosion, which lie more in the policy arena, and thereby diverts attention and political will from enacting the policies needed to effectively address it.

Socioeconomic impacts of the Preferred Alternative

Sustainability is an often-claimed attribute or goal of American agriculture, yet it is easy to lose sight of what it actually means. Sustainable farming systems are "capable of maintaining their productivity and usefulness to society indefinitely. Such systems ... must be resource-conserving, socially supportive, commercially competitive, and environmentally sound."[19] By these measures, U.S. agriculture is becoming progressively less sustainable, and genetically engineered, herbicide-resistant crops have contributed substantially to this deteriorating trend.

"Socially supportive" farming systems must provide a decent income and employment for farm families, a prerequisite to healthy rural communities. Technologies that facilitate increasing scale of production through reducing labor needs have been the rule in U.S. agriculture for at least a century. They have been a major factor leading to continual consolidation of farmland in ever fewer hands, accompanied by the exit of small and mid-size producers from farming (MacDonald et al 2013) and the decline of rural communities. Many now believe it is time to switch course, and implement agricultural systems such as organic farming that do a better job of providing employment rather than saving labor.

Weed control has traditionally been one of the more labor-intensive tasks in farming. Roundup Ready (RR) soybeans have been estimated to reduce labor needs for weed control by 15% (DEIS, p. 95). USDA economists agree that: "HT [herbicide-tolerant] seeds reduce labor requirements per acre" (MacDonald et al 2013, p. 28). APHIS regards this as a "benefit" of RR crops, in that it frees up time for off-farm employment (DEIS, p. 95). However, it is unclear whether working two jobs rather than one is a benefit, since it may be an undesired consequence of insufficient income from farming. In any case, farmers may choose to employ their "saved labor" in other ways that APHIS fails to consider. For instance, RR crop growers may seek to farm more acres rather than seek off-farm employment, bidding up prices for land (including leases). Larger growers are generally in a better position to absorb these added costs, and so outcompete small and medium-size growers, who are thereby put at a competitive disadvantage and potentially put out of business. As USDA economists have concluded: "GE seeds may partly explain increased

[19] John Ikerd, as quoted by Richard Duesterhaus in "Sustainability's Promise," *Journal of Soil and Water Conservation* (Jan.-Feb. 1990) 45(1): p.4. NAL Call # 56.8 J822.

consolidation among field crop farmers since 1995" (MacDonald et al 2013, p. 27). APHIS has failed to assess the negative socioeconomic impacts of either Roundup Ready or Roundup Ready Xtend crop systems.

Likely impacts of the Preferred Alternative on human health

CFS provides a documented discussion of the likely human health impacts of the Preferred Alternative in Appendix A (pp. 46-50). We here summarize that discussion, omitting citations, and supply some additional evidence.

Dicamba exposure has been associated with increased incidence of cancer – including non-Hodgkin's lymphoma and multiple myeloma – in pesticide applicators. Exposure to pesticides has long been suspected as a risk factor in NHL and multiple myeloma due to a striking fact. While farmers are generally healthier, with lower overall cancer rates than the general population, they have higher than average risk of contracting NHL, multiple myeloma and several other cancers. This fact lends weight to epidemiology studies such as those cited above that find associations between these cancers and specific pesticides. A recent exhaustive meta-analysis covering thirty years of epidemiological investigations into links between NHL and pesticides found a 30% to 40% increased risk of NHL in farmers exposed to benzoic acid herbicides (the class to which dicamba belongs) and dicamba, respectively (odds ratios of 1.3 and 1.4) (Schinasi and Leon 2014, Table 5). More recent studies of over 50,000 farmers in Iowa and North Carolina as part of the Agricultural Health Study found suggestive associations between dicamba exposure and both lung and colon cancers.

Preconception exposure to dicamba exposure has also been associated with a greatly increased risk of birth defects in male offspring in the Ontario Farm Family Health Study. Animal experiments in which pregnant mice exposed to low levels of dicamba in drinking water had smaller litters also suggests developmental toxicity.

Dicamba may also have neurological toxicity. One study found 20% inhibition of the nervous system enzyme in pesticide applicators whose only common pesticide used was dicamba.

Dietary exposure to dicamba in the general population may also pose health risks. In Appendix A, CFS discusses how EPA has substantially raised the level of dietary exposure that the Agency considers safe from the standard that it set in 1987, a standard also endorsed by a National Academy of Sciences committee.

Under the Preferred Alternative, farmer and pesticide applicator exposure to dicamba would increase significantly due to higher rates, more applications, and more farmers applying the herbicide than ever before. Because dicamba has moderate persistence and is frequently detected in surface waters, the general population would also likely be exposed to more dicamba than ever before.

Conclusion

The Preferred Alternative would result in a massive increase in the use of dicamba, and a shift to later season applications. Dicamba-resistant weeds would rapidly emerge on a large scale, generating serious problems for farmers in the form of more difficult to control and often noxious weeds. The cost and environmental impact of weed control would continue to rise. Weak monitoring programs intended to detect auxin-resistant weeds years after they emerge will have little or no impact in forestalling weed resistance. Drift-related crop injury episodes would also rise sharply. Dicamba-resistant crops would also help foster consolidation of farmland in fewer hands. One can also expect increased disease from greater exposure to this toxic herbicide, especially in the farming community but perhaps in the general population as well. The Preferred Alternative would do no more to reduce soil erosion than the predecessor HR crop system, Roundup Ready crops, have accomplished. Approval of dicamba-resistant crops would also deepen farmers' already unhealthy reliance on an unsustainable, herbicide-only weed eradication paradigm that is rapidly failing, and delay adoption of more diversified weed management approaches (DEIS, p 171).

Under the No Action alternative, there would be a much greater likelihood that farmers would adopt healthier and more sustainable forms of weed management that rely less on herbicides. This outcome could be fostered by USDA through proper incentives for innovative integrated weed management techniques that prioritize cultural means of control, deemphasize herbicides, and help farmers get off the transgenic and pesticide treadmills (see Appendix G, pp. 32-35).

CFS would be happy to discuss the issues raised in these comments with USDA staff in the interests of a full, rigorous and scientifically credible assessment of dicamba-resistant crop systems.

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Center for Food Safety

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