No. 19-70115

UNITED STATES COURT OF APPEALS
FOR THE NINTH CIRCUIT

NATIONAL FAMILY FARM COALITION, *et al*.,

Petitioners,

v.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY, *et al*.,

Respondents,

and

MONSANTO COMPANY,

Intervenor-Respondent.

ON PETITION FOR REVIEW FROM THE UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY

PETITIONERS' EXCERPTS OF RECORD VOLUME V of IX

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[1] Unless otherwise specified, the document identifier numbers refer to their document numbers as listed in the Certified Indices, ECF Nos. 26-3 (Sections A through P), 34-3 (Section Q).

[2] Respondent United States Environmental Protection Agency (EPA) did not produce, but only provided hyperlinks to, publicly available documents. *See* ECF No. 26-3. For the Court's convenience, Petitioners have produced those hyperlinked documents in their entirety in the Excerpts of Record.

[3] This e-mail contains a hyperlink to an online article that Petitioners have produced in its entirety. For the Court's convenience, Petitioners have produced relevant hyperlinked articles in their entirely in the Excerpts of Record. Throughout the index these documents containing hyperlinks are noted with a double asterisk (*e.g.* __.__**).

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From: Green, Jamie
To: Baris, Reuben; Kenny, Daniel; Lott, Don; Trivedi, Adrienne; Vizard, Elizabeth; Wormell, Lance
Cc: Hackett, Shawn; Frizzell, Damon; Ridnour, Lacey; Taylor, Maren
Subject: FW: Shared with you: Paul.Bailey@mda.mo.gov
Date: Thursday, September 07, 2017 9:28:33 AM

FYI

From: webmaster [mailto:webmaster@deltafarmpress.com]
Sent: Thursday, September 07, 2017 8:22 AM
To: Green, Jamie <Green.Jamie@epa.gov>
Subject: Shared with you: Paul.Bailey@mda.mo.gov

Shared with you by MO Dept of Ag - Pesticide Control.

Interesting article. Might forward to OPP.

Dicamba tests showing similar results from scattered locations

Preliminary data shows agreement on formulations' volatility

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ANSWER PLOTS: The University of Missouri Columbia is conducting research to determine if dicamba drift causes yield loss in soybean fields.

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Dicamba tests showing similar results from scattered locations

Preliminary data shows agreement on formulations' volatility

David Bennett | Sep 06, 2017

As the 2017 spraying season winds down and field days begin to tail off, Mid-South weed scientists are commenting on how similar many of their preliminary dicamba research results appear. These results come from tests well scattered across the northern part of the region.

One word used frequently in their findings regarding new dicamba formulations: volatility.

Related: **What's the latest on dicamba drift in Missouri?**

"We have data that supports volatility being a part of the problem otherwise we wouldn't say it," said Kevin Bradley, University of Missouri weed scientist, in late August . "And surrounding states and research have similar data and support for the volatility bucket. What we're seeing isn't much different than what's being found in Arkansas and Tennessee."

Hoops

Related: **How might new technologies help with dicamba troubles?**

In Arkansas, University of Arkansas weed scientists Bob Scott, Jason Norsworthy and Tom Barber studied "hoop" set-ups in the northeast (Keiser), the central part of the state (Lonoke) and in the southeast (Rohwer).

"The purpose of the hoop studies was to observe if any differences existed between the old and new dicamba formulations in regards to volatility," says Barber. "Although we haven't analyzed all the locations together, it appears the data is going to fit together pretty well."

The trio looked at some of the older dicamba products like Banvel, some of the older DGA products like Clarity and compared those to XtendiMax, Engenia, Roundup Xtend (a pre-mix formulation). They also had an XtendiMax treatment with AMS, or ammonium sulfate.

"We did the tests in 'hoops.' The hoops are about 20-feet long, covering two rows of soybean. In the middle of the hoops, we placed two standard (18 x 26 in) greenhouse trays full of moistened soil from the field the research was conducted. We sprayed the soil in the trays and then set them in the hoop for 48 hours."

To avoid contamination, each individual treatment or herbicide was handled by a separate individual and those individuals were not allowed anywhere in the study except their specific treatment.

The hoops are made out of a PVC frame with visqueen plastic -- a miniature greenhouse out in the field. The ends are open and weather stations were used to take temperatures inside/outside the hoop.

Symptomology

The trays were left in the hoops for 48 hours before they were taken down.

"So, all the data – all the volatility from the hoop studies, anyway – were based on what came off the soil in those trays in those 48 hours.

"We took plant counts, percent injury and height data from the center of the plot in both directions, either side of the center, in increments, on two rows. Usually, with dicamba injury, symptoms begin showing up about 14 days after application. So, we collected data at 14, 21, and 28 days.

"What we were looking for was dicamba symptomology on soybean, the number of plants showing symptoms, and if there was any reduction in height. The biggest thing that stuck out in all the hoop trials was some of the first dicamba formulations like the acids or DMA salts had very high volatility. That led to very high soybean injury to the plants in the hoop as well as reduction in plant height."

One of the highest injury-causing treatments was when AMS was mixed with XtendiMax. "The AMS caused the DGA salt in XtendiMax to disassociate from the parent acid. That allowed the parent acid to readily volatilize, resulting in a lot of injury to the plots."

When it came to Clarity, a DGA salt, "we had less visual injury symptoms than with dicamba acids, with Banvel, or when we added AMS to DGA salts.

Statistical differences?

"At this point, we don't know if there will be any statistical differences between Clarity, Engenia, and XtendiMax in terms of volatility because the data have not been analyzed. What we do know is they all injured soybeans to some extent in the rows where the trays were placed.

"Now, in one location, injury from Clarity may have been higher than Engenia or Xtendimax than in another but, when the data is all brought together from these three locations, I don't expect there will be large differences. I believe the data will show anytime we put AMS with a dicamba formulation we'll significantly increase volatility. If older formulations like Banvel are used, DMA salts or the dicamba acids, you'll also see an increase in volatility and subsequent injury."

Regardless of whether or not researchers are able to statistically separate Engenia and XtendiMax from Clarity, "they all volatilized enough to cause some level of injury and it was, significant enough to notice (3 to 10 percent). Remember the scale; we are talking about injury from only two 18x26 in trays of soil sitting inside the hoops for 48 hours."

Going in, the trio was "just trying to tease out differences between the dicamba formulations," says Barber. "The claims going in said these formulations would show a significant reduction in volatility over older products like Banvel and Clarity.

"Based on these preliminary data we have now, I agree those formulations are less volatile than Banvel, other DMA salts or dicamba acids. But in terms of soybean response, it doesn't appear that the volatility is greatly reduced from Clarity, a standard DGA salt that is widely used. Again, this is preliminary.

However, "even if these new products show reduced volatility, they are still volatile and can cause injury."

In other studies , the Arkansas researchers "sprayed 3 to 4 acres in a sensitive soybean field and either covered plants with buckets or inserted plants from the greenhouse we are observing volatility up to 48 hours after application.

Barber points to a term – "atmospheric loading" -- used frequently during the dicamba spraying controversy. "The research tells us that because these newer formulations remain volatile they can potentially load the atmosphere with dicamba. Is that the only way to load it? Nope. But we know when you spray a dicamba product over large acreage the amount available to volatilize, and the amount that can fill the air, can continue to increase for at least 48 hours."

Source URL: http://www.deltafarmpress.com/soybeans/dicamba-tests-showing-similar-results-scattered-locations

From: Sorokin, Nicholas
To: AO OPA OMR CLIPS
Subject: Reuters: Exclusive: EPA eyes limits for agricultural chemical linked to crop damage,9/5/17
Date: Tuesday, September 5, 2017 10:40:40 AM

Reuters
http://www.reuters.com/article/us-usa-pesticides-epa-exclusive/exclusive-epa-eyes-limits-for-agricultural-chemical-linked-to-crop-damage-idUSKCN1BG1GT
Exclusive: EPA eyes limits for agricultural chemical linked to crop damage
By Tom Polansek and Emily Flitter, 9/5/17

(Reuters) - The U.S. environmental agency is considering banning sprayings of the agricultural herbicide dicamba after a set deadline next year, according to state officials advising the agency on its response to crop damage linked to the weed killer.

Setting a cut-off date, possibly sometime in the first half of 2018, would aim to protect plants vulnerable to dicamba, after growers across the U.S. farm belt reported the chemical drifted from where it was sprayed this summer, damaging millions of acres of soybeans and other crops.

A ban could hurt sales by Monsanto Co (MON.N) and DuPont which sell dicamba weed killers and soybean seeds with Monsanto's dicamba-tolerant Xtend trait. BASF (BASFn.DE) also sells a dicamba herbicide.

It is not yet known how damage attributed to the herbicides, used on Xtend soybeans and cotton, will affect yields of soybeans unable to withstand dicamba because the crops have not been harvested.

The Environmental Protection Agency (EPA) discussed a deadline for next year's sprayings on a call with state officials last month that addressed steps the agency could take to prevent a repeat of the damage, four participants on the call told Reuters.

It was the latest of at least three conference calls the EPA has held with state regulators and experts since late July dedicated to dicamba-related crop damage and the first to focus on how to respond to the problem, participants said.

A cut-off date for usage in spring or early summer could protect vulnerable plants by only allowing farmers to spray fields before soybeans emerge from the ground, according to weed and pesticide specialists.

Monsanto spokeswoman Christi Dixon told Reuters on Aug. 23, the day of the last EPA call, that the agency had not indicated it planned to prohibit sprayings of dicamba herbicides on soybeans that had emerged. That action "would not be warranted," she said.

The EPA had no immediate comment.

EPA officials on the last call made clear that it would be unacceptable to see the same extent of crop damage again next year, according to Andrew Thostenson, a pesticide specialist for North Dakota State University who participated in the call.

They said "there needed to be some significant changes for the use rules if we're going to maintain it in 2018," he said about dicamba usage.

State regulators and university specialists from Arkansas, Missouri, Illinois, Iowa and North Dakota are pressuring the EPA to decide soon on rules guiding usage because farmers will make planting decisions for next spring over the next several months.

Tighter usage limits could discourage cash-strapped growers from buying Monsanto's more expensive dicamba-resistant Xtend soybean seeds. Dicamba-tolerant soybeans cost about $64 a bag, compared with about $28 a bag for Monsanto's Roundup Ready soybeans and about $50 a bag for soybeans resistant to Bayer's Liberty herbicide.

Already, a task force in Arkansas has advised the state to bar dicamba sprayings after April 15 next year, which would prevent most farmers there from using dicamba on Xtend soybeans after they emerge.

Arkansas previously blocked sales of Monsanto's dicamba herbicide, XtendiMax with VaporGrip, in the state.

"If the EPA imposed a April 15 cut-off date for dicamba spraying, that would be catastrophic for Xtend - it invalidates the entire point of planting it," said Jonas Oxgaard, analyst for investment management firm Bernstein.

Monsanto has projected its Xtend crop system would return a $5 to $10 premium per acre over soybeans with glyphosate resistance alone, creating a $400-$800 million opportunity for the company once the seeds are planted on an expected 80 million acres in the United States, according to Oxgaard.

By 2019, Monsanto predicts U.S. farmers will plant Xtend soybeans on 55 million acres, or more than 60 percent of the total planted this year.

RISKY DRIFT

About 3.1 million acres of soybeans vulnerable to dicamba were hurt by sprayings this summer, accounting for 3.5 percent of U.S. plantings, according to the University of Missouri.

Chemical companies have blamed the crop damage on farmers misusing the herbicides.

Specialists, though, say the weed killers are also risky because they have a tendency to vaporize and drift across fields, referred to as volatility. Summer can be a riskier time for sprayings, they said, because high temperatures can increase volatility.

Monsanto previously denied requests by university researchers to study its XtendiMax herbicide for volatility, as previously reported by Reuters. In the end, the EPA gave dicamba weed killers from Monsanto and BASF abridged two-year registrations, less than the five years experts say is more common.

To address the crop damage, the EPA has also asked state officials about enhanced training for dicamba users; tighter restrictions on when and how the herbicides can be sprayed; and the possibility of reclassifying the products so the general public could not buy them, according to participants on the call.

“Everything is an option,” said Jason Norsworthy, a University of Arkansas professor who was on the call.

Monsanto Chief Technology Officer Robb Fraley said in a statement that the company was communicating with the EPA, which is “evaluating potential actions to facilitate enhanced training and compliance for 2018.”

DuPont, too, is working with the EPA and state regulators on issues involving its dicamba herbicide, FeXapan, spokeswoman Laura Svec said.

Rival BASF “could see some label enhancements” to its dicamba herbicide, Engenia, if the EPA requires changes, spokeswoman Odessa Hines told Reuters. The company “will be as flexible as possible” so farmers can use the product, she said.

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From:	Wyatt, TJ
To:	Becker, Jonathan; OPP BEAD BAB; OPP BEAD EAB; Jones, Arnet; Rowland, Grant; Kenny, Daniel; Rosenblatt, Daniel; Baris, Reuben; Montague, Kathryn V.; Meadows, Sarah
Subject:	RE: FYI - WP article on dicamba
Date:	Thursday, August 31, 2017 8:32:06 AM

You all probably saw the Washington Post article yesterday.

https://www.washingtonpost.com/business/economy/this-miracle-weed-killer-was-supposed-to-save-farms-instead-its-devastating-them/2017/08/29/33a21a56-88e3-11e7-961d-2f373b3977ee_story.html?utm_term=.f557dc9ebdd1

From: Becker, Jonathan
Sent: Thursday, August 31, 2017 7:40 AM
To: OPP BEAD BAB <OPP_BEAD_BAB@epa.gov>; OPP BEAD EAB <OPP_BEAD_EAB@epa.gov>; Jones, Arnet <Jones.Arnet@epa.gov>; Rowland, Grant <Rowland.Grant@epa.gov>; Kenny, Daniel <Kenny.Dan@epa.gov>; Rosenblatt, Daniel <Rosenblatt.Dan@epa.gov>; Baris, Reuben <Baris.Reuben@epa.gov>; Montague, Kathryn V. <Montague.Kathryn@epa.gov>; Meadows, Sarah <Meadows.Sarah@epa.gov>
Subject: FYI - BNA article on dicamba

Pesticides
As Dicamba Dust Settles, Scientists and Industry Spar

Snapshot
• Widely used weedkiller sparks debate over damage caused to neighboring farms
• Scientists, industry at odds over causes, impacts, solutions
By Tiffany Stecker
Arkansan soybean farmers are wrapping up a summer of harvesting bumper crops alongside the crippling devastation of their neighbors' fields. The same herbicide is causing both optimism and bitterness in the region, and discussions over its future use is dividing farmers, scientists, and industry.
Dicamba, a weedkiller first registered in 1967, has undergone a makeover to fight weeds immune to most herbicides. BASF Corp., Monsanto Co., and DuPont this year stocked new versions of dicamba, designed for use with Monsanto's soybeans and cotton that are genetically-engineered to withstand the new herbicides. But the herbicide spread easily to neighboring farms, falling on vulnerable crops.
This summer was one the best growing seasons in years for Arkansans in terms of controlling insidious weeds that creep into fields. It also was a year of unusual harm to nearly a third of the state's soybean crops, marked by curled leaves, stunted growth, poor yields, and J-shaped pods that have been tied to new formulations of the herbicide.
What was a blockbuster year for many growers cost others millions of dollars, pitting farmer against farmer and scientists against the herbicide's manufacturers.
State university scientists believe the new formulations can't be managed to control the damage. They easily evaporate, or "volatilize," and can spread potentially thousands of feet over a couple of days into a neighbor's field.

"As a weed scientist, I can't tell you how to fix this problem," Jason Norsworthy, an extension scientist with the University of Arkansas told a group of farmers and industry representatives Aug. 17.

The manufacturers are loathe to blame volatility, saying the herbicides were studied extensively before their launch earlier this year. The damage, they say, could be due to errors in applying the herbicide, poorly written instructions, and generally weak control of physical drift—the travel of liquid droplets of dicamba via wind or weather patterns.

To avoid a repeat of the disaster next year, Arkansas' Plant Board convened a task force of growers and trade association representatives to craft recommendations on the spraying of dicamba.

On Aug. 24, the task force agreed to develop preliminary recommendations for the Plant Board to send to the governor. The panel suggested that the Plant Board impose an April 15 cut-off date for spraying the chemical and thereby prevent spraying in the hot summer months. The cut-off date also effectively would bar use of the herbicide for many farmers, given that most of the soybean planting happens in May.

The task force will incorporate the recommendations in a formal report due in the next three weeks. If implemented by the Arkansas Plant Board, the recommendations will drive hundreds of farmers' decisions next year. A compromise between those who have gained from the new dicamba and those who have suffered won't be easy. Farmers in Arkansas have been clamoring for solutions to their weed problems for years, and are feeling the pressure of declining grain prices that can threaten the viability of their farm operations in just one season.

Grasping for Solutions

"It's something that we desperately need to control the weeds," Justin Blackburn, a 33-year old, eighth generation soybean and corn grower in Northeastern Arkansas, told Bloomberg BNA. "We're grasping for anything that works."

Hundreds of thousands of soybean acres, plus trees, vegetables crops, and flowering plants that feed honeybees, have shriveled this year as the new product for killing weeds came on the market.

Soybeans are particularly sensitive to dicamba. The only crops that are safe are Monsanto Xtend seeds that are genetically engineered to withstand the herbicide. About 35 percent of the soybeans planted this year in the state are Xtend crops.

"We've got some serious issues we've got to address," Wes Ward, the state's Agriculture Secretary, told Bloomberg BNA. "We're hoping that this task force...can try to nail this down a little better."

In preparing its recommendations, the 19-person panel must consider conflicting information from university researchers and the manufacturers of the new herbicide.

Manufacturers hailed new formulations as a cure for stubborn weeds that suffocate crop yields. The aptly-named pigweed—also called palmer amaranth—began to resist applications of the widely-used weedkiller glyphosate after the turn of the 21st century. Weeds also have developed resistance to another class of herbicides called protoporphyrinogen oxidase (PPO) inhibitors. Resistant weeds can cut yields by up to 91 percent in corn and up to 79 percent in soybean, according to Purdue University Extension.

The new products were made to be less prone to evaporate and spread to neighboring fields than the dicamba of the past. But starting in late May, complaints began to mount. Dozens of calls to the Plant Board turned to hundreds. To date, 950 complaints have been filed.

The State Plant Board voted to ban spraying of dicamba in crops on June 23. As of Aug. 10, an estimated 900,000 acres of Arkansas soybean fields have been allegedly damaged by dicamba, according to state extension scientists, about one-third of the total soybean damage for the nation as a whole.

Ground Zero

Dicamba works by mimicking plant hormones that make weeds grow abnormally and eventually die. More than 2,200 reports of dicama injury, affecting more than 3 million acres of soybeans, are being investigated nationwide, according to the University of Missouri's Integrated Pest Management program. Northeastern Arkansas is ground zero for the damage.

In Mississippi County, a sprawling horizon of soybean and cotton fields one hour northwest of Memphis, Tenn., 240 dicamba misuse complaints were filed this year—one quarter of all of the complaints in the state.

David Wildy, a task force member who pushed for an April 15 cutoff date for spraying the chemical, is one of the most vocal critics of the new formulations. A silver-haired grower of soybeans, corn, and other crops from Manila, in the northeastern part of Arkansas, he's earned awards for his high production, management style, and outreach to the agricultural community.

Earlier this season, Wildy estimated his loss from soybean damage to be a little shy of $1 million, injury that is not covered by federal crop insurance or private insurance unless a neighbor admits to spraying dicamba and agrees to cover the loss with liability insurance.

"This technology is driving a wedge between farmers," he told Bloomberg BNA.

Arkansas was the only state of 34 not to approve XtendiMax for use, despite allowing farmers to plant Extend seeds that can withstand applications of dicamba. The Plant Board denied XtendiMax's approval because university scientists were not able to do independent tests, particularly under local conditions, Arkansas Agriculture Department spokeswoman Adriane Barnes told Bloomberg BNA in an email. This dampened their confidence in the product.

In A Pickle

Monsanto's vice president of global strategy Scott Partridge said the refusal to approve the use of Xtendimax drove farmers to use older versions of dicamba not suitable for use with the company's genetically-modified seeds. It's no surprise that Arkansas has fared the worst in the dicamba crisis, Partridge told Bloomberg BNA.

"I can understand why Arkansas is scrambling," he said. "I think they got themselves into a bit of a pickle."

Some states that have seen little to no problems with dicamba, a pattern BASF attributes to more in-person training. Arkansas Agriculture Secretary Ward told Bloomberg BNA that his state relied on the protocol for Mississippi, which did not require face-to-face training.

On a press call Aug. 17, BASF pointed to the in-person training in states like Alabama, North Carolina, and Georgia as a likely reason for fewer complaints in those states.

"We do recognize differences in agriculture around the country, but we shouldn't be quick to discount the value of in-person and face-to-face training," Scott Kay, vice president of U.S. Crops forBASF, said. "We do believe that's an important contributor to their reduced numbers of alleged complaints coming from those states."

But Norsworthy said those differences could be attributed to different agricultural systems, like smaller fields and forests interspersed with farmland.

In that county, a farmer was shot and killed after a dispute with a dicamba-spraying neighbor last year. At the time, Xtend seeds were legal, but the Environmental Protection Agency had not yet approved the new versions of dicamba, leading to widespread "off-label" use. It is illegal to use older versions of dicamba on the genetically-engineered plants.

This year was supposed to be different. The EPA approved the new formulations last November, more than a year after the Agriculture Department allowed for Monsanto's Xtend seeds to go on the market. But this year's calls to the Arkansas Plant Board have far outpaced last year's 33 complaints, 23 of which were confirmed to be dicamba injury.

Record Soybean Crop

The crisis won't lead to a national soybean shortage. On the contrary, the U.S. is set to break its soybean record this year, and Arkansas is expected to produce 400,000 more acres than in 2016, with a slight increase in yields per acre, according to USDA. Monsanto Chief Technology Officer Robb Fraley said Aug. 29 that the company is planning to supply enough Xtend seeds for up to half of the U.S. soybean acreage for next year's growing season.

But that gain comes at a significant cost, Wildy said. Sycamore trees are wilting. Tomato plants are wiped out. Wildy needs and wants the technology. But if this is the price of progress, he says, it's not worth it. Non-agricultural plants—from ornamental trees to flowers that feed honeybees—have been affected too.

"When the general public gets involved, to me that's very serious," he said, referring to the broader number of groups affected.

Wildy planted about 300 of his 3,300 soybean acres with Xtend seeds this year. He said he will plant more next year as a protective measure if the state Plant Board allows continued use. Farmers pay about $8 more per acre for dicamba-resistant beans than for LibertyLink seeds, Bayer AG's technology that matches glufosinate-tolerant crops to a new version of the herbicide glufosinate—another result of farmers' clamor for tools to beat weeds.

Arkansas farmer Blackburn tends to 1,700 acres with his brother in Greene County. Last year, he was hit with a wave of dicamba that damaged his soybeans. This year, he went on the defense. The brothers planted every acre of their soybeans to be dicamba-resistant. It was an extra expense, he said, but worth it. It worked wonderfully until late June, when the state imposed its ban.

That bothers Blackburn. This new technology has brought benefits to farmers, and smearing the formulations with a broad brush means a step backwards.

"We followed all of the regulations, all of the guidelines," he said. "They're sort of making it out to be that everybody who sprays this stuff is an outlaw, is a criminal."

Still, Blackburn thinks the product is "flawed" because it's been so easy for farmers to misuse.

An April 15 cutoff wouldn't work for Blackburn, who spends that month planting corn and begins sowing soybeans in May.

'This Is A Product That Is Broken'

The task force meetings on Aug. 17 and Aug. 24 were held at the Winthrop Rockefeller Institute, atop the fog-covered Petit Jean Mountain north of Little Rock. Named after the state's Republican governor who pushed for civil rights and prison reform in his state, the resort-like stone lodge serves as a neutral outpost to discuss the region's most pressing matters, from rural healthcare to agricultural trade with Cuba.

The dicamba matter may be the most contentious issue addressed there yet. Norsworthy gave an hour-long presentation to the audience of about 50 at the Aug. 17 meeting, summarizing a number of his field studies on the new dicamba formulations.

In one experiment that was replicated by scientists at the University of Tennessee, Norsworthy covered certain soybeans with buckets in a field where he sprayed XtendiMax (Monsanto's dicamba herbicide) and Engenia (BASF's new formulation). He removed the buckets 30 minutes after spraying, and soon after, the plants exhibited the telltale signs of dicamba damage. Had it been drift, the weedkiller would have moved away from the areas in minutes, Norsworthy said.

In another trial, Norsworthy sprayed two 3.5 acre plots with Engenia and XtendiMax each, with wind traveling 2.9 miles per hour. Though applied well below the label instruction limit of 15 miles per hour, the herbicide traveled more than 300 feet. With field sizes in the thousands of acres, a real life situation could see dicamba travel well beyond the state's quarter-mile buffer zone, he said.

His conclusion: When it comes to volatility, there's no buffer big enough, no nozzle spray fine enough, no wait period long enough, to control the movement. Drift can be controlled by the type of nozzle, by the boom height, and by refraining from spraying at times of high wind speed and at certain times of the day.

The distinction between drift and volatility is important. Regulations and label instructions on its use can control physical drift. Volatility is uncontrollable, Norsworthy said.

"This is a product that is broken," he told the task force Aug. 17.

Those findings bristled the handful of manufacturer representatives present, who had just a few minutes to defend their new herbicides. The presentation, they said, would taint farmers' opinions of the product and bring on hasty recommendations to restrict a necessary tool for clearing weeds.

"I wasn't happy with the process," Dan Westburg, a BASF technical services manager with a doctorate in weed science, told Bloomberg BNA at the meeting.

Companies worked hard to suppress this in their new formulations. Monsanto's proprietary VaporGrip technology was developed specifically to reduce volatility by preventing the formation of dicamba acid in a solution.

Perry Galloway, a farmer in Northeastern Arkansas and proponent of the technology, agreed that a presentation from only the extension scientists was "biased."

'Dicamba Is Heavier Than Air'

The companies brought their concerns to the Arkansas Plant Board. A week later at the second task force meeting, Monsanto deployed three scientists to defend their data. BASF had one presentation.

Monsanto has conducted extensive volatility studies since 2009, company scientists said at the Aug. 24 meeting. Those studies, mostly done in closed enclosures called humidomes, show that dicamba concentration in the air drops dramatically in the first day, meaning it can't volatilize and travel far.

"Volatility does occur, it absolutely occurs, but the amount that occurs will happen very quickly in 24 hours," Ty Witten, North America Crop Protection Systems Lead for Monsanto, told the participants. "Dicamba is heavier than air, it's going to fall over time."

Can dicamba drift? Yes, said Witten, maybe by 40 or 100 feet. But not by half a mile or ten miles, as some have suggested.

Tom Mueller, a professor of weed science at the University of Tennessee Institute of Agriculture, challenges this 24-hour claim from Witten in recent trials. He found that dicamba concentrations in the air can shoot back up the day following an application after dipping overnight.

Mueller has repeated this trial several times. "It always follows the same pattern," he told Bloomberg BNA.

Mueller attributes the increase in concentrations to higher temperatures the following day rather than in the evening. Heat drives volatility, and researchers link the dicamba problems to a relatively new phenomenon in its use. Older formulations were applied only on corn in the cooler temperatures of early spring, he said, whereas the new versions are being sprayed in 90-degree June weather.

The EPA ultimately will decide the herbicide's future. The agency gave companies a provisional two-year registration for the herbicides in 2016 and it is investigating the complaints and meeting weekly with Arkansas and other states affected via teleconference.

The underlying causes of the various cases of damage are not yet clear, EPA spokesman Robert Daguillard said, "but EPA is reviewing the available information carefully."

If the EPA revokes the registration, or imposes greater restrictions, on use of the herbicides, they would not go into effect until the 2019 growing season. That leaves another year of rising tensions in the Heartland.

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Editors' Notebook

Dicamba's PTFE Problem

8/29/2017 | 4:45 PM CDT

By Greg D Horstmeier , DTN Editor-in-Chief

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It's hard to know every compound that goes into a herbicide, particularly all the bits covered by that "inert ingredients" descriptor on the label.

One thing I was confident that was not part of any herbicide formulations is a little compound known as poly (1,1,2,2-tetrafluoroethylene). You may have seen that shortened to PTFE. Most of the world knows it as Teflon.

These days, however, I'm inclined to look harder at the labels of anything connected to dicamba and the Xtend, or dicamba-tolerant, seeds. For it seems this new weed-control package is completely lathered in the non-stick stuff, given the "It's not our fault" reactions to the reports of off-field movement and damage related to dicamba.

The latest University of Missouri-gathered total puts the low-end of damage due to chemical trespass occurrences at around 3.1 million acres in at least 20 states. State ag departments have more than 2,200 official damage reports on file. Yes, some of those may be false reports due to dicamba paranoia. I'd counter that number also does not include farmers and others who failed to report but peacefully resolved issues "over the fence."

Every farmer meeting we attend, every conversation we have with real producers and applicators, indicates this is the subject of the year. Still, no one is responsible. To some in the herbicide industry, it isn't even happening. Move along, nothing to see here.

The responsibility-deflection process started almost immediately. In 2016, when industry pushed to be allowed to sell the traited seeds, without the new and improved herbicides designed to go with them, we all held our breath and waited for the inevitable. When crop damage and the angry, even deadly, confrontations around dicamba made headlines, industry response was swift.

"Not our fault. We had meetings. We told them not to use old dicamba products."

Even EPA got blamed, for not approving the improved dicamba products fast enough.

This season, with those improved products in hand and wrapped in some of the most stringent label requirements ever, the damage reports started as soon as sprayers started running in the Delta.

So did the deflection.

There's no proof this is dicamba damage, we were told. It's certainly not the new herbicides, these are improved formulations. It's due to weather extremes, unusual Delta conditions, contaminated Liberty drift, or my personal favorite: Some soybeans just pucker on their own.

Referencing those excuses, one veteran weed scientist was reported to have said, through clenched teeth, "I think I know what (expletive) dicamba symptoms look like."

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Today, we've talked to many farmers who did everything by the book, paid attention to all label requirements, and still damaged neighbors' crops, trees and lawns not just across the fence, but a mile, 3 miles, even 5 miles away. I'm talking about farmers in North Dakota and Minnesota, not just in the humid Delta.

The Teflon response hit its zenith with me during a recent press conference on dicamba with Monsanto's science chief, Robb Fraley. DTN asked how farmers should square the fact that practically every university weed scientist in soybean country was reporting significant dicamba damage, while Fraley's statements to the press told of only a tiny amount of issues, and those he blamed on applicator errors or the weather.

"I'd have to agree that there's a mixed view," Fraley said. "I would point out that back in 1996, there were mixed views from some of the weed scientists about the adoption of Roundup Ready technology, too," he continued.

Indeed, there is quite the history of alternative facts between that company and the weed science community. Allow me to take you on a little mental detour about that.

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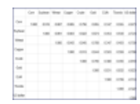

Greg Horstmeier

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The story starts at a Weed Science Society of America meeting in Seattle, some time around 1994 or '95, as U.S. farmers were anticipating the first Roundup Ready seed sales. At that meeting, Australian weed scientists presented research that showed the repeated use of glyphosate had quickly led to resistant ryegrass across the wheat-growing areas of "Oz."

I was at that meeting, and heard the Aussies implore their U.S. counterparts, "Don't let this happen here."

It won't happen, Monsanto representatives said sternly in speeches immediately following those presentations. There was no proof U.S. weeds would become resistant to glyphosate, they continued. Ryegrass wasn't a significant problem here. The Australian research had no relevance.

Weed scientists in the room were dumbfounded. But the promise of that silver bullet -- Roundup Ready -- was strong in the marketplace. Farmers couldn't wait to get their hands on it. The idea of slowing adoption by some kind of regulatory action or restrictions on use was deemed downright un-American.

Fast forward a couple of years after that meeting, as weed-control problems started popping up in RR fields.

Each new find got the same initial response from the corporate PR machine: "It's not resistance." Rather, blame was placed on "poor applications," "adverse weather conditions," and my personal favorite: "Difficult-to-control species." In other words, it was the weed's fault.

Soon, those deflected situations became known by names that eventually stuck: Glyphosate-resistant marestail, glyphosate-resistant tall waterhemp, and glyphosate-resistant Palmer amaranth, to state but a few.

There has never been a serious discussion about how the proliferation of those weeds might have been avoided. The denial continued until the problem could no longer be denied. Then blame was laid at farmers' and applicators' feet.

"We had meetings. We told them to use multiple modes of action. Not our fault." Farmers began clamoring for a new silver bullet, and corporate talk quickly shifted to the latest invention, dicamba-tolerant seeds.

So, back to those seeds.

On Aug. 9, the American Soybean Association announced it was going to step into the current dicamba issue.

"ASA is invested in bringing all parties together to find answers and solutions," that organization's president and Illinois farmer Ron Moore said in a news release.

That's truly necessary. As we've said many times in these pages, farmers need all the help they can get, including dicamba, to battle those now infamous, but all so real, resistant weeds.

We have to find a way to use the technology cautiously, sparingly. We have a large-scale chemical trespass mess with only 25 million acres of the seed planted in 2017. Those in the know, and by that I mean those who will acknowledge there actually is a problem, say at least some of the damage is due to the impossibility of spraying all the acres needed in proper weather conditions. There just aren't enough perfect spraying days.

How's that going to get better when we increase, perhaps even double, the Xtend acreage, as Monsanto is predicting for 2018?

I'm told ASA realizes it needs to work quickly, as farmers will be buying 2018 seed soon. For more on that, see Pam Smith's article on the seed buying dilemma at http://bit.ly/...

Teflon can seem like a miracle for slick, easy post-breakfast clean up. But it's easily undone. One jab with a metal fork while flipping some bacon and that magical coating can start to come apart.

So I applaud ASA and its farmer leaders for starting to poke around into what's really going on with dicamba. Hopefully, they'll do more than scratch the surface on this.

For the latest info on dicamba issues, see "Dicamba Answers" by DTN staff reporters Russ Quinn and Emily Unglesbee: http://bit.ly/...

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EPA Responds to Dicamba Complaints

by:- Ag Professional

Since June 2017, the EPA has learned of formal dicamba off-target complaints for this growing season. And as the soybean season progressed, those complaints continued north into Ohio, Nebraska, Minnesota, North Dakota and South Dakota.

“The agency is very concerned by off-field dicamba damage,” says Reuben Baris, acting branch chief of EPA’s Office of Pesticide Programs, Registration Division herbicide branch. “The underlying causes are not yet entirely clear. We are evaluating all available information.”

There have been 2,400 formal dicamba complaints. There are 3.1 million acres of soybeans affected, and that total doesn’t include other crops.

“We don’t consider this normal growing pains for a new technology,” says Dan Kenny, Office of Pesticide Programs, Registration Division Deputy Director (Acting). “We don’t feel it’s helpful to solve a problem for one grower and create a problem for another.”

The agency officials say the issue with dicamba is very dynamic, and as soon as numbers are reported, they are outdated.

The regulatory agency is reacting to potentially make changes for the 2018 growing season. Of note, EPA has regulatory oversight for the pesticides—not the traited seed.

“We are working as fast as we can to make meaningful changes for the 2018 growing season. We are working with the registrants to make meaningful regulatory changes so growers are able to make the most informed decisions for the 2018 season," Baris says.

Additionally, the current follow up is informing the approval process for the dicamba formulations, BASF's Engenia and Monsanto's XtendiMax with Vapor Grip Technology, which is also licensed to DuPont and sold as FeXapan, which were registered with a two-year expiration timeframe.

"The 2-year expiration was put in place because of the concerns about resistance and off-target movement. After our review a few things could happen. The expiration could be removed if everything is working well. In the worst-case the risks outweigh the benefits, and the registration expires," Kenny says.

While the expiration provides a looming deadline, it could be a tool to find resolution.

"Expirations can help get everyone at the table in a short time frame. We hope we can make this a workable program. More tools are important for growers. We have to ensure these products meet the registration standard in order to protect human health and the environment, otherwise, our hands are tied," Kenny says.

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August 28, 2017

On August 2, 2017, the IFCA Board and staff at the IFCA sent a dicamba management survey to our ag retail members only, and asked them to respond to the survey by August 11, 2017. We used the SurveyMonkey platform for the survey.

IFCA has 178 ag retail companies as members. There are 491 individual members linked to the main company membership. These individual members include individuals who are the general managers of an ag retail entity, plant managers, agronomy managers and commercial applicators. Our ag retail members include company owned organizations, regional cooperatives, large, mid-size and small independent retailers and mid-size and small cooperatives. IFCA's ag retail members in Illinois are a varied blend of ownership and management styles, and all support the mission of the IFCA which is *to assist and represent the industry and promote the sound stewardship and utilization of agricultural inputs*.

We received 124 responses to the survey. In many cases, the main ag retail office replied on behalf of all their branches and applicators, thus in many cases one response reflected the experiences of dozens of branch offices and applicators. We are very pleased with the response rate to this survey.

In addition to this survey, IFCA staff fielded many calls over the summer from our members expressing concern with the issues they were dealing with relative to the use of dicamba on soybeans, and asking IFCA for assistance and guidance on the issue.

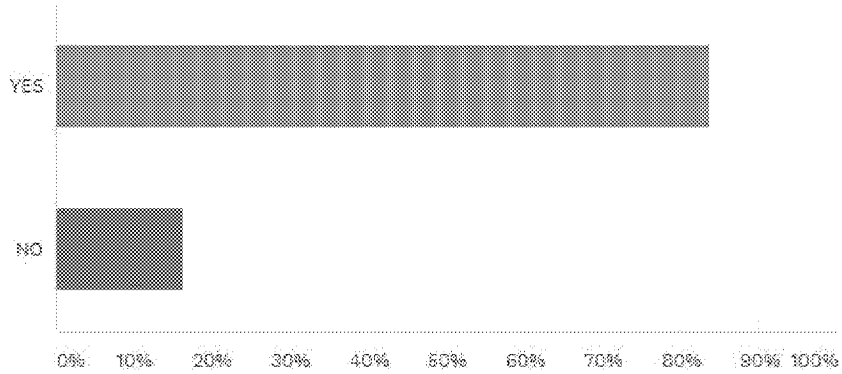
The survey responders answered the questions, but also provided extensive written comments. The IFCA Board and staff evaluated all the written comments provided by the retailers; we have summarized the most common suggestions and statements provided by our retail members following each survey question.

IFCA will share this report with our members, with key stakeholders including farm groups and with our partners in the pesticide policy and regulatory arena. Our members clearly wish to improve the use of this new technology not just for these particular dicamba herbicides, but to ensure sound stewardship and policy relative to all pesticide uses. IFCA is committed to providing leadership toward the development of methods that will enhance a trained applicator's ability to make the best possible decisions based on scientific data and a practical regulatory framework. IFCA members are very cognizant of their stewardship responsibilities, and aware of the expectations of farmer customers and the public relative to how we successfully manage all pesticides, and nutrients. Society rightfully expects the pesticide industry to successfully co-exist in increasingly diverse rural and urban communities.

Please direct questions about this survey to Jean Payne, IFCA President, at (309) 827-2774 or jeanp@ifca.com. Visit our website at www.ifca.com for an overview of the programs and issues managed by IFCA on behalf of our members. The IFCA dicamba management survey results follow.

If you applied dicamba to soybeans, did you experience any instances of symptoms in adjacent sensitive soybean fields? If NO, please provide the approximate number of soybean acres you treated with dicamba. Then proceed to question #26 to provide information on your experience with the product.

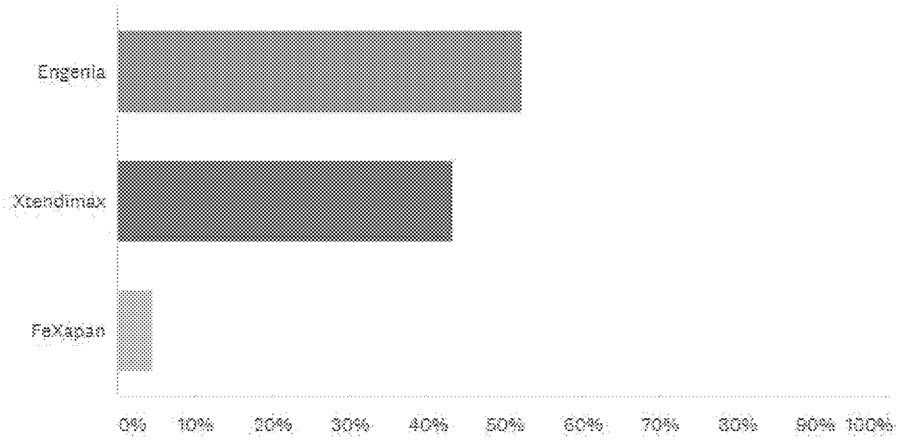
Answered: 116 Skipped: 8



The retailers applied anywhere from 100 acres to 25,000 acres, it was very mixed. The majority fell in the 350 to 3,500 acres applied category.

What formulation of dicamba did you primarily use on soybeans?

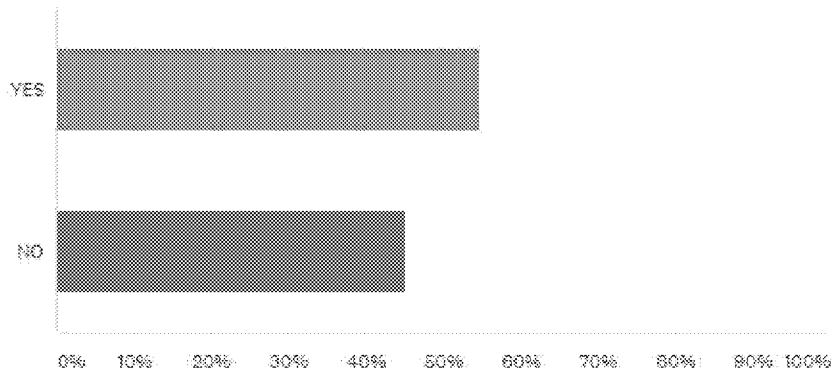
Answered: 111 Skipped: 11



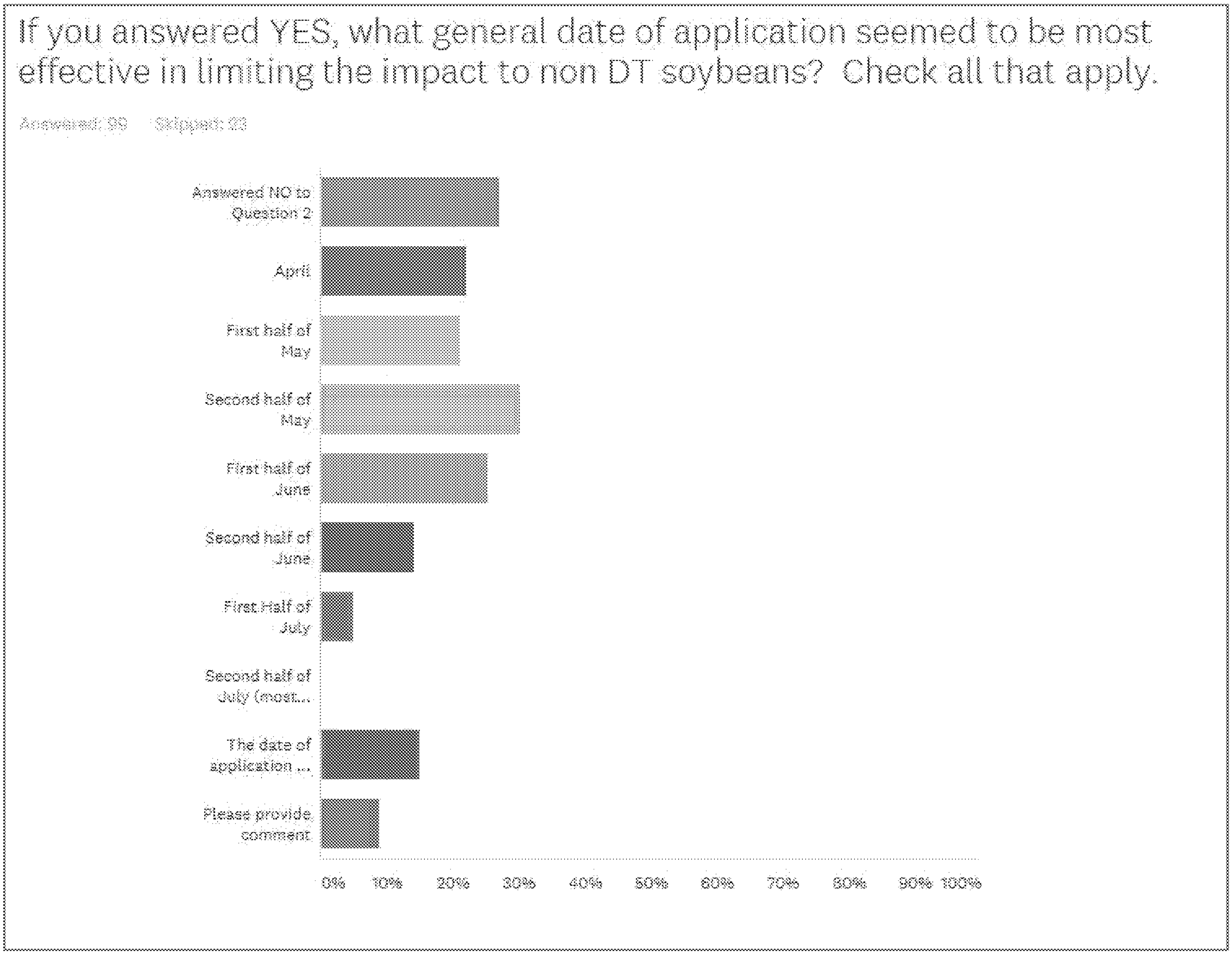
Comments: Retailers felt the performance of the products were similar in terms of effective weed control and in terms of issues with symptomology in sensitive soybeans. Several retailers commented they used all three, and observed movement of the product in all three.

In your experience evaluating fields following the application of dicamba on soybeans, did the date of application appear to have an impact on symptoms shown in nearby non DT soybeans?

Answered: 106 Skipped: 16



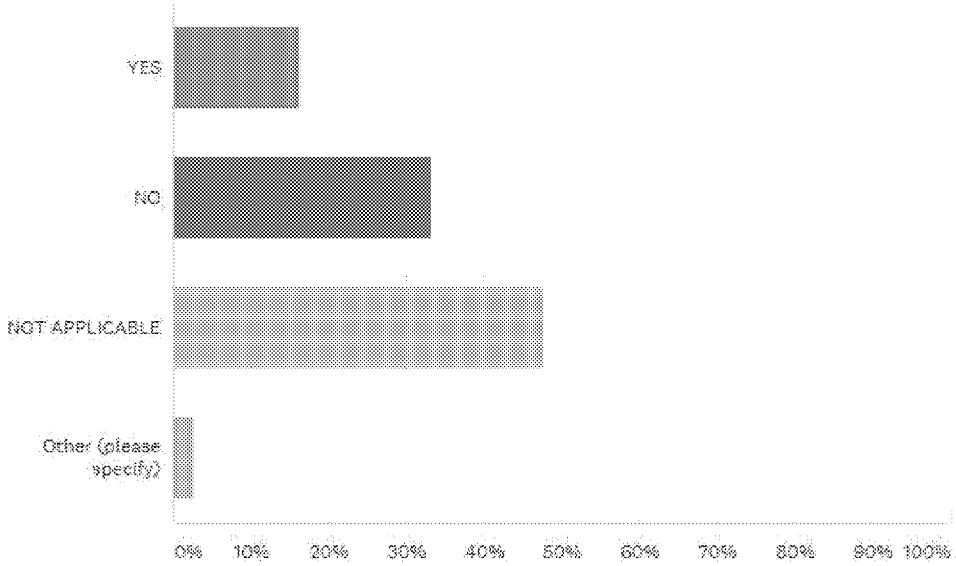
Comments: Many stated they had no issues with use of dicamba as a burn down product. Several stated that for earlier application on beans planted in April, they had no issues. Many acres were treated toward the end of June and that is when problems started, 7-10 days later. Beans started showing symptoms in late June and it increased from that point forward. Many retailers stated they applied the majority of acres in the 3rd week of June, as they felt the weather (wind speeds) finally enabled what they felt was a condition conducive to safe application. But then they observed symptoms about two weeks later. Majority of commenters stated that heat and humidity correlated with symptoms and complaints, but some commented they had problems no matter what date they applied the product.



Comments: As shown in the graph above, when they felt that temperatures at the time of application was a variable in the off target movement of the product, the majority felt that the 2nd half of May, up to mid June, was the best time to apply to minimize problems.

Did you apply, or were you requested to apply, dicamba on double crop soybeans in Southern Illinois even when nearby non DT soybeans were in or nearing reproductive stage?

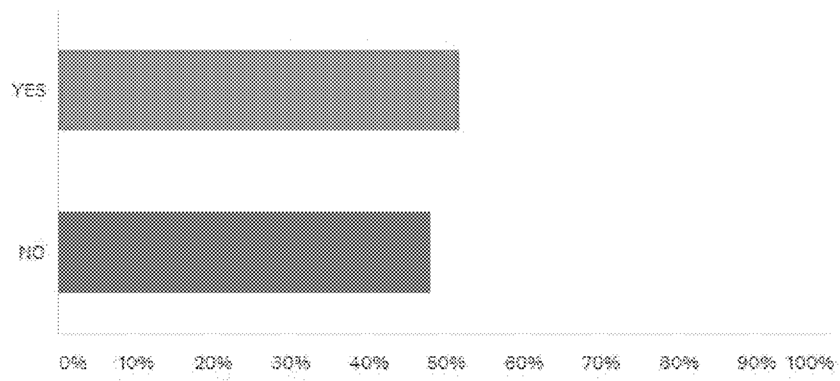
Answered: 111 Skipped: 11



Comments: Retailers from southern Illinois cited significant symptoms of damage in the far southern counties of Illinois. Some commented they were asked to treat double crop soybeans but refused to do so based on the already problematic issues they were encountering with symptoms on sensitive soybeans.

For in crop applications, do you feel the air temperature during the time of application affected the performance of the product relative to impact on non DT soybeans?

Answered: 108 Skipped: 14



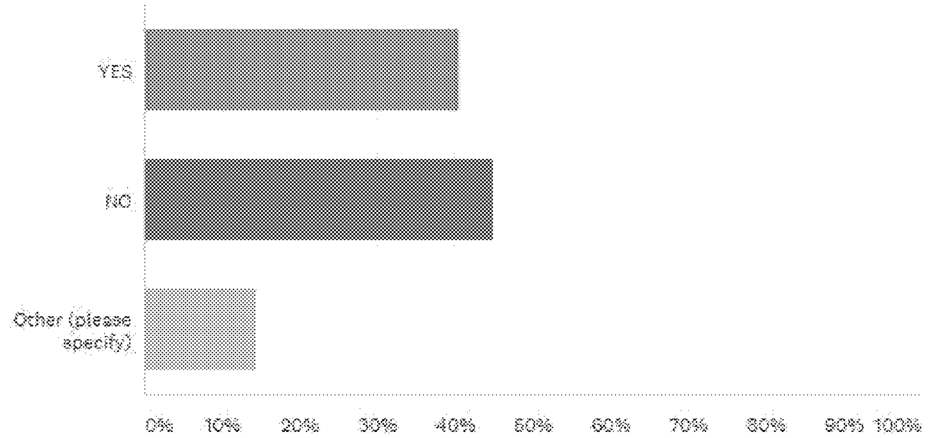
Comments: Retailers were split on the temperature at the time of the application, but many commented that higher temps in weeks following they felt attributed to problems in nearby sensitive soybeans.

If you answered YES, at what air temperature during the season do you feel is the maximum air temperature to mitigate off target impact on nearby non DT soybeans?

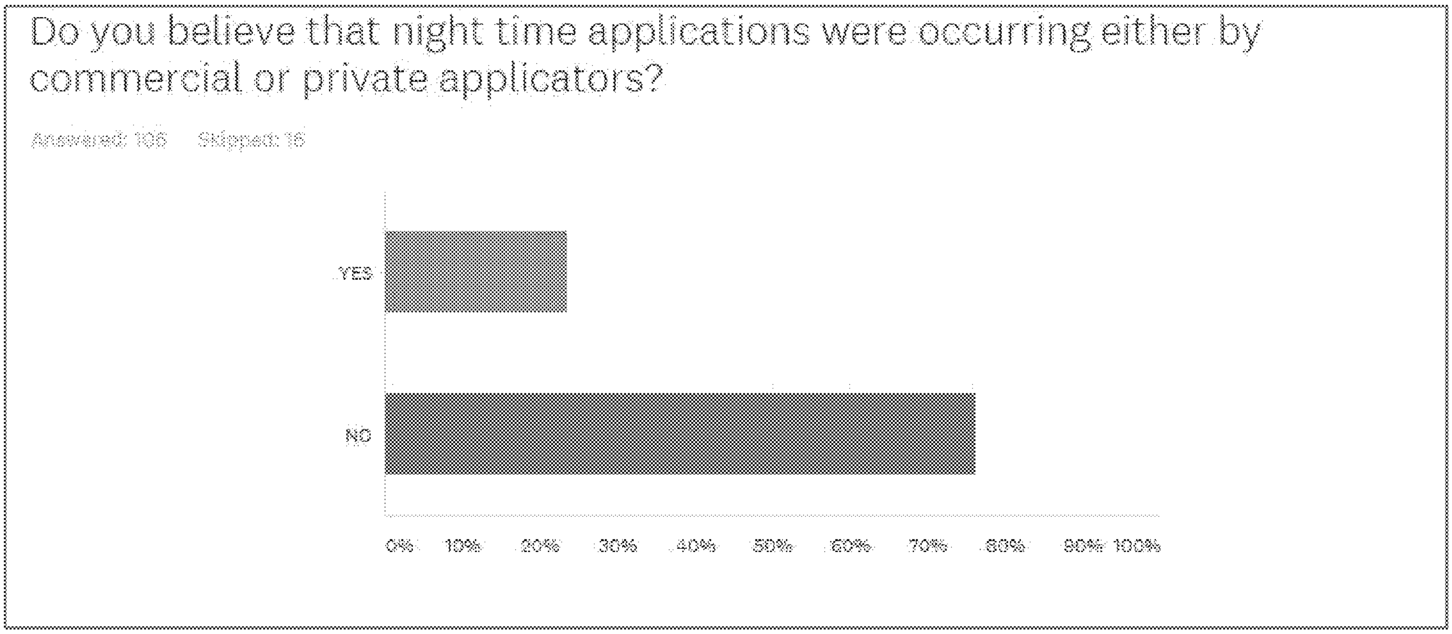
Comments: The majority of those responding suggested that between 80-85 degrees should be a cutoff temperature for a safe application. Many noted that temps above 90 degrees days to weeks following application were very problematic. More than a few suggested 80 degrees during the application and in the days following was the temperature at which they observed the fewest problems.

Do you believe that early morning applications made to avoid potential windy conditions later in the day attributed to possible inversion movement of the herbicide that caused off target movement?

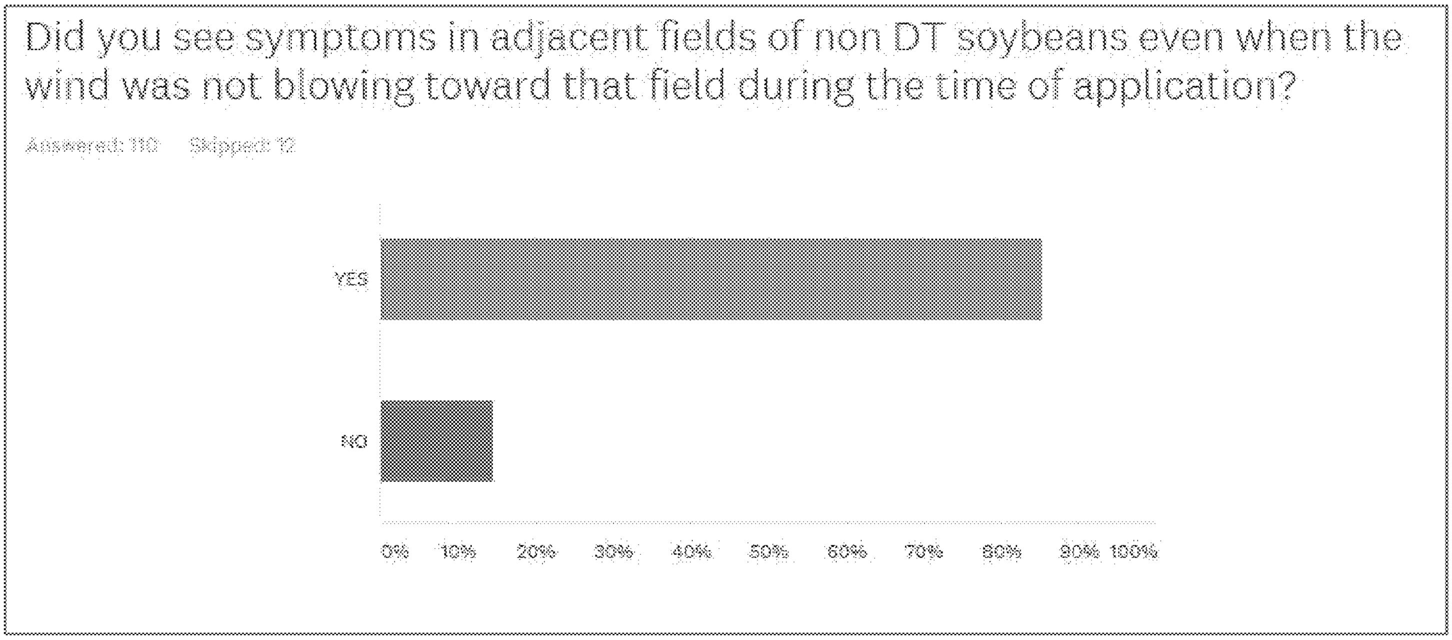
Answered: 111 Skipped: 11



Comments: Many commented that early morning applications did not occur because winds were less than 3 mph so it would be off label. Some commented that waiting later in the day to avoid inversions made it very difficult to comply with the wind speed restrictions especially in central Illinois where 3-10 or 3-15 mph days are hard to come by.



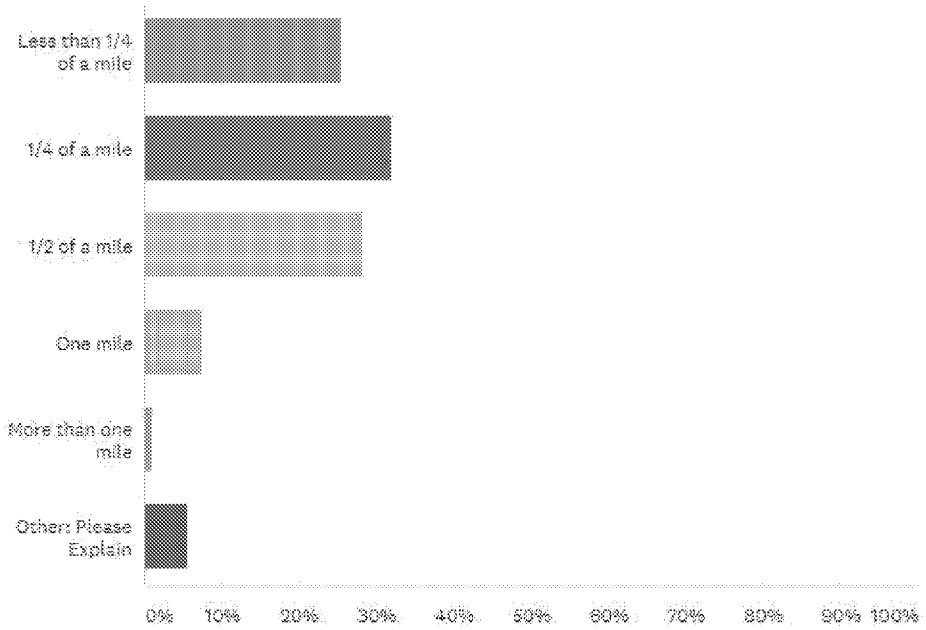
Comments: A few commented they witnessed some farmers and a few retailers applying after 5 pm but before dark. The majority said they were not aware of night time spraying occurring.



Comments: Retailers provided extensive comments on this question. They stated that many of their problems occurred in non DT soybean fields that were in the opposite direction of the Xtend fields at the time they made the applications. They cited volatility and vapor drift as their main suspicions for the damages since they were especially careful to choose days to apply when winds were in the opposite direction of the sensitive soybeans. They expressed strongly they had followed the label and put their best applicators on the job and observed symptoms when winds shifted towards the sensitive fields days later, and especially in hot conditions. They also wondered if an inversion event days later caused the product to move from the applied field.

If you saw symptoms in non DT soybeans, even when the product was applied in accordance with rate, pressure, boom height, wind speed and buffer requirements, at what distance do you note the symptoms from the field of application?

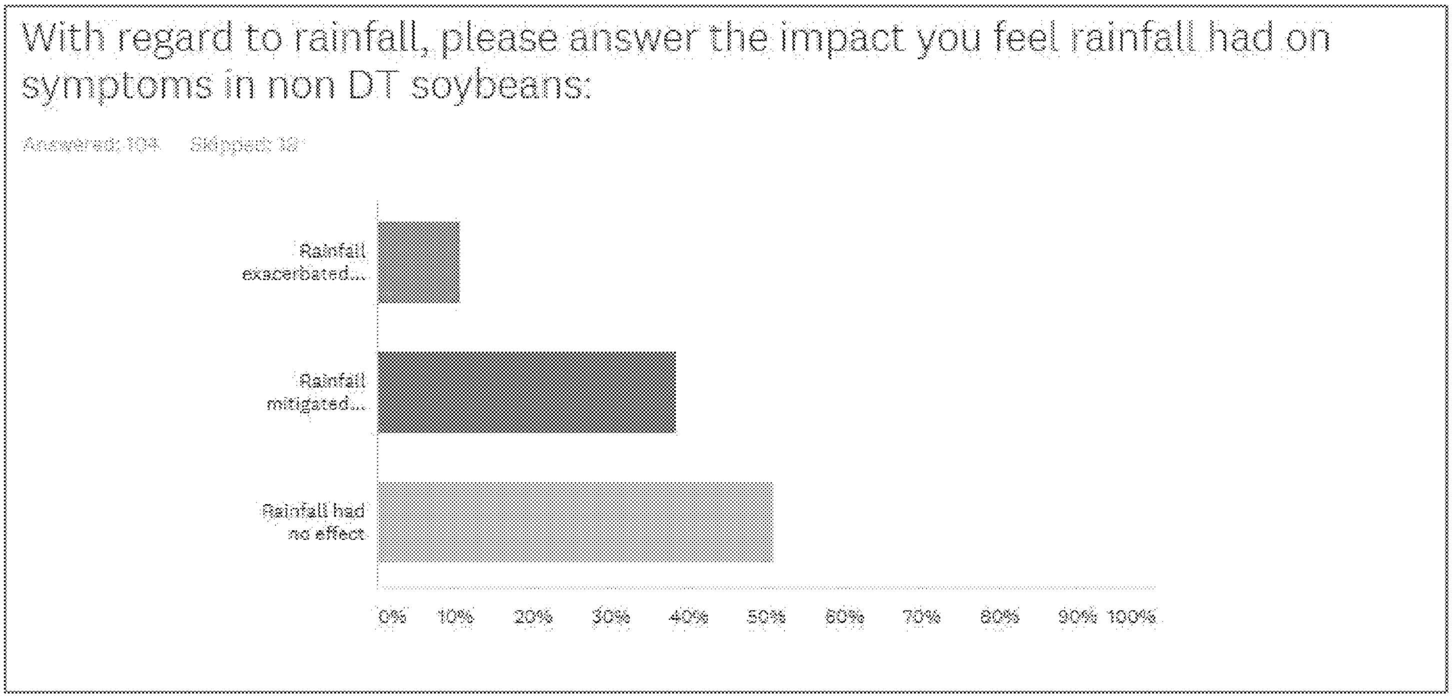
Answered: 105 Skipped: 16



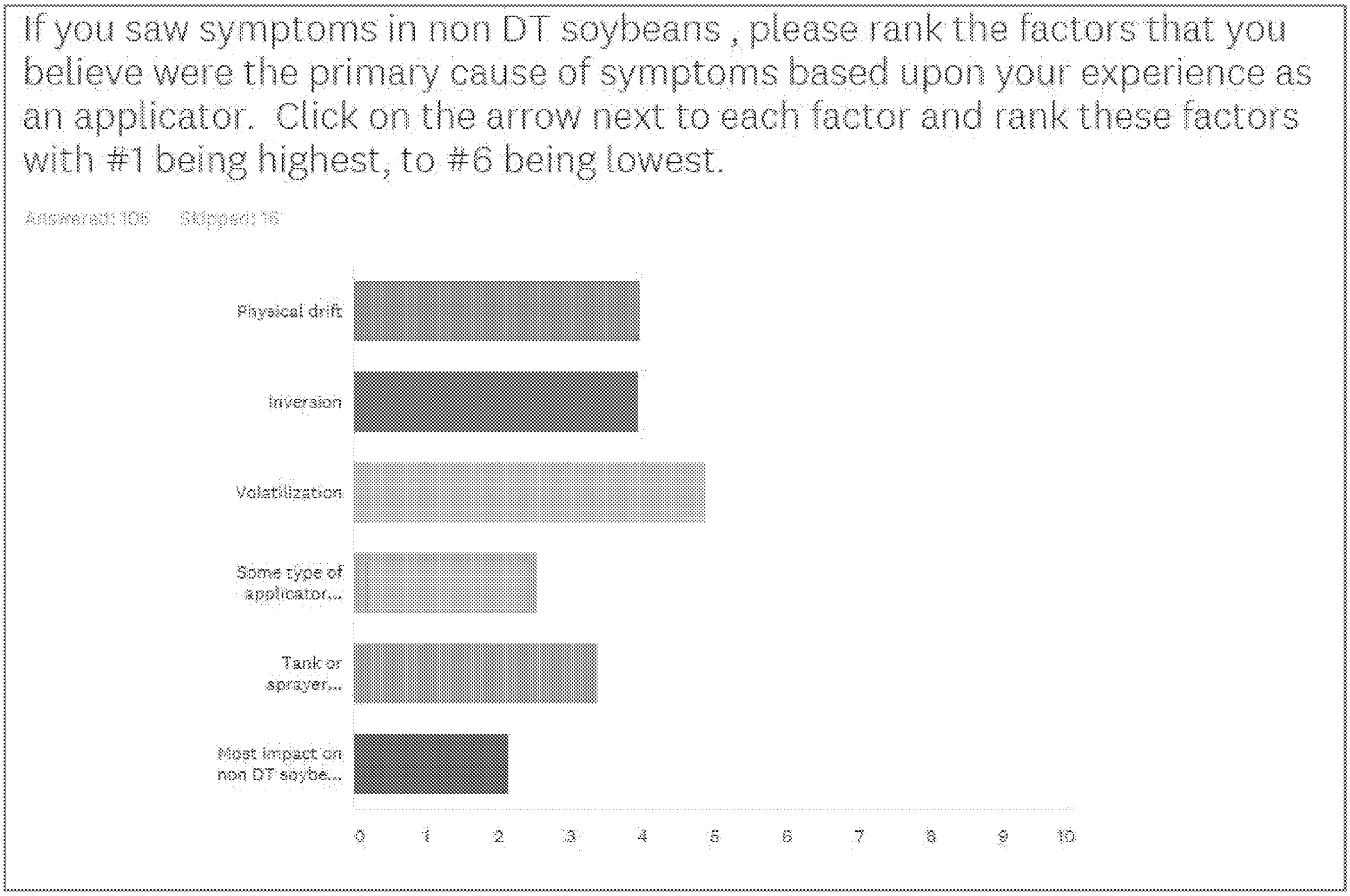
Comments: As the chart indicates from ¼ to ½ mile was nearly 60% of the responses we received, with less than ¼ mile getting 25% response.

What % of non DT soybeans in the vicinity of an application on Xtend soybeans did you observe had symptoms of dicamba exposure?

Comments: Most of written responses (105 responses) to this question stated that 50% of the fields near an Xtend field that received an application showed symptoms. Some said it ranged from 15-30%. When the field was immediately adjacent to the applied field, many stated they observed damage more than 50% of the time. Some noted is was quite variable, from 10% in some fields to entire fields in some cases.



Comments: The commenters stated that rainfall in many cases did not occur for up to 3 weeks after application which they felt stressed the soybeans with symptoms and also prolonged the farmer concerns. Many also stated they observed no connection between rainfall in subsequent days to the application. They noted rain was helpful to new growth on the affected beans.

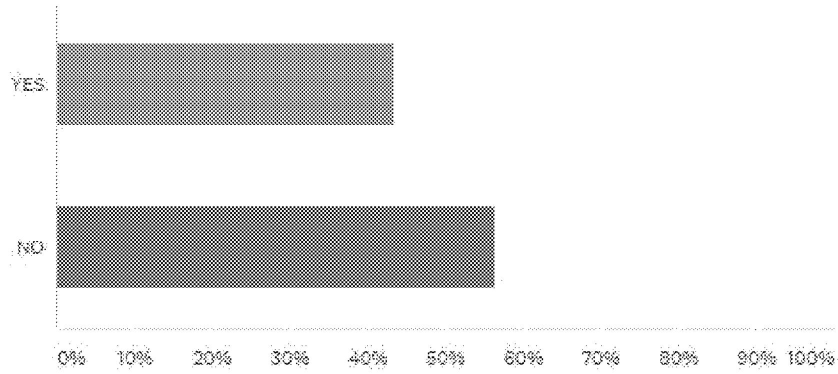


Comments: There was no opportunity to comment on this question; IFCA's observation of the responses indicates that retailers are very aware of the various potential causes of off target movement and were honest in admitting that while volatility ranked highest, that there are also other issues that need to be addressed.

The last ranking (in purple) was that they also observed symptoms on soybeans from dicamba applications made to corn, since many acres of corn were replanted while soybeans were also planted or developing at the same time as the corn. In verbal conversations with retailers, they believe that soybean planting will continue to occur earlier and it is a challenge as a retailer to treat both soybeans and corn in the same time period (it used to be they sprayed corn first, then switched over to beans). Trends are now for soybeans to be planted earlier and many farmers have two planters, enabling many to plant both crops at the same time.

In the previous questions, if you cited tank contamination as a possible cause, do you feel that tank cleanout, using generally accepted tank clean out practices in our industry, is effective in removing dicamba from the closed system?

Answered: 101 Skipped: 21

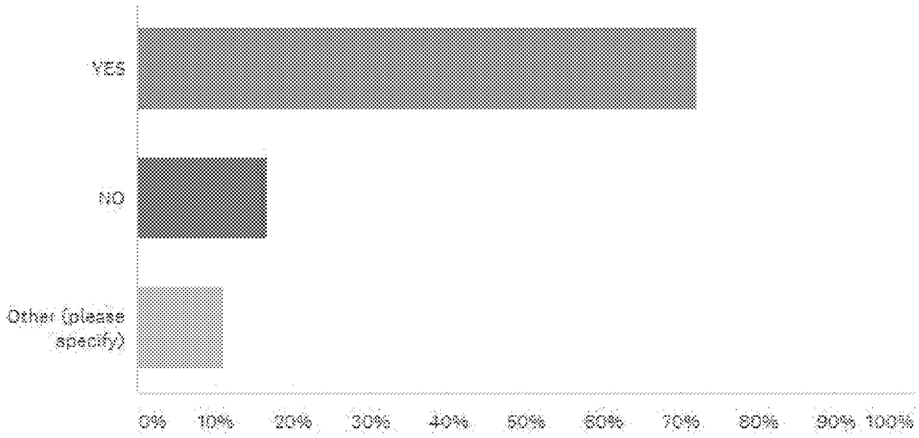


Comments: Over 50% commented that standard cleanout methods that have been effective in the past do not work well with removing dicamba from the system. Some retailers said that injection systems on the sprayer helped, but mixing hot loads at the agrichemical facility for farmer applicators was an issue as the chemical plant, as they felt later that they could not clean their mixing/loading equipment adequately to remove all traces of dicamba and thus even these minute amounts caused symptoms in subsequent applications to non DT beans. They also wondered if a build up of clay based products such as atrazine caused the "holding" of dicamba in parts of the sprayer system, which simple flushing of the system will not easily address. Many questioned whether drift reduction agents attributed to the volatility of the dicamba. While many noted that injection units on the sprayers can help, they expressed concern about tying up one machine just for dicamba from a return on investment standpoint.

Tank Mix Partners: They cited the most common tank mix partners as Roundup Powermax, Weathermax, Glyphosate and Warrant. A few mentioned they just used water, nothing else. Abundit, Intact, Astonish, Outlook and Zidua made up the remainder of tank mix partners mentioned.

Do you believe that the nozzles required on the label were effective in the performance of the product in terms of weed management?

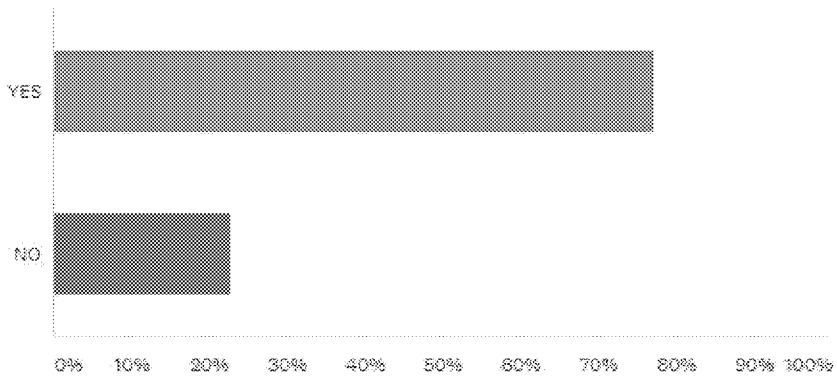
Answered: 108 Skipped: 14



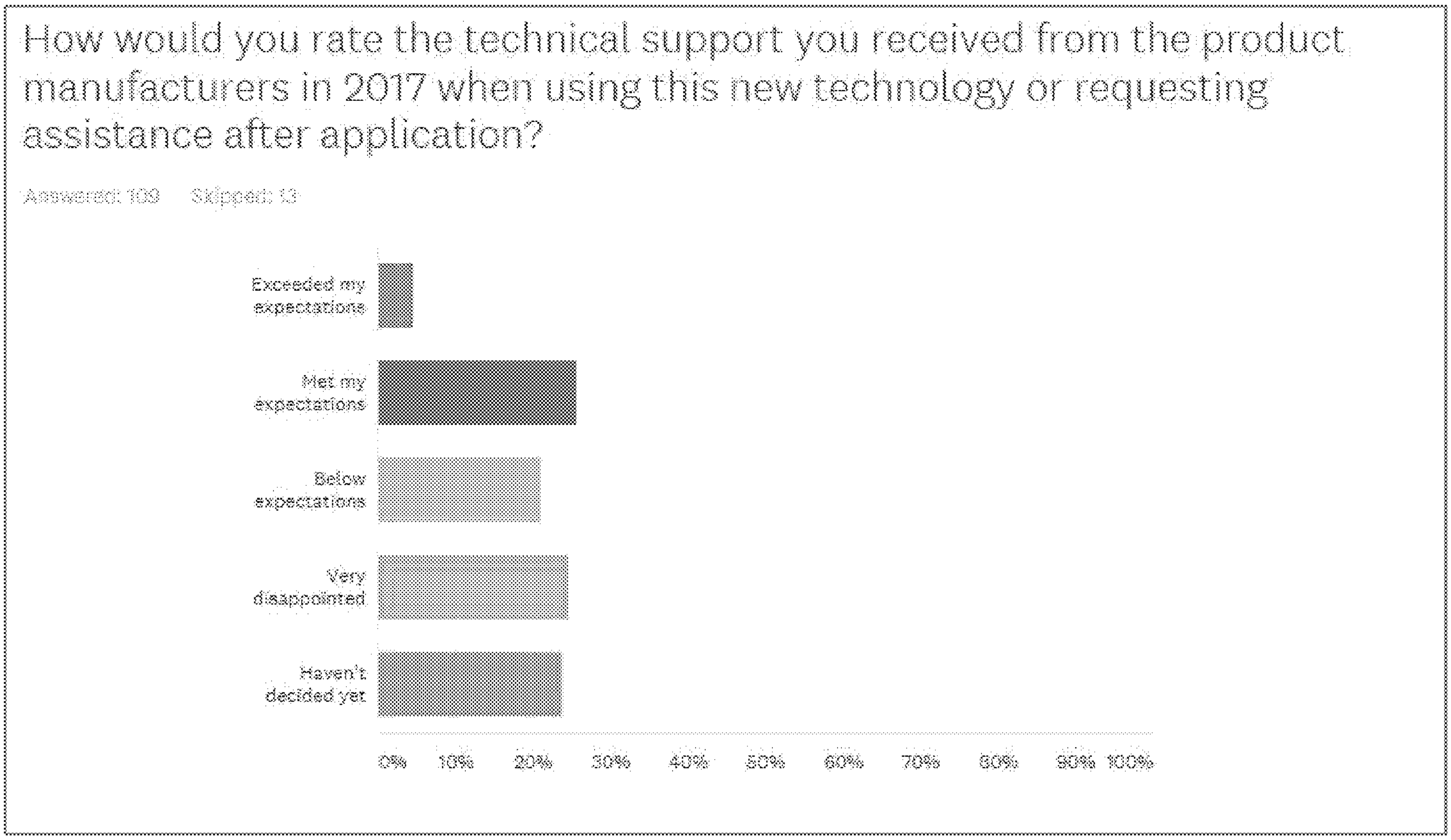
Comments: Many mentioned using the higher side of the PSI on the label seemed to help, and also using 20 GPA. They commented there were some escapes on small broad leaves, grasses and volunteer corn.

Do you believe the nozzles required on the label were effective in the performance of the product in terms of mitigating off target movement?

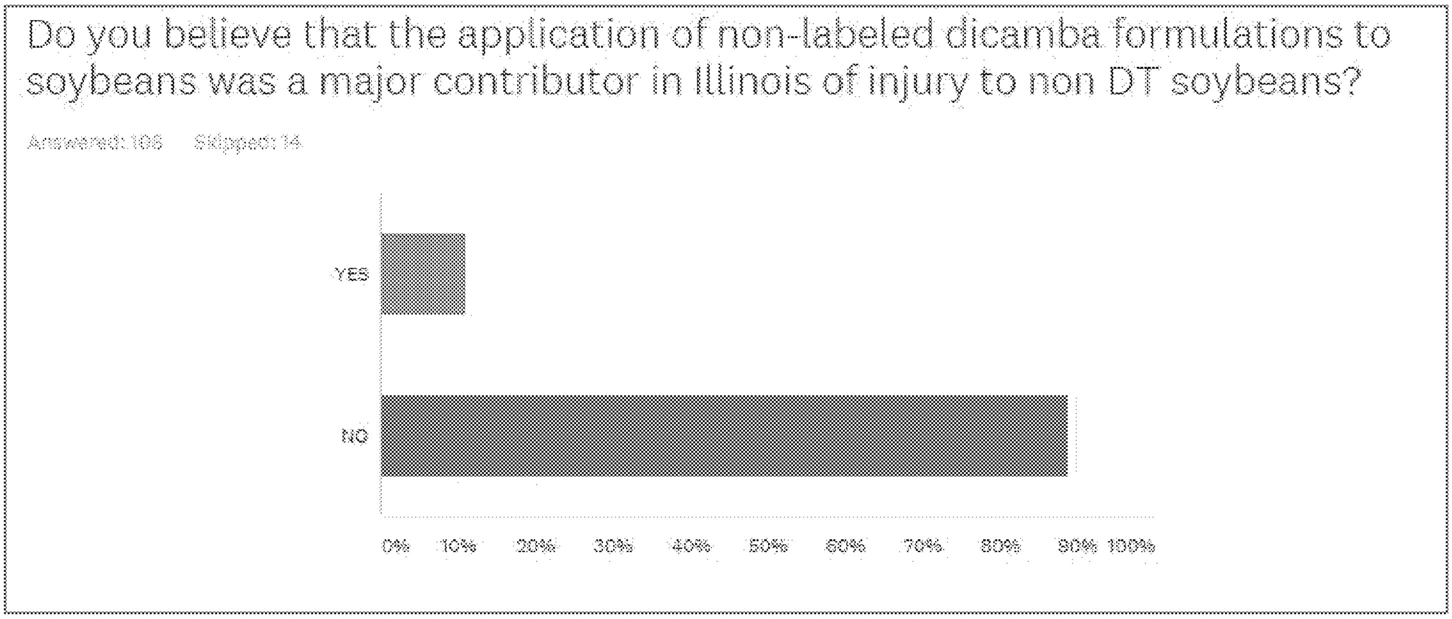
Answered: 105 Skipped: 17



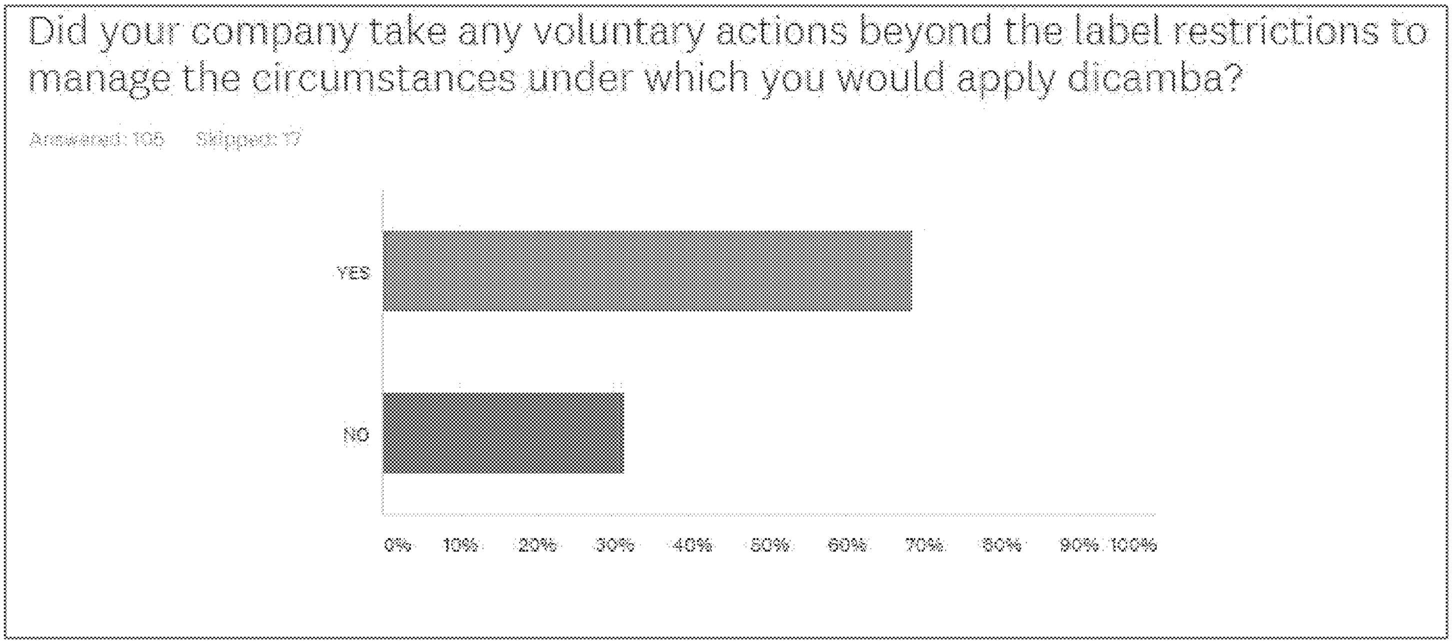
Comments: Many stated they had no problems with physical drift and a few even indicated that using these nozzles would likely improve dicamba control when used in corn. But they felt the nozzles did nothing to combat the volatility issues because volatility is not a particle that can be mitigated by a nozzle.



Comments: The retailers felt very much as they were on the front line for handling complaints; when a situation was controversial between farmer neighbors they felt the manufacturers were even more reluctant to get involved. They were disappointed the product reps could not even discuss what the retailers and farmers felt were obvious volatility issues. Some commented that their reps did the best job they could, but that the industry itself has not done enough work to thoroughly understand how to use this product effectively. More than a few comments mentioned their BASF rep was much more responsive than the other company reps.

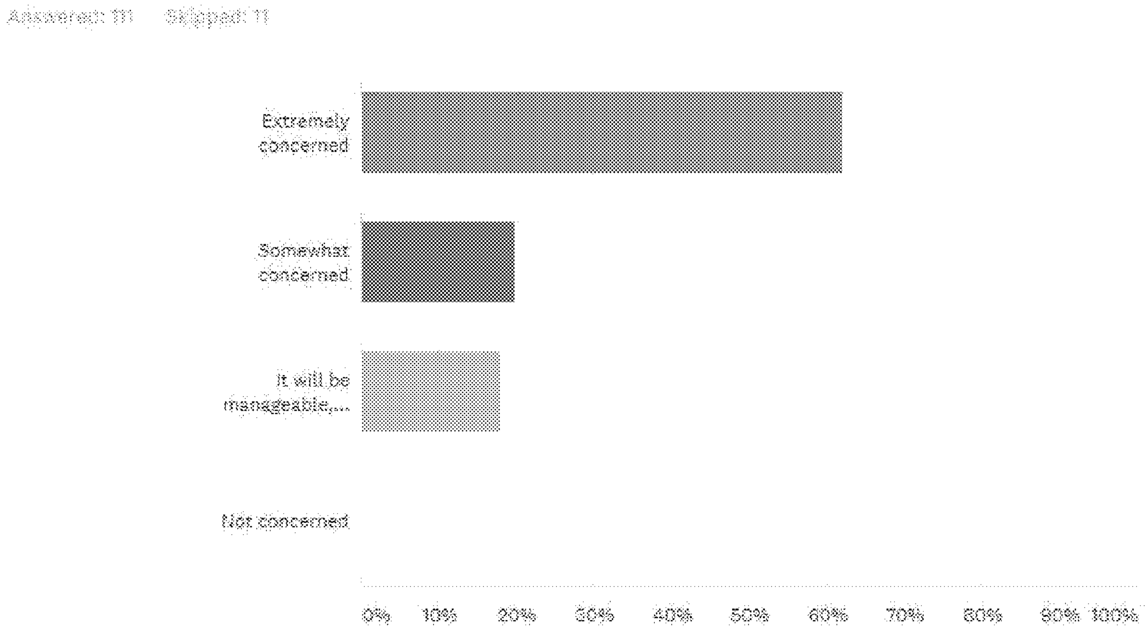


Comments: Retailers were adamant in their comments that they, and the farmers they sold product directly to, all used the new products on soybeans. A few suspected "tin sheds" and "brokers" of possible off label sales. Some mentioned again the dicamba issues from products applied to corn as having an early impact on some soybeans.



Comments: The most common comment was retailers stated they applied a cut off date for applications (most said they quit the last week of June and did not apply anytime in July) and turned down business after those dates. Several said they applied a buffer even when it was not indicated on the label during an upwind application toward a sensitive crop or doubled the buffer to a sensitive crop. Many stated they refused to apply if an orchard, vineyard or nursery was within one mile, or refused to spray at all in areas highly populated with homeowners. Some required their customers to identify all fields surrounding their Xtend field before the spray order would be considered. A few flagged sensitive fields. Many dedicated sprayers to dicamba or used injection units. A few who completed the survey stated they did not apply the product at all, just sold the seed.

Rate the level of concern you have regarding the future use of these products as the % of acres of DT soybeans increases, regarding their potential impact on sensitive crops other than soybeans (i.e. orchards, vegetable crops, gardens, trees, etc.)



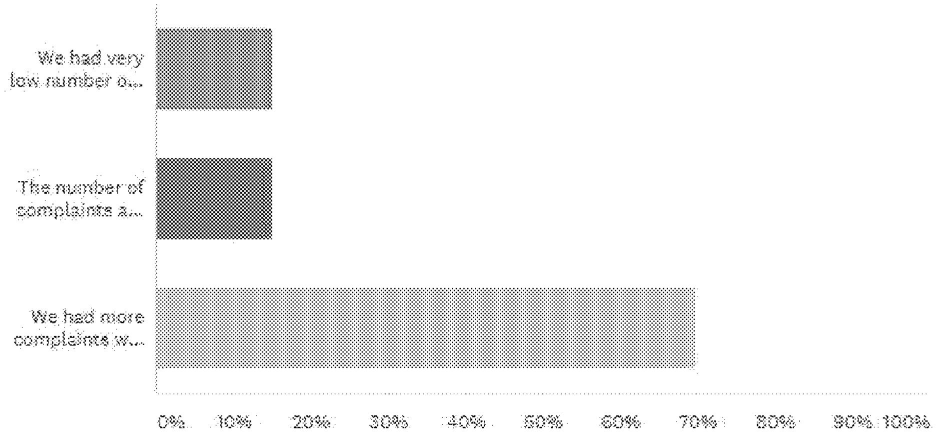
Comments: Many comments said they could improve upon drift and contamination occurrences but the volatility issues are beyond their control as an applicator. Many expressed that if the volatility issue is not addressed, that increased soybean acres being treated with dicamba will result in more homeowner and specialty crop damages. They stated that even with more Xtend acres next year, there will still be a lot of non-GMO, organic and Liberty Link fields that must be protected. If more farmers plant Liberty beans, there will be an even bigger problem. Some were anxious to see how yields would be impacted in fields with symptoms.

Many commented that the weed control was impressive, but there are so few optimum days to spray that they can't see how they are going to cover more acres given the narrow window of "perfect days" and even then the volatility afterwards is an issue. Many said there will simply not be enough optimum days to get the job done, but the farmers will still expect it to get done, putting intense pressure on commercial applicators.

Several stated they are very concerned about political repercussions if damage migrates to homeowners, vineyards and orchards if more acres are applied next year without addressing the problems that occurred this year. They feel in areas of the state where there are a lot of specialty crops and more populated areas, the liability to apply these products is simply too great for the applicator.

As of Aug 1, the IL Dept of Ag has received 143 formal complaints regarding dicamba use on soybeans. How did your experience with complaints, insurance claims or issues with dicamba use on soybeans compare to your general experience as a commercial applicator with other pesticide use issues in a given season?

Answered: 106 Skipped: 16



Note: As of August 24, 2017 the IDA is at 239 misuse complaints attributed to dicamba.

Comments: Retailers stated they did an incredible amount of hand holding with farmers, even on fields they did not commercially apply. It took up most of their summer. Many said the it most complaints they have handled by far, in their entire career. Many stated that they saw more issues with famer applied fields. Several stated there were very serious issues between farmers and in communities; most farmers did not call the IDA.

Several stated they have a few problems of their own, but a multitude of problems with farmer applied fields. Most were hoping the yields would not be impacted and claims would not be followed through on with insurance companies. Some stated that increased Xtend acres may help mitigate issues between farmers but there will still be issues with non-GMO, Liberty Link and other non-DT soybeans.

If there could be any changes on the labels for these products, what would you suggest to improve the use of these products in the 2018 season?

Comments: The most prevalent suggestion was to address temperature and humidity; the manufacturers need to figure out the conditions that lead to volatility and make necessary changes, or research these products more. Other comments, in order of the number of times these were suggested are as follows:

Designate a timeframe for spraying, and look at mid June as the cutoff and some suggested by mid May or end of May.

If temperature exceeds 85 degrees, require an additional setback to sensitive crops, such as ¼ mile, which could help protect a nearby sensitive field from any volatility issues.

The restrictions for applications near sensitive crops and areas needs to be increased; several suggested ¼ mile and up to 1 mile. Don't apply it at all if a sensitive soybean field is immediately adjacent on any side.

Make the tank mix partners consistent regardless of it being Xtendimax or Engenia; need more tank mix partners and more research in this area as to how tank mix partners impact the product volatility.

Restrict applications to only trained professionals; make it restricted use.

These products should only be used for burn down, not on soybeans.

What type of specific educational sessions would you like IFCA to offer during the winter of 2017-2018 to help better understand the situation going forward?

Comments: Please give us honest answers on the volatility and how to manage this if these products are going to stay on the market. What were the conditions that reduced volatility?

Private applicators need a lot more education, who is going to educate them?

Put on sessions for farmers, they need to better understand herbicide symptoms and what is realistic in terms of when we can apply these products.

Help us with cleanout procedures for spray rigs, tenders, and mix plant. Manufacturers or researchers need to help us in this area. What level of dicamba can still be present to harm soybeans and how do we test for it in our cleanout methods?

Review the findings and investigations from this year and recommend ways to improve it. Give a report on what the IL Dept of Ag determined with their investigations.

More education on drift reduction additives.

More understanding on inversions, and also how inversions can impact the field days after application.

Will the manufacturers agree to step up to the plate and take some ownership and stewardship of this product, would like to hear more about what they are going to do to help the situation. Educate the manufacturers on the real world and what it is like to manage this product label with all the weather challenges and demands of our customers to get it done.

Please provide your observations on the conditions at the time of application that were conducive to an effective experience with these new products.

Comments: These are listed by the number of times they were mentioned with the first being the most mentioned and then in descending order of mention.

Apply earlier in the growing season in cooler temperatures.

If either corn or Xtend soybeans were surrounding the field we had very good experience and good weed control overall.

Ground must be dry, calm winds, 75-80 degree temps max and no non DT soybeans within a half mile or a mile away.

Low temperature and humidity during and after application.

Spray only when non DT soybeans are in early vegetative stages.

Between 65-85 degrees with humidity between 50-75% and winds below 10 mph.

The more water the better: 12.5 to 15 gallons per acre.

Use 20 gallons per acre.

Apply only after 8 am and quit at 3 or 4 pm: Spray during "bankers" hours.

Apply when rainfall is expected within a few days of application (but can't control the weather!)

We followed the label exactly, tried to do everything right, and we still had problems.

Apply before the non DT soybeans or other sensitive crops emerge.

Please provide your observations about the conditions at the time of application that you believe attributed to problems encountered with the use of these new products.

Comments: These are listed by the number of times they were mentioned with the first being the most mentioned and then in descending order of mention.

Hot weather and humidity was a big problem. Also extended periods without rain after application was a problem.

We applied too late in the year.

Variable winds after application carried the product over fields after we applied. The change of wind within a few hours of application caused problems.

Wind that shifted after application moved the product a lot farther than I could have imagined.

When cool nights followed the application, we saw movement.

Fields where no residual was applied resulted in us spraying weeds using very large droplets and not catching the small weeds in the canopy.

Don't spray too late in the evening.

Farmer applicators caused more problems than commercial applicators.

Winds at 4-6 mph blowing towards adjacent sensitive soybeans, even when we left the required buffer, still results in the non DT beans being damaged.

We thought we did everything right, but still had problems! Not sure what to suggest.

Extremely dry conditions in the weeks following the application caused problems.

What can be done about the product getting up and moving 7-10 days after application? The buffers didn't seem to make much difference; if the wind is blowing toward a non DT soybean field a 110 foot buffer doesn't seem to help.

Nitrogen in our system could have been an issue; sprayers used for Y drops and later for dicamba may have still contained small amounts of liquid nitrogen and maybe that unlocked the "vapor grip?" Not sure how little N it may take to cause problems with increasing product volatility.

Please provide any additional comments to IFCA on this issue. Thank you!

We received many comments on this open-ended question. In no order, here are some of the responses.

I hope we can use this technology responsibly with more help and answers from the manufacturers than we had this year. We need this product to manage weeds especially water hemp.

We need a task force of experts, independent from the manufacturers, to help the retailers and farmers and landowners when there are questions and problems. We are spending an incredible amount of time dealing with this with no return on our investment for the time spent handling issues that the manufacturers should be working to address and handle.

The manufacturers need to admit that there is still volatility with these products and that non-DT beans will be difficult to protect from these products.

This product and the marketing platform was pushed into the marketplace without adequate research. Go back to the drawing board and start over.

The problems we had this summer speaks for itself: we need this technology to remain available but we also need answers.

These products are important tools in the toolbox but more work must be done to figure out when it can be used and when to stop spraying dicamba.

This product worked well to control weeds. I hope that the symptoms do not result in reduced yield potential in fields that had symptoms.

We will not use these products again until science can assure us a product that will not get up and move out of the field. We will educate our growers to make a good fall burndown, a good early spring burndown, and a safe post program.

Our main issues were with tank and sprayer contamination, but the volatilization and inversion issues concern me a great deal.

I've never been stressed so much in 15 years as an applicator and it's going to continue through harvest. I'm ready for another career; however, when I see the weed control it provides I am hopeful we can improve upon the other issues going forward.

Tin sheds and brokers need to be addressed; the rules are so lax with the sale of these products.

Something with the label and formulations is not correct. When we applied the products during the seed production years and we had to use Clarity without AMS and with regular old spray tips and conditions, and we did not experience the cupping and damage issues we had this year using the new products, nozzles and following the new label.

IFCA should lobby to remove this product for use on soybeans. We need to ensure dicamba remains a viable product for use in burndown and in corn.

The use of this product is going to create resistance in 4 years or less in both corn and soybeans.

China needs to approve the Enlist trait, we need more choices.

The manufacturers rushed this product to the marketplace and placed all the liability on the applicators and his/her insurance company. If these claims continue we will not be able to afford insurance to operate.

Farmers thought everyone planted Xtend soybeans. Unless they buy from a reputable seed dealer they get no information on proper use of this product.

There is no way a responsible applicator can cover the acres of Xtend soybeans that will be planted with the wind, temperature, humidity and inversion issues. There aren't enough days or sprayers out there to apply this chemical according to the label on the few days that the environmental conditions allow for it.

I'm very glad we did not apply this product.

I am offended by the manufacturers and their lack of willingness to provide answers and solve the problems; instead they assign blame to poor buffers, illegal products, generic dicamba and tank contamination. They are more concerned about their quarterly earnings reports than the customers they serve.

Don't use roundup or surfactants in the tank; make a second application to get the grasses.

The manufacturers need to invest in a product that does not drift or volatilize. In most areas of Illinois, we have way too many homes and specialty crops to take the risk of using this product as it is today.

We need to protect this technology, but farmers also need to better understand herbicide crop response.

I can't thank IFCA enough for being proactive and searching for solutions to this problem.

IFCA

Illinois Fertilizer & Chemical Association

Supply • Service • Stewardship

Dicamba Call with States 8/23/2017

Reuben Baris, Dan Kenny introduction. We're looking for feedback on what we can/want to do as soon as possible. We want growers to have access to information ASAP so they can make informed choices for 2018 season.

These are elements that we've entered into negotiation with the 3 registrants: Classifying these products as restricted use (record keeping) - Waiting on registrants to voluntarily do that, wind speed restriction, tractor speed restriction, timing of application, required training.

Tony Cofer from Alabama -Didn't have a lot of tools to approach this process appropriately early on. Tried to do what they could do in short turn-around time. Individual states could see this coming – and the SLNs were the states' effort to get some control. Would have preferred as a state restricted use, but didn't have time. They did the 24c with mandated training and wind restriction. Not sure if this had an effect, but record keeping would be essential, and timing of application would be good to look at. Maybe with a date cutoff. Probably growth stage restriction. Don't know how you get enhanced training onto federal label. Not all states are set up to do enhanced training. Training requirement should be put on registrant. We're forcing people into buying into new technology out of fear. Need to differentiate between old and new products. A marker or registrant is required to give up polymer analysis to the labs.

Cary Giguere – Vermont. Make it restricted use, require additional training. Do something about volatilization. Unfortunate that we're still talking theoretical changes at this point. It's a seed technology problem more than herbicide problem.

Reuben Baris - Apologized that we're not farther along in negotiations, but wanted to keep the partnership with the states going. EPA considering options for making the 2018 products – separate registrations. Asking for your feedback on that proposition.

Arkansas – Jason Norsworthy. Weed scientists now have a better understanding of data. Field trials are pointing to volatilization. Many others have the same data. Most of the regulatory suggestions EPA thinking about focus on physical drift – not volatility. If we're going to shift a product from burndown to over the top product, there's nothing we can do for a volatile product as far as label changes. Measuring volatility up to 72 hours after treatment in the field. Not sure what path forward would be. Acreage is going to be much higher in 2018, and these solutions won't address that. Willing to continue to share data.

EPA asked for label language examples that may address the issue based on his data. Jason - working on collecting the data to help with that. Still seeing volatility at 80 degrees (lower than earlier this season.)

Question: Are studies done in other states at lower temperatures? Volatilization is not fully understood, and we don't know the threshold that will result in minimal risk. Not sure what other states are seeing.

? Bradley - University of Arkansas. Supports what Jason said. Cutoff date could make a difference. Not sure what kind of education program they could put together for a volatile product.

Dan K: RUP would help with compliance. Record keeping could help with knowing what happened when. Tractor and wind speed restrictions would help with drift. Temp restrictions, humidity restriction, growth stage restriction, and allowing a single application only are other options. Eliminating double cropping applications or time of year restrictions.

David Wayne – Kentucky. Low number of complaints. Having a RUP would be beneficial. Cutoff dates would be a moving target for each state, and be cumbersome. Training is not the best way to fix the issue.

Tommy Gray - Georgia. Agree with use restrictions, would support these products being federally restricted use with agronomic crops covered under supplemental label. How would it happen? Spending a lot of time looking at purchasing info for generic products. It would help us monitor products and track via dealers

Kerry Richards? - National pesticide safety education center. Possibly package Georgia's training via livestream videos to other states. May be a coordinated message throughout country.

Andrew Thostenson – ND State. Tommy's query about RUP designation - One thing to have an RUP for new formulations, but there's been significant off label use of generics on Xtend beans. Concerned whether RUP would be for generics as well? Dan R. - It's unresolved. Goals for this intervention are focused on cotton and soybeans, and changes to generics would take us longer then would be effective in 2018 use season.

Dan K- Restricted use requires recordkeeping, so would protect against misuse of generics.

Paul Bailey - Missouri Department of Ag. FIFRA doesn't require private applicator to keep records.

In Pennsylvania they require record keeping for private applicator.

Dave Scott - Indiana. Question for Tommy Gray. Any official complaints? No. Presentations this morning showed that with this technology increasing next year, it's going to get so much worse. Homeowners don't know what to look for yet, in terms of damage.

Dan K. - We are looking for something that could help. Anyone on the call have any ideas?

Cary Ann Rose? from Ohio. Like the hard and fast date restriction. Or make it an early post emergence product. R1 is too late. It's definitely volatility.

Andrew Thostenson. ND. The date would be great, but not practical across states. Growth stage wouldn't be a good idea, because planting dates vary greatly. Possible temperature thresholds. Have to make them stick? The label is too complicated now.

Tony from APCO – label is too complicated now, and people are never going to comply if we make it even more complicated.

Andrew says growth stage is dramatically different across the state. Cotton? Double cropped beans?

Jim Reese - Oklahoma. Can't each state register the products as restricted use if they choose? Yes, so why is everyone asking for it to be federal restricted use?

Karen: Did Arkansas ban the use of these products? Yes. What was the grower pushback? The ban offered the crop an opportunity to recover from the damage.

Bob Spencer - Idaho Dept of Ag. Are the applicators already certified? Will making it RUP really solve the problem? If RUP, there are Record keeping requirements for private applicators under USDA.

Dave Scott - If applicators are all using the product correctly, when does it turn into a stop sale and an enforcement case to the companies? Brought up Imprelis example. Dan K– SSURO would be possible

Cofer: we need to make a quick decision. Growers need to know how to approach next year. Also state agencies don't have resources to support this issue. Another year of this isn't possible. If product is beyond salvaging – that call needs to be made. Listen to research scientist. EPA and state agencies can't take another year like this. We don't have the resources.

Cary from Vermont asked about monetary support from EPA for states.

From: Green, Jamie
To: Kenny, Daniel; Baris, Reuben; Pease, Anita; Jones, Arnet; Wormell, Lance; Vizard, Elizabeth; Lott, Don; Chism, William
Cc: Ridnour, Lacey; Frizzell, Damon; Hackett, Shawn; Taylor, Maren
Subject: FW: Off-target Movement of Dicamba in Missouri. Where Do We Go From Here?
Date: Tuesday, August 22, 2017 9:54:08 AM

FYI - In the event Dr. Bradley didn't send this along himself

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From: Slade, Darryl [mailto:Darryl.Slade@mda.mo.gov]
Sent: Tuesday, August 22, 2017 8:42 AM
To: Hackett, Shawn <hackett.shawn@epa.gov>; Green, Jamie <Green.Jamie@epa.gov>; Frizzell, Damon <Frizzell.Damon@epa.gov>
Subject: Off-target Movement of Dicamba in Missouri. Where Do We Go From Here?

https://ipm.missouri.edu/IPCM/2017/8/Off-target_movement/

Darryl Slade
Enforcement Program Coordinator
Missouri Department of Agriculture
Plant Industries Division
Office: (573) 751-5511
agriculture.mo.gov

Case: 19-70115, 08/13/2019, ID: 11396549, DktEntry: 36-5, Page 63 of 294

Integrated Pest Management
University of Missouri

Off-target Movement of Dicamba in Missouri. Where Do We Go From Here?

Kevin Bradley
University of Missouri
(573) 882-4039
bradleyke@missouri.edu (mailto:bradleyke@missouri.edu)

PUBLISHED: AUGUST 21, 2017

The situation. In 2017, there have been numerous instances of off-target movement of dicamba throughout the state of Missouri and beyond. While the majority of the injury on a per land unit area has definitely occurred in the boot heel of Missouri, there are many problems with off-target movement of dicamba in the rest of the state. The Missouri Department of Agriculture is currently investigating over 280 dicamba-related injury cases (Figure 1), and based on University of Missouri Extension field visits, we estimate 325,000 acres of soybean injured by dicamba across 54 counties in Missouri. On a national scale, there are now more than 2,200 dicamba-related injury investigations being conducted by various state Departments of Agriculture, and more than 3.1 million acres of soybean estimated with dicamba injury (see our recent update here (https://ipm.missouri.edu/IPCM/2017/8/Update-on-Dicamba-related-Injury-Investigations-and-Estimates-of-Injured-Soybean-Acreage/)). In my opinion, we have ***never*** seen anything like this before; this is not like the introduction of Roundup Ready or any other new trait or technology in our agricultural history.

Case: 19-70115, 08/13/2019, ID: 11396549, DktEntry: 36-5, Page 64 of 294

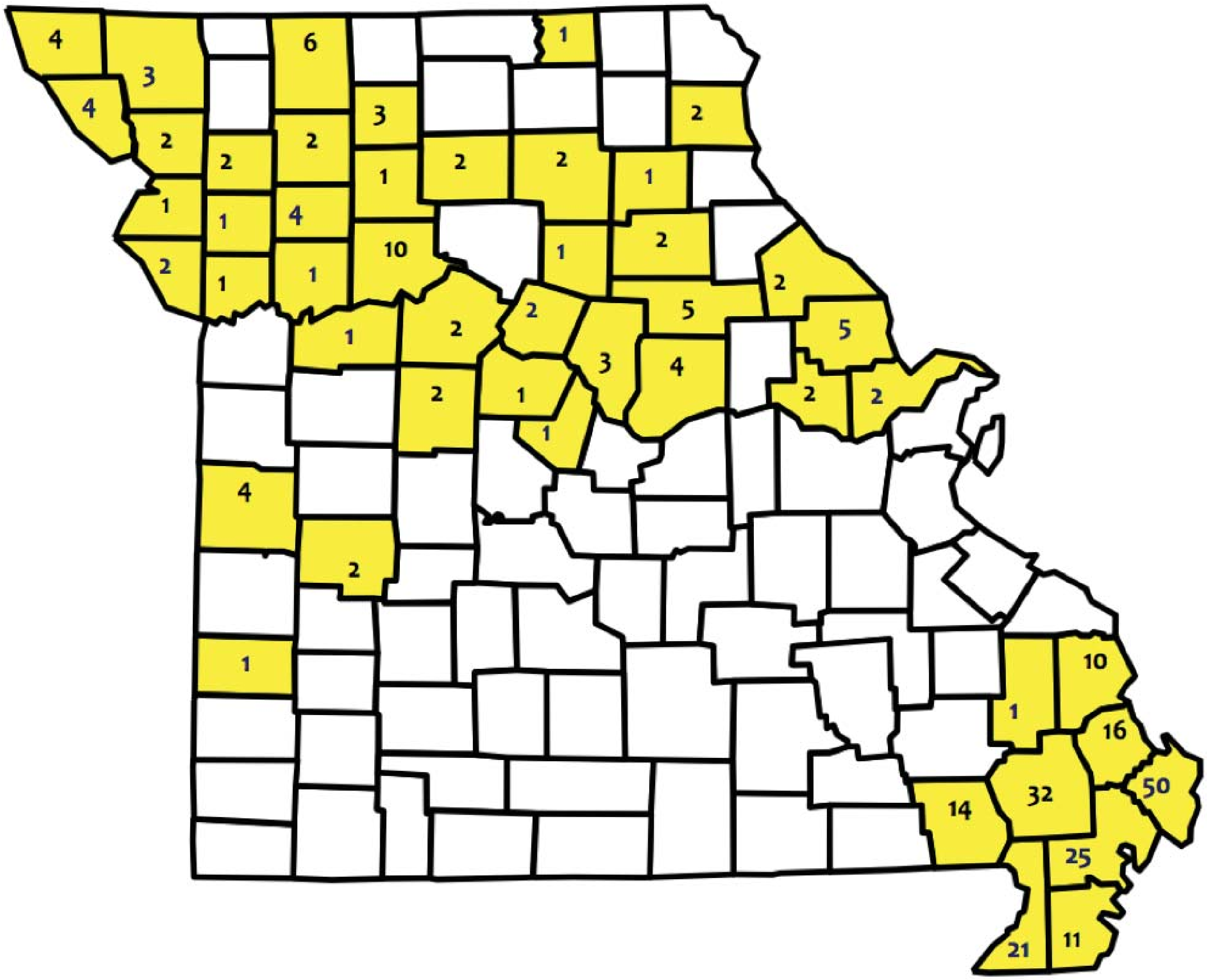

Figure 1. Official dicamba-related injury investigations as reported by the Missouri Department of Agriculture (updated August 17, 2017).

Reasons. In my opinion, there are basically four routes by which dicamba can move away from its intended target, and we have experienced every one of these in 2017. The real debate seems to be about what percent of the total off-target movement should be placed into each one of these categories.

First, dicamba can move off-target by way of physical drift at the time of application. This can occur due to spraying when wind speeds are too high, use of improper nozzles that produce fine droplets, or to a host of other factors that we can just chalk up to "bad sprayer decisions or set-up at the time of application." There's no doubt that physical drift of dicamba has occurred this season and that this is one of the major reasons for off-target movement of dicamba. But it isn't the only reason. I have visited and talked with many farmers and applicators who have done it right and still experienced movement of dicamba away from the direction of the prevailing winds at application.

ER 1098

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A second way that dicamba can move off-target is through tank contamination. This usually occurs due to improper spray tank cleanout. Unfortunately, many have learned the hard way that it takes very, very little dicamba in the tank to cause problems on non-Xtend soybean that are sprayed after a dicamba application. There's no doubt that some portion of our issues with off-target movement of dicamba have been due to improper sprayer cleanout and tank contamination. However, many growers with injured soybean fields didn't even plant any Xtend soybean or spray a dicamba product through their sprayers. Some retailers also have dedicated sprayers for dicamba products only.

Another way that tank contamination can occur is through contamination of an actual herbicide product, such as what Monsanto says has occurred with a certain generic glufosinate product. I'm not aware that any trade names of glufosinate products have been put forth or of any actual data presented about this potential problem at the time of this writing, but of course contaminated glufosinate could not explain any of the injury we have seen on Roundup Ready or conventional soybean, or any of the other vegetable or ornamental crops or trees that have been injured by dicamba.

A third way that dicamba can move away from its intended target is through temperature inversions. Temperature inversions usually occur in the evening hours around sunset when the air nearest the earth's surface becomes cooler than the air above it. This cooler air forms a stable mass that can be moved horizontally along the earth's surface and then can deposit anything that may have been in it once it dissipates. So for example, if an application of an approved dicamba product is made at 7 or 8 PM into a temperature inversion, any fine droplets that may have been part of this application may not land on the intended target, but instead may be redistributed some distance away once the temperature inversion dissipates the next morning. As a result of our work on temperature inversions over the past several years, our data indicates that we usually experience a temperature inversion at least one-half to two-thirds of the days in June and July, and that these inversions typically start around 6 to 8 PM and persist for 8 to 10 hours. Also as a result of funding from Missouri soybean growers, we now have a network of weather stations (http://agebb.missouri.edu/weather/realTime/maps/index.php#temp_inversion) in Missouri that are able to tell users whether or not an inversion is occurring. There is some off-target movement of dicamba that occurred in 2017 that can be explained by spraying directly into a temperature inversion, but in my opinion most of our applicators are now very aware of this possibility and have avoided these evening or nighttime applications. However, another possible way that dicamba droplets could end up in an inversion is through volatilization, which brings me to the fourth point.

The final way that dicamba can move away from its intended target is through volatility. Dicamba is an inherently volatile herbicide. We know that the older formulations of dicamba are more volatile and are illegal to apply. So if illegal applications of the older generic dicamba products have been applied, I have no doubt that dicamba has moved off-site in those applications through volatility. But in my experiences and discussions with farmers and retailers throughout the state, it does not seem that illegal applications of these older formulations have occurred on a wide scale with any regularity. I do not believe that the scope and scale of this issue can be explained away by illegal applications of older dicamba formulations.

As most on all sides of this issue are well aware, both BASF and Monsanto have taken steps and invested a lot of money to make these newly approved formulations less volatile. And they are less volatile. But as many have said, less volatile does not mean not volatile. We have been in the process of gathering volatility data on these newly approved dicamba products for several months. All of our results thus far indicate that we can detect dicamba in the air following an application of Engenia or XtendiMax/Fexapan for as many as 3 or 4 days following the

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application. University weed scientists in surrounding states are seeing similar results in their research. And so we come to the crux of the matter. I have yet to hear any manufacturer of the approved dicamba products say that volatility is one of the possible ways that dicamba has moved away from its intended target in 2017. But yet many university weed scientists like myself believe this is one of the major routes by which off-target movement of dicamba has occurred, because our air sampling data, field volatility studies, and field visits indicate that to be the case. To say that all of these problems have occurred due to physical drift, tank contamination, or temperature inversions but not volatility is, in my opinion, disingenuous at best.

My recommendation. We are in the process of trying to understand how or if these cases can be correlated back to any particular environmental condition such as air or soil temperature, moisture, humidity, etc. That process isn't easy and it can't be done quickly, and any conclusions we can make will only be as good as the data we can get. I'm not sure what that process will yield, but from where I sit right now the only conclusions I can make are that the areas in Missouri that planted the most of the Xtend trait and sprayed the most Engenia, XtendiMax, or Fexapan are the areas where we saw the greatest amount of off-target movement and damage.

I know farmers are looking for answers and will soon be making decisions about their traits and weed management programs for next year. So my recommendation for those growers who wish to plant the Xtend technology is to go back to using dicamba at a timeframe and in a manner when it has been used "successfully" in the past. Based on our history of dicamba use in corn in April and May, and even on our experiences this year using these approved dicamba products in pre-plant burndown applications prior to June, we have seen far fewer problems with off-target movement of dicamba in that timeframe than what we experienced in June, July, and August. Even this season I was not notified of any problems with off-target movement of dicamba until early June, and the Missouri Department of Agriculture didn't receive their first dicamba complaint until June 13th. It seems that almost all of the problems with off-target movement occurred once in-crop, post-emergence applications started to be made for waterhemp and Palmer amaranth. Most of those occurred in June and July this season. I wish I had some definite date for a cutoff but at this time I do not; we will be conducting more weather analyses in the coming weeks and hopefully this process will help us understand which factors lead to more risk when applying these herbicides.

So for the sake of neighboring non-Xtend soybean fields, trees, vegetable crops, gardens, ornamentals, and our industry as a whole, my recommendation for those who want to plant the Xtend trait in 2018 is to use the approved dicamba products for the control of resistant horseweed (a.k.a. marestail), ragweed species and winter annuals in the pre-plant burndown where these products have a great fit, but to abstain from applying these products later in the season. In Xtend soybean, resistant waterhemp will have to be managed using an integrated approach that includes cultural practices like cover crops, narrow row spacings, etc. along with an overlapping residual herbicide program. For more information on managing waterhemp in different soybean system, see this multi-state publication: *Waterhemp Management in Soybean* (http://weedscience.missouri.edu/publications/50737_3_TA_FactSheet_Waterhemp.pdf).

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Printed from: https://ipm.missouri.edu
E-mail: IPM@missouri.edu

From:	Green, Jamie
To:	Kenny, Daniel; Baris, Reuben
Cc:	Taylor, Maren; Ridnour, Lacey; Hackett, Shawn; Frizzell, Damon
Subject:	FW: Letter to Topeka paper
Date:	Tuesday, August 22, 2017 9:48:12 AM

In case you had not seen:

Posted August 20, 2017 07:10 pm

Letter: Time for Kansas to outlaw use of Dicamba

Several states have outlawed the use of Dicamba for weed control on soybeans. (2016 file photograph/The Associated Press)

This year has begun the large scale use of Monsanto's Roundup Ready 2 Xtend soybeans, which are genetically modified and tolerant to chemical Dicamba. Dicamba is a broad-spectrum broadleaf (non-grass plants) control chemical. It has been used for years in the spring with Corn.

Until recently, Dicamba use has been limited to use at lower temperatures (85 degrees and below). At higher temperatures, Dicamba tends to volatize (volatization is when a field is sprayed and afterward the chemical travels to an off-target location (sometimes miles away). When a Dicamba-tolerant soybean was developed, Monsanto and BASF both worked on developing a "low-volitatzation" Dicamba. (Xtend Max and Ingenuity) In fact, these two products are the only ones labeled to be used on the Dicamba-tolerant soybeans.

It hasn't worked out well. Off-target damage is rampant all across the country and here in Kansas. I know of several farmers who have non-Xtend soybeans and have had damage on most of their fields from neighbors who used a Dicamba program on their soybeans. I have a neighbor whose garden was "nuked" by off target Dicamba, and I have had soybeans and clover damaged as well.

Several states have outlawed the use of Dicamba in Soybeans, and it's time for Kansas to do so as well. There are many other options for weed control in soybeans. The Xtend systems are by far the most hazardous to neighboring farms, gardens and vineyards. One of the primary roles of our government is the protection of private property. If our government fails to stop this Dicamba disaster by ignoring property rights, then we have started down a slippery slope that ends in anarchy. Where have all the flowers gone? Dicamba.

ROSS WAHL, Riley

From: Sorokin, Nicholas
To: AO OPA OMR CLIPS
Subject: Reuters: U.S. farmers confused by Monsanto weed killer"s complex instructions, 8/21/17
Date: Monday, August 21, 2017 10:06:14 AM

Reuters
http://www.reuters.com/article/us-usa-pesticides-labels-idUSKCN1B110K
U.S. farmers confused by Monsanto weed killer's complex instructions
By Tom Polansek and Karl Plume, 8/21/17

CHICAGO (Reuters) - With Monsanto Co's (MON.N) latest flagship weed killer, dicamba, banned in Arkansas and under review by U.S. regulators over concerns it can drift in the wind, farmers and weed scientists are also complaining that confusing directions on the label make the product hard to use safely.

Dicamba, sold under different brand names by BASF (BASFn.DE) and DuPont (DD.N), can vaporize under certain conditions and the wind can blow it into nearby crops and other plants. The herbicide can damage or even kill crops that have not been genetically engineered to resist it.

To prevent that from happening, Monsanto created a 4,550-word label with detailed instructions. Its complexity is now being cited by farmers and critics of the product. It was even singled out in a lawsuit as evidence that Monsanto's product may be virtually impossible to use properly.

At stake for Monsanto is the fate of Xtend soybeans, it largest ever biotech seed launch.

Monsanto's label, which the U.S. Environmental Protection Agency (EPA) reviewed and approved, instructs farmers to apply the company's XtendiMax with VaporGrip on its latest genetically engineered soybeans only when winds are blowing at least 3 miles per hour, but not more than 15 mph.

Growers must also spray it from no higher than 24 inches above the crops. They must adjust spraying equipment to produce larger droplets of the herbicide when temperatures creep above 91 degrees Fahrenheit. After using the product, they must rinse out spraying equipment. Three times.

"The restriction on these labels is unlike anything that's ever been seen before," said Bob Hartzler, an agronomy professor and weed specialist at Iowa State University.

The label instructions are also of interest to lawyers for farmers suing Monsanto, BASF and DuPont over damage they attribute to the potent weed killer moving off-target to nearby plants.

A civil lawsuit filed against the companies in federal court in St. Louis last month alleged it might be impossible to properly follow the label. Restrictions on wind speed, for example, do not allow for timely sprayings over the top of growing soybeans, according to the complaint.

The companies failed "to inform the EPA that their label instructions were unrealistic," the lawsuit said.

Monsanto said that while its label is detailed, it is not difficult to follow.

"It uses very simple words and terms," Scott Partridge, Monsanto's vice president of strategy, told Reuters. "They are not complex in a fashion that inhibits the ability of making a correct application." BASF and DuPont could not immediately be reached for comment on the lawsuit on Friday.

Monsanto and BASF have said they trained thousands of farmers to properly use dicamba. Monsanto also said the crop damage seen this summer likely stemmed largely from farmers who did not follow label instructions.

Those detailed instructions led some growers and professional spraying companies to avoid the herbicide altogether.

Richard Wilkins, a Delaware farmer, abandoned plans to plant Monsanto's dicamba-resistant soybeans, called Xtend, this year because a local company would not spray the weed killer.

"The clean-out procedure that you have to go through to ensure that you don't have any residue remaining in the applicator equipment is quite onerous," he said.

In Missouri, farm cooperative MFA Inc said it stopped spraying dicamba for customers last month partly because high temperatures made it too difficult to follow the label.

STUDYING WIND, TEMPERATURES

The EPA is reviewing label instructions following the reports of crop damage.

Monsanto has a lot riding on the EPA review. The company's net sales increased 1 percent to $4.2 billion in the quarter ended on May 31 from a year ago, partly due to higher U.S. sales of Xtend soybeans. Since January, the company has increased its estimate for 2017 U.S. plantings to 20 million acres from 15 million.

One confusing requirement on its dicamba label, farmers said, prohibits spraying during a "temperature inversion," a time when a stable atmosphere can increase the potential for the chemical to move to fields that are vulnerable.

To follow the rule, some growers used their smart phones to check weather websites for wind speeds and information on inversions.

"You have to be a meteorologist to get it exactly right," said Hunter Raffety, a Missouri farmer who believes dicamba damaged soybeans on his farm that could not resist the chemical.

Nicholas Sorokin
Office of Media Relations Intern

U.S. Environmental Protection Agency
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From:	Green, Jamie
To:	Kenny, Daniel; Baris, Reuben; Jones, Arnet; Chism, William; Pease, Anita; Wormell, Lance; Vizard, Elizabeth; Lott, Don
Cc:	Frizzell, Damon; Hackett, Shawn
Subject:	FW: Dicamba update 8-17-17
Date:	Sunday, August 20, 2017 10:31:49 AM
Attachments:	Dicamba update 08-17-2017.pptx

Latest report – contains some information on specialty crops, etc. that have been damaged in addition to soybeans. Also has an interesting graph illustrating the number of complaints they received both pre and post their SSURO and revised labeling. It's not clear to me whether the reductions in complaints were due primarily to the label changes or is more related to the bulk of the applications occurring earlier.

From: Slade, Darryl [mailto:Darryl.Slade@mda.mo.gov]
Sent: Friday, August 18, 2017 2:48 PM
To: Green, Jamie <Green.Jamie@epa.gov>; Frizzell, Damon <Frizzell.Damon@epa.gov>; Hackett, Shawn <hackett.shawn@epa.gov>
Cc: paul.bailey@mda.mo.gov
Subject: Dicamba update 8-17-17

Dicamba update 8-17-17. I have added one new slide to the presentation. A chart tracking Dicamba complaints received per time period and comparing when SSURO and 24c labels were issued.

Darryl Slade
Enforcement Program Coordinator
Missouri Department of Agriculture
Plant Industries Division
Office: (573) 751-5511
agriculture.mo.gov

MISSOURI DEPARTMENT of AGRICULTURE

DICAMBA UPDATE

August 17, 2017

Agriculture.Mo.Gov

2016 DICAMBA COMPLAINTS

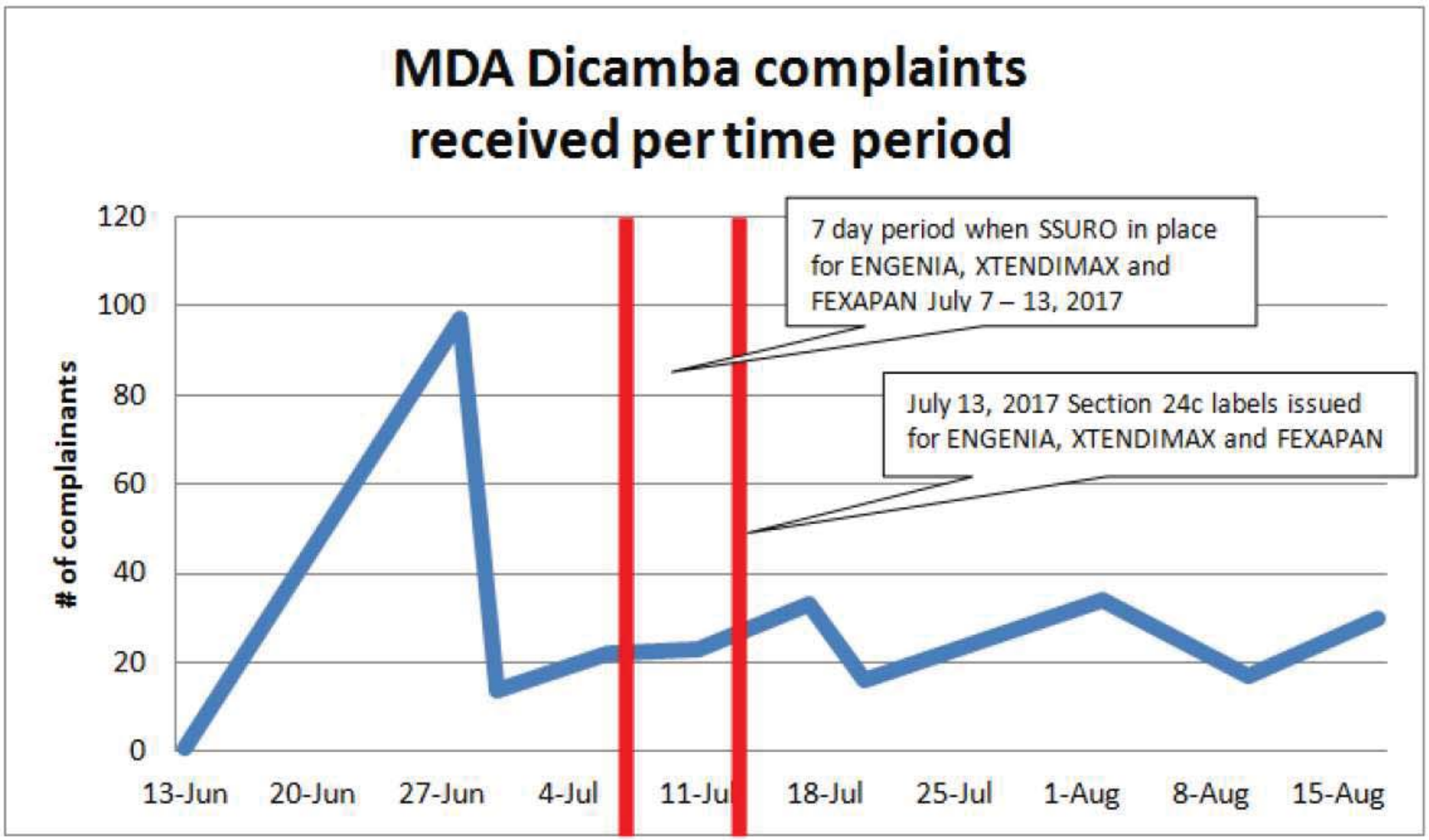
- 130 – Total Dicamba complaints for 2016
- June 22, 2016 - Received first Dicamba complaint

2017 DICAMBA COMPLAINTS

- 287– Dicamba complaints received (as of COB 8/17/2017)
- June 13, 2017 - Received first Dicamba complaint

Agriculture.Mo.Gov

2017 DICAMBA COMPLAINTS



Agriculture.Mo.Gov

2017 DICAMBA COMPLAINTS

Crops damaged as identified by complainants:
(as of 8/17/2017)

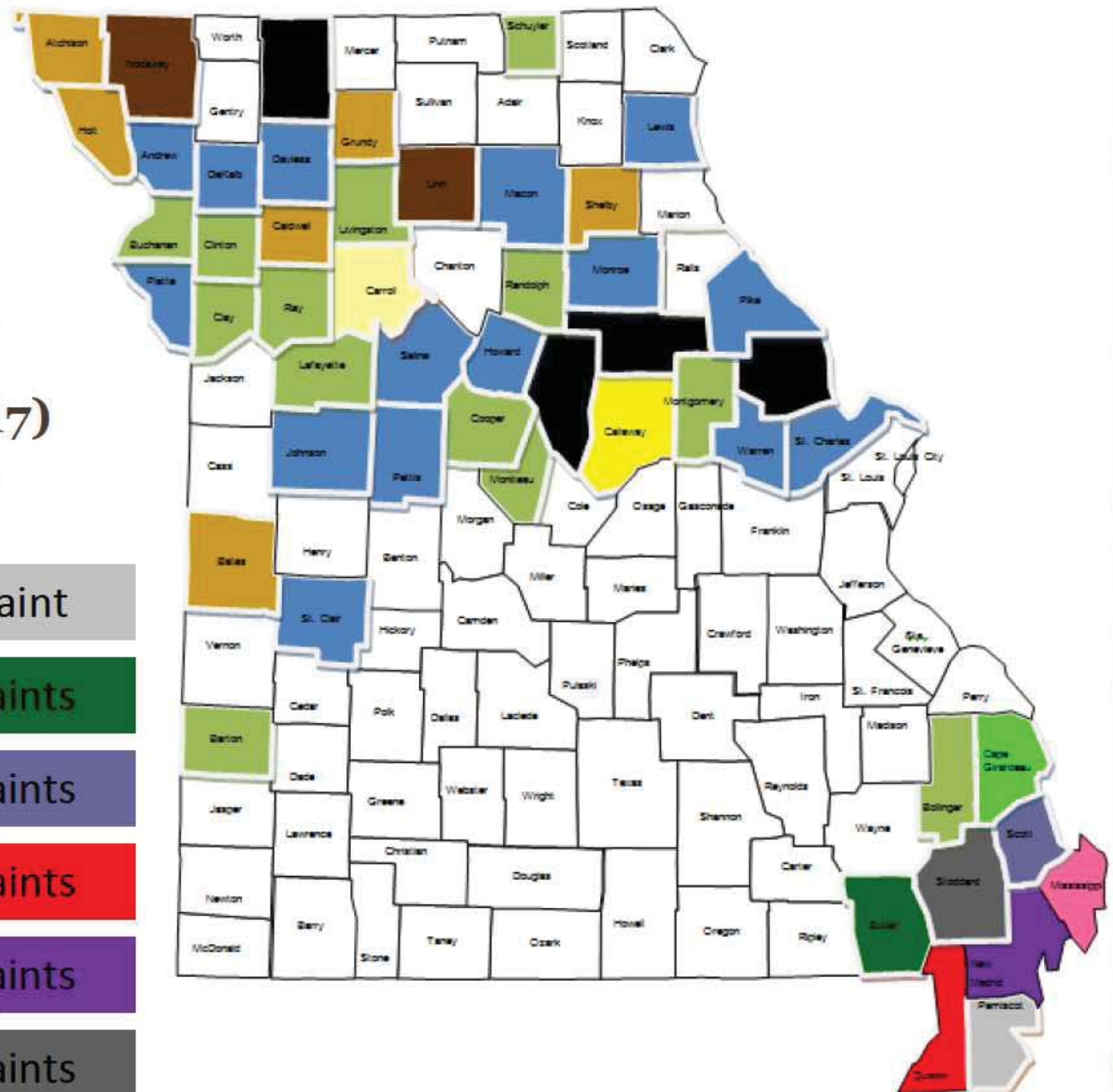
- 106,687 acres of soybeans
- 18,904 tomato plants
- 758 acres of peaches
- 130 acres rice
- 122 acres of watermelons
- 122 acres of vineyards
- 35 acres of alfalfa
- 24 acres certified organic vegetables
- 15 acres of pecan trees
- 12 acres of apple trees
- 11 commercial gardens
- 10 acres of cantaloupes
- 2 acres of pumpkins
- 900 mums
- 34 residential properties (gardens/trees/shrubs)

Agriculture.Mo.Gov

2017 Dicamba Complaints

(as of COB 8/17/2017)

1 Complaint	
2 Complaints	12 Complaint
3 Complaints	14 Complaints
4 Complaints	19 Complaints
5 Complaints	24 Complaints
6 Complaints	28 Complaints
10 Complaints	31 Complaints
11 Complaints	59 Complaints



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From: Bradley, Kevin
To: Baris, Reuben
Subject: Re: WSSA committee
Date: Friday, August 18, 2017 12:03:06 PM
Attachments: A68295E2-4431-4EF5-944A-3488169A97FC[7].png
5939E0CA-ECB1-4FAB-9D4D-0C2C4E8C81AE[7].png
DC0AC5B9-FA42-47CB-A189-C396E5A5E7E4[7].png

Reuben, this is what we have come up with at this point in time. Is this what you had in mind?

The following species sensitivity rankings are based on published literature and/or studies:

Extremely Sensitive:
Grapes
Lima Bean
Southern Pea
Snap Bean
Soybean
Tobacco
Peach
Elderberry
Dogwood
Oaks
Viburnum

Very Sensitive:
Cotton
Pepper
Pumpkin
Tomato
Watermelon

Moderately Sensitive:
Cantaloupe
Cucumber
Squash
Apple
Maple
Elm
Redbud
Rose

Dogwoods

Low Sensitivity:
Peanut
Broccoli
Cabbage
Kale
Mustard
Turnip
Walnut
Pecan
Raspberry
Strawberry
Sweetgum
Crabapple
Hydrangea

Species which appear to be sensitive based on observations from the field but no published data:
Ginkgo
Paulinao
Frindge
Sycamores
Cypress
Boxelder
Birch
Catalpa
Honeylocus
Spruce
Poplar

Kevin Bradley, PhD
Associate Professor,
Division of Plant Sciences
University of Missouri

Weed Science Website: http://weedscience.missouri.edu
Weed ID Website: http://weedid.missouri.edu

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From:	Green, Jamie
To:	Baris, Reuben; Kenny, Daniel; Jones, Arnet; Pease, Anita; Miller, Michele; Wormell, Lance; Hopkins, Yvette; Lott, Don; Vizard, Elizabeth
Subject:	FW: Article
Date:	Thursday, August 10, 2017 2:48:20 PM

FYI

From: Slade, Darryl [mailto:Darryl.Slade@mda.mo.gov]
Sent: Thursday, August 10, 2017 1:35 PM
To: Green, Jamie <Green.Jamie@epa.gov>; Hackett, Shawn <hackett.shawn@epa.gov>; Frizzell, Damon <Frizzell.Damon@epa.gov>
Subject: FW: Article

https://www.arktimes.com/arkansas/farmer-vs-farmer/Content?oid=8526754

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From: May, Melissa
Sent: Thursday, August 10, 2017 1:31 PM
To: Bailey, Paul; Wall, Dawn; Slade, Darryl; Grundler, Judy
Subject: FW: Article

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From: Jason Robertson [mailto:Jason.Robertson@aspb.ar.gov]
Sent: Thursday, August 10, 2017 12:33 PM
To: May, Melissa
Subject: Article

https://www.arktimes.com/arkansas/farmer-vs-farmer/Content?oid=8526754

Good dicamba article

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NEWS » COVER STORIES AUGUST 10, 2017

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Farmer vs. farmer

The fight over the herbicide dicamba has cost one man his life and turned neighbor against neighbor in East Arkansas.

By David Koon

click to enlarge

BRIAN CHILSON

IN MONETTE: Karen Wallace, widow of Mike Wallace, wants to see the pesticide dicamba banned.

At the peak of summer in the little town of Monette in Craighead County, the soybeans and cotton in surrounding fields a jealous green, the pear tree that stands 20 feet from the grave of Mike Wallace looks like it has been blowtorched, every leaf blighted, curled and black at the edges. It's the ugly residue of drifting dicamba, the herbicide for which Wallace literally gave his life.

According to investigators, on Oct. 27, 2016, Wallace, who farmed 5,000 acres of corn, soybeans and cotton near the Arkansas/Missouri border, arranged by phone to meet a farmhand named Allan Curtis Jones, 26, of Arbyrd, Mo., on West County Road 38 north of the Mississippi County town of Leachville to discuss Wallace's suspicions that the farm where Jones worked was the source of drifting dicamba that had damaged some of Wallace's crops. Wallace, who had been vocal in his opposition to the herbicide, had been quoted in an August 2016 story in The Wall Street Journal, telling the newspaper that at least 40 percent of his soybean crop had been damaged by drifting dicamba since June. He'd filed complaints twice with the Arkansas State Plant Board, the state agency that oversees claims of crop damage, about damage from drifting dicamba and had encouraged other farmers to report their damage as well.

When Wallace and Jones met outside of Leachville, Jones brought along his cousin and a gun. According to statements issued by Mississippi County Sheriff Dale Cook at the time of the shooting, Jones told investigators that an argument had ensued. In the midst of it, Wallace, who was not carrying a weapon, grabbed Jones by the arm. At that point, investigators say, Jones pulled away, pulled his pistol, and fired into Wallace's body until the magazine was empty. Wallace, a father of two who'd farmed in Mississippi County since he was a boy, was hit at least four times, and died in the dust on the south shoulder of the county road, with Jones' cousin using his shirt in a futile attempt to stop the bleeding. Jones soon was arrested on a charge of first-degree murder, and later released on $150,000 bond.

Whether the shooting was self-defense or homicide will be up to a jury. Jones is scheduled to go to trial Sept. 11. A spokesman for the Mississippi County Sheriff's Office referred all questions about Wallace's murder to the prosecutor for Mississippi County. The prosecutor handling the case did not return a call seeking comment at press time. Calls to the Blytheville defense attorney representing Jones also went unreturned at press time.

However the case against Jones turns out, Wallace's family has been working since his death to see justice done in another way: by trying to get the use of dicamba banned statewide. A 120-day ban was put in place in early July, the fine for illegal spraying of the herbicide increased 25-fold on Aug. 1, and a task force was established to look for solutions.

But a permanent ban on dicamba would run afoul of the needs of farmers, who are facing a shrinking pool of options in the fight against herbicide-resistant weeds, and of corporate investment in genetically modified, dicamba-tolerant crop technology that is easily worth billions. It's a quest that has put Wallace's family at odds with many of their neighbors and, in some ways, even their own best interests as farmers. But they say it is a fight Mike Wallace would make if he were alive.

On the wind

Developed in 1958 by the German-based chemical company BASF and first used on corn crops in the mid-1960s, dicamba is a plant-hormone-mimicking herbicide that's deadly to a host of weeds and other plants, including many common vegetable crops and species of ornamental flowers and trees, like the Bradford pear that stands near Wallace's grave. While it works like gangbusters against pigweed, which has been a bane of row crop agriculture long before the plant began developing a stubborn genetic resistance to glyphosate-based herbicides like Roundup, cotton and soybean farmers in East Arkansas didn't use it much during the growing season because dicamba is highly lethal to those crops, which have long been the lifeblood of the area. Even a light dose of dicamba on soybeans can cause curled leaves, stunted plants and a reduction in yield. A medium-to- heavy misting can kill them outright. That, combined with dicamba being prone to drift if applied improperly and its "volatility" — the tendency to change back to a vapor, lift off of crops and float away to neighboring fields under the right atmospheric conditions — would have made the idea of Arkansas farmers spraying large amounts of dicamba in high summer unthinkable 10 years ago, not to mention illegal. Until this year, spraying dicamba beyond April 15, after vulnerable crops had emerged from the soil, was against the law in Arkansas, with violations carrying up to a $1,000 fine. When it was used, dicamba was mostly employed as a "burn down" herbicide to clear an agricultural slate in preparation for planting, before the plants it might harm had sprouted or leafed out.

But that was then. This is now.

click to enlarge

ALLAN CURTIS JONES

In 2015, the Missouri-based agricultural giant Monsanto released its Xtend brand cottonseed. A year later it put out Xtend soybeans. Both are genetically modified to be tolerant of dicamba. Potentially worth billions, the GMO technology promised to be a new weapon in farmers' ongoing fight against several stubborn weed varieties, including pigweed, resulting in higher yields and incomes. To farmers stretched thin, it must have sounded like a godsend.

The new dicamba-tolerant seeds hit the market quickly, and more cotton and soybean farmers began to plant them. But they could not yet use a legal dicamba-based herbicide on their crops, because one was not available. BASF's Engenia, advertised as being less likely to drift off target, was not approved for use in the state until fall 2016, and another low-volatility dicamba formulation, Monsanto's Xtendimax with Vapor Grip, is still not approved for use in Arkansas.

Early adopters who had purchased dicamba-tolerant seed with the expectation they'd soon be able to spray their fields with reformulated dicamba and watch weeds melt away were disappointed with the progress of getting the lower volatility formulas approved. Whether out of greed, historically tight financial margins or desperation at out-of-control weeds, some farmers became outlaws in 2015 and 2016, spraying older, more drift- and volatility-prone formulas of dicamba on their dicamba-tolerant crops, knowing that even if they got caught, the $1,000 fine amounted to a speeding ticket when compared to the increased profits they stood to reap. In the same August 2016 Wall Street Journal article that featured Wallace speaking out about dicamba damage, an assistant director of enforcement with the Arkansas State

Plant Board was quoted as saying she'd been openly told by farmers spraying dicamba in violation of the law: "We'll write you a check." If a farmer has 5,000 acres or more under cultivation, all planted with dicamba-tolerant seed, it's not hard to divide by $1,000 and do the financial math.

With some farmers planting dicamba-tolerant crops in proximity to their neighbors' dicamba-susceptible crops and then spraying the older formulations of dicamba, the result in recent years has been like dropping a bomb on East Arkansas agriculture. According to a report released July 25 by a scientist at the University of Missouri, 17 states have received reports of dicamba-related crop damage since the dicamba-tolerant seeds were introduced, with an estimated 2.5 million acres affected. Arkansas was the hardest hit by far, according to the report, with an estimated 850,000 acres of crops in the state damaged. As of early August, the State Plant Board had received over 840 complaints of suspected dicamba-related issues. Gardens and landscaping, some of it miles away from the nearest dicamba-tolerant fields, were scorched and stunted. In a moment that might be funny if it wasn't so indicative of the chaos that's been sown in East Arkansas, the damage this year included 100 acres of soybeans unexpectedly whacked by drifting dicamba at the University of Arkansas's Northeast Research and Extension Center in Mississippi County. A June press release on the damage noted ironically that the damaged soybean plots, which had to be plowed under and replanted, were to be used in research on dicamba drift and volatility. In another irony that might be shocking if it weren't so sad, members of Mike Wallace's family, who have every reason in the world to hate dicamba and what the controversial herbicide has done to relationships in the close-knit farming communities of Northeast Arkansas, planted a sizable part of their acreage this year in dicamba-tolerant crops, solely in self-defense. Tales of defensive planting of dicamba-tolerant seeds have become common, with a kind of forced monopoly-by-attrition taking hold. According to Monsanto, 18 million acres of dicamba-tolerant soybeans were planted in the U.S. this year, including 1.5 million acres in Arkansas — about half the total estimated soybean crop in the state.

Having approved the use of BASF's Engenia in the fall of 2016 over the objections of the Wallace family, the State Plant Board reversed itself on June 23 and voted to recommend a temporary ban on the "in-crop" use of dicamba-based herbicides, a decision that soon received the approval of Governor Hutchinson. A statement released by Monsanto after the Plant Board's vote said the board didn't allow farmers who had already planted dicamba-tolerant seeds to describe how a ban would affect their operations. "Instead," the statement read, "the Board based its decision on off-target movement claims that are still being investigated and have not been substantiated. ... Arkansas farmers should not be forced to continue to operate at a disadvantage to farmers in other states where bans like the board's current proposed action do not exist."

The issue was referred to a joint meeting of the state House and Senate committees on agriculture, economic development and forestry on July 7. By the time the joint committee meeting started at 9 a.m. that day, the room's large, curved gallery was packed, legislators in suits shoulder to shoulder with farmers in plaid shirts and mesh trucker caps who'd driven through the dawn from East Arkansas to be there. The public comment period was crowded and divided: farmers talking about their extensive dicamba-related crop damage vs. farmers talking about the need for the new technology to help solve their herbicide-resistant weed problems. A representative from a small poultry producer told the committee that his niche business model of selling non-GMO chicken was being threatened by damage to the soybeans his business grows for feed. Weed scientist Dr. Ford Baldwin, who called dicamba the biggest train wreck to ever hit agriculture, told the assembled legislators that the day before the meeting, a farmer in that very room had been involved in a fistfight with another farmer over crop damage. He didn't say whether the farmer in question was for or against the ban.

As it has been at every state-level meeting on dicamba that's been held since October 2016, Wallace's family was there, pushing for a ban. Kerin Hawkins, Wallace's sister, addressed the committee. The month after her brother's death, she and other members of her family had pleaded with the Plant Board to ban dicamba, but BASF's lower-volatility formulation Engenia had been approved with restrictions, including a quarter-mile buffer zone between dicamba spraying and non-dicamba-tolerant crops. Hawkins appeared again in July to ask the joint committee to support the ban. She said that in addition to damage to her family's peanut crops, their 10-acre garden patch inside the city of Leachville, which she said is over a quarter mile from any dicamba spraying, had also been damaged by drift.

After the joint committee voted to recommend the ban, an eight-member subcommittee of the Arkansas Legislative Council officially took no action on the plan, which allowed the 120-day ban on in-crop dicamba use to go into effect on July 11. A $25,000 fine for illegal spraying of the herbicide went into effect last week.

click to enlarge

KNOWING THE KILLER HERBICIDE: Weed scientist Dr. Ford Baldwin.

An act of man

State Rep. Joe Jett, a Republican who lives at Success in far Northeast Arkansas, is a retired farmer and looks the part. A supporter of the temporary ban, Jett attended the July 7 meeting and invited Baldwin to speak. Jett said heavy rains in Northeast Arkansas this spring helped keep dicamba damage from being worse this year, simply because farmers couldn't get into the waterlogged fields to spray. "Had it not been for that," Jett said, "I think the atmosphere would have really loaded up with dicamba and you would have seen a lot more widespread damage than what we saw as it was."

Jett said he is in favor of advanced technology to help farmers, including genetically modified seeds, but wouldn't use dicamba himself "in good, clear conscience" given the damage he's seen in Northeast Arkansas. "Knowing that we're going to go out here and hurting people and putting ourselves in front of our neighbors? I can't get my head wrapped around that," he said. "Obviously you're always going to have some folks out there who don't care what's right and who are going to take care of themselves. But I think a lot of it is that the margins are just so tight [in farming], and farmers need every break they can get. They're willing to look the other way and be more worried about themselves surviving than they are about their neighbors surviving. I think that's a lot of it."

Asked whether members of the legislature have discussed a way to financially assist farmers in the state hit by dicamba-related crop loss, Jett said the state is on a tight budget and will be unlikely to help. "I don't know how you could ever get into that," he said. "Farmers have insurance, but [the damage] can't be manmade. It has to be an act of God. To answer your question: No, I think that's probably beyond the state. We don't have the means to help in that regard." Federal crop insurance only covers losses due to drought, flood or natural disasters. The only remedy for those farmers whose incomes were damaged by dicamba may be to sue, and some are doing that. There are at least two civil suits against Monsanto and BASF over dicamba use in Arkansas, one representing farmers who planted non-Xtend crops and suffered losses due to dicamba drift, and another by farmers who planted Xtend seeds expecting to be able to use the lower-volatility formulations of dicamba but can't because of the ban. Both lawsuits are seeking class-action status.

Terry Fuller, a member of the State Plant Board who runs Fuller Seed and Supply in Poplar Grove in Phillips County and farms 3,000 acres near the Indian Bay community, spoke in favor of the ban at the July 7 meeting. While he said farmers in his area appear to be abiding by the dicamba ban for the most part, he believes the reduction in yields to non-dicamba resistant crops caused by damage early in the season could be severe.

click to enlarge

BRIAN CHILSON

DRIFT: A Bradford pear tree near her Wallace's grave shows the damage dicamba causes to vegetation, including crops.

"It's going to be dire because we didn't ban it sooner," Fuller said. "It's crazy how much damage we've got, and it's going to be real damage. It's going to amount to millions." Fuller, who told the joint committee in July that he couldn't leave his house in any direction without seeing extensive crop damage caused by dicamba, said he believes the companies behind the dicamba-tolerant seed and low-volatility herbicide are engaging in "a strategy to force everybody to plant" the dicamba-tolerant seed. While the chemical companies have tried to put at least some of the blame for damage in Arkansas this year on misapplication of Engenia, Fuller said he doesn't buy it. "I contend that we've got world-class farmers; the best there are anywhere in the world," he said. "I don't just believe they were applying [Engenia] right, I absolutely, positively know that a lot of it was applied exactly right."

The sad part, Fuller said, is that some of those world-class farmers are the ones getting the black eye. "We're trespassing on our neighbors, and we're trespassing on our neighbors in town," he said. "It's not just our neighbor farmers. There's a lot of damage in yards. You hate to say that and call attention to it, but it is a reality."

Baldwin agrees, and has similar concerns about how the dicamba damage will play to a public already spooked about herbicides. A respected weed scientist who worked for the University of Arkansas for 27 years, Baldwin retired in 2002 and now runs a consulting business, Practical Weed Consultants, with his wife. Baldwin has been something of the Paul Revere of the chaos dicamba-resistant-seed technology could potentially bring to agriculture.

"I said four years ago that dicamba would drive a wedge between farmers, which it has," Baldwin told the Arkansas Times. "You've got 50 percent that wants the technology and 50 percent that doesn't want the technology and don't want the dicamba sprayed on them. And it's going to drive a wedge between agriculture and nonagriculture. I'm not being critical of anybody or slamming anybody. It's just the way it is."

In his testimony before the joint committee in July, Baldwin spoke of his suspicions that even the new, officially less-volatile formulation of dicamba is moving from field to field or even traveling miles away due to volatility and temperature inversions that pull the chemical off sprayed crops and into the air at night. Ford talked of farmers inadvertently "loading the air" with dicamba, which then floated around in the atmosphere like invisible smoke until temperature fluctuations forced it down on farms and yards, decimating crops and ornamental plants almost as if it was sprayed there on purpose.

Baldwin said he never believed he'd see farmers show such disregard for each other as they have since dicamba-tolerant crops were introduced. He called the murder of Wallace "the low point" of his career. "I never dreamed I would see farmers show the insensitivity toward each other in some cases," Baldwin said. "That doesn't apply across the board. But you know some farmers just have the attitude: 'My neighbor knew I was planting Xtend crops, so it's his own fault that I damaged him. He should have planted Xtend crops, too.' Well, hell, he's got a right to plant anything he wants to plant and not have it damaged."

Though the less-volatile forms of dicamba seem like a solution to the drift problems being experienced by farmers, Baldwin said the science of the herbicide seems to show that dicamba's volatility may be a very difficult problem to solve

— one he believes the companies have downplayed. "The problem is there's a difference between less volatile and nonvolatile," Baldwin said. "It's my understanding that there were some totally nonvolatile dicambas developed back in the early days of the herbicide. The problem was that the weed-control efficacy declined as the volatility declined. ... That doesn't mean it couldn't be revisited, but the best information we have right now is there is a relationship between volatility and weed control efficacy [in dicamba]."

Baldwin doesn't believe operator error in spraying BASF's less-volatile version of dicamba and scofflaws continuing to spray older, cheaper formulations of the herbicide in violation of the law account for all the damage he saw early in the 2017 growing season.

"If you go east to Crowley's Ridge, every single field that's not a dicamba [tolerant] crop is basically damaged, and has the same level of damage," he said. "A lot of these fields are several miles away from where any dicamba was applied. You can't do that with physical drift. Drift is the blowing of physical spray particles, and you can't blow those as far as a lot of people think before you blow them completely away. Now you can do a lot of damage close to the source, don't get me wrong. But when you go in areas where every field looks exactly the same over a countywide area or multiple county area, common logic tells you that you're getting the same dose rate of a herbicide spread over a vast number of acres. The only way you can do that is to load the air — load stable air masses during temperature inversions and move it that way."

From the beginning, Baldwin said, everybody knew dicamba-tolerant crops had to be an "all or nothing technology," which will have to be planted on 100 percent of acres before damage to nontolerant crops will cease. But even if farmers plant every acre of cotton and soybeans in the state in dicamba-resistant seeds, Baldwin notes, that still doesn't solve the problem of damage to landscaping, trees, ornamental plants, vegetable gardens and other vegetable crops. He believes that aspect will be bad for agriculture as a whole.

"You get into the horticultural crops, then you get into the home gardens and you get into the trees in town," he said. "To me, the more dicamba we put in the air, the more you're going to affect these other types of vegetation. You might solve the soybean issue short term, but you're going to get this thing outside of agriculture. All of a sudden, when peoples' gardens are affected, when the trees in their yards are affected, then they're going to start asking the questions: 'Is this stuff safe for me to eat? Is it safe for me to breathe?'"

click to enlarge

THE WALLACE FAMILY: Mike kneels on right.

The long row

In a house at the edge of a cotton field in Monette, the crops stretching away to the edge of the world in all directions, Karen Wallace talked about the husband she has to go on without. He was born within three miles of the spot, and started his first crop at 17. Married her at 18. Put her through college so she could realize her own dream of being a teacher. Raised two kids and saw them have children of their own. He was, she said, a man always thinking of the community, the kind of guy who would go around town with his own equipment after rare snowfalls and clear the driveways of elderly folks who'd plowed their lives into the soil of Craighead and Mississippi counties.

"He wasn't a farmer that farmed out of the seat of his truck," Karen said. "He was a hands-on farmer. He was in the field daylight until dark. That was just his life." Which is, of course, what makes his death so hard to understand.

Karen said that in 2015, Mike attended one of the first meetings in the area about the introduction of dicamba-resistant seed at Delta Crawfish in Paragould. "At the meeting, Monsanto just kept discussing that they were going to release the seed, though the herbicide had not been approved yet, but kept telling farmers that by growing season it would be," she said. "We didn't plant any dicamba [tolerant] cotton that year, but we had neighbors that did." Wallace estimates they suffered $150,000 worth of crop damage from dicamba that first year. The issues in the area have only accelerated since then.

"I don't think I've ever seen anything like this that has turned farmer against farmer," Mike's sister, Pam Sandusky, said. "They've always been there to help each other do whatever." Karen Wallace agreed that dicamba-tolerant crops have turned the ethics of farming topsy-turvy. "It was like the farmers who turned their neighbors in [for illegal dicamba use], they're the bad guys," Karen said. "It was like, 'You're causing something we really need to be taken away.' It's just crazy to me."

The day her husband was killed, Wallace said, she'd run an errand in Kennett, Mo. The harvest done, he was leveling ground. Though she knows now that Mike had gotten a number for Allan Curtis Jones from an acquaintance, she said he'd never mentioned the name to her or their son, Bradley, and didn't tell either of them he planned to meet outside of Leachville.

"He told me, 'I'll be right back,' " Wallace said, "and that was that. I never talked to him again."

As soon as her husband was killed, everybody seemed to know it immediately. Word got back to her quickly. Not knowing what else to do, she and several family members met at the gin in Monette, which is run by Mike's cousin. She called her sister in Jonesboro, pleading with her to get to her daughter, Kimberly, who was attending an event at Arkansas State University. By the time she did, Kimberly had already heard through a post on Facebook.

"This man is probably going to claim self-defense," Karen said. "Mike is 56 years old. This man was 26. He's 30 years younger than him, probably 50 pounds heavier. He went and got his cousin. Mike never carried a gun. We don't know why he decided to shoot him."

There were over 1,000 people at Mike Wallace's funeral, the line to pay respects stretching out the door of the First Baptist Church and into the parking lot. When he was buried in the little cemetery in Monette, the farmers for miles around brought their tractors, a burbling second line, and ringed the paved lane around the graveyard. "I knew Mike had a lot of friends," Karen said. "But for that many people to pay their respects to Mike was just unbelievable. It was overwhelming."

The death has been hard on the whole family. Kerin Hawkins, another Wallace sister, displayed two photos. One is of their mother, Mary, standing in deep cotton with son Mike two weeks before his death. Another shows Mary, at least 30 pounds lighter, surrounded by family at this year's Fourth of July celebration.

"I didn't even realize it until we took this picture in July," Hawkins said. "I thought, 'We're losing her.'

"They took Mike from us. They took Mike from his family, from his grandchildren. He had a grandchild born this year, his first grandson with the Wallace name. His grandson will never know him."

Still, both Wallace and Hawkins say they joined many of their neighbors and planted dicamba-tolerant crops in self-defense, knowing they might take a hit bad enough to wipe them out if they didn't. "That's what my husband and my sons did this year," Hawkins said. "We've got all dicamba cotton. ... We were afraid of what would happen to us. It wasn't that we necessarily wanted to plant it. It's that we had to."

Mike Wallace was more than a brother to them, Hawkins and Sandusky said. Abandoned by their biological father when he was a teenager, Mike Wallace stepped up, becoming a father figure, protector, counselor and friend. "One of the first things I said to my husband whenever I found out what happened and that Mike was gone, was, 'I feel like an orphan,' " Sandusky said. "I never realized how much I looked to him, because our dad kind of walked out of our lives. I never realized how much I looked to him for answers, for help, for everything. He took over, and I never realized it until we lost him."

Farming has changed since Wallace started, Karen Wallace said, and not for the better. "I think we're in a society where we want the easiest way out," she said. "The easiest way, the fastest way, regardless of who it hurts or what happens. But farming is not like that. Farming is hard work. Mike was willing to put out the work." There's work to be done now, and Wallace is not here to do it, so Sandusky, Hawkins, Karen Wallace and other family members will keep making the long drive to Little Rock any time there's a meeting on dicamba. They want to see the state's temporary ban made permanent.

"We were raised to be there for each other," Hawkins said. "If one person was hurting in the family, you were there for them. You were there to back them up. You always had their back. It didn't matter. He would have done the same for us. He would be there fighting for us, and we're not going to let him down. We cannot let them get away with what they've done and what they've taken from us."

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Speaking of...

Legislative Council approves dicamba ban

January 19, 2018

by Max Brantley

The Legislative Council today signed off without discussion on a Plant Board rule to ban the use of the herbicide dicamba between April 16 and Oct. 31. /**more**/

UPDATE: Arkansas Plant Board votes again to ban controversial herbicide dicamba

January 3, 2018

by David Koon

The Arkansas State Plant Board is holding a special meeting at this hour to discuss changes to their proposed ban on the controversial herbicide dicamba in the coming growing season. /**more**/

Dicamba task force report to Plant Board recommends ban on herbicide after April 15

September 13, 2017

by Benjamin Hardy

Some regulatory progress is being made on addressing the damage dicamba has caused to many Arkansas farmers. The report says that almost 1,000 complaints alleging dicamba misuse have been filed with the state plant board as of September 1. /**more**/

Monsanto urges state not to ban dicamba

September 7, 2017

by Lindsey Millar

In a letter to Governor Hutchinson on Thursday, agriculture giant Monsanto asked the state to reject a state task force's recommendation that Arkansas ban the use of dicamba herbicides after April 15, 2018. The Arkansas Legislative Council previously imposed a 120-day ban on dicamba use effective July 11. Also, Reuters reports the EPA is considering banning the spraying of dicamba after a certain date next year. /**more**/

Governor backs Plant Board on new pesticide rules

January 4, 2017

by Max Brantley

Gov. Asa Hutchinson has approved the state Plant Board's proposed rule changes to place additional restrictions on the herbicde dicamba. /**more**/

Herbicide use leads to slaying in Mississippi County UPDATE

October 29, 2016

by Max Brantley

KARK reported yesterday the shooting death of a Mississippi County farmer, Mike Wallace of Monette, and the arrest of another farm worker, Allan Jones, in an argument over herbicide drift. /**more**/

NPR: herbicide-resistant GMO soybeans from Monsanto inviting damage from East Ark. scofflaws.

August 1, 2016

by David Koon

A new piece from NPR about chemical giant Monsanto's roll-out of a herbicide-resistant soybean — and the damage drifting sprays are doing to the crops of East Arkansas soybean farmers who haven't made the switch to Monsanto's frankenseeds — is worth a read. /**more**/

Mike Wallace interviews Orval Faubus

April 9, 2012

by Max Brantley

CBS correspondent Mike Wallace died Saturday at 93, leaving a career with more reportorial milestones than you could easily count. /**more**/

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NEWS

Perry Ostmo of Sharon, N.D., surveys his Roundup-ready soybeans -- 12 inches tall in the foreground -- were susceptible to a dicamba herbicide applied to his neighbor's chest-high fields, just behind him. He thinks some of the unabsorbed chemical volatilized and drifted onto his beans like a cloud. Photo taken July 31, 2017, at Sharon, N.D. (Forum News Service/Agweek/Mikkel Pates)

Farmers deal with dicamba drift

By **Mikkel Pates / Agweek Staff Writer** on Aug 7, 2017 at 8:30 a.m.

SHARON, N.D. — Perry Ostmo doesn't blame the "local guys" — the neighbor or the applicator for damages to his soybeans this year. He doesn't even want to be too hard on BASF, the company who developed a chemical formulation he thinks is important but needs improvement.

Ostmo is a board member of the North Dakota Soybean Council. His views do not represent the council, which has not taken a position on dicamba.

Dicamba formulations also are produced by Monsanto and Dupont, in addition to BASF. Several states, including Missouri, Arkansas and Tennessee, have placed restrictions on when and how it can be used due to the possibility of drift and volatility.

Ostmo believes the herbicide applied to the soybeans next to his soybean field somehow "volatilized" and spread like a cloud over his soybeans, curling the leaves and stunting their growth.

"We all get along," Ostmo says. But he thinks something should be done to prevent a kind of spray drift that can happen a day or even two days after the actual spraying, even if applicators have followed the labels.

The neighbor's dicamba-resistant beans are waist-high and green, flourishing in early August, while his are a foot tall. He thinks some might yield only 5 or 10 bushels per acre, rather than at least 30 bushels an acre he expected.

Puzzling pieces

Dr. Richard Zollinger, a North Dakota State University extension weed specialist in Fargo, N.D., says he's getting a daily stream of calls from people — farmers, crop consultants, county agents — reporting problems. It's too soon to draw conclusions, he says.

Zollinger says he's working to set up a reporting system, either through the North Dakota Department of Agriculture, or through NDSU's AgDakota listserv. A survey could be up and running in the next week or two.

Jeff Gunsolus, University of Minnesota extension weed specialist, on Aug. 1 in his blog announced a similar survey effort to collect information on dicamba damage to beans so the public can indicate acres, fields, and counties that may be involved.

"The big unknown in fields presenting dicamba injury symptoms will be dicamba's impact on soybean yield," Gunsolus says. He says sensitivity of non-Xtend soybeans to dicamba makes injury symptoms not reliable indicators of yield loss.

A North Dakota survey would allow an indication of location and the kinds of injury. Zollinger thinks yield loss won't be known until harvest and may be confused by other phenomena, such as a "rapid-growth syndrome," or hormone-type symptom that glyphosate could produce.

Chemical manufacturers BASF and Monsanto both created new formulations. The products and application recommendations were carefully geared to avoid "particle drift." Zollinger says he's heard of academics in southern states doing tests to see whether "volatilization" explains damage on some acres.

15 percent damaged

Ostmo planted 1,400 acres of soybeans and thinks 200 are damaged due to the volatilization drift. He also planted 300 acres of barley, 700 acres of durum wheat and 500 acres of spring wheat.

His beans are "plain Roundup Ready" — genetically-modified soybeans to be resistant to glyphosate herbicide but not to dicamba. Ostmo's beans were planted May 25, and applied with a pre-emerge herbicide shortly after.

The neighbor planted some of the new dicamba-resistant soybeans about two weeks earlier. He'd hired a commercial applicator to spray a dicamba product in early July.

Two weeks later, Ostmo's crop scout consultant called his attention to leaf-curling.

"The stunting had taken place — kind of a dull color, not the nice green ones like my neighbors had," he says. They took plant tissue samples to freeze for later verification. He contacted the applicator who "admitted that some of that drift was theirs." BASF officials came to look.

'Obvious' damage

"It was obvious that some of it was maybe 'direct drift,' but most of it was volatilization," Ostmo says, describing the phenomena where the applied herbicide evaporates from the leaves and drifts in a kind of a cloud, off-target.

"The volatilization probably went for a half-mile to a mile away," he says. It seemed "pretty clear where it hit" because he could see "lines in the field where the volatilization ended, and the unaffected soybeans stood next to them."

In the first week of August, Ostmo can't predict how much yield will be affected by the damage. He's had to spray for weeds because the volatilized drift herbicide affects mostly beans. He's sprayed to control a second flush of weeds, and tank-mixed with an insecticide to kill heavy infestation of soybean aphids.

"I'm not worried about (compensation)" Ostmo says. "We'll come to some agreement," but he doesn't say with whom. He thinks the chemical manufacturers should be more at fault from the volatilization than anyone.

On the other hand, Ostmo says farmers need the new chemistry.

"We have to take that into consideration. If they control the volatilization, it'll be really popular. Until then there's going to be a lot less of those beans seeded," he predicts.

If applicators are held liable for damage from volatilization, "applicators may just refuse to spray it next year," Ostmo says. "I know one local applicator who hasn't sprayed any yet, and he won't spray them, and he's glad he didn't."

LATEST

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Start:	Wednesday, August 2, 2017 2:00:00 PM
End:	Wednesday, August 2, 2017 4:00:00 PM
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Hi all,

Sorry for any confusion/technical difficulties. This should be the final version of the Outlook invite. Please feel free to get in touch with any questions.

Agenda is attached and below.

Thanks,

Emily

Dicamba: Meeting with State Lead Agencies (AAPCO/SFIREG)

August 2, 2017

Agenda

I. Meeting Introductions (OPP)

II. Meeting Format (OPP/RD)

III. Input on Dicamba Incidents: EPA is soliciting feedback from State Lead Agencies focusing on information that could help remedy the unacceptable dicamba incidents in the field. The following questions will be used to focus the discussion:

1. What is the progress on the investigations in your state? What have you learned from these investigations? What is your read on compliance?
2. What regulatory changes have been implemented in your state for the 2017 growing season? What worked? What did not?
3. Based on the leading causes, and information you have received, so far, what approaches does your state recommend to fix the problem?

IV. Available Data

V. Additional Discussion and Questions (time permitting)

VI. Closing Remarks/next steps

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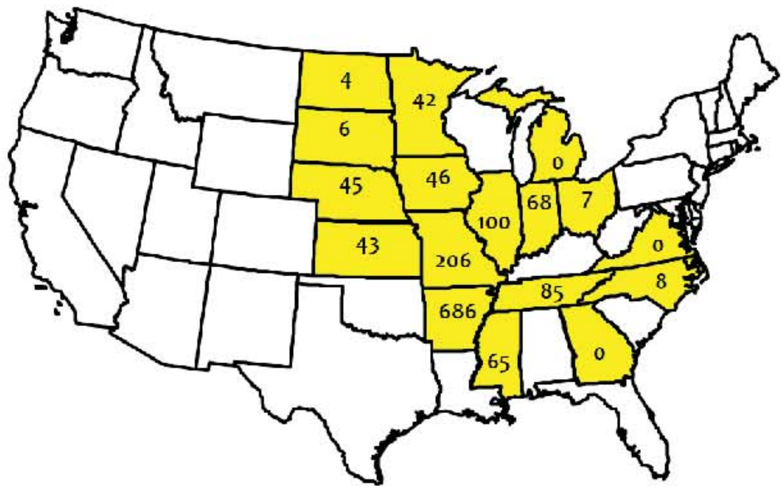
Official Dicamba-related Injury Investigations as Reported by State Departments of Agriculture (*as of July 19, 2017)



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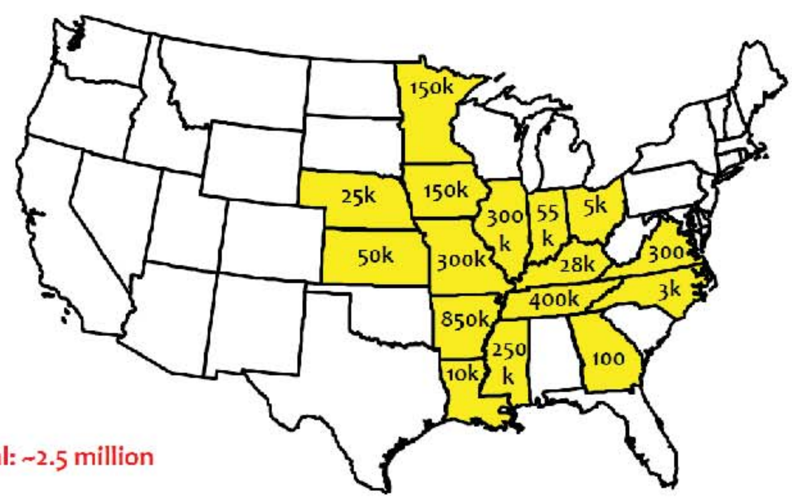
Estimates of Dicamba-injured Soybean Acreage in the U.S. as Reported by State Extension Weed Scientists (*as of July 19, 2017)



*Total: ~2.5 million

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Dicamba Call with APCO 8/2/2017

EPA Representatives from RD, BEAD, FEAD, OECA, Regions 7 and 4; Representatives from WSSA, and USDA-OPMP; State representatives from AAPCO, Universities, Departments of Agriculture from Alabama, Arizona, Arkansas, Florida, Georgia, Illinois, Indiana, Iowa, Kansas, Louisiana, Minnesota, Mississippi, Missouri, Nebraska, New Jersey, North Carolina, North Dakota, Ohio, Oklahoma, Oregon, South Carolina, South Dakota, Tennessee, Vermont, Virginia, Washington, Wisconsin, and Wyoming.

Questions to the call participants from OPP:

1. What is the progress on the investigations in your state? What have you learned from these investigations? What is your read on compliance?

2. What regulatory changes have been implemented in your state for the 2017 growing season? What worked? What did not?

3. Based on the leading causes, and information you have received, so far, what approaches does your state recommend to fix the problem?

Available Data?

Alabama:

- No reported incidents, but may have damage with no reports.
- Upon registration, developed a 24c with wind speed restriction (10 mph) and mandatory training.
- Planned on making state restricted use, but not enough time.
- Not many great regulatory options, especially with no record keeping requirements - don't know who has product, or where it's going.
- The delay in registration with seed going out earlier seems to have empowered applicators to misuse.
- Unprecedented amount of damage nationally
- Alabama may not be getting damage, because 95% are using Xtend, possibly scared people into new technology.
- Difficult to follow label, even with major training, plus a very unforgiving chemistry.
- This is a major resource drain on the state groups.

Arizona:

- No use.

Arkansas:

- 873 complaints.
- Taking photos of damage and furthering investigation
- Forming dicamba task force
- Also damage on gardens, non-cropland.
- Dicamba damage with no dicamba treated fields for miles.

Question from EPA: What's your read on compliance? Hard to track, buffer violations. Other violations, but not in every case.

Question: State regulatory intervention that took place, is it for 2017 only? 120 days temporary emergency rule. Use season is pretty much over for this year. Arkansas has had inversion regulations on the books for years with specific temperature requirements. Temperature weather stations across the state, track when temperature inversions are occurring – available online for all applicators.

Question: Are complaints diminishing? No. Some people may still be applying and some complaints are coming in late, although effects were initiated a while ago. Ban went into effect July 21st, symptomology can be 10-14 days past. $25,000 fine went into effect 8/1/17. Previously was $1000 fine.

Florida:

- No complaints yet.
- Possibly due to Organoauxin rule that has been in effect for a long time.

Georgia:

- No official reports, a few informal cases.
- Auxin training started 3 years ago, anticipated registration, growers thought the training was mandatory and have responded well to training. 24c labels requiring training.
- Drift is #1 problem in Georgia, want to continue training on other pesticide applications.
- Conducted dealer education and outreach as well.
- Technology is working. 2 million acres of cotton and soy have been treated. Successful and positive, overwhelmingly.

Question: is Georgia still considering hooded sprayers? Yes, but they want more information from the registrants.

Indiana:

- 96 dicamba complaints, slowed down a little,
- no state restrictions yet.
- Proposing state restricted use, waiting on final vote at end of the month.
- Investigating, forensic evidence, sample collection and analysis. Trying to assess whether drift or volatilization. Cases are taking time to finalize, no hard data.
- Certain cases appear that directions were not followed – buffers were not followed.
- Some cases damage seen with no identified source.
- Some across field damage, no drift. Checking for failure to clean spray equipment.
- Rumor that glufosinate is contaminated with dicamba, as liberty link beans are the most damaged.
- Recommends that epa makes product federeally restricted. Require certification, good records and fines that encourage people to comply.
- Trying to approach scientifically to determine cause of incident.
- Higher rates than used on corn and much higher numbers.

Comment from Arkansas – Monsanto sent Arkansas possible contamination data.

Question from Indiana: Are registrants under obligation to report what they are finding? Yes, they are required to share, but only from legal use - we need to follow up with OGC. Are agency registration decisions based on unreasonable adverse effects? What are reasonable adverse effects? Is it a quantifiable number? When does it become an unreasonable adverse effect if the applications were made legally. Good questions, we are required to take into account the benefits as well.

Question from EPA: Regarding federally restricted use request – is that primarily for record keeping? Yes. Prefer certified applicator only, or under supervision of? Less critical for certified applicator only, but possible removal of RUP license is a strong deterrent. Missouri: if you consider reclassifying, you would have to make all dicamba products RUP. Indiana is going to make any dicamba products over 6% state restricted. Arkansas requires record keeping for all dicamba products. Registrant needs to put marker in products that doesn't break down as quickly as compound. Need a way to differentiate the product. Marker would need to be volatile as well. Can't track the product after it moves, just where it was sprayed.

Vermont: Drift is a symptom, real issue is the seed, and the gene. No issues where the seed isn't being planted. States have process to control pesticide, but need a way to control the seed. EPA doesn't have statutory oversite for the seed. Trying to have more synchronous decision making between agencies.

Kentucky:

- no complaints officially.
- Relatively minor problems

Louisiana:

- 1 official complaint, dicamba symptomology showing up without complaints.
- Not sure why since so close to Arkansas. Possibly not much dicamba was sprayed. Good control from residual herbicides this year. Dicamba has always been state restricted use, along with 2,4-D.
- Dept of ag required dealers and applicators who purchase and those who apply to take a training.

Kansas:

- Fence to fence symptomology.
- Vapor drift or inversion problem.
- Common throughout state.

Iowa:

- investigations are all still in progress. Too early to make firm conclusions. Probably more info in September.
- Tank contamination issues, some physical drift with wind speed and direction.
- Not much info. on inversions, or incorrect formulation of product applied.
- Large scale cupping of soybean fields. Volatilization.
- Later season than some other states.

- Need help how to handle response to large scale damage and lack of people reporting the issues.
- Having major questions on actual utility of tool.
- 74 complaints.

Illinois:

- 150 complaints
- ½ million acres of non-dicamba soy damaged.
- Other non- soy crops effected.
- Getting calls from media.
- No additional restrictions as of yet.
- Retail group is very concerned, put out survey to applicators. Certain retail suppliers have put out stop sales. EPA would be interested in survey results.

Minnesota:

- 89 reports of dicamba damage, probably a fraction of actual damage.
- Less than half have investigations so far.
- People are hesitant to make complaints about their neighbors.
- Concerns where financial responsibility will fall. People are hearing different things from insurance companies.
- Put together a dicamba webpage and online survey. Asking anyone who experienced damage to complete the survey, reduced volume through complaint line.
- No estimate of number of acres. No investigations concluded. Getting info from complainant and collecting samples.
- Hearing from a lot of people that they are not getting the supplemental labels and don't have them in hand when applying. Asked registrants how were going to ensure end user had supplemental label. 2 companies said they planned to follow epa's website supplemental label directions. One registrant said they would make them online only.

Question from EPA: Uses on gmo crop are only allowed via supplemental label. Some folks used the product, without the supplemental label? That is the way it was distributed? Yes. One retailer asked if they are responsible for giving the sup label to end user.

- Many acres of damaged soybeans. Registrants have giving nozzles to commercial applicators, but private applicators are not using correct nozzles possibly

Mississippi:

- 64 dicamba complaints – all soy.
- Mostly label violations, wind, nozzles, buffers.
- State restricted use, required training, 10 mph wind restriction.
- Only one violation was over 15 mph.

Missouri:

- 240 complaints, mostly northeast.

- Implemented 24c for 3 post products, with timing and wind restrictions. Can't tell if it's helped yet. Haven't visited many applicators yet.
- Soybean damage, watermelons, vineyards, peaches, trees. Small towns with all trees damaged.
- Farmers are very upset, as they feel backed into a corner. Want liberty link, but may need to buy dicamba tolerant soy. Dilemma in state.
- Entire fields have been effected.
- EPA needs to make a decision or make no decision, so states can move forward. Growers will be making decisions soon, and are asking states what rules will be.
- There is a human element, that needs to be considered.
- Rumor 'next year will be payback'. Threats of 2,4-d misuse next year.
- 240 complaints are 3 years of work in 1 month. Need assistance from federal level, or will have to protect on state level. Freedom to farm situation.
- Monsanto is complaining that UPI's glufosinate products are contaminated. Other crops have been damaged, it's not just liberty crops. Family farm on island in Mississippi River - 660 acres of true conventional beans, all beans are damaged. .5 mile of woods between field and treated area. Growers can't keep product on the field.

Nebraska:

- 70 cases with 1 inspector.
- Ceased collecting samples due to funding issues.
- For every field with cupped beans, samples have shown dicamba residues.
- Allegation of dicamba contamination in glufosinate contamination is troubling. Should we look at glyphosate for contamination?

New Jersey:

- no complaints or issues.
- Most dicamba is applied to turf.

North Carolina:

- 13 cases of dicamba drift reported.
- 24cs with 10 mph restriction with mandatory training. Think the training is what worked.
- Extension has much higher number, but people don't want to complain about neighbor, and think that soy will recover.
- Tobacco is major issue. Tobacco so damaged that it won't be able to be sold. Tobacco is ultra-sensitive to dicamba. No tobacco samples have shown detection of dicamba.
- Some drift patterns and some corner to corner damage.
- Growers don't have supplemental labels and 24cs in hand. Dealers aren't giving them out.
- Buffer zone label language and sensitive areas language was confusing. Very concerned that greenhouses were allowed within buffers.
- No cases with ornamentals yet. 1 peanut case.
- 24c may be more restrictive next year, time 9-4.
- Certified applicator restriction may not help.
- Growers made some good decisions due to weather and wind speeds, postponed spraying.

- Hard to get the weather data.
- Growers are working out things themselves, and then call the dept of ag if not resolvable.
- 1 Sweet potato damage case.

North Dakota:

- 16 cases, 43 people have called.
- Significant injury in southern red river valley.
- Liberty, Rup ready, and conventional beans are showing problems.
- Seeing drift patterns and tank contamination patterns.
- Increasingly seeing fence to fence damage.
- Geography makes it difficult to identify where dicamba is coming from.
- Not sure if it is illegal formulations at this point.
- Severe drought, damage on beans is much more pronounced. Beans growing slowly because of drought stress. Typical cupping, no flowers or pods. Adjacent DT beans with 6 pods normally growing.
- Most followed label or at least tried. Collecting samples, gathering info. Wind, tips, buffers.

Ohio:

- People calling extension more than dept of ag.
- 14 incidents.
- 1 was tank contamination.
- No lab results yet. What are the quantifiable levels?

Nebraska – test down to 1 ppb. 2.5-15 ppb is what samples are showing – taken 3-4 weeks after application. Are you looking for the metabolite? Yes, but it only is detectable on intolerant beans. Genetic mod beans detoxify beans. APCO's dicamba website has all of the lab information.

- Less was sprayed postemergent, so fewer issues.
- Possible issues from flooded dicamba fields running to another.

Oregon:

- Very few acres of soybeans – interested in glufosinate and glyphosate contamination.
- Finding insecticides contaminated with other insecticides. Wants to stay in contact those testing and looking for contaminates.

South Carolina:

- 3 official cases this week are first cases.
- Issues not being reported.
- No regulatory changes for state registration.

South Dakota:

- 60 complaints officially filed.
- 50 complaints from 1 ag retailer, but none went through to dept of ag.
- No documentation of incorrect products being used.

- 75% of dicamba samples run so far have detected.
- No extra restrictions for state.
- Drought, and same leaf symptoms as North Dakota.
- Some calls about gardens damaged.
- Some want products banned.
- Some retailers aren't going to sell the product next year.
- No one is looking at the tank mixing website.

North Dakota was in survey from Dr. Bradley, but it was too early to report acreage.
Epa is always looking for more estimates of acreage.

Question: tank mixing website? People aren't paying attention? Website isn't cutting it.

Label is really complicated and hard to follow.

Georgia is hoping hooded sprayers would relax the tank mix restrictions. Hooded sprayer stays in contact with ground and moves at low speed, so no drift. There still could be volatility though.

Tennessee:

- 100 complaints, taking time.
- July 12th, emergency rules started through October 1st.
- Must keep records, prohibit old dicamba formulations, required to be applied by a certified applicator, 9-4 window for application, applying dicamba over top of cotton after first bloom is prohibited.
- Putting together a work group.
- Fields have all had a second incident of damage.

Question: have the restrictions helped at all? Any trend in incidents decreasing? Can't say yet.

Vermont:

- sfiereg should look into formulation contamination complaints.

Virginia:

- no complaints.
- Weed scientists provided best estimates on acreage effected.
- No negative comments, some positive comments on tool.
- Comments on label being too complicated.
- No state restrictions.
- Basf rep reached out and asked if there were any complaints.
- Some commercial applicators are hesitant to use product.

Wisconsin:

- Similar to Virginia, no complaints on dicamba applied to soy.
- One corn application damaged the adjacent soy.
- Not many people are using it,

- No state restrictions.
- Continuing education and outreach.
- Some ag suppliers are hesitant to use new labels, so not recommending it.
- Yields are not as good with extend soy.
- Less weed pressure

Wyoming:

- no complaints

Question from Alabama: adverse effects reporting – has epa received anything from registrants? No 6a2 for 2016-2017 yet. The agency does find that concerning.

Question about adoption rates: high or low, highly adopted on cotton in Georgia. Some states are protected, because no one is using it, some are protected because everyone is using it.

Right to farm, should be able to grow what you want.

Has epa established a timeline for a decision? No, however, we have heard loud and clear the timing needs for an intervention. We are working on the premise that we would aggressively continue information gathering. We need this to be a science based call, as the registration was a science based decision.

Are we contemplating additional label restrictions for 2018? Nothing is off the table.

Minnesota: on last call, someone asked what data or information epa may need. Answer was looking at pattern of damage – edge to edge vs drift? Any other information that is helpful? Yes: yield data, what type of damage (drift, volatility, etc.), looking for data from universities. Compliance – what's not being followed and why.

Asked for minutes from the phone meetings.

From:	Adeeb, Shanta
To:	Kenny, Daniel
Subject:	Dicamba notes form July 28th
Date:	Tuesday, August 01, 2017 12:02:29 PM
Attachments:	Dicamba Call 07 28 2017 S. Adeeb Notes.docx

Dan,

Please see the attached notes. Please keep in mind that I left the meeting 30 mins early so I wasn't able to capture that part of the meeting.

Shanta Adeeb, M.S.
Risk Manager
Herbicide Branch
Registration Division
Office of Pesticide Programs
U.S. Environmental Protection Agency
Email: adeeb.shanta@epa.gov
Number: 703-347-0502

Dicamba Call 7/28/2017 S. Adeeb Notes

Attendees:

At Potomac yard: Reuben Baris, Mike Goodis, Dan Rosenblatt, Shanta Adeeb, Kay Montague, Dan Kenny, Bill Echols, Yevette Hopkins, Meretta E…., Anita Peas, Mark Corbin, Ed Odin, Brain ?. Linda?

EPA On Phone: Johnathan Becker, Bill Chism, Sarah Meadows, Adrian, Trenetti, Stacy H., Nicole Burgers, Jamie Grand, Shawn Hackent, Mich Mercer

USDA: Cheryl Knicks, Jill Schroder

States: Missouri: Kevin Bradley, Dr. Marrubus; Arkansas: Norsworthy, Tom., Dr. Bengr…; Tennessee: Lary, Tom Muller; Indiana: Bill Johnson, Joe Liker, Brian Young; Ohio: Mark; Kansas: ????; Iowa: Mike; Illinois: ??????; Georgia: Dr. Cru…; Mississippi: Jason; Nebraska:?????; Alabama: Greg

Agenda

Mike Goodis RD/OPP: Thanks for being on the phone. Agency is concerned about the incidences of crop damage. This talk with extension agents and APPCO so everyone is better informed about the incidences. We think it's important to have these conversations so that the right use of these chemicals happen

Cheryl USDA
Appreciates working w/ EPA to get lessons learned. Thanks extension folks for working on the issue and on the ground. Appreciates all the work everyone is doing on this.

Dan Kenny EPA
Thanks your perspective is great. We would like to hear anything you feel is important and what you feel is the chief root cause that you can share with the agency. What do you think would be fixes in the field that could prevent incidences?

Format
Mapping incidences from university Weed Scientists and the Extension Agents

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Kevin
The incidence maps are already out of date. A few weeks ago EPA spoke with state Ag Departments to find out what was happening. First map as of July 29th was what Kevin could het from state Departments of Ag. Second map, major soybean areas estimate of damage. Estimated approx. 2.5 million acres of damage as of July 19th.

Reuben EPA
Looking for info that can help remedy the situation. [Goes through the three questions from the agenda.]

Arkansas
[Approx.] 850,000 acre estimate from 8 counties. More damage in North East Arkansas in 8 counties. Ninety percent of damage is a result of atmospheric loading. Inversions, high use if product, multiplied with PPO resistant pigweed. Reduce the number of fines with the nozzle. The fines from the nozzle when evaporated can get dispersed great distances. Also physical drift, dust, etc. Has data on volatility and secondary movement on dicamba. Has gotten a call that growers of horticulture crops have also been effected. Largest bee keeper has honey production plummeted, lower honey production. Will be testing for dicamba. Path forward, volitization, evaporation of fines. Temp is a major cause of incidences. Consider having a state specific cutoff date for this use. [Approx.] 771 complaints as of 7/28/2017. Physical drift and directions for use this year. Even with an extensive training program [in this state] there has been a major issue with people not following the buffer zones. But drift was often beyond what the buffer would have been. The majority of dicamba that went out was Eugenia. Dicamba still moves when the label directions are followed.

Georgia
Official complaints have been very low. Not having the issues of other states. Dicamba being sprayed on cotton but just not seeing problems. Either not happening or not reported. Soybean growth stage R2 and R3 currently. Approx. 180 acres of soybeans

Illinois
Number of complaints approx. 125. In the past there were 5 complaints per year, [complaints] up 2400% from last year. Most incidences are south of interstate 80 about 50% of non dicamba soybeans have damage. West going to St. Louis, damage drops to 5 based on geography. Three issues: physical drift, spray tank contamination, volatility. Uniform symptoms. Approx. 10 million acres of soybean grown in the state. Temp is playing a huge role. Application cutoff date will help but not the only answer. Looking at effects of multiple exposure events to soybeans, working on getting data.

Indiana
Same issues as other states discussed. 80/100 complaints this year are dicamba related. In the past huge…[??????] you couldn't have picked a worst year to introduce a tool based in the weather in the state which is a major contributor. Used dicamba on corn for a lot of decades. June 19th was when first report of dicamba injury. Steady 2-4 incidents per day since. Weather and compressed windows for [pesticide] application. Do have some data for single exposure events and how it effects soybean growth and the yields. The preseason work to educate about dicamba drift on tomatoes worked. No tomato incidents. [Restriction] don't spray dicamba within ½ mile of tomatoes. [To strengthen enforcement efforts] make sure [monetary] fines work/hurt when misuse happens. Applicators lying on spray report. Need more verification of wind conditions.

Q: How does growth stage of corn relate to dicamba use?

A: Could be used from seeding to waist high [corn].

This year corn dicamba use was sprayed over a very long time. No idea about which dicamba formulations are/were used on corn.

Illinois
Had a dry period, symptoms showed up after rain event

Iowa

Sixty-four official complaints. Volatility, drift, runoff. When extension visits fields [where damaged occurred] the applicator isn't present, only the farmer with damage is present. This makes it hard to get incident data. Having an early cutoff for application date wouldn't work due to temp variability. [Dicamba] mostly used to control water hemp. [Date restriction] would limit utility of product [to control water hemp]. Boom height negatively effects the off target movement. Short application season makes following directions hard. Buffer makes the technology hard to use. Doesn't see much that can be done to eliminate or minimize the problem. Magnitude of problem based on treated acres is scary. It is disingenuous to say drift doesn't affect yield. Growers don't want any crop damage even if it doesn't affect yield.

Boom height and drift

Most application equipment cannot run at 24 inches above target. With the equipment they [applicators/farmers] use they cannot follow directions. [The boom height is an] impractical direction that would cause damage to equipment.

Kansas
Instead of a cutoff date more guidelines with temp restrictions.
Q from EPA: Thoughts about relative humidity with temp.

Answer: Data all over when it comes to humidity

Kentucky
Tolerant vs non tolerant soybean fields can be easily distinguished. More restricted use, Eugenia or all dicamba formulas. Cutoff dates or times of dicamba.

Mississippi

Had extensive training program going into this year. Didn't see anything different from the other states. First 2 – 3 weeks a patter to [dicamba] movement. From June to July large block without a visible path. Seeing it in yards, gardens, trees. CRP planting have seen dicamba damage. Beyond agricultural damage. Hitting people beyond the industry, has a program for soybean for response to multiple exposures. Looking at additives added to products. Proximity to river and surface water in delta. Delta areas my effect movement. Dicamba move across rover. Application in Arkansas moved to Mississippi. River effects the movement.

Missouri

Timeline: around June 1st was when incidents started. Don't really have issues about weather messing them [applicators] up. People sprayed when needed. On July 7th Ag Dept. started a stop sale. Released again in Missouri with more restrictions. MFA doe most spray work [in state] and prior to July 7th decided not to spray any more dicamba. Buffer may never work, likely doesn't make a difference. More fields with injury across than with clear drift events. Most are due to volatility. Doesn't believe the old formulas are the problem here. MFA will probably do a stop date/ Missouri Dept. of ag. Looking at a stop date. May reduce number of complaints but not solve the problem. Regardless of what happens the [GMO] trait is still in the marketplace.

Q: Is it possible sprayer tank contamination is a bigger issue than volatility?

A: Tank contamination would get less over time.

Missouri Continued

Inversions, and atmospheric loading, volatility into an inversion may be happening.

Q EPA: Potential of sprayer contamination, is this a normal part of investigations that are being tested.

A: Can't imagine tank contamination is getting to a whole crop. A field or two would be possible. A lot of crops weren't sprayed when symptoms were seen in the crops. Contaminated fields look different from [drift/ volatility]. Checking tanks/ tank mix for contamination is not typical. Missouri Dept. of Ag inspects the grower calling in an incident [this may be the reason for less calls about incidents]

Georgia

Both sides

Arkansas
Even when buffers were measured damage was seen. [When incidents are reported in this state] with dicamba calls both the applicator and the person with damaged field [come during the inspection]

Q EPA: Has anyone noticed high temps with inversions prior to incidents?

A: About 2/3 to ½ of days in July have inversion in Missouri. In June/July likelihood of inversion id high.

[Dicamba] volatizing and then getting into temperature inversion.

Ohio

Not seeing much particle drift. People not calling much [to report incidents]. More pre-plant [use] than post emergence. Not seeing pre-plant incidents. Some applicators refused to do post emergence spray this year. In NW Ohio due to flooding dicamba is moving into ditches and field to field. [Dicamba is] going to be unmanageable if flooding is causing injury/movement. When beans are under stress they won't grow/recover from injury [and have lower yield].

Tennessee

Movement with water into adjacent fields after a big rain event. Complaints coming in from double crop soybeans. Farmers getting drifted in 2nd and 3rd times. Incidents occurred after new rules took place (July 11th or 12th. Rule Applications can only be made from 9 am to 4 pm. A lot of folks adhered to new rule about applying after 9 am, it didn't work. Sales folks have been selling lots of Eugenia. Eugenia was used on a lot of acres. Most in season was Eugenia was Extenda Max.

From:	Baris, Reuben
To:	Rosenblatt, Daniel; Kenny, Daniel; Adeeb, Shanta; Montague, Kathryn V.; Meadows, Sarah
Subject:	RE: copy of my notes
Date:	Friday, July 28, 2017 2:10:41 PM
Attachments:	dicamba - teleconference with extension - 7-28.docx

Wow. Thanks Dan! This is great! I think between all of us we should be able to capture most if not all of the major discussion points (as well as a lot of the nuances…).

Reuben Baris | Product Manager, Team 25 | Herbicide Branch
U.S. Environmental Protection Agency, Office of Pesticide Programs | (703) 305-7356

From: Rosenblatt, Daniel
Sent: Friday, July 28, 2017 1:40 PM
To: Kenny, Daniel <Kenny.Dan@epa.gov>; Baris, Reuben <Baris.Reuben@epa.gov>; Adeeb, Shanta <Adeeb.Shanta@epa.gov>; Montague, Kathryn V. <Montague.Kathryn@epa.gov>
Subject: copy of my notes

I didn't' catch everything – but wanted to share this.

Attendees

Missouri ; Arkansas ; Tennessee; Indiana; Ohio; Iowa ; Georgia; Mississippi; Nebraska; Alabama ; (also Tony Cofer from Deprt of Ag in Alabama; Amy Bamber; USDA – Sheryl Kunickiis

EPA: RD, EFED, BEAD, FEAD

Kevin Bradley – generated map of U.S. – in order to get national picture – data requested was damage incidence – time window is as of July 19th . Bradley acknowledges his numbers are underestimate and out of date. He only sought damage reports for soybeans – not other crops. Overall total is that 2.5M acres of soybeans have been damaged. Take away is that this is major – national problem.

Arkansas – Jason Norsworthy – NE Arkansas is most impacted area of his state – covers 8 counties – where damage seen – 90% of damage. His diagnosis is that movement is result of combination of atomospheric factors where environmental loading and movement is possible. 850,000A of soybeans in AR have been damaged. DT soybeans growing and there was high use of dicamba product – sometimes multiple applications. Volatility is part of problem. Another point is that the TTI nozzle doesn't eliminate 'fines' – higher temperatures – help make the 'fines' dispersable – also there is physical drift – with dicamba on dust – Jason has 5-6 trials on volatility and secondary movement – data underway now – 2017 – damage is extensive – beyond soybeans – horticultural crops – bee grower in state – very low levels of honey production seen. Dave Mortenson studying relationship between dicamba and flowering. Temperature is big factor. Jason suggesting that one path forward for mitigating risk is to set a date cut off for use. AR has large number of complaints - 770 complaints to state. AR did extensive training program to smooth out introduction concerns – but didn't seem to work.

GA – not experiencing problem – official complaints very low – either not happening or extension not hearing about it – GA is using dicamba on cotton – so it's either not happening or we're not hearing any concerns. GA hardly grows any soybeans. Those are now at R2 or R3 stage –

Illinois – Aaron Hager – complaints – up to 125 complaints – typical year they get very small number. 50 % of non DT soybeans have symptoms – but there is variable experiences across different geographies. – so some places not experiencing problems. Attribution of problem could involve spray contamination – volatility – and other causes. Illinois often uses custom application. Path forward 'very challenging' – 10 M acres of soybeans – in state – temperature playing big role – application cutoff date makes sense – he is collecting data on multiple exposure events to soybeans –

IN – Bill Johnson – can blame it on everything that's been mentioned- 80 complaints involve dicamba – this year – difficult to introduce new technology – wet weather compressed – planting – also windy year – have used dicamba in corn for decades – and that hasn't been too problematic. June 19 start of dicamba injury – claims ramped up . Johnson suggests that the enforcement fine needs to be severe and meaningful – will help make growers follow label requirements – people will lie to say wind speed is ok – IN has pockets where the complaints are coming in – this year – corn sprayed over long period of time –

IA – 64 official comtraplaints – they see it as no 'one' problem – volatility – physical drift and run off all at play – typically – it's the injured party who complains – and the applicator tends to not be available in reviewing the situation – IA concerned about the idea of an application cut off – it would help some – but likely not solve issues. They might offer that the pre-emergence use could be restricted – In IA waterhemp is key pest – June applications help control waterhemp – IA had short application season – buffers don't resolve the problem – they make the technology hard to use – not sure there is much we can do to reduce or eliminate the problems – frightening to think about the future – relatively small number of beans that were treated this year in IA – Rob Fraley – (company rep?) claiming yields won't be seriously impacted – also 24 inch boom height is too strict – won't be readily followed – because it's too low.

KS - poor phone connection - Doesn't support cut off date – suggests instead – more guidelines on temperature restrictions – older dicamba had more restrictions regarding temperature – –

KY – easy to pick out DT versus non – DT soybean – tend to attribute it to loading – KY not doing work right now – Open to consideration for more restricted use (for new and old) formulations - cut offs – and times of day –

MS – Bond – growers had extensive training – going in – felt very prepared – first two weeks or so – pattern – then by later in season – more larger blocks seen to be impacted – these are more of an unknown – not understandable – yards – gardens – cypress trees – impacted – forestry areas damaged – so issue is bigger than row crop areas – MS is pulling data – impacts of multiple exposures to soybeans – suggestion on what to attribute this – proximity to river and amount of surface water a potential factor – dicamba can move across the MS River – instance of application in AR and dicamba moved to MS –

MO – Bradley – nothing new – to add- MO saw issues beginning June 1 – and problems ongoing – MO didn't have troublesome season – in other words they could work in the fields – people had openings to spray thanks to good weather – July 7 MO Ag department imposed six day ban – MFA (a commercial dealer – sprayer who supports many growers) voluntarily decided not to spray dicamba on their own – for the rest of the year. No buffer size seems feasible – many fields are injured edge to edge – believes most of problems due to volatility – whole fields seem to be injured – formulation – don't really believe old formulations are culprit – solutions – MO dept of ag and commercial applicators will probably put a stop date regardless of what EPA may do – likely there will be stop date of June 1 imposed by MO dept of Ag. Complex issue – trait is in the market place – so that's background consideration – so that means people will be tempted to use illegal product. This is novel - no history of damage across the whole fields?

AR – some very careful applications still seen to be resulting in damage – one drift incident seen where drift is ½ mile away. Inversion events extremely common – with – ½ to 2/3 of nights in AR in summer time involve inversion conditions – almost all of June and July –

OH – low incidents of reports – they used product pre plant this year – low complaints because injury seen as not malicious – people doing their best and no one did anything wrong so no complaint typically filed. Dicamba has moved out of ditches and damaged field – and saw field to field movement via water – also application followed by heavy rain can move dicamba very far – not a lot of data of more mature soybeans being hit by dicamba – likely to see yield problems. Ohio see post emergence use as 'not manageable' – earlier cut off of use may need to be imposed.

TN – Steckel – seen it move with water – where goes to adjacent fields – last few days he's gotten flurry of complaints – farmers – angry. Expanded label means some fields get drifted on 2 or 3 times. On July 11 TN issued new rules to try and avoid inversions – narrowed time of day – thinks growers following label – did outreach for growers – you tube and personal letters – but 'didn't work' – BASF sells 3 generics – but also selling a lot of Engenia – 600 percent of what they projected – so Engenia probably highly used – CPS went Extendimax – and sales of that were strong too. Need to apply after 9 am and before 4 pm. This is to avoid inversions. Weed control is 'best in a decade' exceptionally good. Liberty working – Enlist works – Extend works very well – divided agriculture 'like nothing I've ever seen' – He believes registrants need a lower volatility formulation. Also applicators cannot use booms at 24 inches in TN – impractical – too many hills – need at least 3 feet limitation for booms – otherwise – booms break too often.

Larry – there are problems with weed control – some pigweed at 50 percent control – AR – (Jason) closer to river populations are more resistant – can slow it down – 50 to 80 miles away from the year performance is good – proximity to river could be key. Pigweed often needs to be sprayed twice – especially near the river –

Round up may be doing something to impact volatility – AMS should not be in tank – in midwest. AMS not used in all regions.

Difficult to detect dicamba analytically – much more practical to use visual symptoms. Data should be done on bigger scale. Small plots don't mimic actual use. TN data suggests dicamba products with and without roundup will all volatilize . united soybean board funded a study looks at visual injury vs. other factors - they can share that data with epa. Jason has 20 fields studying height yield, injury in a thesis. This can be shared with EPA

This is 'an unacceptable situation' – comment – by extension – (not sure who)

EPA RA relied upon the boom height being only 24 inches. Also – no focus in the RA on movement thanks to drift and run off. Gaps that exist.

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Cc:	Rowland, Grant; Montague, Kathryn V.; Dan Rosenblatt; Goodis, Michael; Keigwin, Richard
Subject:	Conference Call with EPA on Dicamba - July 13, 3:00 EDT
Date:	Wednesday, July 12, 2017 7:05:00 PM
Attachments:	Dicamba Meeting with States 07-13-17 - Agenda and Items of Interest.docx

Hello everyone. This is just a reminder, as I hope you are able to join us this Thursday, July 13th, at 3:00 eastern daylight time to discuss the current issues with dicamba incidences in your state. We would very much appreciate the opportunity to learn from your experience. I have attached an agenda to this email for your information. Although there are many items on the agenda, these are only intended to convey items of high interest to us here at the EPA. This meeting is really designed to be an opportunity for you to discuss information that you would like to share that you think is important, so anything that you can offer, whether it's included in the agenda or not, are most welcome.

Again, thank you for your help with this meeting.

Daniel Kenny
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Dicamba: Meeting with State Representatives

Background: Since June 2017, the EPA has been receiving reports regarding a high number of crop damage incidents involving the active ingredient dicamba. The number of complaints is especially high in Arkansas, Missouri, Mississippi, and Tenessee. Recently, a number of other states are reporting complaints including more northern states.

Dicamba was registered by the Agency for use on dicamba tolerant cotton and soybeans late in 2016 (Monsanto's DGA in November and BASFs BAPMA in December). EPA would appreciate the opportunity to discuss these damage incidents with representatives from the States.

Agenda

I. Meeting Introductions (Dan Kenny - RD)

II. Meeting Objectives (Rick Keigwin - OPP)

III. State Input on Dicamba Incidences (State representatives) - *EPA would like to solicit feedback from state experts (Arkansas, Georgia, Indiana, Mississippi, Missouri, Nebraska, Tennessee) concerning experiences from within their state reflecting damages observed from use of dicamba in the 2017 growing season. Items of particular interest to the Agency are:*

A. What is the scope of damage witnessed so far?
   a. Are there estimates of acres damaged? How does that compare to the acres planted with soybeans that are not dicamba tolerant?
   b. Are there estimates of yield loss?
   c. Is recovery expected?
   d. Is significant damage occurring to other crops?
   e. What is the percent (acres) of tolerant crops vs non tolerant crops being planted in your state?

B. What is/are the source(s) of the damage?
   a. Does damage seem to arise from volatility or drift/temperature inversions/tank contamination? Evidence or Data to support?
      i. Are there indicative symptoms or patterns of each?
      ii. What do you attribute the damage to?
   b. Are approved products being used or is there misuse of unapproved products?
   c. If only approved products are being used, do you believe they are being used according to the label? Are restrictions being followed?
   d. If restrictions are not being followed on approved labels, does it appear intentional or does it appear to be based on misunderstanding the label directions? Are there trends in which restrictions are not being followed?
   e. What suggestions do you have for improving the clarity of the product labels currently registered?

C. What kind of training was conducted in your state?
- a. Was it face to face and/or farm visits vs online training?
- b. Was training widely attended?
- c. Did growers participate in training?
- d. Did registrants participate in training activities?
- e. Did custom applicators/retailer participate?

D. Are there measures that can be identified that, if employed, would likely have helped avoid damage?
- a. What additional measure would you recommend for your state specifically and could they be implemented more widely?

E. What can the state's share regarding their on-going investigations?
- a. What kind of investigation are ongoing?
- b. Are you collecting data on the conditions at the time of the incidents?
- c. Are samples being collected and analyzed?
- d. What is your timeline for reporting results and conclusions from incidents?

IV. Closing Remarks/Discuss Possibility of Additional Meetings (OPP)

Recent Midsouth Studies Show Dicamba not Very Effective on some Populations of Glyphosate/PPO-Resistant Palmer Amaranth.

news.utcrops.com/2017/05/recent-midsouth-studies-show-dicamba-not-effective-populations-glyphosateppo-resistant-palmer-amaranth/

5/4/2017

Last summer Dr. Tom Barber, University of Arkansas weed scientist, invited me to visit his field research on glyphosate/PPO-resistant Palmer amaranth in Crittenden County, Arkansas. As was expected glyphosate and Flexstar provided very poor Palmer amaranth control in his tests.

What was not expected is that a number of other herbicides provided poor control as well. Even dicamba at 0.5 lbs/A (Clarity 16 oz) on small Palmer amaranth provided less than optimal control. The only herbicides that still appeared to work in those trials were atrazine and Liberty. Until I had visited those Arkansas locations I had not seen dicamba on small Palmer amaranth perform that poorly. It was concerning to say the least and as a result we decided to screen Palmer amaranth on the Tennessee side of the river also.

We sent Palmer amaranth that we were confident was glyphosate/PPO resistant from north Shelby County, Tennessee to my colleague Dr. Tom Mueller in Knoxville last fall. He had a graduate student, Alinna Umphres, that subsequently screened this Palmer amaranth for its tolerance to a number of herbicides applied POST. As a check, the researchers also screened Palmer amaranth sourced from Knox County that was known to be resistant to glyphosate but not to PPO herbicides. The herbicides chosen to screen were then applied to the Palmer when it was 4” tall.

The results are below. In short, the Shelby County Palmer amaranth population, as expected, was resistant to glyphosate, Flexstar and Classic. Unfortunately, just like in Crittenden County, the Palmer amaranth also showed tolerance to dicamba and mesotrione. Moreover, just like the research in Arkansas the Palmer amaranth was still readily controlled by atrazine and Liberty.

Resistant to glyphosate, PPO (Flexstar = fomesafen), ALS (Classic = chlorimuron) and tolerant of HPPD (mesotrione) and dicamba.

In the table below the average control for each herbicide by population is compared. The column to the far right labeled Pr>F gives a number for each comparison. The smaller that number the higher the probability that there is a real difference between the populations for that herbicide. This number is important for this type of comparison as the populations are not pure. For example with Clarity about 2/3 of the plants screened for Shelby county were controlled less than 60% (a number showed <5% control) while 1/3 of the population was controlled 100%. In contrast, all the Knox county pigweed plants were controlled better than 92% 14 days after application.

So what is going on? It is known that the PPO-resistance in our Shelby County population has at least 3 different genes for resistance to PPOs. However, we are still finding Palmer amaranth that is resistant to PPO herbicides but does not contain any of those genes. A possible reason is a 4th resistance mechanism is metabolism-based where the plant is producing enzymes that tie up the PPO herbicides. These enzymes can also tie up other herbicides as well. Last year’s field data from Arkansas and now this greenhouse data from Tennessee would suggest that metabolism could very well be an issue for at least some of our PPO-resistant Palmer amaranth in the Midsouth.

So what does this mean for us? This spring in some areas like Crittenden County in Arkansas and Shelby and Tipton Counties in Tennessee there is a good chance that some Palmer amaranth will escape Engenia or Xtendimax applications. Therefore scouting will be critical. Do not assume because Engenia or Xtendimax have been sprayed on Palmer amaranth that they will all be controlled. Have eyes on the field that confirm they are controlled.

So what do we do? Diversity is still the key. PRE applied herbicides containing a good residual for control of Palmer amaranth must be used. Then overlap a POST emergence that has good residual activity on pigweed prior to the PRE playing out, even in Xtend and LL crops. Moreover, cultural methods such as narrow soybean row widths, hand weeding and cover crops will need to be used now more than ever.

Finally should we kick to the curb the herbicides that have such resistance issues? I do not think so for two reasons. First if we no longer utilize herbicides that have resistance issues we have almost none to choose from. Second, even with ones like fomesafen that will miss a lot of Palmer amaranth POST, they still provide a lot of weed control help applied PRE. They just can no longer be applied alone but tankmixed with another good residual herbicide for pigweed like metribuzin, Dual Magnum, Zidua, etc.

But Zidua combined with dicamba and glyphosate did not work on pigweed - see 5-22-17

Rating taking 14 DAA	Knox County Palmer	Shelby County Palmer	
	————-% Control————		Pr>F
Flexstar 16 oz/A	91	39	0.0026
Clarity 16 oz/A	95	65	0.0969
Classic 0.5 ozs/A	10	17	0.6365
Roundup PowerMax 32 ozs/A	11	12	0.9870
Callisto 3 ozsA	89	58	0.0911
Atrazine 32 ozs/A	85	93	0.5545
Liberty 29 ozs/A	91	97	0.7336

DICAMBA & PALMER PIGWEEDS

PINNACLE
CROP TECHNOLOGIES, INC.

May, 2017

by Matt Hagny

While I applaud the industry for developing new traits, I have grave concerns about what is going on with the adoption of Xtend soybeans. Now, if you're planting Xtend (dicamba-resistant) soybeans just to guard against drift of dicamba from elsewhere, then that's fine. But if you're planning to apply dicamba in-crop on Xtend beans, then I have concerns.

If you think you can control sizeable weeds easily with dicamba over the top of Xtend, better think again. Studies conducted in Missouri in 2012 show only ~85% control of 2 - 4" Palmer pigweeds with 0.5 lb/a of dicamba, which is the max labeled rate for post-emerge use in Xtend soybeans. Control of larger Palmers was very poor. (And control of waterhemp was also marginal.) There are already reports of failures applying dicamba products post-emerge on Xtend beans (In talking to other agronomists, there are plenty more of these failures; but the sales reps for these products keep on spewing hype -- and everyone really wants to believe it's just that easy.)

Palmer pigweeds are extremely aggressive, and will choke out most anything else. And they love it hot & dry. On Palmers this size, and this thick, there's not much to be done except paraquat. (Unless they still happened to be susceptible to glyphosate, and that hope is fading fast across most of the USA.)

Furthermore, weed scientist Jason Norsworthy in Arkansas has created dicamba-resistant Palmers in just 3 generations! He applied doses of dicamba that killed part, but not all, of a Palmer population, then grew them out and replanted those seeds. He repeated it for a second generation. By the third generation, a full dose (half-pound) of dicamba didn't control them at all.

We've been selecting for dicamba-tolerant Palmers for 30+ years where dicamba has been used in corn, milo, or on fallow acres. In Kansas, we generally cannot kill Palmers with straight dicamba if they're more than 3" (Status works on somewhat larger ones, but that's not straight dicamba, and not anything that can be used on Xtend soybeans).

Furthermore, we really need to preserve the efficacy of dicamba on Palmers for the corn & milo portion of our crop rotations. Putting more selection pressure on the Palmer population by also using dicamba on Xtend soybeans seems unwise (although your neighbor might create the problem and you get it via pollen anyway).

If you've already planted Xtend beans, hopefully you put down a substantial rate of sulfentrazone (Authority-type products) (0.37 lb a.i., or 0.75# of straight sulfentrazone product) to take care of the brunt of the pigweed problem. (Or hope that glyphosate is still effective on your populations of pigweeds, but that hope is unwise for many of you.) If little or no sulfentrazone was applied, I would strongly encourage you to spray your dicamba product onto the Xtend beans very early when the weeds are very small (and Palmers grow 2 - 3"/day when it's warm). And I'd run products such as Prefix either pre-emerge or early post-emerge (but after the first trifoliate is full-size), perhaps spiked with extra S-metolachlor (be careful with the rate of fomesafen in Prefix & other products, as it can carryover to corn, sorghum, and some cover crops).[1] You'll probably still need a follow-up spray with a tankmix of a couple 'burner' (PPO chemistry) herbicides, and perhaps with Warrant, Outlook, or Zidua added. After that, it's down to rogueing -- which is entirely justified if you plan to continue farming a tract. Palmers are rapidly becoming resistant to everything, and are a serious threat to your ability to grow summer crops. I'm not one to be careless in how much money or effort I recommend throwing at a problem, but this particular weed is the most formidable pest I've encountered in 24 years of agronomy work.

If you haven't yet planted, consider switching to LibertyLink -- but still use sulfentrazone, Prefix, etc.

In the foreground a small Palmer is regrowing after being burned by a full rate of PPO herbicide, lots of water & adjuvants, and no interference with the spray pattern. It takes some really fabulous activity with post-emerge PPOs to kill the dozens of growing points on very small pigweeds. Are you feeling lucky? I don't. Have seen too many failures. But by mixing two different PPOs together, and spraying at the optimum time during the day, it can take out small (2") Palmers satisfactorily, although there's increasing tolerance & partial resistance to post-emerge PPOs in various Palmer populations across the country. Don't put yourself into these desperate situations!

For more on the explosion of glyphosate-resistant Palmers in KS & Oklahoma (and they were already resistant to ALS & triazines), read my past newsletter. It also contains many photos to help distinguish Palmers from other pigweed species.

[1] Prefix isn't labeled with either Engenia or XtendiMax (dicamba products for post-emerge treatment of Xtend beans). Reflex & Flexstar are labeled for tankmixing with XtendiMax, but not Engenia (and note that if using Reflex, there's a compatibility problem with K-salt of glyphosate -- although other glyphosate formulations are okay, as are other fomesafen products, such as Flexstar, and most generics -- but there's an inert ingredient in brand-name Reflex that is quite likely to make goo if it's tankmixed with K-salt of glyphosate, which are usually the more concentrated products -- more than 4 lb/gallon glyphosates.) No S-metolachlor product is labeled with either Engenia or XtendiMax, although Zidua and Warrant are.

Crop Protection (/Crop-Protection)

First Signs of Dicamba Resistance?

By **Chris Bennett** March 10, 2017 | 6:00 am EST

Phillips County Extension agent Robert Goodson examines resistant Palmer amaranth in eastern Arkansas, an area with PPO resistance.
Photo by Chris Bennett

Greenhouse and field trials have Arkansas weed scientists looking for answers

It only takes three generations for a demon seed to produce a flower of fire. In a greenhouse setting in 2015, Palmer amaranth developed full-blown dicamba resistance. As the herbicide dominoes fall, weed resistance is forever around the corner and strong management requires multiple effective modes of action.

Jason Norsworthy transferred virgin Palmer from a soybean field to a greenhouse and sprayed the first two generations with dicamba at sublethal doses. After he selected the survivors and grew them out, the third generation was resistant to a full label rate of dicamba (0.5 lb. acid equivalent per acre). Even though this resistance was recorded in an artificial environment, the research confirms herbicide resistance can develop in just three years if the same weed population is exposed to sublethal chemical doses.

Norsworthy, an Extension weed scientist with the University of Arkansas, ensured a timely application by spraying a low dose of dicamba on 1.5" to 2" Palmer that provided good but partial control on the first generation. (It killed most of the plants.) The experiment mirrored potential coverage or calibration issues often encountered in the field. The Palmer survivors crossed and produced seed. Norsworthy slightly

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increased the dicamba dosage for the second generation and once again killed most of the Palmer after a spray application.

The process was repeated once more for the third generation of Palmer, except the application rate was boosted to the commercially labeled field rate. This time a quarter of the plants survived the full dicamba rate.

"Under greenhouse conditions, we shifted the tolerance of pigweed to dicamba about three-fold in only three generations," Norsworthy says.

The speedy development of resistance isn't unique to dicamba and can be demonstrated in other herbicides, including 2,4-D. (In 2010, Norsworthy showed basically the same results with glyphosate and Palmer.) However, the third-generation dicamba findings are particularly relevant considering current tank mix and buffer prohibitions on XtendiMax, Engenia and FeXapan.

Dicamba-tolerant crop systems bring a unique resistance dynamic to farmland. After weighing multiple factors, many producers are shifting entire farms to dicamba-tolerant soybeans and cotton. Questions over boom cleaning, separate spray rigs, drift concerns and overall efficiency boil down to money and time. With a farmer possibly facing thousands of acres in need of attention in a tight window, speed and efficiency become paramount. The bare truth: Monoculture is far simpler.

However, simplicity plays into the waiting hands of weed resistance. Smoking fields with glyphosate was once the ultimate in efficiency, but all silver bullets lose their sheen. Economics and practicality work against weed resistance management.

Norsworthy and weed science colleagues Bob Scott and Tom Barber have trials across Arkansas, and recent results from soybean fields in the northeast part of the state raise questions. Norsworthy and Barber note reduced dicamba efficacy on PPO-resistant Palmer. Generally, dicamba is highly effective against 3" to 4"-tall Palmer, but the PPO-resistant populations are showing a lower level of control. "We're not saying we have dicamba-resistant pigweed in these fields. We don't fully understand what we're seeing and are investigating the data," Norsworthy says.

Barber was surprised by the diminished level of Palmer control in Marion (Crittenden County), but he hasn't seen the same results in his research in nearby Marianna and Newport (Lee and Jackson counties), where dicamba efficiency remains strong. However, Marianna and Newport don't have documented PPO-resistant Palmer.

"We're not saying this is dicamba resistance in northeast Arkansas, but what we're seeing is a decrease in overall efficacy of dicamba," Barber says.

In Marion, the dicamba is affecting Palmer and causing injury, but the plants are able to recover, even after repeat applications. "If we get two years of data saying the same thing, it'll be an issue of worry," Barber says.

At the Marion plots in 2016, Barber tested Roundup Ready, LibertyLink and Xtend soybeans. He looked at 27 pre-emergent options to determine the best at-planting combination to control PPO-resistant Palmer. (If plants are PPO resistant, Valor is out of the running.) After each pre-emergent combination, the research team came back 28 days later and sprayed Roundup with Flexstar in the Roundup Ready system, Liberty in the LibertyLink system and dicamba in the Xtend system.

The Roundup Ready system offered minimal control with Palmer already resistant to glyphosate and PPOs. The LibertyLink system was fairly clean after two applications. However, after two dicamba applications, the Xtend system was less effective than the LibertyLink system.

</table>

I-40 essentially splits Arkansas east to west and serves as the Mason-Dixon of PPO-resistance for weed scientists. Palmer growing north of I-40 has a 50% chance of PPO-resistance, and Barber believes the percentage is set to rise. The northeast Arkansas corridor is a hotbed of PPO-resistance, and if more fields respond to dicamba in the same manner observed in Crittenden County, Barber fears it will translate to more herbicide applications and more potential for off-target movement.

In the general area of PPO resistance (Arkansas, Mississippi, Missouri and Tennessee), a solid weed control program relies on two pre-emergent residuals to tackle PPO resistant Palmer. Barber recorded optimal results from combinations of Metribuzin and Zidua, or Metribuzin and Dual Magnum.

"Those are our recommendations in 2017. If we're not robust at planting with pre-emerge herbicides, whether in the Xtend or Liberty system, we'll be behind the eight ball once pigweeds start to break," Barber says.

Scott confirms the robust nature of PPO-resistant Palmer in northeast Arkansas and says dicamba, Liberty and 2,4-D choline weren't entirely effective at three farm trial sites this past year. Yet, at Scott's research farm in nearby Newport, where Palmer is merely glyphosate-resistant and ALS-resistant, the same chemicals were highly effective.

"I think there will be surprises waiting if growers only use dicamba to kill pigweed in 2017," he adds.

The absolute necessity of multiple modes of chemical action is very important in 2017, Norsworthy adds. "Choosing two effective modes of action is required, and I emphasize 'effective.' Otherwise, a grower is simply not doing enough to mitigate the risks of resistance and the weeds will get worse," he says.

With an increasingly hostile roster of resistant weeds, crops are under constant waves of assault that necessitate a diversified response. The days of polite recommendations to mix modes of action have given way to outright demand: Multiple, effective modes of chemistry are a farming absolute.

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Data Evaluation Record (DER)

Chemical names	CAS number	PC code
Dicamba: diglycoamine (DGA) salt	104040-79-1 (DGA salt)	128931 (DGA salt)
Dicamba: dimethylamine (DMA) salt	2300-66-5 (DMA salt)	029802 (DMA salt)
Dicamba: acid	1918-00-9 (Dicamba acid)	029801 (Dicamba acid)

Study Citation:
MRID 49925703.
Gavlick, W.K. 2016. Determination of Plant Response as a Function of Dicamba Vapor Concentration in a Closed Dome System. Unpublished study prepared by Monsanto Company. Study Number REG-2016-0170.

Purpose of Review (Note: DP Barcode required for Quantitative studies): Dicamba DGA field buffer distance evaluation; DP 434344

Date of Review: 11/8/2016

Summary of Study Findings: Soybean plants (*Glycine max*; variety AG2632) at the V2 growth stage at study initiation were exposed to various volatilized dicamba formulations in closed dome systems for 24 hours. The specific dicamba formulations tested are identified by treatment in **Table 1**. It appears that some dicamba formulations were combined within individual treatments to create a dicamba vapor exposure concentration series. Each treatment was replicated three times with four soybean plants per replicate. For each treatment and replicate, six petri dishes (90mm ID, glass) were sprayed with the specific dicamba formulation at a rate equivalent to 10 gallons product per acre and placed in a closed dome system with the soybean plants (petri dishes in the control were not sprayed). Each humidome (**Figure 1**) was connected to a vacuum pump that circulated air through the humidome, plastic tubing, and a polyurethane foam filter at a rate of two standard liters per minute for 24 hours (atmospheric conditions in the humidome were maintained at 85°F for 16 hours and 70°F for 8 hours with 40% relative humidity). Following the 24 hour exposure to dicamba vapor in the closed dome systems, the soybean plants were moved to a greenhouse for 21 days. Visual phytotoxic responses were evaluated on days 14 and 21 post-treatment and plant height measurement were taken on day 21 post-treatment. Also following the completion of the 24 hour exposure phase, the polyurethane foam filter was removed and the dicamba trapped by the filter was extracted using methanol and quantified using LC-MS.

Table 1. Dicamba treatments, weight percent dicamba acid, and test chamber mean measured dicamba acid concentrations

Treatment Number	(w/w) Composition	(w/w) Dicamba Acid	Mean Measured Dicamba Acid Concentration (μg/m^3)
1	100% M1691 (1.2% ae)	1.2%	0.0177
2	75% M1691 (1.2% ae) & 25% Banvel® (1.2% ae)	1.2%	0.539
3	50% M1691 (1.2% ae) & 50% Banvel® (1.2% ae)	1.2%	1.002
4	25% M1691 (1.2% ae) & 75% Banvel® (1.2% ae)	1.2%	1.004
5	100% Banvel® (1.2% ae)	1.2%	1.597
6	50% Banvel® (1.2% ae) & 50% Dicamba Acid (0.45% ae)	0.83%	3.059
7	25% Banvel® (1.2% ae) & 75% Dicamba Acid (0.45% ae)	0.64%	2.881
8	No treatment	Zero	None detected

M1691 active ingredient: dicamba DGA salt
Banvel® active ingredient: dicamba DMA salt

Figure 1. Picture of a humidome apparatus used in the study

Results:

Plant height was statistically significantly reduced compared to the control at vapor-phase exposure to dicamba at air concentrations of 0.539 μg/m^3 and above based on the study author's analysis (**Table 2**). No significant decrease in plant height was seen at the 0.0177 μg/m^3 vapor-phase dicamba air concentration based on the study author's analysis, making this treatment concentration the study NOAEC.

Table 2. Mean Dicamba Exposure Concentrations and Mean Plant Height Across Three Replicates

Treatment Number	Mean Measured Dicamba Acid Concentration (μg/m^3)	Mean Plant height (cm)
1	0.0177	29.21
2	0.539	19.46*
3	1.002	19.96*
4	1.004	17.70*
5	1.597	20.92*
6	3.059	15.54*
7	2.881	11.67*
8	None detected	28.79

*Height values with an asterisk are statistically significantly reduced compared to the control (treatment 8)

Study Classification: While this study was not conducted per an EPA OCSPP guideline protocol (no such protocol exists), it was conducted in accordance with Good Laboratory Practice standards. The study is scientifically sound and classified as supplemental, suitable for quantitative use in risk assessment.

Rationale for Use: The explicit purpose of this study was "to examine the relationship between dicamba vapor concentration and plant response to identify a no observed effect concentration that can be used to support the risk assessment for dicamba use on dicamba-tolerant crops." Analytical and biological results were obtained. The analytical results explain that, percent acid equivalency dicamba applied being equal, the DGA form of applied dicamba is less volatile than the other dicamba formulations (*i.e.*, dicamba DMA and dicamba acid) as indicated by the amount of dicamba extracted from the polyurethane foam filter compared to the other formulations. The biological results indicate that soybean height is not significantly reduced compared to control plants following 24 hours of exposure (at 85°F for 16 hours and 70°F for 8 hours with 40% relative humidity) to vapor-phase dicamba at concentrations less than or equal to 0.0177 μg/m^3; however, 24 hour exposure (at 85°F for 16 hours and 70°F for 8 hours with 40% relative humidity) to concentrations of vapor-phase dicamba greater than or equal to 0.539 μg/m^3 significantly reduced soybean height compared to control plants.

Limitations of Study: It is notable that the dose spacing in this study results in an approximately 30x difference between the NOAEC and LOAEC, creating uncertainty as to where effects to plants from vapor-phase exposure to dicamba may occur. Generally, definitive toxicity studies are conducted with lower dose-spacing (*e.g.* 1.5-3x geometric spacing between doses). Additional data examining a range of doses between the NOAEC and LOAEC from this study would reduce the uncertainty.

Also of note: only one concentration of dicamba DGA was tested in this study. Without multiple concentrations of the dicamba DGA formulation tested it is uncertain whether the amount of volatilized dicamba linearly correlates with the amount of dicamba DGA applied. Further, the influence of the atmospheric conditions of the test design (*i.e.*, temperature and relative humidity) on the amount of volatilized dicamba and subsequent entrapment in the polyurethane foam and on the observed phytotoxic and height response is uncertain.

Lastly, the track sprayer was not cleaned between the spray applications of different dicamba formulations; rather, the sprayer was "rinsed with a portion of the next treatment before spraying the petri dishes to minimize carryover." While the spray solutions were analytically confirmed prior to spraying, the employed methodology of rinsing versus cleaning introduces exposure source uncertainty.

Primary Reviewer: Nathan Miller

NATHAN MILLER

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Secondary Reviewer (required if study results are used quantitatively): Michael Wagman

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, DC 20460

OFFICE OF CHEMICAL SAFETY AND POLLUTION PREVENTION

PC Code: 128931
DP Barcode: 436602
Date: November 8, 2016

MEMORANDUM

Subject: Addendum to Dicamba Diglycolamine (DGA) Salt and its Degradate, 3,6-dichlorosalicylic acid (DCSA) Refined Endangered Species Risk Assessments for New Uses on Herbicide-Tolerant Cotton and Soybean in 34 U.S. States (Alabama, Arizona, Arkansas, Colorado, Delaware, Florida, Georgia, Illinois, Iowa, Indiana, Kansas, Kentucky, Louisiana, Maryland, Michigan, Minnesota, Mississippi, Missouri, Nebraska, New Mexico, New Jersey, New York, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Virginia, West Virginia and Wisconsin) to Account for Listed Species not included in the Original Refined Endangered Species Risk Assessments

To: Grant Rowland, Risk Manager Reviewer
Kathryn Montague, Product Manager Team 23
Dan Kenny, Branch Chief
Herbicide Branch
Pesticide Registration Division (7505P)
Office of Pesticide Programs

From: Michael Wagman, Biologist
Environmental Risk Branch 6
Environmental Fate and Effects Division (7507P)
Office of Pesticide Programs

MICHAEL WAGMAN
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Through: Mark Corbin, Branch Chief
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This document includes the assessment of endangered and threatened species newly listed since EFED conducted the original listed species assessments (USEPA, 2016c-e). In March, 2016, EFED issued a Section 3 screening-level risk assessment for the use of diglycolamine salt of dicamba (dicamba DGA) on dicamba herbicide-tolerant cotton (USEPA, 2016a), an addendum to the 2011 Section 3 screening-level Risk Assessment for the use of dicamba DGA on dicamba herbicide-tolerant soybeans (USEPA, 2016b) and three addenda to the risk assessments (USEPA, 2016c-e) that refined the screening-level risk assessment to include species-specific assessments for threatened and endangered (hereafter referred to as "listed") species present in 34 states (Alabama, Arizona, Arkansas, Colorado, Delaware, Florida, Georgia, Illinois, Iowa, Indiana, Kansas, Kentucky, Louisiana, Maryland, Michigan, Minnesota, Mississippi, Missouri, Nebraska, New Mexico, New Jersey, New York, North Carolina, North Dakota, Ohio, Oklahoma, Pennsylvania, South Carolina, South Dakota, Tennessee, Texas, Virginia, West Virginia and Wisconsin).

The screening-level risk assessments concluded that potential direct risk concerns could not be excluded for:

- mammals (chronic, from the soybean use only, due to residues from dicamba's metabolite, DCSA, rather than from parent dicamba);
- birds (acute from parent dicamba for both soybean and cotton uses; chronic from DCSA residues only in soybean but not in cotton), considered surrogates for reptiles, and terrestrial-phase amphibians; and
- terrestrial plants (soybean and cotton uses)

In the screening-level risk assessments, indirect effect risk concerns for all taxa were possible for any species that have dependencies (e.g., food, shelter, and habitat) on mammals, birds, reptiles, terrestrial-phase amphibians, or terrestrial plants.

Additionally, the screening-level assessment showed that direct risk levels of concern were not exceeded for:

- mammals (acute) and (chronic—for the cotton use only);
- birds, reptiles, and terrestrial-phase amphibians (chronic from parent dicamba or DCSA degradate from use on cotton);
- terrestrial insects (acute and chronic);
- freshwater fish (acute and chronic);
- aquatic-phase amphibians (acute and chronic);
- estuarine/marine fish (acute and chronic);
- freshwater invertebrates (acute and chronic); estuarine/marine invertebrates (acute and chronic); and

- aquatic plants[1]

As described below, in the screening-level cotton risk assessment and soybean addendum as part of the earlier public comment process, EFED concluded that mitigation measures, including the use of rainfast mitigation to limit runoff exposure, limiting nozzles to those that restrict droplet spectra to extra-coarse and ultra-coarse, restricting appications under certain wind conditions (*i.e.* only apply when wind speeds are between 3 and 15 mph), and the use of a 110-foot buffer (for a 0.5 lb a.i./A application) in the direction of wind to account for spray drift and applying that buffer in every direction to account for potential volatilization (a discussion of the updates to this assessment is provided below), would limit any exposures beyond the treated field to levels below thresholds that would trigger any risk concerns for any taxa. These assessments concluded that by applying the rainfast mitigation and utilizing the spray drift and volatility buffer as setbacks from the edge of the field ("in-field buffers"), exposures that could potentially trigger risk concerns would be limited to the treated field.

Since these risk assessment documents were issued, the registrant provided additional volatility data for dicamba DGA formulations that indicated dicamba DGA was unlikely to volatilize off-field at concentrations above threshold levels (USEPA, 2016f. D435792). Therefore, EPA decided that the requirement of a volatility buffer in all directions is not required to be placed on the labeling (but maintained the requirement of a spray drift buffer in the direction of wind). This assessment uses the most current label language that includes requirements that are expected to limit exposures (that would exceed a level of concern to any taxa) to the treated field. Additionally, the labeling contains a rainfast mitigation measure that prevents off-field exposures above any threshold levels via runoff. With these labeling restrictions, EFED determined that the vast majority of listed species would be off-field and therefore would not be part of the action area and consequently reached a No Effect decision for those species. Species that were potentially on the treated field or utilizing resources from the treated field and for which the screening-level risk assessment indicated concerns for that taxa would need further refinement to determine the potential for risk.

EPA has a specific process based on sound science that it follows when assessing risks to listed species for pesticides like dicamba that will be used on seeds that have been genetically modified to be tolerant to the pesticide. The Agency begins with a screening-level assessment that includes a basic ecological risk assessment based on its 2004 Overview of the Ecological Risk Assessment Process document. [USEPA, 2004, available at http://www.epa.gov/oppfead1/endanger/litstatus/riskasses.htm]. That assessment uses broad default assumptions to establish estimated environmental concentrations of particular pesticides. If the screening-level assessment results in a determination that no levels of concern are exceeded, EPA concludes its analysis. On the other hand, where the screening-level assessment does not rule out potential effects (exceedances of the level of concern) based on the broad default assumptions, EPA then uses increasingly specific methods and exposure models to refine

[1] The listed species LOC was exceeded for non-vascular aquatic plants; however, there are no listed species of this taxa.

its estimated environmental concentrations. At each screening step, EPA compares the more refined exposures to the toxicity of the pesticide active ingredient to determine whether the pesticide exceeds levels of concern established for listed aquatic and terrestrial species. EPA determines that there is no effect on listed species if, at any step in the screening level assessment, no levels of concern are exceeded. If, after performing all of the steps in the screening-level assessment, a pesticide still exceeds the Agency's levels of concern for listed species, EPA then conducts a species-specific refined assessment to make effects determinations for individual listed species. The refined assessment, unlike the screening-level assessment, takes account of species' habitats and behaviors to determine whether any listed species may be affected by use of the pesticide.

Using this process and based on EFED's LOCATES v2.4.0 database and information from the U.S. Fish and Wildlife Service (USFWS), the three addenda issued in March, 2016 respectively examined: a) 183 listed species in 16 states (USEPA, 2016c. D416416+ covering AR, IL, IN, IA, KS, LA, MN, MS, MO, NE, ND, OH, OK, SD, TN, WI); b) 307 listed species in 7 states (USEPA, 2016d. D422305 covering AL, GA, KY, MI, NC, SC, TX); and c) 322 species in 11 states (USEPA, 2016e. D425049 covering AZ, CO, DE, FL, MD, NM, NJ, NY, PA, VA and WV).

The purpose of this document is to update the refined endangered species risk assessments for the 34 states assessed to reflect the current understanding of all listed species within these states. Since the addenda were issued, some species have been either added or removed from the list of endangered or threatened species in these states. EPA revisited the list of species and identified 70 additional species, discussed below. EPA consulted U.S. Fish and Wildlife Service Recovery Plans to determine whether listed species in these states would be expected to occur in an action area encompassing the treated soybean and cotton fields. The refined assessment was then conducted on those species that could not be excluded from the action area. For these species, EPA also consulted the recovery plans for additional habitat information and incorporated species biological information regarding dietary items (used to model dicamba DGA residues in prey tissue) and body weight (used to determine food consumption rates and scale ecotoxicity data from the tested surrogate species, the bobwhite quail and rat, to the body weight of the listed species). Sixty-six of the new species that had not previously been assessessed were excluded from the action area and consequently result in No Effect determinations. These species and the rationales for their exclusion from the action area are described in **Appendix A**. The remaining four new species (Northern long-eared bat, Mexican wolf, Gunnison Sage Grouse and the Eastern Massasauga rattlesnake) could not immediately be excluded from the treated field and this addendum includes a refined species-specific assessment for these listed species.

In the March, 2016 dicamba refined endangered species assessment addenda, EPA described the lesser long-nosed bat (*Leptonycteris curasoae yerbabuenae*), the Mexican long-nosed bat (*L. nivalis*) and the Canada lynx (*L. canadensis*) as species that would not be in the action area – defined as the area limited to the treated field (Appendix 2 of USEPA, 2016e). The action area is limited to the treated field because EPA expects that with the mitigation measures for spray drift and runoff in place, dicamba will remain within the field being treated. EPA determined that these species would not be in the action area because none of these species' habitats or any of their resources (*Agave* plants for both bat species, snowshoe hares for the lynx) are present on the treated field. No Effect determinations were therefore made for these species.

EPA acknowledges that the recently released ecological risk assessment and listed species effects determinations for 2,4-D Choline salt (Enlist Duo formulation) on 2,4-D tolerant corn, cotton and soybean (USEPA, 2016g. D428301) determinations of no effect for these three species may appear to be different than this dicamba assessment. In the Enlist Duo assessment, EFED included these three species in the summary list of effects determinations for listed species within the action area (**Table 1** on pp. 6-7 of that assessment), whereas the dicamba assessment states that these species are outside the action area. The ultimate determinations of no effect in both assessments are correct; however, the process differs slightly. For Enlist Duo, EFED determined that these species could have been within the action area, but upon further refinement (including a thorough analysis of the lynx and the bat recovery plans) it was determined that because their resources are outside the action area, a No Effect determination was made.

For dicamba, EFED found that because the resouces for these species are outside the action, the species themselves were considered to be outside the action area. The bottom line is that the resources for these species are not within the action area, therefore a No Effects determination is appropriate. In an effort to remain consistent between the 2,4-D and dicamba DGA risk assessments, **Table 1** below includes both the Mexican and lesser long-nosed bat species and the Canada lynx.

Table 1 summarizes the effects determinations for listed species expected to occur within this action area (*i.e.* species for which available habitat requirement information suggests that they could co-occur with cotton or soybean fields). This table is identical to the combined list of species identified as within the action area from the three endangered species refined risk assessment addenda (USEPA, 2016c-e), with the exceptions of the aforementioned additions of four newly assessed species (Northern long-eared bat, Mexican wolf, Gunnison Sage Grouse and the Eastern Massasauga rattlesnake), the additions of the Canada lynx and the Mexican and lesser long-nosed bat species, and the removal of the Louisiana black bear, lesser prairie-chicken, Delmarva peninsula fox squirrel and Florida panther (as a result of these being delisted by USFWS since the time of the original endangered species assessment addenda).

This list does not include the potential of additional mitigation measures of prohibiting use in certain counties or states (see below) on the product labeling. When considering the 27 listed species within the action area, one likely to adversely affect (LAA) determinations was made, two not likely to adversely affect (NLAA) determinations are made and no effect (NE) determinations are made for the remaining species. The refined risk assessment rationale that led to the effects determinations in this table can be found in the three endangered species risk assessment addenda (USEPA, 2016c-e). The methodology used in this addendum is identical to that used in the previously issued endangered species assessment addenda for dicamba's use on tolerant-soybean and cotton plants. Full details on EPA's methodology of effects determination, spray drift mitigation and evaluation of exposure through runoff can be found in the endangered species assessment addenda (USEPA, 2016c-e)

Table 1. Summary of Effects Determinations for Federally Listed Threatened or Endangered Species within the Action Area

Species	Effects determination	Crops Pertinent to Effects Determination*	Areas of Concern
Indiana bat	NE	Cotton, Soybean	NA
Lesser long-nosed bat	NE	Cotton, Soybean	NA
Mexican long-nosed bat	NE	Cotton, Soybean	NA
Northern long-eared bat	NE	Cotton, Soybean	NA
Ozark Bat	NE	Cotton, Soybean	NA
Virginia big-eared bat	NE	Cotton, Soybean	NA
Canada Lynx	NE	Cotton, Soybean	NA
Gray wolf	NE	Cotton, Soybean	NA
Mexican wolf	NE	Cotton, Soybean	NA
Red wolf	NE	Cotton, Soybean	NA
Jaguar	NE	Cotton, Soybean	NA
Gulf-Coast jaguarundi	NE	Cotton, Soybean	NA
Ocelot	NE	Cotton, Soybean	NA
Sonoran pronghorn antelope	NE	Cotton, Soybean	NA
Whooping crane	NE	Cotton, Soybean	NA
Attwater's greater prairie-chicken	NE	Cotton, Soybean	NA
Eskimo curlew	NLAA	NA	NA
Gunnison Sage Grouse	NE	Cotton, Soybean	NA
Mississippi Sandhill crane	NE	Cotton, Soybean	NA
Audubon's Crested Caracara	NLAA	Cotton	Palm Beach County in Florida
	NE	Soybean	NA
California condor	NE	Cotton, Soybean	NA
Eastern Massasauga rattlesnake	NE	Cotton, Soybean	NA
Indigo snake	NE	Cotton, Soybean	NA

Species	Effects determination	Crops Pertinent to Effects Determination*	Areas of Concern
Gopher tortoise	NE	Cotton, Soybean	NA
Houston toad	NE	Cotton, Soybean	NA
American burying beetle	NE	Cotton, Soybean	NA
Spring Creek bladderpod	LAA	Cotton, Soybean	Wilson County in Tennessee
NA – Not Applicable as a No Effect determination has been reached or consultation has been concluded NE-No Effect NLAA- May Effect, Not Likely to Adversely Affect LAA- May Effect, Likely to Adversely Affect *Considering soybeans and cotton, which are the focus of the previous assessments and this addendum.			

Consultation has concluded for the Eskimo curlew, the U.S. Fish and Wildlife Service concurs with the NLAA Effects Determination and no further action need be taken relative to this species (USEPA, 2016d-e).

The draft XtendiMax™ With VaporGrip™ Technology (EPA Reg. No. 524-617) includes the following language:

> "XtendiMaxTM With VaporGripTM Technology is approved by U.S. EPA to be used in the following states, subject to county restriction as noted: Alabama, Arkansas, Arizona, Colorado, Delaware, Florida (excluding Palm Beach County), Georgia, Illinois, Indiana, Iowa, Kansas, Kentucky, Louisiana, Maryland, Michigan, Minnesota, Mississippi, Missouri, Nebraska, New Jersey, New Mexico, New York, North Carolina, North Dakota, Oklahoma, Ohio, Pennsylvania, South Carolina, South Dakota, Tennessee (excluding Wilson County), Texas, Virginia, West Virginia, Wisconsin."

Under these conditions, an approved label with these prohibitions would place the Audubon's caracara and the Spring Creek bladderpod outside of the action area of the uses on cotton and soybean and therefore **no** Effects Determination would be needed or, if done, the conclusion would be **No Effect**.

Determinations for Critical Habitat Modification

The Agency has considered the potential for modification of critical habitat for the 70 additional listed species identified in the states of proposed product use. Critical habitats have been designated for 11 (10 off-field and 1 on-field species) of the 70 species and the Agency reached a **No modification** determination for each (**Appendices C-D**), concluding that the uses of dicamba DGA on dicamba-tolerant soybean and cotton do not result in any modification of designated critical habitat.

Species-specific ecological risk assessment for the remaining species potentially exposed to dicamba residues

As noted above, the species remaining to be assessed are the Northern long-eared bat (*Myotis septentrionalis*), Mexican wolf (*Canis lupus baileyi*), Gunnison Sage Grouse (*Centrocercus minimus*) and the Eastern Massasauga rattlesnake (*Sistrurus catenatus*). The methodology used in this addendum is identical to that used in the previously issued endangered species assessment addenda for dicamba's use on tolerant-soybean and cotton plants. Full details on EPA's methodology of effects determination, spray drift mitigation and evaluation of exposure through runoff can be found in the endangered species assessment addenda (USEPA, 2016c-e).

For the effects determinations for the Northern long-eared bat, Mexican wolf, Gunnison sage grouse and the Eastern Massasauga rattlesnake, a refined risk assessment approach was used to evaluate additional lines of evidence to determine whether the conservative generic assumptions in the screening-level risk assessment apply to a particular species of interest (*e.g.*, the Mexican wolf). For example, in the case of the Mexican wolf, the refined risk assessment investigated the impacts of more wolf-specific data related to:

1. Mammal size (as the wolf is larger than the 1000g large mammal category used in the initial screen)

2. Mammal food consumption tailored to:
   a. The true weight of the mammal
   b. Energy requirements of the wolf
   c. Improvement on the generic food intake model of the screen to assess energy content of the diet and the actual free living energy requirements of a mammal the size of a Mexican wolf

3. Toxicity endpoints scaled from the weight of the tested surrogate species (laboratory rat) to reflect the comparatively larger actual size of the wolf

Using the Mexican wolf as the example to show how EPA made its effects determinations, EPA determined that the Mexican wolf would be primarily feeding on carcasses of large mammals that may have been present in treated cotton and soybean fields. EPA therefore assumed that the predicted concentrations of dicamba DGA salt found in large (1000g) mammals that were exclusively feeding on short grass exposed to dicamba residues from the spray application would be a conservative prey analysis for the wolf consistent with the preliminary risk concerns identified in the screening assessments. For chronic exposures to DCSA residues, EPA assumed the prey mammal was feeding exclusively on soybean forage containing the maximum measured DCSA concentrations. This analysis is conservative as it assumes 1) that 100% of the wolf's food consumption comes from 1kg mammals that have fed exclusively on dicamba exposed short grass (the dietary item with the highest modeled residue levels) or DCSA residues in exposed dicamba-tolerant soybean plants (the only plants that would have significant DCSA residues) and 2) the level of dicamba DGA residues assumed to be on the consumed short grass is based on the upper bound Kenaga residues expected for short grass directly exposed to spray applications of dicamba DGA while the level of DCSA residues is assumed to be the maximum measured concentration (61.1 ppm). Additionally, using the residues in a 1 kg mammal carcass is also likely conservative, given that the wolf primarily feeds on larger prey species such as deer and elk. EPA determined the field metabolic rate of the wolf through the use of a published peer reviewed allometric equation that relates bodyweight to energy requirements. Values were obtained from a published peer reviewed EPA document produced by the Office of Research and Development for Agency-wide use in conducting ecological risk assessment (USEPA, 1993) and the work of Dunning, 1984. The mass of dicamba DGA in the mammalian prey diet is determined from the T-REX run found in the addendum to the screening-level risk assessment (USEPA, 2016a). The mass of prey consumed per day is then multiplied by mass of dicamba in the mammal's diet to determine the mass of dicamba or DCSA in the wolf's daily diet in mg/day. Then the daily dose that the wolf (considering its bodyweight) receives is determined by multiplying the mass of dicamba or DCSA in the exposed mammalian prey (which had consumed exclusively exposed plants) divided by the bodyweight of the wolf. Then EPA scaled the chronic toxicity endpoint (based on the tested surrogate mammal species, laboratory rat, default weight of 350 grams) to the bodyweight of the wolf to determine the chronic oral toxicity for the wolf. Similarly for exposures to DCSA residues, the rat chronic toxicity endpoint from DCSA exposure was used. The chronic RQ for parent dicamba exposures is then calculated by dividing the daily dose of dicamba from consuming the exposed mammal carcasses by the chronic oral toxicity endpoint while the chronic RQ for DCSA exposures is calculated by dividing the daily dose of DCSA by the chronic toxicity endpoint. In this case, the chronic RQ for parent dicamba was 0.1, which is below the listed and non-listed chronic level of concern (LOC) of 1.0, while the chronic RQ for the metabolite DCSA was 0.41 which is below the listed and non-listed species chronic LOC of 1.0. At this point, EPA was able to conclude that dicamba DGA would not have an effect on the Mexican wolf.

Mammals

The screening-level assessments indicated that acute risk to mammals was not expected as no acute RQs exceeded the Agency's LOC (0.1) for acute risk (USEPA 2011. D378444, p. 15). However, the soybean screening-level assessment (USEPA, 2011) indicated that mammals could be at reproductive risk from chronic exposures to dicamba DGA on treated fields, though the cotton screening-level and concurrently issued soybean addendum (USEPA, 2016a-b) indicated that chronic exposures to dicamba DGA would be below the chronic LOC (1.0). This difference is due to the soybean screening-level risk assessment's use of a chronic endpoint from the rat 2-generation study (MRID 43137101), of 45 mg/kg-bw for the NOAEL, based on decreased pup weight at 136 mg/kg-bw compared to the concurrent controls. EPA's Health Effects Division (HED) recently reanalyzed the data from this study (USEPA, 2016h; D378366+) in comparison to the historical control database range and determined that the NOAEL and LOAEL should be raised to 136 and 450 mg/kg-bw, respectively, as pup weights in each generation in the 136 mg/kg-bw treatment group were within the historical control range and above the historical control mean for the F1, F2A and F2B generations. Therefore, the cotton screening-level risk assessment, the concurrently issued soybean addendum and this refined endangered species risk assessment use this revised NOAEL for dicamba DGA salt.

The concurrently issued soybean addendum did indicate that chronic exposures to dicamba's metabolite, DCSA, residues in soybean could be a concern, while the screening-level cotton assessment indicated that chronic exposures to DCSA residues in cotton would not exceed the Agency's LOC for chronic risk. Therefore, EPA only conducted a refined assessment for chronic exposures to DCSA in soybeans for listed species that could reasonably be expected to occur on treated soybean fields.

Of the new (not previously assessed) mammalian species identified as potentially at risk in the thirty four states, two are reasonably expected to occur on treated soybean fields (Mexican Wolf and Northern long-eared bat). Species-specific biological information and dicamba DGA use patterns were considered in more depth to further refine the assessment and effects determinations for the two species potentially expected to occur on treated soybean fields.

Mexican Wolf

Dicamba Chronic Effects Assessment

According to the USFWS listing document (https://www.gpo.gov/fdsys/pkg/FR-2015-01-16/pdf/2015-00441.pdf, USFWS 2015b), Mexican wolves show a strong preference for elk compared to other ungulates, and other documented sources of prey include deer and occasionally small mammals and birds. Mexican wolves are an average of 70 kg and, like other grey wolves, they are habitat generalists. Mexican wolves are a carnivorous species. While the species is not likely to feed on agricultural resources itself, the primary prey species of the wolf may be expected to feed on plant material within the field during the period of applications. Based on this information, it is reasonable to conclude that the Mexican wolf may be exposed to dicamba DGA residues in prey and EPA conducted the following species-specific analysis for the Mexican wolf. Using the conservative assumptions that the prey species is represented by a 1000g mammal (conservative for the wolf's primary prey) that feeds exclusively on exposed short grass receiving the upper bound Kenaga residues from the spray application of dicamba DGA and that the wolf exclusively feeds on this prey species, exposure assumptions and risk calculations were adjusted to account for the species' biology (namely body weight and food ingestion rate) and body weight specific adjusted toxicity endpoints:

Field metabolic rate kcal/day = $0.6167(70000)^{0.862}$ = 9258 kcal/day (USEPA 1993, body weight reflects mean wolf weight from

https://www.gpo.gov/fdsys/pkg/FR-2015-01-16/pdf/2015-00441.pdf)

Mass of prey consumed per day = 9258 kcal/day/(1.7 kcal/g-ww X 0.84 AE) = 6483 g/day [1.7 is energy content of prey item from USEPA (1993); 0.84 is assimilation efficiency from USEPA 1993, 1 kg mammal diet from Whitaker and Hamilton (1998)]

Mass of dicamba DGA in 1 kg mammal diet = 40.17 mg/kg-ww from T-REX run

Mass of dicamba in daily diet = 6483 g/day X 40.17 mg dicamba DGA/kg-ww mammal prey X 0.001 = 260.4 mg/day

Daily dose in wolf = 260.4 mg dicamba DGA/day/70 = 3.7 mg/kg-bw/day

Wolf dicamba chronic NOAEL mg/kg-bw/day = 136 mg/kg-bw X $(350/70000)^{(0.25)}$ = 36.2 mg/kg-bw

The RQ for chronic effects = 3.7/36.2 = 0.10

A chronic RQ of 0.10 does not exceed the chronic LOC of 1.0. **Consequently, a "no effect" determination is made for the wolf.**

DCSA Chronic Effects Assessment for Mexican wolf consuming prey that had previously consumed exposed soybean forage

Using the conservative assumptions that the prey species is represented by a 1000 g mammal that feeds exclusively on exposed soybean forage containing the maximum measured DCSA residues (61.1 mg/kg), exposure assumptions from the screening assessment were adjusted to account for the wolf's biology:

The first step in the refinement process is to calculate DCSA residues in the prey species. Using the assumption that the prey species is represented by a 1000 g mammal and the conservative assumptions that the prey animal feeds exclusively on exposed soybean forage containing the maximum measured residues of 61.1 ppm, EFED calculated the residues based on the following allometric equations (USEPA, 1993):

1000 g mammal prey ingestion rate (dry) = $0.621(1000)^{0.564}$ =30.56 g /day

1000 g mammal prey ingestion rate (wet) = 30.56/0.2 = 152.8 g/day

DCSA residue in prey eating soybean forage/hay 61.1 mg DCSA/kg-food (ww) x 0.1528 kg food/kg-bw = **9.34 mg/kg-bw/day**

The next step is to determine the expected daily dose for a typical 70 kg wolf, the adjusted NOAEL value and the chronic dose-based RQ for the wolf based on the following allometric equations:

Field metabolic rate kcal/day = $0.6167(70000)^{0.862}$ = 9258 kcal/day (USEPA 1993, body weight reflects mean wolf weight from:

https://www.gpo.gov/fdsys/pkg/FR-2015-01-16/pdf/2015-00441.pdf)

Mass of prey consumed per day = 9258 kcal/day/(1.7 kcal/g-ww X 0.84 AE) = 6483 g/day [1.7 is energy content of prey item from USEPA (1993); 0.84 is assimilation efficiency from USEPA 1993, 1 kg mammal diet from Whitaker and Hamilton (1998)]

Mass of DCSA in 1 kg mammal diet = 9.34 mg/kg-ww (conservative estimate for a 1 kg mammal feeding on soybean forage containing the maximum measured empirical residues of 61.1 mg/kg)

Mass of DCSA in daily diet = 6483 g/day X 9.34 mg DCSA/kg-ww mammal prey X 0.001 = 60.6

Daily dose in wolf = 60.6 mg DCSA/day/70 kg = **0.9 mg/kg-bw/day**

Wolf DCSA chronic NOAEL mg/kg-bw/day = 8 mg/kg-bw X $(350/70000)^{(0.25)}$ = **2.1 mg/kg-bw**

The RQ for chronic effects = 0.9/2.1 = 0.41

A chronic RQ of 0.41 does not exceed the chronic LOC of 1.0. **Consequently, a "no effect" determination is made for the wolf.**

Northern long-eared bat

Dicamba Chronic Effects Assessment

The northern long-eared bat is an insectivorous myotine bat (Whitaker and Hamilton, 1998). With an average weight of 6.5 g, this bat forages principally in forested areas but has been shown to forage over water, open clearings and along roads (https://www.gpo.gov/fdsys/pkg/FR-2015-04-02/pdf/2015-07069.pdf, USFWS 2015a). Consequently, its potential use of open areas without canopy could place the species foraging over agricultural land on insects from treated fields. Therefore, EPA conducted the following species-specific analysis for the northern long-eared bat. Using the conservative assumption that the bat's diet consists entirely of insects having been exposed to the upper bound Kenaga residues from the spray application of dicamba DGA, exposure assumptions and risk calculations were adjusted to account for the species' biology (namely body weight and food ingestion rate) and body weight specific adjusted toxicity endpoints:

Field metabolic rate kcal/day = $0.6167(6.5)^{0.862}$ = 3.1 kcal/day

(USEPA 1993, body weight 6.5 g reflects mean weight for the bat based on https://www.gpo.gov/fdsys/pkg/FR-2015-04-02/pdf/2015-07069.pdf)

Mass of insect prey consumed per day = (3.1 kcal/day)/(1.7 kcal/g ww X 0.87) = 2.1 g/day (1.7 is energy content of prey item from USEPA (1993); 0.87 is assimilation efficiency from USEPA 1993)

Mass of dicamba DGA in insect diet = 102.99 mg/kg-ww from T-REX run

Mass of dicamba DGA in daily diet = 2.1 g/day X 102.99 mg dicamba DGA/kg-ww mammal prey X 0.001 = 0.22 mg/day

Daily dose in bat = 0.22 mg dicamba DGA/day/0.0065 = **36.2 mg/kg-bw/day**

Northern long-eared bat parent dicamba NOAEL mg/kg-bw/day = 136 mg/kg-bw X $(350/6.5)^{0.25}$ = **368.4 mg/kg-bw**

RQ for chronic exposure = 36.2/368.4 = 0.09

A chronic RQ of 0.09 does not exceed the chronic LOC of 1.0 for listed species. **Consequently, a "no effect" determination is made for the northern long-eared bat.**

DCSA Chronic Effects Assessment for Northern long-eared bat consuming prey that had previous consumed exposed soybean forage

EFED considered DCSA residues in arthropods to be the maximum measured DCSA residues from broadleaf plants, modified by the Kenaga nomogram relationship between broadleaf plant and arthropods (specifically, insects) as a conservative pesticide load in the prey base. This is considered a conservative approach as 100% of the bat's diet would be considered to consist of exposed arthropods feeding on dicamba-tolerant soybean plants that had the highest measured DCSA residues. A biologically representative refinement to the screening assessment follows.

Field metabolic rate kcal/day = $0.6167(6.5)^{0.862}$ = 3.1 kcal/day

(USEPA 1993, body weight 6.5 g reflects mean weight for the bat based on https://www.gpo.gov/fdsys/pkg/FR-2015-04-02/pdf/2015-07069.pdf)

Mass of insect prey consumed per day = (3.1 kcal/day)/(1.7 kcal/g ww X 0.87) = 2.1 g/day (1.7 is energy content of prey item from USEPA (1993); 0.87 is assimilation efficiency from USEPA 1993)

Mass of DCSA in insect diet 42.5 mg/kg-ww (conservative assumption of Kenaga nomogram relationship between arthropod residues and broadleaf plant tissue residues based on 61.1 mg/kg maximum value from empirical data for soybean forage)

Mass of DCSA in daily diet = 2.1 g/day X 42.5 mg DCSA/kg-ww insect prey X 0.001 = 0.089 mg/day

Daily dose in bat = 0.089 mg DCSA/0.0065 = **13.73 mg/kg-bw/day**

Northern long-eared bat parent dicamba NOAEL mg/kg-bw/day = 8 mg/kg-bw X $(350/6.5)^{0.25}$ = **21.67 mg/kg-bw**

RQ for chronic exposure = 13.73/21.67 = 0.63

A chronic RQ of 0.63 does not exceed the chronic LOC of 1.0. **Consequently, a "no effect" determination is made for the northern long-eared bat.**

Birds

The screening-level assessments showed that birds could be at risk of mortality from acute exposures to dicamba DGA on treated fields, but chronic risk to dicamba was not expected as no chronic RQs exceeded the Agency's LOC (1.0) for chronic risk (USEPA 2011. D378444, p. 15). The concurrently issued soybean addendum indicated that chronic exposures to DCSA residues in soybean could be a concern, while the screening-level cotton assessment indicated that chronic exposures to DCSA residues in cotton would not exceed the Agency's LOC for chronic risk. Therefore, for listed species that could reasonably be expected to occur on treated soybean and cotton fields, EPA conducted a refined assessment for acute (dicamba only) and chronic (DCSA only, and only for soybean) exposures.

Of the new (not previously assessed) bird species identified as potentially at acute or chronic risk in the thirty four states, one is reasonably expected to occur on treated soybean and cotton fields. Therefore, species specific biological information and dicamba DGA use patterns were considered in more depth to further refine the assessment and effects determinations for this species.

Gunnison Sage Grouse

The November 20, 2014 designation of critical habitat document for the Gunnison sage grouse (https://www.gpo.gov/fdsys/pkg/FR-2014-11-20/pdf/2014-27113.pdf, USFWS, 2014) indicates that this bird will consume a mixture of vegetable and animal matter and the crop of the bird is too weak for seed consumption. This is likely seasonally dependent being composed of nearly 100 percent sagebrush in the winter, and forbs and insects as well as sagebrush in the remainder of the year. Insect consumption may coincide with the time period associated with application of dicamba DGA. Based on this information, it is reasonable to conclude that the sage grouse may be exposed to dicamba DGA residues in insect prey items on crop fields, therefore EPA conducted the following species-specific analysis for the sage grouse.

Dicamba Acute Effects Assessment

Using the conservative assumption that the grouse's diet consists entirely of insects having been exposed to the upper bound Kenaga residues from the spray application of dicamba DGA, exposure assumptions and risk calculations were adjusted to account for the species' biology (namely body weight and food ingestion rate) and body weight specific adjusted toxicity endpoint.

Field metabolic rate kcal/day = $1.146(2400)^{0.749}$ = 389.9 kcal/day

(USEPA 1993, body weight reflects mean for the bird from Dunning (1984)

Mass of prey consumed per day = 389.9 kcal/day/(1.7 kcal/g-ww X 0.72 AE) = 318.5 g/day

(1.7 is energy content of prey item from USEPA (1993); 0.72 is assimilation efficiency from USEPA 1993, assumption of insect prey USFWS 1983)

Mass of dicamba DGA in insect diet = 102.99 mg/kg-ww from T-REX run

Mass of dicamba DGA in daily diet = 318.5 g/day X 102.99 mg dicamba DGA/kg-ww insect prey X 0.001 = 32.8 mg/day

Daily dose in bird = 32.8 mg dicamba DGA/day/2.4 = 13.7 mg/kg-bw/day

Grouse LD50 mg/kg-bw = 188 mg/kg-bw X $(2400/178)^{(1.15-1)}$ = 277.7 mg/kg-bw

The RQ for acute effects = 13.7/277.7 = 0.05

An acute RQ of 0.05 does not exceed the acute LOC of 0.1 for listed species. Further, if the diet was composed of a forb such as the treated crop plants (*i.e.* broadleaf plants), the screening level-risk assessment would place the dicamba DGA residue at 147.91 mg/kg instead of 102.99 mg/kg, resulting in a slight increase in the RQ for the bird to 0.07, which is still below the LOC of 0.1. **Consequently, a "no effect" determination is made for the Gunnison sage grouse**

DCSA Chronic Effects Assessment for Gunnison sage grouse consuming prey that had previously consumed soybean forage

EFED considered DCSA residues in arthropods to be the maximum measured DCSA residues from broadleaf plants, modified by the Kenaga nomogram relationship between broadleaf plant and arthropods as a conservative pesticide load in the prey base. This is considered a conservative approach as 100% of the grouse's diet would be considered to consist of exposed arthropods feeding on dicamba-tolerant soybean plants that had the highest measured DCSA residues. A biologically representative refinement to the screening assessment follows.

Field metabolic rate kcal/day = $1.146(2400)^{0.749}$ = 389.9 kcal/day
(USEPA 1993, body weight reflects mean for the bird from Dunning (1984)

Mass of prey consumed per day = 389.9 kcal/day/(1.7 kcal/g-ww X 0.72 AE) = 318.5 g/day
(1.7 is energy content of prey item from USEPA (1993); 0.72 is assimilation efficiency from USEPA 1993, assumption of insect prey USFWS 1983)

Mass of DCSA in daily diet = 318.5 X 42.5 X 0.001 = 13.5 mg/day

Daily dose in grouse = 13.5 mg DCSA/day/2.4 = **5.6 mg/kg-bw/day**

Avian Chronic Endpoint of 695 mg/kg-diet (from mallard duck study for parent dicamba) modified by ratio of parent dicamba to metabolite DCSA from chronic rat studies (17x) results in Avian chronic NOAEC of **40.88 mg/kg-diet.**

RQ for chronic exposure: RQ = 5.6/40.88 = 0.14

An RQ of 0.14 does not exceed the chronic LOC of 1.0. Further, if the diet was composed of a forb such as the treated crop plants (*i.e.* broadleaf plants), and considered to contain the maximum measured DCSA residues in soybean forage (61.1 mg/kg), the RQ would rise to approximately 0.20, which is still below the chronic LOC of 1.0; **consequently a "no effect" determination is concluded for the Gunnison sage grouse.**

Reptiles and amphibians

Using birds as a surrogate for reptiles and terrestrial-phase amphibians, consistent with the Overview document (USEPA, 2004), the screening-level assessment suggests that reptiles and terrestrial-phase amphibians could be at risk of effects from acute exposures to dicamba DGA or chronic exposures to DCSA on treated fields. Of the new reptile and amphibian species identified as potentially at risk in the 34 states, one reptile is reasonably expected to occur on treated soybean and cotton fields. Therefore, species specific biological information and dicamba DGA use patterns were considered in more depth to further refine the assessment and effects determinations for that species.

Eastern Massasauga rattlesnake

The eastern massasauga rattlesnake is an inhabitant of open to forested wetlands and adjacent upland areas that is known to eat voles, mice, other small mammals, small birds, amphibians, and also other species of snakes (https://www.fws.gov/midwest/endangered/reptiles/eama/). Therefore, the species was determined to potentially occupy treated cotton and soybean fields and thus be subject to exposure to Dicamba DGA on the treated field. The snake feeds largely on small mammals, (http://mnfi.anr.msu.edu/emr/eco.cfm). Using the conservative assumptions that the prey species is represented by a 35g mammal that feeds exclusively on exposed short grass receiving the upper bound Kenaga residues from the spray application of dicamba DGA and that the snake exclusively feeds on this prey species, exposure assumptions and risk calculations were adjusted to account for the species' biology (namely body weight and food ingestion rate) and body weight specific adjusted toxicity endpoints.

Dicamba Acute Effects Assessment

Field metabolic rate kcal/day = $0.0530(350)^{0.799}$ = 5.7 kcal/day

> (USEPA 1993, body weight is mean of reported values in https://www.aboutanimals.com/reptile/massasauga-rattlesnake/).

Mass of prey consumed per day = 5.7 kcal/day/(1.7 kcal/g ww X 0.78 AE) = 4.3 g/day

> (1.7 is energy content of prey item from USEPA (1993); 0.78 is assimilation efficiency from USEPA 1993)

Mass of dicamba DGA in a 35-g mammal diet = 173.26 mg/kg-ww from T-REX run

Mass of dicamba DGA in daily diet = 4.3 g/day X 173.26 mg/kg-ww mammal prey X 0.001 = 1.0 mg/day

Daily dose in rattlesnake = 1.0 mg/day dicamba DGA/0.350 = **2.82 mg/kg-bw/day**

Appropriate scaling factors are not available for reptiles and amphibians so the acute toxicity value for the bobwhite quail (most sensitive avian species for which acute data are available) serves as a surrogate (USEPA, 2004) toxicity value for the rattlesnake:

Rattlesnake LD_{50} mg/kg-bw = **188 mg/kg-bw**

RQ for acute effects = 2.82/188 = 0.015

An acute RQ of 0.015 does not exceed the acute listed species LOC of 0.1. **Consequently, EPA makes a "no effect" (NE) determination for the Eastern Massasauga rattlesnake.**

DCSA Chronic Effects Assessment for Eastern Massasauga rattlesnake consuming prey that had previously consumed exposed soybean forage

As noted above, the Eastern Massasauga rattlesnake feeds largely on small mammals and also birds, amphibians and other snakes. Using the conservative assumptions that the prey species is represented by a mammal that feeds exclusively on exposed soybean plant tissue containing the maximum measured DCSA residues of 61.1 ppm and that the snake exclusively feeds on this prey species, the assumptions in the initial screen were adjusted to account for the rattlesnake's biology:

Field metabolic rate kcal/day = $0.0530(350)^{0.799}$ = 5.7 kcal/day (USEPA 1993, body weight is mean of reported values in https://www.aboutanimals.com/reptile/massasauga-rattlesnake/).

Mass of prey consumed per day = 5.7 kcal/day/(1.7 kcal/g ww X 0.78 AE) = 4.3 g/day (1.7 is energy content of prey item from USEPA (1993); 0.78 is assimilation efficiency from USEPA 1993)

Mass of DCSA in a mammal diet 61.1 mg/kg-ww (maximum empirical residue data on soybean forage)

Mass of DCSA in rattlesnake's daily diet = 4.3 g/day X 61.1 mg dicamba DGA/kg-ww mammal prey X 0.001 = 0.26 mg/kg-bw/day

Daily dose in rattlesnake = 0.26 mg DCSA/day/0.350 = **0.75 mg/kg-bw/day**

Avian Chronic Endpoint of 695 mg/kg-diet (from mallard duck [most sensitive avian species for which chronic data are available and serves as the surrogate species for reptiles] study for parent dicamba) modified by ratio of parent dicamba to metabolite DCSA from chronic rat studies (17x) results in Avian chronic NOAEC of **40.88 mg/kg-diet.**

RQ for chronic exposure: RQ = 0.75/40.88 = **0.02**

An RQ of 0.02 does not exceed the chronic LOC of 1.0**; consequently a "no effect" determination is concluded for the Eastern Massasauga rattlesnake.**

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Appendix A. Summary List of Species Considered for Effects Determinations

Entity ID	Name	Scientific Name	Status	Group	States	Habitat Description	ON/OFF Field	References
10021	Red-crowned parrot	*Amazona viridigenalis*	Candidate	Birds	Texas	primarily urban areas that have large trees. The species requires forested cover not expected to be provided by land cleared for the proposed use sites for the pesticides	Off Field.	https://www.gpo.gov/fdsys/pkg/FR-2015-12-24/pdf/2015-32284.pdf Endangered and Threatened Wildlife and Plants; Review of Native Species That Are Candidates for Listing as Endangered or Threatened; Annual Notice of Findings on Resubmitted Petitions; Annual Description of Progress on Listing Actions
2567	Skiff milkvetch	*Astragalus microcymbus*	Candidate	Plants	Colorado	spotty distribution within Gunnison and Saguache Counties in Colorado, where it is found in open, park-like landscapes in the sagebrush steppe ecosystem on rocky or cobbly, moderate-to-steep slopes of hills and draws. Elevation range for the species id Greater than 7500 feet. The species occurs in habitat not suitable for agrcultual planting of the proposed use-site crops for the pesticides	Off Field	https://www.gpo.gov/fdsys/pkg/FR-2015-12-24/pdf/2015-32284.pdf Endangered and Threatened Wildlife and Plants; Review of Native Species That Are Candidates for Listing as Endangered or Threatened; Annual Notice of Findings on Resubmitted Petitions; Annual Description of Progress on Listing Actions
6596	Pecos amphipod	*Gammarus pecos*	Endangered	Crustaceans	Texas	Found in all flowing water habitats associated with the Y Diamond Spring system.	Off-field	USFWS. 2013. FR Notice. 78 FR 41227 41258 http://www.gpo.gov/fdsys/pkg/F R-2013-07-09/pdf/2013-16222.pdf
6620	Sonoyta mud turtle	*Kinosternon sonoriense longifemorale*	Candidate	Reptiles	Arizona	Sonoyta mud turtles are found both in natural and artificial spring-fed ponds and stream channels. Adults are typically captured in the deeper sections of the pond near dense stands of tules and	Off-field	U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM

						other vegetation. Vegetation free shorline habitat is used for nesting.		http://ecos.fws.gov/docs/candidate/assessments/2014/r2/C067_V01.pdf
3497	Roundtail chub	*Gila robusta*	Candiddate	Fishes	New Mexico, Arizona, Colorado	Mid size to larger streams; localized in protected pools, The most frequently occupied pools have current velocities reaching a maximum of 0.18m/s. and average 0.03m/s, with a pH of 8.1.; .4 to 1.4 m deep with a mean of .8 m, velocities ranging from 0 to .8 m/s with mean of .32 m/s, (juveniles occupied areas with velocities of 0 to .6 m/s with mean of .2 m/s, and larval occurred in essentially still water 0 to .3 m/s mean of .06 m/s pools below riffles but adults were also found in deeper pools, closer to the stream bottom and in faster water	Off-field	http://ecos.fws.gov/docs/life_histories/E00R.html http://ecos.fws.gov/speciesProfile/profile/speciesProfile.action?spcode=E00R
10145	North Pacific Right Whale	*Eubalaena japonica*	Endangered	Mammals	Virginia, Florida, Maryland, New York, New Jersey, North Carolina, South Carolina, Delaware, Georgia	Designated critical habitat is in waters off the coast of Alaska. Since 1996, observed in Bristol Bay, southeastern Bering Sea, during the summer months. Have been sited in central North Pacific and Bering Sea, central Baja California in the eastern North Pacific, Hawaii in the central North Pacific, and the sub-Arctic waters of the Bering Sea and sea of Okhotsk. Based on distribution map (1), it appears that this species may occur off the coast of WA, OR and CA. Shallow coastal waters though movements over deep waters are known to occur.	Off-Field	National Marine Fisheries NOAA Fisheries Species Information. Office of Protected Resources: http://www.nmfs.noaa.gov/pr/species/mammals/cetaceans/rightwhale_northpacific.htm Federal Register, 73(68):19000-19014, April 8, 2008. Available online at: http://www.gpo.gov/fdsys/pkg/FR-2008-04-08/pdf/E8-7233.pdf#page=1

	Rough Cactus Coral	*Mycetophyllia ferox*	Threatened	Corals	Florida	Aquatic habitats in the Caribbean Sea, Florida, Puerto Rico, US Virgin Islands	Off-field	NOAA (2015)2 http://coralreef.noaa.gov/aboutcorals/coral101/feedinghabits/welcome.html NOAA (2011) http://www.nmfs.noaa.gov/stories/2012/05/docs/009_corals_status_review_western_atlantic.pdf NOAA (2014) http://www.fisheries.noaa.gov/stories/2014/08/docs/corals_fact_sheet.pdf
5065	Black warrior (=Sipsey Fork) Waterdog	*Necturus alabamensis*	Candidate	Amphibians	Alabama	Found in streams	Off-field	USFWS 2013 SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM for Necturus alabamensis. Available online at: http://ecos.fws.gov/docs/candidate/assessments/2013/r4/D030_V01.pdf
1415	White fringeless orchid	*Platanthera integrilabia*	Candidate	Plants	Alabama, Tennessee, Kentucky, Georgia, South Carolina, North Carolina	Platanthera integrilabia grows in wet, boggy areas at the heads of streams and on seepage slopes. It is often associated with Sphangnum in partially, but not fully shaded areas. The plants flower from late July through September and the small narrow fruting capsule matures in October. The hydric regime for this species suggest that it is not reasonable to expect the species on cotton or soybean cultivated fields.	Off-field	USFWS 2012. U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM, http://ecos.fws.gov/docs/candidate/assessments/2013/r4/Q2GF_P01.pdf http://ecos.fws.gov/speciesProfile/profile/speciesProfile.action?spcode=Q2GF

5714	Kenk's amphipod	*Stygobromus kenki*	Candidate	Crustaceans	Maryland	*Occurs in ground water and ground water-related habitats (e.g., caves, seeps, small springsl wells, interstices, and rarely deep ground water lakes). Found in wooded areas where groundwater emerges to form seepage springs. Shading, hydroglogical conditions and organic matter found in woodlands help maintain suitable habitat. Can also be found in dead leaves, or fine sediment submerged in waters for seepage spring outflows.	Off-field	http://ecos.fws.gov/tess_public/profile/speciesProfile.action?spcode=K04P http://ecos.fws.gov/docs/candidate/assessments/2015/r5/K04P_I01.pdf
9721	Florida bristle fern	*Trichomanes punctatum ssp. floridanum*	Proposed Endangered	Ferns	Florida	Florida bristle fern is always associated with shaded limestone outcrops. Plants usually grow on bare limestone, but are occasionally found on tree roots growing on limestone. In Miami-Dade County, it has been found exclusively in oolitic (composed of minute rounded concretions resembling fish eggs) limestone solution holes and rocky outcrops in rockland hammocks. Solution holes are formed by dissolution of subsurface limestone followed by a collapse above (Snyder et al. 1990, p. 236). Solution holes vary in size, from shallow holes less than 0.5 meter (m) (1.6 feet [ft]) deep to those that cover over 100 m2 (1,076 ft2) and are several meters deep. The bottoms of most solution holes are filled with deep organic soils. Deeper solution holes penetrate the water table and have (at least historically) standing water for part of the year. Humidity levels are higher in and around the solution holes because of standing water and moisture retained in the organic soils. The canopy cover is typically very dense where Florida bristle fern occurs, and consists of a mix of temperate and tropical hardwood trees. Soils are composed of limestone, oolitic (composed of minute rounded concretions resembling	Off-field	USFWS 2012. SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM for Trichomanes punctatum ssp. Floridanum http://ecos.fws.gov/specesProfile/profile/speciesProfile.action?spcode=S02G

						fish eggs) limestone solution holes and rocky outcrops in rockland hammocks as well as organic soils. Soils at the Miami-Dade County sites are classified as Matecumbe Muck (http://www.fgdl.org/). In Sumter County, the plants occur in a mesic/hydric hammock on limestone boulders. Florida bristle fern grows on boulders with tall, horizontal faces. Soils at the Sumter County station are classified as Mabel Fine Sand, bouldery subsurface. Spores have been recorded in October (J. Possley, pers. comm. 2007), but plants probably produce spores during much of the summer wet season. During the dry season, sporophytes have been observed to desiccate, and probably do not produce spores. For Florida bristle fern, the reproductive requirements, such as moisture levels, needed for each stage of its life history are unknown. The Florida bristle fern is a very small, mat-forming fern, superficially resembling some liverwort species.		
	Squirrel Chimney Cave shrimp	*Palaemonetes cummingi*	Threatened	Crustaceans	Florida	Aquatic species found in one location in caves in Florida. The proposed DGA uses are unlikely to correspond to this location	Off-field	5-Year Review: Summary and Evaluation http://ecos.fws.gov/docs/five_year_review/doc1919.pdf
1678	Bracted twistflower	*Streptanthus bracteatus*	Candidate	Plants	Texas	The species is frequently found within adense understory of small trees and shrubs, including Rhus virens, (evergreen sumac), Acacia roemeriana (Roemer acacia), Mahonia trifoliolata (agarita), Garrya ovata ssp lindheimeri (Lindheimer silk-tassel), Ageratina havanensis (thoroughwort), and Bernardia myricifolia (oreja de raton) We received descriptions of plant species associated with bracted twistflower populations from 12 independent sources (see Appendix 1 for sources). Of the more than 100 species reported, bracted twistflower occurs most often under a tree canopy of Juniperus	Off Field.	Species Profile FWS Website http://ecos.fws.gov/docs/candidate/assessments/2015/r2/Q1R7_P01.pdf USFWS 2011. Review of Native Species That Are Candidates for Listing as Endangered or Threatened; Annual Notice of Findings on Resubmitted Petitions; Annual Description of Progress on Listing Actions http://ecos.fws.gov/speciesProfile/p

						ashei (Ashe juniper), Quercus fusiformis (Texas live oak)), Diospyros texana (Texas persimmon), Sophora secundiflora (Texas mountain laurel), and Quercus buckleyi (Texas red oak). The proposed use is not expected to overlap with agricultural habitat.		rofile/speciesProfile.action?spcode =Q1R7
1535	Sand flax	*Linum arenicola*	Endangered	Plants	Florida	Sand flax is found in pine rockland, disturbed pine rockland, marl prairie, roadsides on rocky soils, and disturbed areas (Bradley and Gann 1999, p. 61; Hodges and Bradley 2006, p. 37). Bradley and Gann (1999, p. 61) stated, It grows on oolitic limestone formations. The pine rockland and marl prairie where this species occurs requires periodic wildfires in order to maintain an open, shrub free subcanopy and reduce litter levels. This taxon is currently rare in relatively undisturbed natural areas, with the exception of plants on Big Pine Key and the grounds of an office building on Old Cutler Road. Several occurrences are in scarified pine rockland fragments that are dominated by native pine rockland species, but have little or no canopy or subcanopy. One population in Miami-Dade County occurs entirely on a levee composed of crushed oolitic limestone in the middle of a sawgrass marsh. The soils are composed of rocky soils and oolitic limestone formations Sand flax is currently known from four occurrences in the Keys and six occurrences in Miami-Dade County (Bradley 2006, p. 5; K. Bradley, pers. comm. 2007, 2011; J. Maschinski, Fairchild Tropical Botanic Garden [FTBG], pers. comm. 2007, 2011; J. Possley, FTBG, pers. comm. 2011; Bradley and van der Heiden 2013, pp. 6, 19). Based upon Bradley and Gann (1999, p. 65), Hodges and Bradley (2006, pp. 37-39), Bradley (2009, pp. 1-13), data from IRC (K. Bradley, pers. comm. 2007; Gann et al. 2001-2010, p. 1), data from FTBG	Off field.	2013 USFWS Species Assessment Form for the *Linum arenicola* Http://ecos.fws.gov/speciesProfile/profile/speceisProfile.action?spcode=Q14H https://www.gpo.gov/fdsys/pkg/FR-2015-09-29/pdf/2015-24291.pdf

						(Maschinski et al. 2002, Appendix B1, p. 6; J. Maschinski, pers. comm. 2007; J. Possley, pers. comm. 2011; J. Maschinski, pers. comm. 2011), Bradley and Saha (2009, p. 10), and Bradley and van der Heiden (2013, pp. 7-12, 19), sand flax is extant at the sites in Table 2. On Big Pine Key, sand flax occurs at the Terrestris Preserve, which is owned by The Nature Conservancy (TNC); this occurrence is included within the Big Pine Key site		
13	Mexican grey wolf	*Canis lupus baileyi*	Endangered	Mammals	New Mexico, Arizona, Texas	Evergreen pine–oak woodlands, pinyon–juniper woodlands, and mixed-conifer montane forests	Potentially on field	USFWS. 1987. Mexican Wolf Recovery Plan. United States Fish and Wildlife Service. Available online at: http://ecos.fws.gov/docs/recovery_plan/820915_1.pdf USFWS. 2000. US Counties in which the Mexican gray wolf, is known to or is believed to occur. United States Fish and Wildlife Service. Available online at: http://ecos.fws.gov/speciesProfile/profile/countiesBySpecies?entityId=13 USFWS. 2015. Species Profile for Mexican Gray Wolf (Canis lupus baileyi). United States Fish and Wildlife Service. Available online at: http://ecos.fws.gov/speciesProfile/profile/speciesProfile.action?spcode=A00E
4064	Gunnison sage grouse	*Centrocercus minimus*	Threatened	Pants	Florida	Sand flax is found in pine rockland, disturbed pine rockland, marl prairie, roadsides on rocky soils, and disturbed areas (Bradley and Gann 1999, p. 61; Hodges and Bradley 2006, p. 37). Bradley and Gann (1999, p. 61) stated, It grows on oolitic limestone formations. The pine rockland and marl prairie where this species occurs requires periodic wildfires in order to maintain an open, shrub free subcanopy and reduce litter levels. This taxon is currently rare in relatively undisturbed natural areas, with the	Potentially on field	

						exception of plants on Big Pine Key and the grounds of an office building on Old Cutler Road. Several occurrences are in scarified pine rockland fragments that are dominated by native pine rockland species, but have little or no canopy or subcanopy. One population in Miami-Dade County occurs entirely on a levee composed of crushed oolitic limestone in the middle of a sawgrass marsh. The soils are composed of rocky soils and oolitic limestone formations Sand flax is currently known from four occurrences in the Keys and six occurrences in Miami-Dade County (Bradley 2006, p. 5; K. Bradley, pers. comm. 2007, 2011; J. Maschinski, Fairchild Tropical Botanic Garden [FTBG], pers. comm. 2007, 2011; J. Possley, FTBG, pers. comm. 2011; Bradley and van der Heiden 2013, pp. 6, 19). Based upon Bradley and Gann (1999, p. 65), Hodges and Bradley (2006, pp. 37-39), Bradley (2009, pp. 1-13), data from IRC (K. Bradley, pers. comm. 2007; Gann et al. 2001-2010, p. 1), data from FTBG (Maschinski et al. 2002, Appendix B1, p. 6; J. Maschinski, pers. comm. 2007; J. Possley, pers. comm. 2011; J. Maschinski, pers. comm. 2011), Bradley and Saha (2009, p. 10), and Bradley and van der Heiden (2013, pp. 7-12, 19), sand flax is extant at the sites in Table 2. On Big Pine Key, sand flax occurs at the Terrestris Preserve, which is owned by The Nature Conservancy (TNC); this occurrence is included within the Big Pine Key site		
7800	Eastern Massauga Rattlesnake	*Sistrurus catenatus*	Threatened	Reptiles	Ohio, Wisconsin, Pennsulvania, Indiana, Michigan, Illinois, Minnesota, New York, West Virginia, Iowa Missouri	shallow wetland, adjacent upland habitat	Potentially on field	http://ecos.fws.gov/speciesProfile/profile/speciesProfile.action?spcode=C03P http://ecos.fws.gov/docs/candidate/assessments/2013/r3/C03P_V01.pdf http://www.fws.gov/midwest/endangered/reptiles/eama/eama-fct-sht.html

10043	Northern long-eared bat	*Myotis septentrionalis*	Threatened	Mammals	Wisconsin, West Virginia, Tennessee, South Dakota, Iowa, Pennsylvania, Delaware, Missouri, Minnesota, Indiana, Texas, Kentucky, New York, Oklahoma, Virginia, North Dakota, Illinois, Arkansas, New Jersey, Georgia, Louisiana, South Carolina, Maryland, Kansas, Michigan, Nebraska, Ohio, North Carolina, Alabama	Forests (hardwood), caves, bark, cavities and crevices of live and dead trees	Potentially on field	USFWS. 2015. Species Profile for Northern long-eared Bat (Myotis septentrionalis). United States Fish and Wildlife Service. Available online at: http://ecos.fws.gov/speciesProfile/profile/speciesProfile.action?spcode=A0JE USFWS. 2015. Threatened Species Status for the Northern Long-Eared Bat With 4(d) RuleFR 80, No. 63. Available online at: http://www.gpo.gov/fdsys/pkg/FR-2015-04-02/pdf/2015-07069.pdf
6672	Georgia rockcress	*Arabis georgiana*	Threatened	Plants	Georgia, Alabama	Associated with high bluffs along major rivers with dry-mesic to mesic soils of open rocky woodland and forested slopes, generally within regions underlain or otherwise influenced by granite, sandstone, or limestone. Georgia rockcress grows in a variety of dry situations, including shallow soil accumulations on rocky bluffs, ecotones of sloping rock outcrops, and sandy loam along eroding riverbanks. It is occasionally found in adjacent mesic woods (or glades), but it will not persist in heavily shaded conditions.	Off field.	USFWS. 2013. FR Notice. 78FR 56192 56201 http://www.gpo.gov/fdsys/pkg/FR-2013-09-12/pdf/2013-22129.pdf
5233	Blodgett's silverbush	*Argythamnia blodgettii*	Candidate	Plants	Florida	Occurs in Florida and is found in open, sunny areas in pine rockland, edges of rockland hammock, edges of coastal berm, and sometimes in disturbed areas at the edges of natural areas. Plants can be found growing from crevices on limestone, or on sand.	Off field	USFWS. 2013. Review of Native Species That are Candidates for Listing as Endangered or Threatened; Annual Notice of Findings on Resubmitted Petitions; Annual Description of Progress on Listing Actions http://ecos.fws.gov/speciesProfile/profile/speciesProfile.action?spcode=Q045

2730	Schmoll milk-vetch	*Astragalus schmolliae*	Candidate	Plants	Colorado	Grows in the mature pinyon-juniper woodland of mesa tops in the Mesa Verde National Park area and in the Ute Mountain Ute Tribal Park in Colorado The habitat for Schmoll's milkvetch is dense piñon-juniper woodland of mesa tops in the Mesa Verde area with a preference for reddish lowess soils. These areas are not expected to be planted in the use site crops for the pesticide.	Off field	USFWS. 2014. Review of Native Species That Are Candidates for Listing as Endangered or Threatened; Annual Notice of Findings on Resubmitted Petitions; Annual Description of Progress on Listing Actions. Http://ecos.fws.gov/speciesProfile/profile/speciesProfile.action?spcode=Q07C
1769	Sei whale	*Balaenoptera borealis*	Endangered	Mammals	Texas Virginia Louisiana Florida Maryland New York New Jersey Alabama North Carolina South Carolina Delaware Georgia	Aquatic species	Off field	NMFS. 2012. Sei Whale (Balaenoptera borealis). National Marine Fisheries Service. Available online at: http://www.nmfs.noaa.gov/pr/species/mammals/cetaceans/seiwhale.htm USFWS. 2012. Species profile for Sei Whale (Balaenoptera borealis). United States Fish and Wildlife Service. Available online at: http://ecos.fws.gov/speciesProfile/profile/speciesProfile.action?spcode=A02S http://www.nmfs.noaa.gov/pr/pdfs/recovery/seiwhale.pdf
3199	Blue whale	*Balaenoptera musculus*	Endangered	Mammals	Texas Virginia Louisiana Florida Maryland New Jersey New York Alabama North Carolina South Carolina Delaware Pennsylvania Georgia	Aquatic species	Off field	NMFS. 1998. Recovery plan for blue whale. National Marine Fisheries Service. Available online at: http://www.nmfs.noaa.gov/pr/pdfs/recovery/whale_blue.pdf (3) NMFS. 2012. Blue Whale (Balaenoptera musculus), Office of Protected Resources, NOAA Fisheries Species Information. Date accessed June 4, 2012. Available online at: http://www.nmfs.noaa.gov/pr/species/mammals/cetaceans/bluewhale.htm

								http://www.nmfs.noaa.gov/pr/pdfs/recovery/whale_blue.pdf
8621	Red knot	*Calidris canutus rufa*	Threatened	Birds	Nebraska South Dakota Kentucky Pennsylvania Colorado Oklahoma Ohio Tennessee Virginia West Virginia Texas Louisiana Michigan Indiana Georgia Kansas Florida Illinois North Carolina Missouri New Jersey North Dakota Arkansas Maryland Iowa Minnesota Wisconsin New York New Mexico South Carolina Alabama Delaware	Robin-sized shorebird that annually migrates from the Canadian Arctic to southern Argentina. Use mid-Atlantic stopovers from late April through late May or early June (The stopover time in Delaware Bay is about 10 to 14 days. From Delaware Bay and other mid-Atlantic stopovers, birds tend to fly overland directly northwest to the central Canadian breeding grounds, with many stopping briefly along the shores of James and Hudson Bays	Off field	US FWS. Rufa Red Knot Ecology and Abundance SUPPLEMENT TO Endangered and Threatened Wildlife and Plants; Proposed Threatened Status for the Rufa Red Knot (Calidris canutus rufa) Info from P 20. https://www.fws.gov/northeast/redkn ot/pdf/20130923_REKN_PL_Supplement02_Ecology%20Abundance_Final.pdf
95	Ivory-billed woodpecker	*Campephilus principalis*	Endangered	Birds	Arkansas	Forest – large contiguous forest with numerous large trees	Off field	USFWS. 2010. Recovery plan for the ivory-billed woodpecker. http://ecos.fws.gov/docs/recovery_plan/100719.pdf
13	Mexican gray wolf	*Canis lupus baileyi*	Endangered	Mammals	New Mexico Arizona Arizona New Mexico Texas	Wide ranging: Evergreen pine–oak woodlands, pinyon–juniper woodlands, and mixed-conifer montane forests	On Field	USFWS. 1987. Mexican Wolf Recovery Plan. United States Fish and Wildlife Service. Available online at: http://ecos.fws.gov/docs/recovery_plan/820915_1.pdf

								USFWS. 2000. US Counties in which the Mexican gray wolf, is known to or is believed to occur. United States Fish and Wildlife Service. Available online at: http://ecos.fws.gov/speciesProfile/profile/countiesBySpecies?entityId=13 USFWS. 2015. Species Profile for Mexican Gray Wolf (Canis lupus baileyi). United States Fish and Wildlife Service. Available online at: http://ecos.fws.gov/speciesProfile/profile/speciesProfile.action?spcode=A00E
10130	Arapahoe snowfly	*Capnia arapahoe*	Candidate	Insects	Colorado	Cold, clean and well oxygenated streams and rivers.	Off field	https://www.fws.gov/mountain-prairie/species/invertebrates/arapahoesnowfly/ http://ecos.fws.gov/tess_public/profile/speciesProfile.action?spcode=I0W0 http://ecos.fws.gov/docs/candidate/assessments/2015/r6/I0W0_I01.pdf
4253	Pineland sandmat	*Chamaesyce deltoidea pinetorum*	Candidate	Plants	Florida	Only known from Miami-Dade County, Florida, located on Long Pine Key within Everglades National Park.	Off field	USFWS. 2010. Review of Native Species That Are Candidates for Listing as Endangered or Threatened; Annual Notice of Findings on Resubmitted Petitions; Annual Description of Progress on Listing Actions; Proposed Rule Http://ecos.fws.gov/speciesProfile/profile/speciesProfile.action?spcode=Q03HI
7948	Wedge spurge	*Chamaesyce deltoidea serpyllum*	Candidate	Plants	Florida	estricted to pine rocklands on Big Pine Key in Monroe County, Florida. Inhabits sites with low woody cover (e.g., low palm and hardwood densities) and usually, exposed rock or gravel.	Off field	USFWS. 2010. Review of Native Species That Are Candidates for Listing as Endangered or Threatened; Annual Notice of Findings on Resubmitted Petitions; Annual Description of Progress on Listing Actions; Proposed Rule. Http://ecos.fws.gov/speciesProfile/

								profile/speciesProfile.action?spcode=Q0E7
9965	Wright's marsh thistle	*Cirsium wrightii*	Candidate	Plants	New Mexico Arizona,Texas	wet, alkaline soils in spring seeps and marshy edges of streams and ponds between 3,450 and 7,850 ft (1,152 and 2,393 m) in elevation	Off field	USFWS 2015 - Species Assessment Form for the Cirsium wrightii http://ecos.fws.gov/docs/candidate/assessments/2015/r2/Q3N3_P01.pdf
6901	Yellow-billed Cuckoo	*Coccyzus americanus*	Threatened	Birds	Colorado New Mexico Arizona Texas Colorado New Mexico Arizona Texas	Riparian woodlands. Riparian woodlands with mixed willow cottonwood vegetation, mesquite-thorn-forest vegetation, or a combination of these that contain habitat for nesting and foraging in contiguous or nearly contiguous patches that are greater than 325 ft (100 m) in width and 200 ac (81 ha) or more in extent. These habitat patches contain one or more nesting groves, which are generally willow dominated, have above average canopy closure (greater than 70 percent), and have a cooler, more humid environment than the surrounding riparian and upland habitats. Adequate prey base. Presence of a prey base consisting of large insect fauna (for example, cicadas, caterpillars, katydids, grasshoppers, large beetles, dragonflies) and tree frogs for adults and young in breeding areas during the nesting season and in post-breeding dispersal areas. Dynamic riverine processes. River systems that are dynamic and provide hydrologic processes that encourage sediment movement and deposits that allow seedling germination and promote plant growth, maintenance, health, and vigor (e.g. lower gradient streams and broad floodplains, elevated subsurface groundwater table, and perennial rivers and streams). This allows habitat to regenerate at regular intervals, leading to riparian vegetation with variously aged patches from young to old. Open woodland with clearings and scrubs that are associated with watercourses. Breeds in riparian areas.	Off-field	http://ecos.fws.gov/speciesProfile/profile/speciesProfile.action?spcode=B06R

5273	Florida prairie-clover	*Dalea carthagenensis floridana*	Candidate	Plants	Florida	This shrub is found in pine rocklands, edges of rockland hammocks, coastal uplands, and marl prairie. Fire is probably very important to the livelihood of this taxon. In 1999, each of the five occurrences known at that time were located in slightly different habitat types: disturbed pine rockland, pine rockland / rockland hammock ecotone, pine rockland / rockland hammock ecotone along road edges, edge of roadside in marl prairie, and ecotone between rockland hammock and marl prairie and flatwoods. Substrate-Rocky and rocklands. Scarification has a positive effect on the germination of this plants seeds. Residential and commercial development and agriculture have drastically reduced the habitat for this species throughout pine rockland habitats in south Florida.	Off field	USFWS 2013. Species Assessment Form for the Dalea carthagenensis floridana. Http://ecos.fws.gov/speciesProfile/profile/speciesProfile.action?spcode=#3HL
10310	Pillar Coral	*Dendrogyra cylindricus*	Threatened	Corals	Florida	Aquatic species	Off field	NOAA (2015) http://coralreef.noaa.gov/aboutcorals/coral101/feedinghabits/welcome.html NOAA (2011) http://www.nmfs.noaa.gov/stories/2012/05/docs/009_corals_status_review_western_atlantic.pdf NOAA (2014) http://www.fisheries.noaa.gov/stories/2014/08/docs/corals_fact_sheet.pdf
4712	Florida pineland crabgrass	*Digitaria pauciflora*	Candidate	Plants	Florida	Plants occur most commonly along the ecotone between pine rockland and marl prairie, but do overlap somewhat into both of these ecosystems. These habitats, particularly marl prairie, do flood for one to several months every year in the wet season. habitat types for Florida pineland crabgrass at Long Pine Key to consist of pineland/prairie ecotones and prairies. It was found 49 percent of the time in mixed marl and rock substrate, 22 percent in marl, and 6 percent on rock. IPrior to research by Gann et al. (2006, p. 7), this species was known from the following	Off field	2013_USFWS_Species Assessment Form for the Digitaria pauciflora. Http://ecos.fws.gov/speciesProfile/profile/speciesProfile.action?spcode=Q1VG

						locations within Long Pine Key: Hole-in-the Donut, Pine Blocks A, C, D, H. Follow-up surveys of historical locations yielded two additional extant occurrences of this species in the Hole-in-the-Donut (Gann et al. 2006, p. 8). In addition, Jimi Sadle, botanist at ENP, located the species at Pine Blocks SW2, B, and F2 . Gann et al. (2006, p. 9) also expect to find new occurrences of Florida pineland crabgrass within ENP as work continues to establish the limits of this species habitat requirements. Florida pineland crabgrass appears to have a much wider range than previously thought		
8434	Black mudalia	*Elimia melanoides*	Candidate	Snails	Alabama	Clings to clean gravel, cobble, boulders and logs in flowing water on shoals and riffles.	Off field	http://ecos.fws.gov/tess_public/profile/speciesProfile.action?spcode=G0C7 http://ecos.fws.gov/docs/candidate/assessments/2013/r4/G0C7_I01.pdf
10060	Kentucky arrow darter	*Etheostoma spilotum*	Candidate	Fishes	Kentucky Virginia	Aquatic species	Off field	https://ecos.fws.gov/tess_public/profile/speciesProfile.action?spcode=E0BF
6782	Guadalupe fescue	*Festuca ligulata*	Candidate	Plants	New Mexico Texas	he known habitats of Guadalupe fescue are pine-oak-juniper woodlands of talus slopes above 1,829 meters (m) (6,000 feet (ft)) elevation in trans-Pecos Texas and Coahuila, Mexico (Poole 1989, p. 8).. Guadalupe fescue flowers primarily in August and September, or occasionally earlier, in response to rainfall (Gordon and Poole 2009, p. 1). The Chisos Mountains population in BIBE is the only known population remaining in the United States. Botanists have extensively surveyed the limited amount of potential habitat at BIBE, where the elevation exceeds 1,829 m (6,000 ft), as well as most of the potential habitat in the Davis Mountains of Texas, but have not found additional populations (BIBE and Service 2008, p. 3). Despite intensive searches, Guadalupe fescue was last observed in the Guadalupe Mountains in 1952 (Texas Natural Diversity Database 2007, pp. 3073-3074).. However, undiscovered populations might exist in the New Mexico portion of GUMO where the habitat appears suitable.	Off field	2014 USFWS Species Assessment Form for the Festuca ligulata. Http://ecos.fws.gov/speciesProfile/profile/speciesProfile.action?=spcode=Q0UM

8765	Berry Cave salamander	*Gyrinophilus gulolineatus*	Candidate	Amphibians	Tennessee	Aquatic trogloditic species. Pesticide runoff from agricultural activities is cited as a contributing threat. If the pesticide poses not concerns for runoff to aquatic animals, no concern here as the species will not be on the agricultural field	Off field	U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM https://ecos.fws.gov/docs/candidate/assessments/2015/r4/D03B_V01.pdf
3412	Dakota Skipper	*Hesperia dacotae*	Threatened	Insects	South Dakota North Dakota Minnesota Iowa	Undisturbed (remnant, untilled) high quality prairie, ranging from wet-mesic tallgrass prairie to dry-mesic mixed grass prairie.	Off field	US FWS, Threatened Status for Dakota Skipper and Endangered Status for Poweshiek Skipperling (2013) http://www.gpo.gov/fdsys/pkg/FR-2013-10-24/pdf/2013-24175.pdf
2767	Stephan's Riffle beetle	*Heterelmis stephani*	Candidate	Insects	Arizona	Aquatic species	Off field	U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM https://ecos.fws.gov/docs/candidate/assessments/2015/r4/D03B_V01.pdf
9694	Arizona Treefrog	*Hyla wrightorum*	Candidate	Amphibians	Arizona New Mexico	oak woodland and savannah, pine-oak woodland, mixed conifer forest, grassland; Ponds used for breeding	Off field	USFWS 2013 Species Assessment Form for the Hyla wrightorum (Huachuca/Canelo Population). Available online at: http://ecos.fws.gov/docs/candidate/assessments/2014/r2/D03S_V02.pdf
10038	Texas fatmucket	*Lampsilis bracteata*	Candidate	Clams	Texas	Aquatic species	Off field	https://ecos.fws.gov/tess_public/profile/speciesProfile.action?spcode=F04I https://ecos.fws.gov/docs/candidate/assessments/2015/r2/F04I_I01.pdf
3628	Relict leopard Frog	*Lithobates onca*	Candidate	Amphibians	Arizona	Leopard frogs generally require shallow water with emergent vegetation for foraging and basking, and deeper water, root masses, undercut banks, and debris piles for cover and hibernacula	Off field	U.S. FISH AND WILDLIFE SERVICE SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM http://ecos.fws.gov/docs/candidate/

								assessments/2014/r8/D00E_V01.pdf
7482	Striped newt	*Notophthalmus perstriatus*	Candidate	Amphibians	Georgia Florida	*Ephemeral ponds, upland habitats (forest, scrub); aquatic and terrestrial	Off field	USFWS 2014 SPECIES ASSESSMENT AND LISTING PRIORITY ASSIGNMENT FORM for the Notophthalmus perstriatus. Available online at: http://ecos.fws.gov/docs/candidate/assessments/2014/r4/D02P_V01.pdf
10147	Poweshiek skipperling	*Oarisma poweshiek*	Endangered	Insects	South Dakota, Minnesota, Iowa, North Dakota, Michigan, Wisconsin	Include prairie fens, grassy lake and stream margins, moist meadow, sedge meadow, and wet-to-dry prairie.	Off Field	USFWS. 2014. FR Notice. 79FR 63671 63748 http://www.gpo.gov/fdsys/pkg/F R-2014-10-24/pdf/2014-25190.pdf
2859	Band-rumped storm-petrel	*Oceanodroma castro*	Candidate	Birds	Florida	Forages in ocean. Nests on islands free of mammalian predators.	Off Field	http://ecos.fws.gov/speciesProfile/profile/speciesProfile.action?spcode=B08V
10311	Lobed Star Coral	*Orbicella annularis*	Threatened	Corals	Florida	Florida, Puerto Rico and US Virgin Islands	Off Field	NOAA (2014) http://www.fisheries.noaa.gov/stories/2014/08/docs/corals_fact_sheet.pdf https://www.gpo.gov/fdsys/pkg/FR-2014-09-10/pdf/2014-20814.pdf
10312	Mountainous Star Coral	*Orbicella faveolata*	Threatened	Corals	Florida	Florida, Puerto Rico, US Virgin Islands and Gulf of Mexico	Off Field	NOAA (2014) http://www.fisheries.noaa.gov/stories/2014/08/docs/corals_fact_sheet.pdf https://www.gpo.gov/fdsys/pkg/FR-2014-09-10/pdf/2014-20814.pdf
10908	Boulder star coral	*Orbicella franksi*	Threatened	Corals	Florida	Florida, Puerto Rico, US Virgin Islands and Gulf of Mexico	Off Field	NOAA (2014) http://www.fisheries.noaa.gov/stories/2014/08/docs/corals_fact_sheet.pdf

								https://www.gpo.gov/fdsys/pkg/FR-2014-09-10/pdf/2014-20814.pdf
9126	Killer whale	*Orcinus orca*	Endangered	Mammals	Texas, Virginia, Louisiana, Florida, Maryland, New Jersey, New York, Alabama, North Carolina, South Carolina, Delaware, Pennsylvania, Georgia	Southern Resident killer whales are concentrated in Washington State and British Columbia (Strait of Georgia, Strait of Juan de Fuca, and Puget Sound) and can extend south to Oregon and Central California and north to Queen Charlotte Islands Most common in coastal marine waters at higher latitudes. NMFS. 2008. Recovery plan for Southern Resident Killer Whales, (Orcinus orca). National Marine Fisheries Service, Northwest Region, Seattle, Washington. Available online at: http://ecos.fws.gov/docs/recovery_plan/whale_killer.pdf.	Off Field	
3670	Rattlesnake-master borer moth	*Papaipema eryngii*	Candidate	Insects	Illinois, Arkansas, Indiana, Kansas, Michigan, Oklahoma, North Carolina	*Obligate residents of undisturbed praires and woodland openings.	Off field	https://ecos.fws.gov/docs/candidate/assessments/2015/r3/I0LJ_I01.pdf https://ecos.fws.gov/tess_public/profile/speciesProfile.action?spcode=I0LJ
4431	Pearl darter	*Percina aurora*	Candidate	Fishes	Alabana, Mississippi	Occurs in moderately sized rivers, with mud, sand, gravel and cobble substrate. Found in water depths < 2 feet.	Off field	https://ecos.fws.gov/tess_public/profile/speciesProfile.action?spcode=E07A https://ecos.fws.gov/docs/candidate/assessments/2014/r4/E07A_V01.pdf
6097	Black pine snake	*Pituophis melanoleucus lodingi*	Proposed Threatened	Reptiles	Alabama, Louisiana	Fire e-dependent long leaf pine forests; Riparian areas, hardwood forests	Off Field	http://ecos.fws.gov/docs/candidate/assessments/2013/r4/C029_V01.pdf

3722	Louisiana pine snake	*Pituophis ruthveni*	Candidate	Reptiles	Louisiana Texas	Fire-dependent long leaf and short leaf pine forest; Use of burrows of bairds pocket gopher	Off Field	
1358	Magnificent ramshorn	*Planorbella magnifica*	Candidate	Snails	South Carolina, North Carolina	Occurs in lentic (slow flowing) aquatic habitats and shallow, still freshwater waterbodies with abundance of aquatic vegetation and a neutral pH. An endemic species in southeastern North Carolina. Only recorded in Greenfield Lake (millpond tributary) to the Cape Fear River.	Off field	http://ecos.fws.gov/tess_public/profile/speciesProfile?spcode=G02R
2917	Texas Hornshell	*Popenaias popei*	Candidate	Clams	New Mexico Texas	Small grained substrata (silt, sand, clay gravel), and in undercut riverbanks, crevices, shelves and at the base of large boulders.	Off-field	https://ecos.fws.gov/docs/candidate/assessments/2013/r2/F02M_I01.pdf https://ecos.fws.gov/tess_public/profile/speciesProfile.action?spcode=F02M
5064	Clifton Cave beetle	*Pseudanophthalmus caecus*	Candidate	Insects	Kentucky	Limestone caves	Off-field	https://ecos.fws.gov/docs/candidate/assessments/2014/r4/I0Q7_I01.pdf https://ecos.fws.gov/tess_public/profile/speciesProfile.action?spcode=I0Q7
6464	Coleman Cave beetle	*Pseudanophthalmus colemanensis*	Candidate	Insects	Kentucky	Limestone caves	Off-field	https://ecos.fws.gov/docs/candidate/assessments/2014/r4/I0Q7_I01.pdf https://ecos.fws.gov/tess_public/profile/speciesProfile.action?spcode=I0Q7
2862	Icebox Cave beetle	*Pseudanophthalmus frigidus*	Candidate	Insects	Kentucky Tennessee Virginia	Found in limestone caves with leaf litter, small bits of organic matter, or bat guano.	Off-field	http://ecos.fws.gov/docs/candidate/assessments/2014/r4/I0JD_I01.pdf http://ecos.fws.gov/tess_public/profile/speciesProfile.action?spcode=I0JD

7134	Tatum Cave beetle	*Pseudanophthalmus parvus*	Candidate	Insects	Kentucky	Found in limestone caves with leaf litter, small bits of organic matter, or bat guano.	Off-field	http://ecos.fws.gov/tess_public/profile/speciesProfile.action?spcode=I0QE http://ecos.fws.gov/docs/candidate/assessments/2014/r4/I0QE_I01.pdf
7745	Nobletts cave beetle	*Pseudanophthalmus paulus*	Candidate	Insects	Tennessee North Carolina	Trogloditic species not expected to occur ontreated agricultural field	Off-field	http://explorer.natureserve.org/servlet/NatureServe?searchName=Pseudanophthalmus+paulus
3379	Louisville Cave beetle	*Pseudanophthalmus troglodytes*	Candidate	Insects	Indiana Kentucky	Found in limestone caves with leaf litter, small bits of organic matter, or bat guano.	Off-field	https://ecos.fws.gov/tess_public/profile/speciesProfile.action?spcode=I0QJ https://ecos.fws.gov/docs/candidate/assessments/2014/r4/I0QJ_I01.pdf
6739	Huachuca springsnail	*Pyrgulopsis thompsoni*	Candidate	Snails	Arizona New Mexico	Occur in seeps, marshes, spring pools, outflows and lotic waters. Firm substrate (e.g, cobble, gravel, woody debris and aquatic vegetation).	Off-field	http://ecos.fws.gov/tess_public/profile/speciesProfile?spcode=G05C http://ecos.fws.gov/docs/candidate/assessments/2014/r2/G05C_I01.pdf
10039	Golden orb	*Quadrula aurea*	Candidate	Clams	Texas	Flowing waters in moderately sized rivers. Found in one reservoir in lower Nueces River. Wave action can enhance flowing water conditions. Occurs in substrates including firm mud,gravel, sand, but not unstable substrates (i.e., loose silt and sand)	Off-field	https://ecos.fws.gov/docs/candidate/assessments/2015/r2/F04J_I01.pdf https://ecos.fws.gov/tess_public/profile/speciesProfile.action?spcode=F04J
9969	Smooth pimpleback	*Quadrula houstonensis*	Candidate	Clams	Texas	Occurs in moderately sized rivers, with mud, sand, gravel and cobble substrate. Found in water depths < 2 feet.	Off-field	https://ecos.fws.gov/tess_public/profile/speciesProfile.action?spcode=F04G https://ecos.fws.gov/tess_public/profile/speciesProfile.action?spcode=F04G
9968	Texas pimpleback	*Quadrula petrina*	Candidate	Clams	Texas	Occurs in moderately sized rivers, with mud, sand, gravel and cobble substrate. Found in water depths < 2 feet.	Off-field	http://ecos.fws.gov/tess_public/profile/speciesProfile?spcode=F04F http://ecos.fws.gov/docs/candidate/assessments/2015/r2/F04F_I01.pdf
4395	Everglades bully	*Sideroxylon reclinatum ssp. austrofloridense*	Candidate	Plants	Florida	Occurs on pinelands, pineland/prairie ecotones, and prairies in Everglades National Park and private lands in Miami-Dade County, and Big Cypress National Preserve in Monroe County, Florida. Everglades bully is restricted to pinelands with tropical understory vegetation on	Off-field	USFWS 2007. Review of Native Species That Are Candidates for Listing as Endangered or Threatened; Annual Notice of Findings on Resubmitted Petitions; Annual Description of Progress on Listing Actions; Proposed Rule.

						limestone rock (pine rocklands) which are covertypes not associated with cotton or soybean agriculture		Http://ecos.fws.gov/speciesProfile/profile/speciesProfile.action?spcode=Q31M
4228	Penasco least chipmunk	*Tamias minimus atristriatus*	Candidate	Mammals	New Mexico Texas	Spruce fir forest, Douglas/white fir mixed conifer, ponderosa pine, woodlands, savanna, grassland, riparian, barren, dryland and irrigated land.	Off-field	USFWS. 2015. Species Profile for Penasco least chipmunk (Tamias minimus atristriatus). United States Fish and Wildlife Service. Available online at: http://ecos.fws.gov/speciesProfile/profile/speciesProfile.action?spcode=A08G 3) USFWS. 2014. Species assessment form. Available online at: http://ecos.fws.gov/docs/candidate/assessments/2014/r2/A08G_V01.pdf
9967	Texas fawnsfoot	*Truncilla macrodon*	Candidate	Clams	Texas	Occurs in rivers with soft sandy sediement and moderate water flow.	Off-field	https://ecos.fws.gov/tess_public/profile/speciesProfile.action?spcode=F04E https://ecos.fws.gov/docs/candidate/assessments/2015/r2/F04E_I01.pdf
123	Least Bell's vireo	*Vireo bellii pusillus*	Endangered	Birds	Arizona	The least Bell's vireo is an obligate riparian species during the breeding season and is characterized as preferring early successional habitat in structurally diverse woodlands along watercourses. They winter in mesquite scrub vegetation, arroos, but also use palm groves and hedgerows associated with agricultural fields and rural residential areas.	Off-field during growing season when applications are made or when residues are likely to be present	http://ecos.fws.gov/ecp0/profile/speciesProfile?sId=5945

Appendix B

Species with Habitat Attributes Considered to Include Treated Cotton or Soybean Fields

(n=4)

7800	Eastern massauga rattlesnake	*Sistrurus catenatus*	Endangered	Reptiles	Ohio, Wisconsin, Pennsylvania, Indiana, Michigan, Illinois, Minnesota, New York, West Virginia, Iowa Missouri	Potentially on field.

10043	Northern long-eared bat	*Myotis septentrionalis*	Threatened	Mammals	Wisconsin, West Virginia, Tennessee, South Dakota, Iowa, Pennsylvania, Delaware, Missouri, Minnesota, Indiana, Texas, Kentucky, New York, Oklahoma, Virginia, North Dakota, Illinois, Arkansas, New Jersey, Georgia, Louisiana, South Carolina, Maryland, Kansas, Michigan, Nebraska, Ohio, North Carolina, Alabama	Potentially on field.
4064	Gunnison sage grouse	*Centrocercus minimus*	Threatened	Birds	Florida	Potentially on field.
13	Mexican grey wolf	*Canis lupus baileyi*	Endangered	Mammals	New Mexico, Arizona, Texas	Potentially on field.

Appendix C

Critical Habitat Accounting Tables

Summary of Species Identified as Being on Agricultural Fields With and Without Critical Habitat Designations[2]

Species Name	Primary Constituent Elements (PCE)	Source
Species with Critical Habitat Designations		
Gunnison Sage Grouse	PCE's: 1) Extensive Sagebrush Habitat with at least 25% sagebrush cover 2) Breeding Habitat containing sagebrush, shrubs, grass, and forb cover. 3) Summer-fall habitat including sagebrush communities as well as agricultural fiels, wet meadow and riparian habitat types. 4) Winter habitat of sagebrush plant communities	https://www.fws.gov/mountain-prairie/species/birds/gunnisonsagegrouse/

[2]Critical habitat designation status determined using U.S. Fish & Wildlife Service's Environmental Conservation Online System (ECOS) species profiles.

	5) Alterative, mesic habitats primarily used in summer-late fall including riparian communities, springs, seeps and mesic meadows.	
Species without critical habitat designations		
Eastern Massasauga	Found in wet areas including prairies, marshes and low areas along rivers and lakes. Use adjacent uplands during parts of the year. Hibernate in crayfish burrows and often found under logs and tree roots or in small mammal borrows.	https://www.fws.gov/midwest/endangered/reptiles/eama/eama-fct-sht.html
Northern Long-Eared Bat	Roost underneath bark, in cavitites and crevicces of live and dead trees. Males and non-reproductive females roost in cooler places like caves or mines.	https://ecos.fws.gov/ecp0/profile/speciesProfile?spcode=A0JE
Mexican Grey Wolf	Found in southwestern habitats. Preferably mountain woodlands with cover water and prey availability.	https://ecos.fws.gov/ecp0/profile/speciesProfile?spcode=A00E#lifeHistory

Appendix. D

Listed Species Identified as being off Agricultural Fields with and without Critical Habitat Designations Assessed for 2,4-D

Critical Habitat Designation	Common Name	Scientific Name
Species off agricultural fields with critical habitat designations *(10 species)*	Georgia rockcress	*Arabis georgiana*
	Yellow-billed Cuckoo	*Coccyzus americanus*

	Kentucky Arrow Darter	*Etheostoma spilotum*
	Dakota Skipper	*Hesperia dacotae*
	Least Bell's vireo	*Vireo bellii pusillus*
	Black pine snake	*Pituophis melanoleucus lodingi*
	North Pacific Right Whale	*Eubalaena japonica*
	Pecos amphipod	*Gammarus pecos*
	Killer whale	*Orcinus orca*
	Poweshiek skipperling	*Oarisma poweshiek*
Species off agricultural Fields without critical habitat designations (*56 species*)	Blodgett's silverbush	*Argythamnia blodgettii*
	Roundtail chub	*Gila robusta*
	Sonoyta mud turtle	*Kinosternon sonoriense longifemorale*
	Rough Cactus Coral	*Mycetophyllia ferox*
	Black warrior (=Sipsey Fork) Waterdog	*Necturus alabamensis*
	Squirrel Chimney Cave shrimp	*Palaemonetes cummingi*
	Skiff milkvetch	*Astragalus microcymbus*
	Schmoll milk-vetch	*Astragalus schmolliae*
	White fringeless orchid	*Platanthera integrilabia*
	Florida bristle fern	*Trichomanes punctatum ssp. floridanum*
	Kenk's amphipod	*Stygobromus kenki*
	Sei whale	*Balaenoptera borealis*
	Blue whale	*Balaenoptera musculus*
	Red knot	*Calidris canutus rufa*
	Ivory-billed woodpecker	*Campephilus principalis*
	Arapahoe snowfly	*Capnia arapahoe*
	Big Pine partridge pea	*Chamaecrista lineata keyensis*
	Pineland sandmat	*Chamaesyce deltoidea pinetorum*
	Wedge spurge	*Chamaesyce deltoidea serpyllum*
	Wright's marsh thistle	*Cirsium wrightii*
	Florida prairie-clover	*Dalea carthagenensis floridana*
	Pillar Coral	*Dendrogyra cylindricus*
	Hirst Brothers' Panic grass	*Dichanthelium (=Panicum) hirstii*
	Florida pineland crabgrass	*Digitaria pauciflora*
	Guadalupe fescue	*Festuca ligulata*
	Berry Cave salamander	*Gyrinophilus gulolineatus*
	Stephan's Riffle beetle	*Heterelmis stephani*
	Hawaiian stilt	*Himantopus mexicanus knudseni*
	Arizona Treefrog	*Hyla wrightorum*
	Texas fatmucket	*Lampsilis bracteata*
	Relict leopard Frog	*Lithobates onca*
	Striped newt	*Notophthalmus perstriatus*
	Band-rumped storm-petrel	*Oceanodroma castro*
	Lobed Star Coral	*Orbicella annularis*
	Mountainous Star Coral	*Orbicella faveolata*
	Boulder star coral	*Orbicella franksi*
	Rattlesnake-master borer moth	*Papaipema eryngii*
	Pearl darter	*Percina aurora*
	Louisiana pine snake	*Pituophis ruthveni*

	Magnificent ramshorn	*Planorbella magnifica*
	Texas Hornshell	*Popenaias popei*
	Clifton Cave beetle	*Pseudanophthalmus caecus*
	Coleman Cave beetle	*Pseudanophthalmus colemanensis*
	Fowler's cave beetle	*Pseudanophthalmus fowlerae*
	Icebox Cave beetle	*Pseudanophthalmus frigidus*
	Tatum Cave beetle	*Pseudanophthalmus parvus*
	Nobletts cave beetle	*Pseudanophthalmus paulus*
	Louisville Cave beetle	*Pseudanophthalmus troglodytes*
	Golden orb	*Quadrula aurea*
	Smooth pimpleback	*Quadrula houstonensis*
	Texas pimpleback	*Quadrula petrina*
	Everglades bully	*Sideroxylon reclinatum ssp. austrofloridense*
	Sand flax	*Linum arenicola*
	Bracted twistflower	*Streptanthus bracteatus*
	Penasco least chipmunk	*Tamias minimus atristriatus*
	Texas fawnsfoot	*Truncilla macrodon*

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON D.C., 20460

OFFICE OF
CHEMICAL SAFETY AND
POLLUTION PREVENTION

PC Code: 128931
DP Barcode: 435792

MEMORANDUM

DATE: November 3, 2016

SUBJECT: M-1691 Herbicide, EPA Reg. No. 524-582 (Active Ingredient: Dicamba Diglycolamine Salt) and M-1768 herbicide, EPA Reg. No. 524-617 (AI: Diglycolamine Salt with VaporGrip™) – Review of EFED Actions and Recent Data Submissions Associated with Spray and Vapor Drift of the Proposed Section 3 New Uses on Dicamba-Tolerant Soybean and Cotton

TO: Grant Rowland, Risk Manager Reviewer
Kathryn Montague, Product Manager 23
Daniel Kenny, Branch Chief
Herbicide Branch
Registration Division (7505P)

FROM: Nathan Miller, Biologist
Michael Wagman, Biologist
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Environmental Risk Branch 6
Environmental Fate and Effects Division (7507P)

11/03/2016

THRU: Mark Corbin, Branch Chief
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The Environmental Fate and Effects Division's March 2011 risk assessment for the proposed new use of dicamba diglycolamine (DGA) on dicamba-tolerant soybean discussed the potential for adverse effects on non-target plants due to spray drift and identified volatility (*i.e.*, vapor drift) as an uncertainty requiring additional evaluation (USEPA 2011).

In 2014, EFED issued an addendum to the 2011 risk assessment that looked more closely at the risk to terrestrial non-target organisms exposed to dicamba through spray drift and vapor drift using additional information submitted by Monsanto Company (USEPA 2014). The 2014 addendum acknowledged that volatility had been associated with dicamba historically, but did not quantitatively assess the risk for the new use on dicamba-tolerant soybeans, and acknowledged that it was an uncertainty in the assessment. Based on the weight of evidence analysis, it was concluded that the dominant route of off-field exposure to non-target terrestrial and aquatic organisms was more likely to be a result of spray drift and runoff than the volatilized mass of dicamba from a treated field. The 2014 addendum concluded that without product- and nozzle-specific drift curves based on empirical data, the off-field distance that effects are expected for terrestrial plants remained uncertain. The addendum also noted that the uncertainties associated with estimated dicamba vapor concentrations in air and estimated deposition on plants would be greatly reduced by the submission of a terrestrial plant vapor phase toxicity study measuring both toxic response and air exposure concentrations.

In March 2016, EFED issued a second addendum to the 2011 risk assessment that incorporated new field trial data (based on applications conducted in accordance with the draft label requirements {*e.g.* nozzles, spray pressures, ground speeds} designed to reduce spray drift), data from plant damage incidents, laboratory volatility data, and terrestrial plant reproductive effects data, all in relation to spray drift and volatilization (USEPA 2016a). Also in March 2016, EFED finalized a Section 3 new use risk assessment for use of dicamba DGA on dicamba-tolerant cotton (USEPA 2016b).

The March 2016 addendum and risk assessment concluded that based on the available data, a volatilization buffer equal to the spray drift buffer, extending 110 feet (for the 0.5 lb ae/A application rate) in all directions from the treated field, was justified. Among the available data, one open literature study (Egan and Mortensen 2012) directly addressed the potential for volatilization and transport of dicamba and the potential for damage to the most sensitive tested species, soybean (non dicamba-tolerant). Based on damage assessments of non dicamba-tolerant soybean plants placed near treated fields after spray drift from a 0.5 lb/A dicamba DGA salt application had dissipated, the authors estimated the exposure at distance by correlation to known dose-damage correlations. Egan and Mortensen estimated the 95% upper bound vapor exposure would drop below the soybean no-observed-adverse-effect-concentration (NOAEC) at a distance of approximately 25 meters (82 feet). This is well within the 110-foot downwind-only spray drift buffer proposed for the 0.5 lb/A rate. Thus, the March 2016 addendum and risk assessment concluded that the 110-foot buffer distance should be adequately protective of EPA's apical endpoints of plant height and yield following potential volatilization exposure.

Two product formulations of dicamba are discussed below. M-1691, a diglycolamine (DGA) salt of dicamba, is less volatile than older dicamba formulations such as dimethylamine (DMA) salts. (Dicamba DMA salts were not considered for use on genetically engineered soybeans or cotton). M-1768, or VaporGrip™, also a DGA salt, is formulated to be even less volatile than M-1691.

Recent data submissions, including field volatility (flux) studies of both M-1691 and M-1768 in Georgia and Texas, laboratory vapor-phase toxicity studies, and laboratory vapor-phase exposure (humidome) studies, provide evidence that decrease concerns and address earlier uncertainty about off-site vapor-phase exposure. The fair weather conditions (characterized by high temperatures in the low 90^0s F during the day and a strong diurnal cycle of heating and cooling, humidity, and mixing conditions) throughout the study periods for both TX and GA made for near-idealized conditions for volatilization occurring after applications. These data indicate that off-site volatility exposures will be less than the terrestrial plant level of concern (LOC) for listed plants (the NOAEC) for the M-1768 formulation, and will be between the NOAEC and the lowest-observed-adverse-effect-concentration (LOAEC) for M-1691. The margin between the expected exposure for M-1691 and the LOAEC is about ten-fold.

Based on the data described in the Appendix below, including the registrants' field studies and volatilization modeling, the 110-foot omnidirectional buffer for volatilization is no longer warranted for the M-1768 formulation, because the expected exposure at field's edge is less than the NOAEC. A buffer for the M-1691 formulation is also not warranted, taking the uncertainty of exposure and toxicity estimates into account, because the exposure is ten-fold less than the lowest effect level (LOAEC) at the edge of the field.

However, EFED finds that the in-field spray drift buffer of 110 feet downwind (0.5 lb/A rate) or 220 feet (1.0 lb/A) at the time of application must be maintained, because spray drift remains the main concern for potential off-site exposure.

As with all risk assessments, conclusions are made within the bounds of the stated uncertainties. In this case, these principally include whether the submitted field volatility studies adequately encompass the extremes of conditions that cause volatilization, and the statistical uncertainty in the calculation of the level of concern, which is based on the no-effect level for the most sensitive tested plant, soybean. It is possible that volatilization could be greater under conditions outside the scope of the submitted studies. Within these uncertainties, we conclude that no volatilization buffers are needed.

Results of the Georgia and Texas field volatility studies indicate that exposures from the M-1691 formulation are between the NOAEC and LOAEC for the most sensitive plant, while those from the M-1768 formulation are below the NOAEC. Thus, the M-1768 formulation is less likely to cause off-field effects from volatilization.

In August 2016, EPA's Office of Enforcement and Compliance Assurance issued a Compliance Advisory entitled "High number of complaints related to alleged misuse of dicamba raises concerns" (USEPA, 2016c). This document noted that 117 plant damage incidents affecting 42,000 acres have been reported to the Missouri Department of Agriculture (MDA) in the summer of 2016 due to alleged illegal "over-the-top" (post-emergent) use of currently registered dicamba products on dicamba-resistant cotton and soybeans and noted that similar reports have been received by Alabama, Arkansas, Illinois, Kentucky, Minnesota, Mississippi, North Carolina, Tennessee and Texas. These alleged applications would have been inconsistent with the label approved at that time because the over-the-top use had not yet been registered by EPA. Since the over-the-top use has not yet been approved, the labels on these products would not have had the restrictions on the current draft label (*e.g.,* specifying extremely-coarse or ultra-coarse nozzles, spray pressures, equipment speeds and the use of a 110 foot in-field buffer) designed to reduce spray drift. It is not clear at this time what caused these incidents. It is also not clear how the reported damage relates to the apical endpoints (plant height and weight) that are the basis of EPA's risk assessment. As more information becomes available on these and any other incidents, EPA will evaluate the incidents.

If registration of M-1691 and/or M-1768 is granted, EFED recommends analysis of any post-registration incident reports associated with their usage to confirm the findings in this analysis concerning the volatilization route of exposure. Comprehensive post-registration documentation of any incidents should include: wind and other weather conditions surrounding the associated application, whether label language designed to reduce spray drift was followed, and the distance between the application and the location with plant damage.

EFED's March 2016 addendum discussed previous incidents (2012-2015) that had been associated with dicamba use on dicamba-tolerant crops and noted that the Missouri Department of Agriculture had concluded that one incident was a result of volatilization of dicamba, rather than spray drift. EFED also noted in the March 2016 addendum that the incident observations were qualitative measures of visual injury (*e.g.* leaf spotting or curling), rather than quantitative estimates of damage (*i.e.* directly relating to EPA's apical endpoints of plant height, biomass and survival). Submission of field data that quantitatively link visual estimates of plant damage from dicamba to EPA's apical endpoints would be helpful for understanding the nature of the reported incidents and better incorporating any such data into future risk characterization of dicamba's potential effects due to potential volatilization.

Appendix. EFED Summary Conclusions on Vapor-Phase Toxicity of Dicamba and M-1691 and M-1768 Field Volatility (Flux) Studies and Deposition Analysis

Dicamba Vapor Phase (*Humidome*) *Study Conclusions*

A dicamba vapor toxicity response laboratory study was conducted and submitted by Monsanto Company to EPA in 2016 (Gavlick, 2016; MRID 49925703, supplemental suitable for quantitative use). The goal of this dose-response study was to identify a no-effect dicamba air exposure concentration for non-dicamba-tolerant soybean plants. Analytical and biological results were obtained. The analytical results explain that, percent acid equivalency dicamba applied being equal, the DGA form of applied dicamba is less volatile than the other dicamba formulations (*i.e.*, dicamba DMA and dicamba acid) as indicated by the amount of dicamba extracted from the polyurethane foam filter compared to the other formulations. The biological results indicate that soybean height (the only apical endpoint measured) is not significantly reduced compared to control plants following 24 hours of exposure (at 85°F for 16 hours and 70°F for 8 hours with 40% relative humidity) to vapor-phase dicamba at concentrations less than or equal to 0.0177 $\mu g/m^3$; however, 24 hour exposure (at 85°F for 16 hours and 70°F for 8 hours with 40% relative humidity) to concentrations of vapor-phase dicamba greater than or equal to 0.539 $\mu g/m^3$ significantly reduced soybean height compared to control plants (~32% reduction at the LOAEC of 0.539 $\mu g/m^3$). It is notable that the dose spacing in this study results in an approximately 30x difference between the NOAEC and LOAEC, creating uncertainty as to where effects to plants from vapor-phase exposure to dicamba may occur. Generally, definitive toxicity studies are conducted with lower dose-spacing (*e.g.* 1.5-3x geometric spacing between doses). Additional data examining a range of doses between the NOAEC and LOAEC from this study would reduce the uncertainty.

A separate humidome study was conducted by Monsanto Company to compare the volatility differences among dicamba DMA, dicamba DGA, and dicamba DGA plus VaporGrip™ (MRID 49770303). Nominally, 14.48 mg of dicamba acid was applied to 200 in^2 of bare soil in replicate humidomes (three humidomes for dicamba DGA, four humidomes for dicamba DGA plus VaporGrip™) which approximates the maximum single application rate of 1 pound dicamba a.e. per acre. For dicamba DGA applied alone, the study showed 0.0008% of the amount of dicamba applied volatilized off the soil, based on filter recoveries. The vapor-phase concentrations were determined to be 0.0407 $\mu g/m^3$, in line with upper bound concentration predicted by PERFUM from the flux data described in the field volatility study summaries (see next section titled: *Field Volatility (Flux) Studies and Deposition Estimates*), above the vapor-phase NOAEC, but below the vapor-phase LOAEC as determined in MRID 49925703. For dicamba DGA plus VaporGrip™, the study showed 0.00006% of the amount of dicamba applied volatilized off the soil, based on filter recoveries. The vapor-phase concentration was determined to be 0.00298 $\mu g/m^3$, which is below the vapor-phase NOAEC determined in MRID 49925703.

Field Volatility (Flux) Studies and Deposition Estimates

Field volatility research on the dicamba DGA salt formulation (M-1691) and dicamba DGA plus VaporGrip™ additive (M-1768) was conducted by Monsanto Company on treated fields in Georgia and Texas in 2015/2016 and submitted to EPA (Jacobson 2016a-d, respectively MRIDs 49888401, 49888403, 49888501 & 49888503). The fair weather conditions (characterized by high temperatures in the low 90^0s F during the day and a strong diurnal cycle of heating and cooling, humidity, and mixing conditions) throughout the study periods for both TX and GA made for near-idealized conditions for volatilization occurring after applications. The flux data were incorporated into the EPA recommended AERMOD dispersion model[1] to estimate dicamba acid-equivalent (a.e.) deposition downwind from the treated field. Furthermore, the PERFUM model,[2] which is a post-processor for EPA recommended dispersion models, was used to provide estimated peak air concentrations for dicamba. Findings and deficiencies noted during review of these two studies and submitted deposition modeling by the registrant are discussed in greater detail below.

Upper-bound deposition and peak air concentrations predicted by AERMOD and PERFUM, respectively, from the flux data in these studies resulted with the M-1691 formulation. As a conservative estimate of vapor drift, the combined 90^{th} upper-bound percentile predicted deposition (*i.e.* upper-bound predicted dry plus upper-bound predicted wet deposition) at 5-meters from the edge of field would be 3.12×10^{-5} lb a.e./A for the M-1691 formulation in Georgia, and the predicted peak air concentration is 6.03×10^{-2} µg/m^3. Deposition estimates are generally an order of magnitude lower than the most sensitive vegetative vigor NOAEC, 2.61×10^{-4} lb a.e./A for soybean height from the available vegetative vigor data for terrestrial plants. The peak air concentration estimates, however, are above the NOAEC from the vapor-phase study discussed above (0.0177 µg/m^3), but well below the LOAEC of 0.539 µg/m^3 for soybean height. The upper-bound predicted combined deposition at 5-meters from the edge of field was ~ 50-60% lower for the M-1768 formulation (1.29×10^{-5} and 8.95×10^{-6} lb a.e./A deposition values or 2.08×10^{-2} and 8.80×10^{-3} µg/m^3 peak air concentration values, respectively, in Georgia and Texas) compared to the M-1691 applications.

Based on the results from the deposition and air concentration analyses and considering the degree of uncertainty with these analyses (discussed in detail in the deficiencies section below), vapor drift occurring due to volatilization appears unlikely to be a concern for impacts off the treated field. Although the predicted peak air concentration for the M-1691 formulation exceeds the soybean vapor-phase exposure toxicity study NOAEC, it is well below the study's LOAEC. Additionally, the predicted upper bound peak air concentration values for the M-1768 formulation are essentially at or below the soybean vapor-phase NOAEC. Therefore, it is expected that the unidirectional spray drift buffer currently on labels mitigates deposition of dicamba material off the treated field.

The uncertainties associated with the flux data and deposition analysis, especially for the flux data from Texas, could result in underestimates of vapor drift under conditions more conducive

[1] Available on-line: https://www3.epa.gov/ttn/scram/dispersion_prefrec.htm#aermod
[2] Available on-line: http://www.exponent.com/experience/probablistic-exposure-and-risk-model-for-fumigants/?pageSize=NaN&pageNum=0&loadAllByPageSize=true

to codistillation than were tested in these studies. These are fully described below but include a) the lack of off-field sample data from the TX studies to determine volatilization flux during the application, b) volatilization flux during the applications measured at the GA site was not considered in the flux profile constructed for the modeling inputs and, and therefore not accounted for in modeling inputs, c) the time duration for deposition values are not specified in the study report and confounds the comparison of accumulated deposition with respect to toxicological endpoints, and d) applications timings occurred later in the day and missing the morning transition window of what would include the greatest differences in relative humidity and heating with conditions vulnerable to codistillation (this is particularly true for both M-1691 and M-1768 TX applications and the GA application with M-1691). However, the amount of uncertainty in the exposure estimates is small enough that it is very unlikely that the exposure will exceed the effect threshold (NOAEC). Refer to the fifth discussion point within the Deficiencies section below for further detailed information.

These uncertainties could be addressed through submission of the additional off-field sample data from TX, additional research on applications conducted during the morning weather transition window described above, and measured flux at the time of application with its incorporation into the deposition modeling analysis. Furthermore, the time duration for accumulation of deposition should be clarified to enable a more definitive comparison of exposure from vapor drift to available toxicological endpoints. Additionally, where incidents occur (that could be a result of either exposure to spray drift or volatilization), submission of information regarding the climatic conditions (temperature, relative humidity, wind speed and direction) both under which the suspect application occurred and following the application would assist with understanding the conditions under which volatilization exposure can occur. Additional incident data that would be informative includes quantitative measurements of damage comparable to EPA's apical endpoints (*i.e.* plant height, biomass, yield, etc.)

Findings As Gathered From Field Volatility (Flux) Studies (MRIDs 49888401, 49888403, 49888501, 49888503) and Results from AERMOD Deposition Modeling (MRIDs 49925701 – 02)

1. **Applications During Flux Studies** - The applications encompassing the M-1691 and M-1768 formulations were less than one kilometer apart in GA (pre-emergent app.) and several kilometers apart in TX (post emergent/foliar app. to cotton crop) and applications for both formulations occurring within 1 -2 hours of each other at each site.

2. **Weather Conditions After Applications During Flux Studies** - The fair weather conditions throughout the study periods for both TX and GA lend themselves to near-idealized conditions for volatilization occurring after applications. First, afternoons throughout all studies at both sites were very warm with maximum temperatures in the low 90's F. Furthermore, conditions for codistillation appear to be ideal with the weather as there is a strong diurnal cycle between the stable nocturnal regime (characterized by high relative humidity, relatively cool temps., and stagnant conditions) and convective daytime regime (characterized by relatively hot, low relative humidity, and more mixed conditions) at both sites after the applications.

3. **Flux/Concentration Magnitudes Observed in Flux Studies** - Very small concentrations (on the order of <0.06 μg/m^3) and resulting fluxes (on the order of <0.0081 μg/m^2-sec) found throughout the studies appear to be well supported by good recoveries from the Polyurethane Foam (PUF) analytical method evaluation and field spikes.

4. **Flux Events Observed in Flux Studies** - In most instances over both TX and GA, the highest levels of flux occurred at the time of application which occurred throughout the morning to early afternoon. Furthermore, there appears to be a strong diurnal signal with the timings of subsequent peak flux events. These subsequent events may be dependent on both the maximum heating of the day and/or the transitional periods between morning (relatively cool, high relative humidity, stagnant conditions) and afternoon (hot, low relative humidity, more mixing conditions). In most cases, peak flux events occurred between the hours of 7 – 20 after the application.

5. **Summary of AERMOD Deposition Modeling Estimates:**
Upper-bound estimates of deposition indicate reduced deposition and air concentrations following the M-1768 formulation applications as compared to the M-1691 formulation. **Table 1** shows the AERMOD and PERFUM estimates of the upper bound 90th percentile deposition and concentration, respectively, 5-meters from edge of field:

Table 1. AERMOD estimates of the upper 90th percentile 5-meters from edge of field

Depostion and Air Conc. Model Runs**	Study Site Flux Basis	AERMOD Dry Depostion* (lbs. dicamba a.e./A)	AERMOD Wet Deposition* (lbs. dicamba a.e./A)	AERMOD Upper-Bound Combined (Dry + Wet) Deposition (lbs. dicamba a.e./A)	PERFUM Upper-Bound Peak Air Conc. *,*** (μg/m^3)
Dicamba DGA Formulation (M-1691)					
1-3	Georgia	2.08×10^{-5} – 3.10×10^{-5}	2.60×10^{-8} – 2.34×10^{-7}	**3.12×10^{-5}**	**6.03×10^{-2}**
4-6	Texas	9.99×10^{-6} – 1.89×10^{-5}	4.92×10^{-8} – 1.78×10^{-7}	1.91×10^{-5}	2.48×10^{-2}
Dicamba DGA VaporGrip Formulation (M-1768)					
7-9	Georgia	8.52×10^{-6} – 1.28×10^{-5}	2.03×10^{-8} – 1.14×10^{-7}	**1.29×10^{-5}**	**2.08×10^{-2}**
10-12	Texas	5.15×10^{-6} – 8.86×10^{-6}	2.43×10^{-8} – 8.68×10^{-8}	8.95×10^{-6}	8.80×10^{-3}

Maximum values shown in **bold**.

*Range of upper 90th percentile estimates presented of AERMOD estimates from 3 model runs (see next note below).
**Three iterations of model runs encompass different weather conditions coupled with flux profiles input into AERMOD (deposition) or PERFUM (air concentrations). One year of weather data from Lubbock,

TX (surface) and Amarillo, TX (Upper Air); Peoria, IL (Surface) and Lincoln, IL (Upper Air); Raleigh, NC (Surface) and Greensboro, NC (Upper Air) used in analysis only during time of year with dicamba application windows. Phoenix, AZ weather data are also briefly cited but uncertain how that was used based on the study report alone.

***Peak estimated concentrations are one-hour concentrations.

Deficiencies with Field Volatility (Flux) Studies (MRIDs 49888401, 49888403, 49888501, 49888503) and AERMOD Deposition Modeling Analysis (MRIDs 49925701 – 02)

1. **Air Sampling during Application with Flux Studies** - Flux during the application was captured in the GA field volatility studies for both formulations using off-field samplers (indirect method). However, this was not done in any of the TX field volatility studies. While off-field samplers were included as part of the studies in TX, the data were discarded by the study authors briefly stating that samples possibly contained dicamba from other sources than volatilization. Submission of this discarded data would reduce some of the uncertainties discussed in this document.

2. **Weather Conditions During Application with Flux Studies**
   The application timings for each flux study on each formulation is presented in the table below. As mentioned above, there are two weather phenomenon which may contribute to loss of dicamba via volatilization-related processes. The first is codistillation which may occur during the transition from high relative humidity (rh) conditions in the early morning to low relative humidity conditions in the late morning to early afternoon. The second is direct volatilization which may occur during the heating of the day.

   The Georgia flux studies, particularly for the M-1691 formulation, may have only partially captured the impact of the transition from high rh to low rh conditions, and therefore losses could have been greater if applied earlier. Average relative humidities did fall from levels of 68 percent at 9 am to 51 percent at 10 am then to 34 percent at 11 am. However, rh was substantially higher earlier around 7 am with a maximum value of 94 percent observed. The M-1691 formulation was applied later in the morning, while the M-1768 formulation was applied more encompassing the morning transition (**Table 2**). Therefore, given that this transition may drive codistillation, comparisons in flux between the M-1691 and M-1768 may be confounded by the fact that the M-1768 formulation was possibly applied under potentially more vulnerable conditions for enhanced volatilization and resulting vapor drift.

   For both Texas studies, both dicamba formulations occurred after the morning transition and into the more convective part of the day. While heating may have been a driver for volatilization, applications prior to the morning transition could have provided a more vulnerable set of conditions for loss of dicamba from the field.

Table 2. Dicamba formulation application timing and relative humidity

Formulation Applied	Application Timing	Average RH Range During Day of Study After Application Start	Maximum RH During Day of Study
Georgia Studies			
Dicamba DGA (M-1691)	9:54 am May 5, 2015	68 percent falling to 10 percent	94 percent 7 am
Dicamba DGA VaporGrip (M-1768)	8:05 am May 5, 2015	87 percent falling to 10 percent	
Texas Studies			
Dicamba DGA (M-1691)	11:10 am June 8, 2015	38 percent falling to 18 perent	96 percent 7 am
Dicamba DGA VaporGrip (M-1768)	1:15 pm June 8, 2015	23 percent falling to 18 percent	

3. **Potential for Cross-Contamination Between M-1691 and M-1768 Plots During Flux Studies** To determine flux values ultimately used to estimate air concentrations and deposition, flux values need to be determined from a single field of application in order to arrive at an accurate amount of dicamba material that volatilizes and is ultimately driftable. This stated, it appears that the Georgia M-1691 and M-1768 application plots are very close to each other, within 500 meters of each other. In Texas, the two treated plots for each formulation are farther apart, about 5 kilometers from each other. In both cases, the plots with the M-1768 formulations could potentially have been influenced by dicamba material blowing downwind from the plots treated with the M-1691 formulations **(Figure 1)**. Furthermore, the typical logarithmic decrease of concentrations with height for flux studies was not strong immediately after the application for the Texas M-1768 application, indicating that there may have been some confounding impacts from cross-contamination. However, this was also the case immediately after the application for the Texas M-1691 application which was applied before the M-1768 application. There were no such anomalies in the vertical concentration profile in the Georgia studies where the concentrations with height over the field exhibited the expected logarithmic decreasing trend.

   While cross-contamination can theoretically exist with dicamba applications to multiple fields over a local area, the deposition analysis submitted by the registrant includes up to an 80-acre field treated with each dicamba formulation. This is a large area treated and the resulting exposure to plants off the treated field conveyed in the registrant's analysis would be expected to capture any potential impacts of cross-contamination that can occur accumulated from smaller fields. However, to reiterate, results from a discretely treated field is desired considering the purposes of a field volatility study described above.

Figure 1. Map of GA field sites (top) and TX field sites (bottom). Site 1 delineates M-1691-only application. Site 2 delineates M-1768 application.

4. **Environmental Chemistry Methods and Method Validation Supporting Flux Studies** – Upon review, it appears that the field volatility study reports include an adequate evaluation of the polyurethane foam (PUF) sampling procedure employed in air samples for these studies. However, an independent laboratory validation demonstrating repeatable performance could not be found. A GLP compliance statement was submitted.

5. **Flux Modeling.** Flux during the application period was not modeled for either the GA or TX site. Flux was not reported for the application period in TX; the measured flux in GA was 1.6 to 1.7 times higher (M-1691 and M-1768, respectively) than in any later measurement period. Even if additional flux of this magnitude was included in the modeling exercise, the total exposure from volatilization would still be below the vapor-phase LOAEC and vegetative vigor NOAEC for M-1691. Modeled exposures would also be below vapor-phase and vegetative vigor endpoints for M-1768.

6. **Interpretation of AERMOD Deposition Values** – In all AERMOD deposition values provided by the registrant, the time durations of the deposition values (e.g., one-hour, four-hour, or 24-hour) is not specified. Since deposition reflects a cumulative value of mass accumulation over time, it becomes difficult to compare exposure impacts to toxicological impacts over a period of time if this information is not provided. However, for the PERFUM air concentration modeling analysis, the registrant did provide sufficient air concentration time averages (e.g., 1-hour, 4-hour, 8-hour, and 24-hour period averages) for appropriate comparisons to the toxicological endpoints.

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Comment submitted by National Family Farm Coalition

The is a Comment on the **Environmental Protection Agency** (EPA)
Other: **Public Participation for Dicamba: New Use on Herbicide-Tolerant Cotton and Soybean**

For related information, **Open Docket Folder**

Comment Period Closed
May 31 2016, at 11:59 PM ET

ID: EPA-HQ-OPP-2016-0187-0867

Tracking Number: 1k0-8py0-nipv

Comment

As a coalition representing 25 grassroots member organizations comprised of thousands of family farmers, ranchers, fishermen, rural residents and advocates for fair food and agriculture policy, the National Family Farm Coalition urges the US Environmental Protection Agency to deny Monsanto the permission to release their dicamba-tolerant cotton and soy.

Our growers have expressed concerns over the continued and expanded use of similar deadly herbicides, including increased cases of cancer, Parkinson's disease and other serious illnesses in areas where herbicides are regularly sprayed; 'dead' soil requiring more and more chemical nutrients; diminished biodiversity, particularly the loss of essential pollinator species; and fewer non-GM cotton and soy options. In addition, the use of more herbicides and pesticides leads to the increased use of more herbicides and pesticides as undesirable plants become tolerant. There are other ways to grow these crops using rotations, cover crops and other methods in line with agroecology and healthier, less polluting means; releasing these dicamba-tolerant cotton and soybeans means a step in the wrong direction.

Thank you for the opportunity to submit these comments on behalf of our members.

Document Information

Date Posted:
Jun 20, 2016

RIN:
Not Assigned

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American Institute of Biological Sciences

Navigating a Critical Juncture for Sustainable Weed Management
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Reviewed work(s):
Source: *BioScience*, Vol. 62, No. 1 (January 2012), pp. 75-84
Published by: University of California Press on behalf of the American Institute of Biological Sciences
Stable URL: http://www.jstor.org/stable/10.1525/bio.2012.62.1.12
Accessed: 13/01/2012 13:57

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Navigating a Critical Juncture for Sustainable Weed Management

DAVID A. MORTENSEN, J. FRANKLIN EGAN, BRUCE D. MAXWELL, MATTHEW R. RYAN, AND RICHARD G. SMITH

Agricultural weed management has become entrenched in a single tactic—herbicide-resistant crops—and needs greater emphasis on integrated practices that are sustainable over the long term. In response to the outbreak of glyphosate-resistant weeds, the seed and agrichemical industries are developing crops that are genetically modified to have combined resistance to glyphosate and synthetic auxin herbicides. This technology will allow these herbicides to be used over vastly expanded areas and will likely create three interrelated challenges for sustainable weed management. First, crops with stacked herbicide resistance are likely to increase the severity of resistant weeds. Second, these crops will facilitate a significant increase in herbicide use, with potential negative consequences for environmental quality. Finally, the short-term fix provided by the new traits will encourage continued neglect of public research and extension in integrated weed management. Here, we discuss the risks to sustainable agriculture from the new resistant crops and present alternatives for research and policy.

Keywords: agriculture production, agroecosystems, transgenic organisms, sustainability, biotechnology

Overreliance on glyphosate herbicide in genetically modified (GM) glyphosate-resistant cropping systems has created an outbreak of glyphosate-resistant weeds (Duke and Powles 2009, NRC 2010). Over recent growing seasons, the situation became severe enough to motivate hearings in the US Congress to assess whether additional government oversight is needed to address the problem of herbicide-resistant weeds (US House Committee on Oversight and Government Reform 2010). One of our coauthors (DAM) delivered expert testimony at these hearings, in which he expressed the views described in this article. Biotechnology companies are currently promoting second-generation GM crops resistant to additional herbicides as a solution to glyphosate-resistant weed problems. We believe that this approach will create new resistant-weed challenges, will increase risks to environmental quality, and will lead to a decline in the science and practice of integrated weed management (IWM). The rapid rise in glyphosate-resistant weeds demonstrates that herbicide-resistant crop biotechnology is sustainable only as a component of broader integrated and ecologically based weed management systems. We argue that new policies are needed to promote integrated approaches and to check our commitment to an accelerating transgene-facilitated herbicide treadmill, which has significant agronomic and environmental-quality implications (figure 1).

Effective weed management is critical to maintaining agricultural productivity. By competing for light, water, and nutrients, weeds can reduce crop yield and quality and can lead to billions of dollars in global crop losses annually. Because of their ability to persist and spread through the production and dispersal of dormant seeds or vegetative propagules, weeds are virtually impossible to eliminate from any given field. The importance of weed management to successful farming systems is demonstrated by the fact that herbicides account for the large majority of pesticides used in agriculture, eclipsing inputs for all other major pest groups. To no small extent, the success and sustainability of our weed management systems shapes the success and sustainability of agriculture as a whole.

In the mid-1990s, the commercialization of GM crops resistant to the herbicide glyphosate (Monsanto's Roundup Ready crops) revolutionized agricultural weed management. Prior to this technology, weed control required a higher level of skill and knowledge. In order to control weeds without also harming their crop, farmers had to carefully select among a range of herbicide active ingredients and carefully manage the timing of herbicide application while also integrating other nonchemical control practices. Glyphosate is a highly effective broad-spectrum herbicide that is phytotoxically active on a large number of weed and crop species across a wide range of taxa (Duke and Powles 2009). Engineered to express enzymes that are insensitive to or can metabolize glyphosate, GM glyphosate-resistant crops have enabled farmers to easily apply this herbicide in soybean, corn, cotton, canola, sugar beet, and alfalfa and to control problem weeds without harming the crop (Duke and Powles 2009).

Growers were attracted to the flexibility and simplicity of the glyphosate and glyposhate-resistant crop technology package and adopted the technology at an unprecedented rate. After emerging on the market in 1996,

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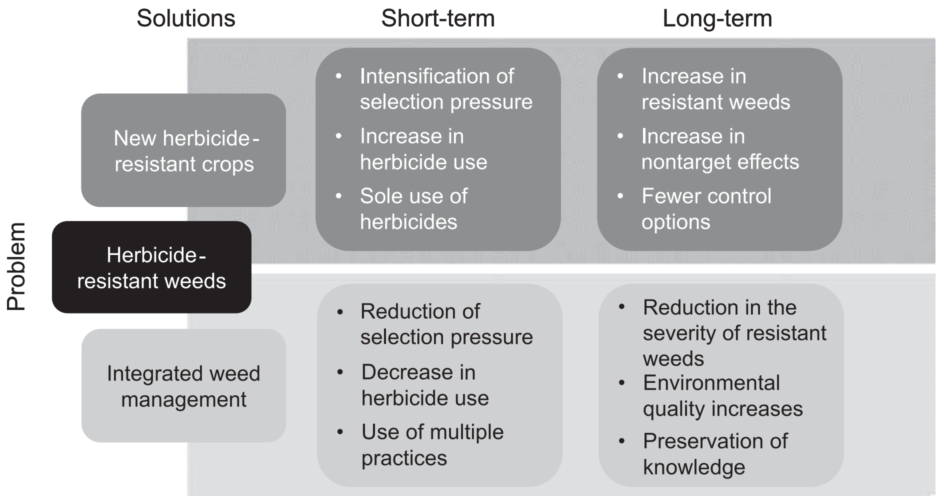

Figure 1. A conceptual model of the alternative solutions—and their potential consequences—presently available for addressing glyphosate-resistant weed problems.

glyphosate-resistant soybeans accounted for 54% of US hectares by 2000 (Duke and Powles 2009). In 2008, crops resistant to glyphosate were grown on approximately 96 million hectares (ha) of cropland internationally and account for 63%, 68%, and 92% of the US corn, cotton, and soybean hectares, respectively (Duke and Powles 2009). The technology is effective and easy to use, and farmers have often responded to these benefits by exclusively planting glyphosate-resistant cultivars and applying glyphosate herbicide in the same fields, year after year (Duke and Powles 2009, NRC 2010).

Unfortunately, this single-tactic approach to weed management has resulted in unintended—but not unexpected—problems: a dramatic rise in the number and extent of weed species resistant to glyphosate (Heap 2011) and a concomitant decline in the effectiveness of glyphosate as a weed management tool (Duke and Powles 2009, NRC 2010). As the area planted with glyphosate-resistant crops increased, the total amount of glyphosate applied kept pace, creating intense selection pressure for the evolution of resistance. This dramatic increase in glyphosate use would not have been possible without glyphosate-resistant crop biotechnology. The number and extent of weed species resistant to glyphosate has increased rapidly since 1996, with 21 species now confirmed globally (Heap 2011). Although several of these species first appeared in cropping systems where glyphosate was being used without a resistant cultivar, the most severe outbreaks have occurred in regions where glyphosate-resistant crops have facilitated the continued overuse of this herbicide. The list includes many of the most problematic agronomic weeds, such as Palmer amaranth (*Amaranthus palmeri*), horseweed (*Conyza canadensis*), and Johnsongrass (*Sorghum halepense*), several of which infest millions of hectares (Heap 2011).

The next generation of herbicide-resistant crops

To address the problem of glyphosate-resistant weeds, the seed and agrichemical industries are developing new GM cultivars of soybean, cotton, corn, and canola with resistance to additional herbicide chemistries, including dicamba (Monsanto) and 2,4-D (2,4-dichlorophenoxyacetic acid; Dow AgroSciences) (Behrens MR et al. 2007, Wright et al. 2010). Dicamba and 2,4-D are both in the synthetic auxin class of herbicides, which have been widely used for weed control in corn, cereals, and pastures for more than 40 years. These herbicides mimic the physiological effects of auxin-type plant-growth regulators and can cause abnormal growth and eventual mortality in a wide variety of broadleaf plant species. In addition to species with recently evolved resistance, several important broadleaf weed species are naturally tolerant to glyphosate but susceptible to synthetic auxins. In cropping systems where glyphosate-resistant or -tolerant weeds are major problems, dicamba and 2,4-D applications would provide an effective weedmanagement tool. Although several other transgene–herbicide combinations are currently in the research and development pipeline (Duke and Powles 2009), these modes of action already have significant resistant-weed issues or do not control weeds as effectively as dicamba or 2,4-D herbicides. Consequently, we expect that synthetic auxin–resistant cultivars will be embraced by growers and planted on rapidly increasing areas in the United States and worldwide over the next 5–10 years.

In addition to their weed management utility, there are a number of agronomic drivers that may further accelerate the adoption of the new resistant cultivars. First, soybean, cotton, and many other broadleaf crops are naturally extremely sensitive to synthetic auxin herbicides and show distinctive injury symptoms when they encounter trace doses (figure 2; Breeze and West 1987, Al-Khatib and Peterson 1999, Everitt and Keeling 2009, Sciumbato et al. 2004). Most US growers rely on commercial applicators to spray herbicides, and when susceptible and synthetic auxin–resistant fields are interspersed, there may be a high probability for application mistakes in which susceptible fields are accidentally treated with dicamba or 2,4-D. Second, synthetic auxins are extremely difficult to clean from spray equipment (Boerboom 2004), and low residual concentrations of these compounds in equipment could damage susceptible cultivars. Growers and applicators may need to have equipment dedicated to dicamba or 2,4-D to avoid damage from residual concentrations. Third, some formulated products of

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Figure 2. Photo of soybean responding to a drift-level exposure to dicamba herbicide, exhibiting typical symptoms of cupped-leaf morphology and chlorotic-leaf margins. Photograph: J. Franklin Egan.

dicamba and 2,4-D have high volatility (Grover et al. 1972, Behrens R and Lueschen 1979), and the combination of particle and vapor drift may generate frequent incidents of significant injury or yield loss to susceptible crops. Moreover, the seed and chemical industries are becoming increasingly consolidated, making it more difficult for growers to find high-yielding varieties that do not also contain transgenic herbicide-resistance traits. Combined, these four agronomic drivers suggest that once an initial number of growers in a region adopts the resistant traits, the remaining growers may be compelled to follow suit in order to reduce the risk of crop injury and yield loss.

If herbicide-resistant-weed problems are addressed only with herbicides, evolution will most likely win

Glyphosate-resistant weeds rapidly evolved in response to the intense selection pressure created by the extensive and continuous use of glyphosate in resistant crops. Anticipating the obvious criticism that the new synthetic auxin–resistant cultivars will enable a similar overuse of these herbicides and a new outbreak of resistant weeds, scientists affiliated with Monsanto and Dow have argued that synthetic auxin–resistant weeds will not be a problem because (a) currently very few weed species globally have evolved synthetic auxin resistance, despite decades of use; (b) auxins play complex and essential roles in the regulation of plant development, which suggests that multiple independent mutations would be necessary to confer resistance; and (c) synthetic auxin herbicides will be used in combination or rotation with glyphosate, which will require weeds to evolve multiple resistance traits in order to survive (Behrens MR et al. 2007, Wright et al. 2010). Although these arguments have been repeated in several high-profile journals, the authors of those arguments have conspicuously left out several important facts about current patterns in the distribution and evolution of herbicide-resistant weeds.

First, similar arguments were made during the release of glyphosate-resistant crops. Various industry and university scientists contended that details of glyphosate's biochemical interactions with the plant enzyme EPSPS (5-enolpyruvylshikimate-3-phosphate synthase) combined with the apparent lack of resistant weeds after two decades of previous glyphosate use indicated that the evolution of resistant weeds was a negligible possibility (Bradshaw et al. 1997).

Second, it is not the case that "very few" weed species have evolved resistance to the synthetic auxin herbicides. Globally, there are 28 species, with 6 resistant to dicamba specifically, 16 to 2,4-D, and at least 2 resistant to both active ingredients (table 1). And although many of these species are not thought to infest large areas or cause significant economic harm, data on the extent of resistant weeds are compiled through a passive reporting system, in which area estimates are voluntarily supplied by local weed scientists after a resistant-weed problem becomes apparent. Synthetic auxin–resistant weeds may appear unproblematic because these species currently occur in cropping systems in which other herbicide modes of action are used that can effectively mask the extent of the resistant genotypes (Walsh et al. 2007). Furthermore, the claim that 2,4-D resistance is unlikely to evolve because of the complex and essential functions that auxins play in plants is unsubstantiated. In many cases in which resistance has evolved to synthetic auxins, the biochemical mechanism is unknown. However, in at least two cases, dicamba-resistant *Kochia scoparia* (Preston et al. 2009) and dicamba-resistant *Sinapis arvensis* (Zheng and Hall 2001), resistance is conferred by a single dominant allele, indicating that resistance could develop and spread quite rapidly (Jasieniuk and Maxwell 1994).

The final dimension of the industry argument is that by planting cultivars with stacked resistant traits, farmers will be able to easily use two distinct herbicide modes of action and prevent the evolution of weeds simultaneously resistant to both glyphosate and dicamba or 2,4-D. The logic behind this argument is simple. Because the probability of a mutation conferring target-site resistance to a single-herbicide mode of action is a very small number (generally estimated as one resistant mutant per 10^{-5} to 10^{-10} individuals [Jasieniuk and Maxwell 1994]), and because distinct mutations are assumed to be independent events, the probability of multiple target-site resistance to two modes of action is the product of two very small numbers (i.e., 10^{-10} to 10^{-20}). For instance, if the mutation frequency for a glyphosate-resistant allele in a weed population is 10^{-9}, and the frequency for a dicamba mutant is also 10^{-9}, the frequency of individuals simultaneously carrying both resistant alleles would be 10^{-18}. If the population density of this species is assumed to be around 100 seedlings per square meter (m^2) of cropland (10^6 per ha), it would require 10^{12} ha of cropland to find just one mutant individual with resistance to both herbicides. For point of reference, there are only about 15×10^8 ha of cropland globally. Therefore, even if the weed species were globally distributed, and all of the world's crop fields

Table 1. Global diversity and extent of the 28 weed species with resistance to synthetic auxin herbicides.

Year	Common name	Scientific name	Herbicides	Location	Acres
1952	Wild carrot	*Daucus carota*	2,4-D	Ontario	<1
1957	Spreading dayflower	*Commelina diffusa*	2,4-D	Hawaii	No data
1964	Field bindweed	*Convolvulus arvensis*	2,4-D	Kansas	No data
1975	Scentless chamomile	*Matricaria perforata*	2,4-D	France	101–500
1975	Scentless chamomile	*Matricaria perforata*	2,4-D	United Kingdom	101–500
1979	Canada thistle	*Cirsium arvense*	MCPA	Sweden	No data
1981	Musk thistle	*Carduus nutans*	2,4-D, MCPA	New Zealand	1001–10,000
1983	Gooseweed	*Sphenoclea zeylanica*	2,4-D	Philippines	1–5
1985	Canada thistle	*Cirsium arvense*	2,4-D, MCPA	Hungary	No data
1985	Common chickweed	*Stellaria media*	Mecoprop	United Kingdom	No data
1988	Yellow starthistle	*Centaurea solstitialis*	Picloram	Washington	1–5
1988	Tall buttercup	*Ranunculus acris*	MCPA	New Zealand	1001–10,000
1989	Globe Fingerrush	*Fimbristylis miliacea*	2,4-D	Malaysia	51–100
1990	Wild mustard	*Sinapis arvensis*	2,4-D, dicamba, dichloprop, MCPA, mecoprop, picloram	Manitoba	51–100
1993	Wild carrot	*Daucus carota*	2,4-D	Michigan	11–50
1993	Corn poppy	*Papaver rhoeas*	2,4-D	Spain	10,001–100,000
1994	Wild carrot	*Daucus carota*	2,4-D	Ohio	1001–10,000
1995	Kochia	*Kochia scoparia*	Dicamba	North Dakota	101–500
1995	Kochia	*Kochia scoparia*	Dicamba, fluroxypr	Montana	1001–10,000
1995	Yellow Burhead	*Limnocharis flava*	2,4-D	Indonesia	1001–10,000
1995	Gooseweed	*Sphenoclea zeylanica*	2,4-D	Malaysia	No data
1996	False cleavers	*Galium spurium*	Quinclorac	Albera	51–100
1997	Italian thistle	*Carduus pycnocephalus*	2,4-D	New Zealand	No data
1997	Kochia	*Kochia scoparia*	Dicamba	Idaho	1–5
1998	Barnyardgrass	*Echinochloa crus-galli*	Quinclorac	Louisiana	501–1,000
1998	Common hempnettle	*Galeopsis tetrahit*	Dicamba, fluroxypr, MCPA	Alberta	101–500
1998	Yellow Burhead	*Limnocharis flava*	2,4-D	Malaysia	11–50
1999	Barnyardgrass	*Echinochloa crus-galli*	Quinclorac	Brazil	1–5
1999	Barnyardgrass	*Echinochloa crus-galli*	Quinclorac	Arkansas	1–5
1999	Gulf cockspur	*Echinochloa crus-pavonis*	Quinclorac	Brazil	1–5
1999	Wild radish	*Raphanus raphanistrum*	2,4-D	Australia	10,001–100,000
1999	Carpet burweed	*Soliva sessilis*	Clopyralid, picloram, triclopyr	New Zealand	6–10
2000	Junglerice	*Echinochloa colona*	Quinclorac	Colombia	11–50
2000	Gooseweed	*Sphenoclea zeylanica*	2,4-D	Thailand	11–50
2002	Smooth crabgrass	*Digitaria ischaemum*	Quinclorac	California	11–50
2002	Marshweed	*Limnophila erecta*	2,4-D	Malaysia	501–1,000
2005	Common lambsquarters	*Chenopodium album*	Dicamba	New Zealand	11–50
2005	Indian hedge-mustard	*Sisymbrium orientale*	2,4-D, MCPA	Australia	51–100
2006	Wild radish	*Raphanus raphanistrum*	2,4-D, MCPA	Australia	1–5
2007	Prickly lettuce	*Lactuca serriola*	2,4-D, dicamba, MCPA	Washington	101–500
2008	Wild mustard	*Sinapis arvensis*	Dicamba	Turkey	101–500
2009	Barnyardgrass	*Echinochloa crus-galli*	Quinclorac	Brazil	No data

Note: Some species have evolved resistance to various synthetic auxin herbicides on multiple independent occasions in different locations. Compiled from Heap (2011).
2,4-D, 2,4-Dichlorophenoxyacetic acid; MCPA, 2-methyl-4-chlorophenoxyacetic acid.

were treated with both herbicides, it would appear virtually impossible to select a single weed seedling exhibiting multiple resistance.

The problem with this reassuring analysis is that it contradicts recent evidence. Weed species resistant to multiple herbicide modes of action are becoming more widespread and diverse (figure 3). There are currently 108 biotypes in 38 weed species across 12 families possessing simultaneous resistance to two or more modes of action, with 44% of these having appeared since 2005 (Heap 2011). Common waterhemp (*Amaranthus tuberculatus*) simultaneously resistant to glyphosate, ALS, and PPO herbicides infests 0.5 million ha of corn and soybean in Missouri (Heap 2011). Rigid ryegrass (*Lolium rigidum*) populations resistant to seven distinct modes of action infest large areas of southern Australia (Heap 2011). Weeds can defy the probabilities and evolve multiple resistance through a number of mechanisms.

First, when a herbicide with a new mode of action is introduced into a region or cropping system in which weeds resistant to an older mode of action are already widespread and problematic, the probability of selecting for multiple target-site resistance is not the product of two independent, low-probability mutations. In fact, the value is closer to the simple probability of finding a resistance mutation to the new mode of action within a population already extensively resistant to the old mode of action. For instance, in Tennessee, an estimated 0.8–2 million ha of soybean crops are infested with glyphosate-resistant horseweed (*C. canadensis*) (Heap 2011). Assuming seedling densities of 100 per m^2 or 10^6 per ha (Dauer et al. 2007) and a mutation

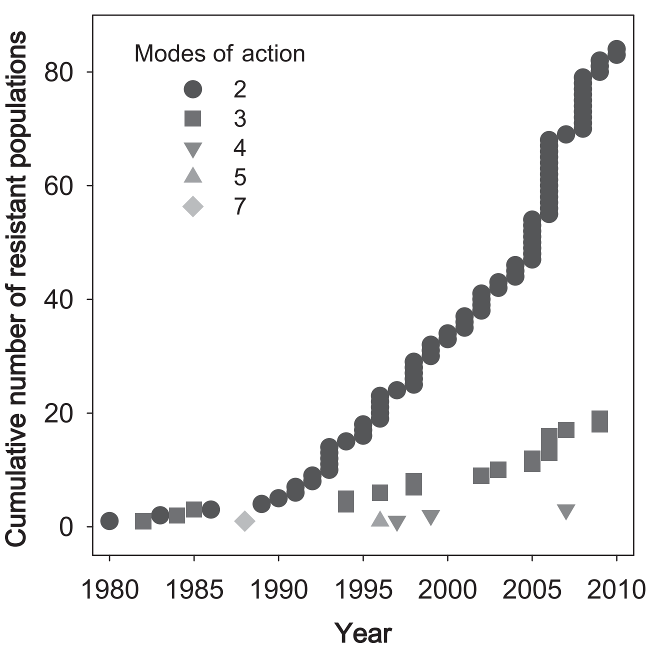

Figure 3. Global increases in the number of weed populations since 1980 across 38 species that exhibit simultaneous resistance to two or more distinct herbicide modes of action (MOA). Data compiled from Heap 2011.

frequency for synthetic auxin resistance of 10^{-9}, this implies that next spring, there will be 800–2000 horseweed seedlings in the infested area that possess combined resistance to glyphosate and a synthetic auxin herbicide ((2×10^6 ha infested with glyphosate resistance) × (10^6 seedlings per ha) × (1 synthetic auxin–resistant seedling per 10^9 seedlings) = 2000 multiple-resistant seedlings). In this example, these seedlings would be located in the very fields where farmers would most likely want to plant the new stacked glyphosate- and synthetic auxin–resistant soybean varieties (the fields where glyphosate-resistant horseweed problems are already acute). Once glyphosate and synthetic auxin herbicides have been applied to these fields and have killed the large number of susceptible genotypes, these few resistant individuals would have a strong competitive advantage and would be able to spread and multiply rapidly in the presence of the herbicide combination.

Second, several weed species have evolved cross-resistance, in which a metabolic adaptation allows them to degrade several different herbicide modes of action. Mutations to cytochrome P450 monooxygenase genes are a common mechanism for cross-resistance (Powles and Yu 2010). Plant species typically have a large number of P450 genes (e.g., the rice genome contains 458 distinct P450 genes), which are involved in a variety of metabolic functions, including the synthesis of plant hormones and the hydrolyzation or dealkylation of herbicides and other xenobiotics. Weeds with P450 mediated resistance are widespread and increasingly problematic. For instance, across Europe and Australia, numerous populations of *L. rigidum* and *Alopecurus myosuroides* occur with various combinations of P450 resistance to the ALS-, ACCase-, and photosystem II–inhibitor herbicides (Powles and Yu 2010). Given the diversity and ubiquity of P450 monoxygenases in plant genomes, it is possible that in the near future, a weed species could evolve a mutation that enables it to degrade glyphosate and the synthetic auxins.

Historically, the use of the synthetic auxin herbicides has been limited to cereals or as preplant applications in broadleaf crops. The new transgenes will allow 2,4-D and dicamba to be applied at higher rates, in new crops, in the same fields in successive years, and across dramatically expanded areas, creating intense and consistent selection pressure for the evolution of resistance. Taken together, the current number of synthetic auxin–resistant species, the broad distribution of glyphosate-resistant weeds, and the variety of pathways by which weeds can evolve multiple resistance suggest that the potential for synthetic auxin–resistant or combined synthetic auxin– and glyphosate-resistant weeds in transgenic cropping systems is actually quite high. One hundred ninety-seven weed species have evolved resistance to at least 1 of 14 known herbicide modes of action (Heap 2011), and the discovery and development of new herbicide active ingredients has slowed dramatically over recent decades. Given that herbicides are a cornerstone of modern weed management, it seems unwise to allow the new GM herbicide-resistant

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crops to needlessly accelerate and exacerbate resistant-weed evolution.

Increasing herbicide applications and the consequences for environmental quality

In the early promotions of their new resistant cultivars, scientists from Dow and Monsanto have been advocating herbicide programs that combine current rates of glyphosate with 225–2240 grams (g) per ha of dicamba (Arnevik 2010) or 560–2240 g per ha of 2,4-D (Olson and Peterson 2011). Therefore, the technology will not involve a substitution of herbicide active ingredients but will instead lead to additional herbicide use. If the rate of adoption of this technology follows the general trajectory of glyphosate-resistant crops, the result could be a profound increase in the total amount of herbicide applied to farmland (figure 4). This trend would move us in the opposite direction of the reduced chemical inputs that scientists in sustainable agriculture have long advocated. As the seed and agrichemical industries move closer to the commercialization of new resistant traits, it is worth pausing to ask what the environmental-quality consequences of this increase may be.

Dicamba and 2,4-D have been widely used in agriculture for over 40 years, and recent US Environmental Protection Agency (USEPA) reviews have classified both herbicides as being relatively environmentally benign (USEPA 2005, 2006). Both herbicides have low acute and chronic toxicities to mammalian, bird, and fish model organisms; degrade fairly rapidly in the soil; and are not known to bioaccumulate. Not surprisingly, however, both dicamba and 2,4-D are extremely toxic to broadleaf plants. For many terrestrial and aquatic plant species, the USEPA assessments rank the ecotoxicological risks for both dicamba and 2,4-D well above their set levels of concern (USEPA 2005, 2006). In a relative-risk assessment comparing a suite of 12 herbicides commonly used in wheat, Peterson and Hulting (2004) reported the risk to terrestrial plants for dicamba and 2,4-D as being 75 and 400 times greater than glyphosate, respectively.

All herbicides can have negative impacts on nontarget vegetation if they drift from the intended areas either as wind-dispersed particles or as vapors evaporating off of the application surface. Because of their volatility and effects at low doses, past experience with injury to susceptible crops has indicated that the synthetic auxin herbicides may be especially prone to drift problems (Behrens R and Lueschen 1979, Sciumbato et al. 2004, US House Committee on Oversight and Government Reform 2010). Research has shown that using recommended application equipment (e.g., spray nozzle types) and applying herbicides under appropriate weather conditions can reduce particle drift. Modern formulations and chemistries of synthetic auxin products also can minimize vapor drift. However, growers and commercial applicators do not always use appropriate or recommended herbicide application practices, especially if these technologies are more costly. The new resistant cultivars will enable growers to apply synthetic auxin herbicides several weeks later into the growing season, when higher temperatures may increase volatility and when more varieties of susceptible crops and nontarget vegetation are leafed out, further increasing the potential for nontarget drift damage.

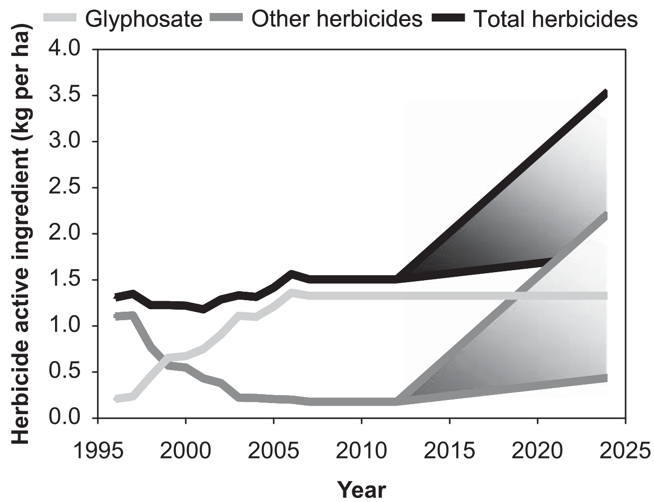

Figure 4. Total herbicide active ingredient applied to soybean in the United States. The data from 1996 to 2007 are adapted from Figure 2-1 in NRC (2010), and the projected data are based on herbicide programs described by Arnevik (2010) and Olson and Peterson (2011). To forecast herbicide rates from 2008 to 2013 we assumed that the applications of glyphosate and other herbicides will remain constant at 2007 levels until 2013, when new resistant soybean varieties are likely to become available. We estimated yearly increases in synthetic auxin herbicides (assumed to drive increases in other herbicides) by assuming that the adoption of stacked synthetic auxin–resistant cultivars mirrors the adoption of glyphosate-resistant cultivars, such that 91% of soybean hectares are resistant to synthetic auxin herbicides within 12 years. We further assumed that all soybean hectares with stacked resistance to glyphosate and synthetic auxin herbicides will receive an annual application of glyphosate and dicamba or 2,4-D. We assumed that the use rates of glyphosate will remain at current levels, and our estimates for dicamba and 2,4-D encompass lower (0.28 kilograms [kg] per hectare [ha]) and higher (2.24 kg per ha) use rates, which are in line with the rates currently used on tolerant crops (i.e., corn and wheat) and with rates being researched and promoted by Dow and Monsanto.

Plant diversity plays fundamental roles in agroecosystem sustainability, and major increases in dicamba and 2,4-D use may negatively affect multiple aspects of this important resource. First, as was discussed above, herbicide drift or misapplications could create a strong incentive for growers to plant resistant seeds as insurance against crop damage from herbicide drift or applicator mistakes, even if they are not interested in applying synthetic auxin herbicides themselves. This effect could further augment the portion of the

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seed market and of the landscape garnered by the resistant seed varieties, which would reduce genotypic diversity and restrict farmers' access to different crop varieties. Second, a large number of agronomic, fruit, and vegetable crops are susceptible to injury and yield loss from drift-level exposures to these herbicides (figure 2; Breeze and West 1987, Al-Khatib and Peterson 1999, Everitt and Keeling 2009). In the past, growers have reported issues with injury from drift and have recently voiced concerns about the expanded use of the synthetic auxin herbicides (Behrens R and Lueschen 1979, Boerboom 2004, Sciumbato et al. 2004, US House Committee on Oversight and Government Reform 2010). Landscapes dominated by synthetic auxin–resistant crops may make it challenging to cultivate tomatoes, grapes, potatoes, and other horticultural crops without the threat of yield loss from drift. Finally, a growing body of research has demonstrated that wild plant diversity in uncultivated, seminatural habitat fragments interspersed among crop fields helps support ecosystem services valuable to agriculture, including pollination and biocontrol (Isaacs et al. 2009). More research is needed in order to understand the impact that increased synthetic auxin applications may have on the quality and function of these plant diversity resources.

IWM: An alternative path forward

Glyphosate-resistant weeds—and herbicide-resistant weeds in general—represent a significant challenge to our food system. However, simply inserting additional resistant traits into crops and promoting the continuous application of glyphosate and dicamba or 2,4-D is by no means the only available or practical solution to this problem (figure 1). Growers and scientists have been working together for decades to develop a robust set of management practices that could be implemented to address resistant-weed issues.

Integrated weed management is characterized by reliance on multiple weed management approaches that are firmly underpinned by ecological principles (Liebman et al. 2001). As its name implies, IWM integrates tactics, such as crop rotation, cover crops, competitive crop cultivars, the judicious use of tillage, and targeted herbicide application, to reduce weed populations and selection pressures that drive the evolution of resistant weeds. Under an IWM approach, a grain farmer, instead of relying exclusively on glyphosate year after year, might use mechanical practices such as rotary hoeing and interrow cultivation, along with banded pre- and postemergence herbicide applications in a soybean crop one year, which would then be rotated to a different crop, integrating different weed management approaches. In fact, long-term cropping-system experiments in the United States have demonstrated that cropping systems that employ an IWM approach can produce competitive yields and realize profit margins that are comparable to, if not greater than, those of systems that rely chiefly on herbicides (Pimentel et al. 2005, Liebman et al. 2008, Anderson 2009). In one study, herbicide inputs were reduced by up to 94%, and profit margins were comparable to those of a conventional system (Liebman et al. 2008).

The introduction of glyphosate-resistant crops was a key factor enabling no-till crop production, which increased from 45 million to 111 million ha worldwide between 1999 and 2009 (Derpsch et al. 2010). Although no-till production can provide soil-quality and conservation benefits, it is dependent on herbicides, and the overreliance on glyphosate now threatens its sustainability. Effective IWM typically involves some tillage, such as interrow cultivation over a multiyear crop rotation. Despite a common misconception that tillage is always destructive to soil, a growing body of cropping systems research has demonstrated that where limited tillage is balanced in an IWM context with soil-building practices such as cover-cropping or manure applications, high levels of soil quality can be maintained. For example, rotational-tillage systems have recently been reported to accumulate and store more soil organic matter than no-till systems (Venterea et al. 2006). Greater soil carbon and nitrogen were observed in integrated systems that used tillage, cover crops, and manure than in a conventionally managed no-till system, regardless of whether cover crops were used in the no-till system (Teasdale et al. 2007). These results illustrate that soil-quality benefits associated with no-till systems can also be achieved using IWM that includes limited tillage.

Recent research has also demonstrated that IWM strategies are effective in managing herbicide-resistant weeds. For example, glyphosate-resistant horseweed in no-till soybean can be controlled by integrating cover crops and soil-applied residual herbicides (Davis VM et al. 2009). In a recent experiment in which the integration of tillage and cover crops was evaluated for controlling glyphosate-resistant Palmer amaranth in Georgia, the combination of tillage and rye cover crops reduced Palmer amaranth emergence by 75% (Culpepper et al. 2011). In addition to cultivation and cover crops, other practices can be used to manage resistant-weed populations. Researchers in Australia suggested two cultural weed management practices for reducing glyphosate-resistant weed populations: increasing a crop's competitive ability through higher seeding rates and preventing seed rain of resistant weeds by collecting or destroying weed seed at harvest (Walsh and Powles 2007). Area-wide management plans in which farmers cooperate to limit the hectares over which a single herbicide is applied can prevent the spread of a resistant species across a landscape (Dauer et al. 2009).

Unfortunately, the knowledge infrastructure needed to practice IWM in the future may be atrophying. Although seed and chemical companies can generate enormous revenues through the packaged sales of herbicides and transgenic seeds, the IWM approaches outlined above are based on knowledge-intensive practices, not on salable products, and lack a powerful market mechanism to push them along. For instance, delaying the planting date one or two weeks until after a flush of summer annual weeds have germinated can facilitate the control of these weeds with burndown

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herbicides and eliminate the need for postemergence herbicide applications. To apply this IWM practice, a farmer would need detailed, region-specific information on crop and weed ecology in order to choose the planting date that optimizes a tradeoff between better weed control and a shorter growing season (Nord et al. 2011). Because the use of this practice might reduce the need for herbicide inputs, modern seed-chemical firms would have little incentive to pursue the required research or to extend the knowledge to growers. IWM knowledge serves as a public good, and it requires locally adapted and ongoing public research, combined with effective extension education programs, in order to address current and future weed management challenges.

In his congressional testimony, Troy Roush (Indiana farmer and vice president of the American Corn Grower's Association) remarked that farmers are "working on the advice largely of industry anymore.… Public research is dead; it's decimated" (US House Committee on Oversight and Government Reform 2010). Indeed, several trends indicate that the public support needed for IWM research and extension is declining. First, the formula funds in the US Farm Bill that have historically provided support for land-grant universities to pursue farming systems research tailored to their growing regions have been steadily phased out in favor of competitive grant programs, in which the research topics and agendas are set by federal funding agencies (Huffman et al. 2006, Schimmelpfennig and Heisey 2009). The total amount of federal public funding for agriculture has basically remained flat since 1980, whereas private research investments have steadily increased (Schimmelpfennig and Heisey 2009). During this period, partnerships between land-grant universities and chemical and biotechnology companies have increased in number and extent (Schimmelpfennig and Heisey 2009), and in several respects, research activities in public colleges of agriculture have transitioned to parallel the activities and priorities of the biotechnology industry (Welsh and Glenna 2006). A recent survey of the membership of the Weed Science Society of America suggests that these patterns are influencing the research priorities of scientists who specialize in weed management (Davis AS et al. 2009). As of 2007, 41% of the membership reported topics related to herbicide efficacy as their primary research focus, whereas only 22% reported focusing on topics with a broader integrated perspective.

When the next major weed management challenge arrives, will we be prepared with the knowledge and skilled workforce capable of implementing an integrated solution?

Policies to cultivate IWM

Several changes in policy could reduce the likelihood that the next generation of herbicide-resistant crops will result in negative consequences for food production and the environment and could ensure that IWM thrives as a sustainable alternative in the future. To be clear, we are not advocating the prohibition of herbicide-resistant crops; there is ample evidence attesting to the economic and environmental benefits that can be realized if these technologies are used judiciously (Duke and Powles 2009). Rather, we are advocating that concrete policy steps be taken to ensure that we learn from our problematic experiences with glyphosate resistance, such that the new herbicide-resistant crops are adopted as only one component of fully integrated weed management systems. Such policies could include USEPA-mandated resistant-weed management plans, fees discouraging single-tactic weed management, improved grower education programs implemented through industry–university–government collaborations, and environmental payments that connect IWM to broader environmental goals.

First, the USEPA, and similar agencies in other countries, should require that registration of new transgene–herbicide crop combinations explicitly address herbicide-resistant-weed management. Weed scientists and industry spokespeople have frequently expressed skepticism that resistance management regulations would be enforceable and have instead placed the burden on education and promotional efforts by agribusinesses or the responsible behavior of individual growers (NRC 2010). However, in *Bacillus thuringiensis* (Bt) cropping systems, regulations requiring non-Bt refugia have largely prevented the evolution of insect resistance to Bt and protected the effective and sustainable use of this biotechnology (NRC 2010), although improvements may be needed in monitoring and compliance (NRC 2010). For herbicides, regulations need not be focused on local refugia but could implement spatially explicit, area-wide management plans that work to reduce selection pressure at landscape or regional scales. These plans could mandate carefully defined patterns of herbicide rotation or could set upper limits on the total sales of a specific herbicide active ingredient or of a resistant seed variety within an agricultural county. Efficient allocation of crop hectares treated with a specific herbicide or planted with a resistant variety could be achieved through a tradable-permit system.

Second, fees directly connected to the sale of herbicide-resistant seeds or the associated herbicides could provide a disincentive for overreliance on the technology package (Liebman et al. 2001). These fees could be scaled to specifically discourage overuse, such that a grower or applicator would be charged only if a specified threshold in planted hectares or successive applications were exceeded. The proceeds from the fees could be funneled directly into funds for public university research and education programs that promote the understanding and adoption of IWM techniques among farmers. In Iowa, similar levies on pesticides are used to fund Iowa State University's Leopold Center, which has played a significant role in the development of IWM science (Liebman et al. 2001).

Third, stronger partnerships among industry, universities, and government could foster IWM through more effective education and extension efforts. When new herbicide active ingredients or herbicide-resistant crop varieties are brought to market, seed and agrichemical companies often develop

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product-stewardship plans intended to educate growers, applicators, and salespeople on IWM practices to prevent or manage herbicide-resistant weeds. However, because past and current stewardship plans have been developed by an industry driven by herbicide sales, the IWM concept articulated in these plans is largely reduced to simply rotating or combining herbicide active ingredients and fails to promote a more comprehensive set of chemical and nonchemical weed management practices. The ever-growing number of herbicide-resistant weeds (figure 3; Heap 2011) indicates that a solely industry-led approach to herbicide stewardship and IWM education is insufficient and ineffective. Before synthetic auxin–resistance traits are brought to market, stewardship plans could be revised with more comprehensive participation and oversight from government and universities. For instance, sales literature and labels for resistant crops and the associated herbicides could include more extensive detail on a wider set of resistance-management practices available to growers and could provide access to university or government IWM information resources. Industry-sponsored field days and promotional events could be required to include university scientists and to provide ample time devoted to IWM education. Renewal of herbicide or GM trait registrations could be made contingent on compliance with these more aggressive stewardship plans.

Finally, as research continues to develop and refine IWM practices, their adoption could be enhanced through environmental-support payments that connect weed management to broader environmental issues. This approach is working in Maryland, where, following growing public concern and awareness of declining water quality and hypoxic "dead zones" from nutrient loading caused by agriculture, the Maryland Department of Agriculture launched a cost-sharing program that provided growers in the Chesapeake Bay watershed with economic incentives to grow winter cover crops (MDA 2011). Cover crops can reduce nutrient losses from fields (Munawar et al. 1990), and by creating weed-suppressive mulches, they can also be a valuable component of IWM systems. This program has been widely embraced by farmers and contributed to cover crops' being planted on hundreds of thousands of hectares, which has had a positive impact on water quality and promoting IWM techniques. This effort is supported by state and federal tax dollars and has been sustained because citizens living within the watershed were provided with information regarding the impact that agricultural practices have on water quality, resulting in a willingness to pay for mitigation efforts, including cover crop cost-sharing programs. The foundation of successful IWM is diversity, which is also a well-recognized pillar of sustainable agroecosystem management. Similar opportunities may exist to connect IWM practices to a range of environmental goals, including on-farm energy efficiency, soil-quality management, or agrobiodiversity conservation, and may help advance toward a more multifunctional agriculture (Boody et al. 2005). Research and extension programs exploring these connections would need to be scaled up if sufficient willingness to pay for alternatives can be achieved.

No single policy will adequately address our growing overreliance on a transgenic approach to weed management. Rather, a combination of policies will be necessary to secure a more sustainable agriculture, including (a) regulatory mandates for resistant-weed management, (b) enhanced funding for IWM research and education, (c) collaboratively designed herbicide stewardship plans, and (d) environmental payment incentives for the adoption of IWM practices. Next-generation GM herbicide-resistant crops are rapidly moving toward commercialization. Given this critical juncture, it is time to consider the implications of accelerating the transgene-facilitated herbicide treadmill and to rejuvenate our commitment to alternative policies that safeguard agriculture and the environment for the long term.

Acknowledgments

We thank Bill Curran, Leland Glenna, Bob Hartzler, and the Penn State weed ecology lab for helpful comments and insights on earlier versions of the manuscript. Ian Graham provided assistance compiling and analyzing data from the International Survey of Herbicide Resistant Weeds database (*www.weedscience.org*).

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CENTER FOR FOOD SAFETY

Dicamba: New Use on Herbicide-Tolerant Cotton and Soybeans
Environmental Protection Agency, Mailcode 28221T
1200 Pennsylvania Ave., NW
Washington, D.C. 20460

Docket No. EPA-HQ-OPP-2016-0187

Comments on the Proposed Unconditional Registration for the New Uses of Dicamba on Genetically Engineered, Dicamba-Resistant Soybean and Cotton

The Center for Food Safety (CFS) hereby submits the following comments on the United States Environmental Protection Agency (EPA or the Agency)'s proposed unconditional registration for the new uses of the herbicide dicamba on genetically engineered (GE), dicamba-resistant soybean and cotton. The proposed new uses will be added to Monsanto Company's currently registered herbicide product M1691 (EPA Registration No. 524-582), which contains 58.1% of the active ingredient dicamba, diglycolamine salt (dicamba or dicamba DGA) for both pre- and post-emergence applications to Monsanto's dicamba-resistant soybean and cotton.

CFS is a national, nonprofit public interest and environmental advocacy organization working to protect human health and the environment by curbing the use of harmful food production technologies. In furtherance of this mission, CFS uses legal actions, groundbreaking scientific and policy reports, books and other educational materials, and grassroots campaigns, on behalf of its nearly 750,000 members. CFS is a recognized national leader on the issue of GE organisms and pesticides, and has worked on improving their regulation and addressing their impacts continuously since the organization's inception in 1997.

The comments submitted by CFS herein also incorporate by reference and supplement the detailed legal and scientific comments and supporting reference materials and studies that CFS submitted at earlier stages of this agency proposal, specifically, the 2012 notice of receipts of new use applications published by EPA, Docket No. EPA-HQ-OPP-2012-0841. CFS will not duplicate and repeat comments that it has already submitted numerous times, nor the detailed critiques and demands for lawful compliance and proper scientific analysis that EPA has yet to answer, address, or explain. Rather, these comments will incorporate previously unaddressed points and add to them with further deficiencies in EPA's proposed new use registration.

As explained in detail in CFS's previous comments and the comments submitted herein, EPA's proposed registration of dicamba for use on dicamba-resistant cotton and soybean violates all applicable statutes, specifically, the Agency's duties under the Federal

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Insecticide, Fungicide, and Rodenticide Act (FIFRA), the Federal Food, Drug, and Cosmetic Act (FFDCA), the Migratory Bird Treaty Act (MBTA), and the Endangered Species Act (ESA). EPA's assessment underestimates the true costs of the proposed new use registration, relies on erroneous assumptions and uncertainties, as well as unenforceable mitigation measures. EPA has not made the requisite finding, mandated under FIFRA, to approve the proposed registration of dicamba on dicamba-resistant GE cotton and soybean. Similarly, EPA's approach to assessing effects to listed species is contrary to the ESA's legal mandate. EPA's current assessment fails to consider available data and literature that identify the significant environmental, human health, and socioeconomic risks of the proposed new uses, as well as effects to listed species and their critical habitats. The proposed registration of dicamba for use on dicamba-resistant cotton and soybean would not only result in unreasonable adverse effects to the environment, but will also jeopardize federally protected species and their critical habitats. Rather than approving the proposed new uses of dicamba on dicamba-resistant, GE cotton and soybean, EPA must cure the numerous legal and scientific deficiencies in their current risk assessments.

RELEVANT LEGAL STANDARDS

The Federal Insecticide, Fungicide, and Rodenticide Act

FIFRA authorizes EPA to regulate the registration, use, sale, and distribution of pesticides in the United States. FIFRA defines pesticides broadly to include herbicides—"any substance or mixture of substances intended for use as a plant regulator, defoliant, or desiccants."[1] Under FIFRA, EPA is "charged to consider the effects of pesticides on the environment."[2]

Pursuant to FIFRA, EPA oversees both initial registration of an active ingredient as well as any new uses of the registered active ingredient of a pesticide. FIFRA mandates that prior to approving any pesticide registration and any new uses of the pesticide, EPA consider the "impacts on human health, occupational risks, and environmental risks"[3] of the proposed pesticide formulation and its proposed uses. FIFRA "protects human health and prevents environmental harms from pesticides" by requiring EPA to conduct a risk-benefit analysis of the pesticides.[4] Under FIFRA, EPA cannot register the pesticide unless EPA concludes that the proposed new use "will not generally cause unreasonable adverse effects on the environment" when "perform[ing] its intended function" and "when used in accordance with widespread and commonly recognized practice."[5] FIFRA defines "unreasonable adverse effects on the environment" as "<u>any</u> unreasonable risk to man or the environment, taking into account the economic, social, and environmental costs and

[1] 7 U.S.C. § 136(u)(2).
[2] *Fairhurst v. Hagener*, No. CV-03-67-BU-SHE, 2004 U.S. Dist. LEXIS 30161, at *49 (D. Mont. Mar. 24, 2004).
[3] EPA, Overview of Risk Assessment in the Pesticide Program (May 9, 2012), at http://www.epa.gov/pesticides/about/overview_risk_assess.htm.
[4] *Wash. Toxics Coalition v. EPA*, 413 F.3d 1024, 1032 (9th Cir. 2005).
[5] 7 U.S.C. § 136a(c)(5).

benefits of the use of any pesticide."[6] FIFRA defines "environment" broadly to include "water, air, land, and all plants and man and other animals living therein, <u>and the interrelationships which exist among these</u>."[7] In sum, FIFRA's broad statutory definition of the phrase "unreasonable adverse effects on the environment" mandates that EPA consider all economic, social and environmental risks, including risks that are interrelated and indirect results of the proposed registration, in the agency's review of a proposed registration.

Section 3(c) of FIFRA states that a manufacturer must submit an application to register the use of a pesticide.[8] Section 3(c) of FIFRA outlines two types of pesticide use registrations: unconditional or conditional.[9] Under Section 3(c)(5) of FIFRA, EPA shall register a pesticide if the agency determines that the pesticide "will perform its intended function without unreasonable adverse effects on the environment" and that "when used in accordance with widespread and commonly recognized practice[,] it will not generally cause unreasonable adverse effects on the environment."[10] EPA may also conditionally register a pesticide or proposed new use conditionally, under section 3(c)(7) of FIFRA. Of relevance to the present applications to register dicamba for uses on dicamba-resistant, GE cotton and soybean, EPA may conditionally amend the existing dicamba registration if EPA determines that "the pesticide and proposed use are identical or substantially similar to any currently registered pesticide and use therefor, or differ only in ways that would not significantly increase the risk of unreasonable adverse effects on the environment," and that "approving the registration or amendment in the manner proposed by the applicant would not significantly increase the risk of any unreasonable adverse effect on the environment."[11] Alternatively, EPA "may conditionally amend the registration of a pesticide to permit additional uses of such pesticide," but only if EPA concludes that "the applicant has submitted satisfactory data pertaining to the proposed additional use," and that "amending the registration in the manner proposed by the applicant would not significantly increase the risk of any unreasonable adverse effect on the environment."[12]

Alternatively, where there are data gaps and missing information, EPA can register a pesticide with conditions (conditional registration) under Section 3(c)(7) of FIFRA "for a period reasonably sufficient for the generation and submission of required data," but only if EPA also determines that the conditional registration of the pesticide during that time period "will not cause any unreasonable adverse effect on the environment, and that use of the pesticide is in the public interest."[13]

FIFRA also mandates that, as part of the registration of a pesticide and its proposed

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[6] 7 U.S.C. § 136(bb) (emphasis added).
[7] 7 U.S.C. § 136(j).
[8] 7 U.S.C. § 136a(c)(1); 40 C.F.R. § 152.42.
[9] 7 U.S.C. § 136a(c)(5), (7).
[10] 7 U.S.C. § 136a(c)(5).
[11] 7 U.S.C. § 136a(c)(7)(A).
[12] 7 U.S.C. § 136a(c)(7)(B).
[13] 7 U.S.C. §136a(c)(7)(C).

uses, EPA shall classify the pesticide and its use as either "general use" or "restricted use."[14] Under FIFRA, EPA must classify a pesticide and its proposed use as "restricted use" if "the pesticide, when applied in accordance with its directions for use, warnings and cautions and for the uses for which it is registered, or for one or more of such uses, or in accordance with a widespread and commonly recognized practice, may generally cause, without additional regulatory restrictions, unreasonable adverse effects on the environment, including injury to the applicator."[15]

The culmination of the registration process is EPA's approval of a label for the pesticide, including use directions and appropriate warnings on safety and environmental risks. It is a violation of FIFRA for any person to sell or distribute a "misbranded" pesticide.[16] A pesticide is misbranded if the "labeling accompanying it does not contain directions for use which … if complied with … are adequate to protect health and the environment."[17]

The Federal Food, Drug, and Cosmetic Act

The FFDCA[18] prohibits the introduction of "adulterated" food into interstate commerce.[19] The Act requires that where use of a pesticide will result in any pesticide residue being left on food, the EPA must either set a "tolerance" level for the amount of allowable pesticide residue that can be left on the food, or set an exemption of the tolerance requirement.[20] The tolerance or exemption requirements apply to raw agricultural commodities such as dicamba-resistant cotton and soybean.[21]

The FFDCA mandates EPA to "establish or leave in effect a tolerance for a pesticide chemical residue in or on a food only if the EPA Administrator determines that the tolerance is safe".[22] For a tolerance level to be "safe," the statute requires EPA determine "that there is a reasonable certainty that no harm will result from aggregate exposure to the pesticide chemical residue, including all anticipated dietary exposures and all other exposures for which there is reliable information."[23] "Aggregate exposure" includes not only dietary exposure through food consumption, but also exposure from all nonoccupational sources, including "exposures through water and residential uses," as well as the cumulative effects of the particular pesticide's residues "and other substances that have a common

[14] 7 U.S.C. § 136a(d)(1)(A).
[15] 7 U.S.C. § 136a(d)(1)(C).
[16] 7 U.S.C. § 136j(a)(1)(E).
[17] 7 U.S.C. § 136(q)(1)(F).
[18] 21 U.S.C. § 301 *et seq.*
[19] 21 US.C. § 331.
[20] 21 U.S.C. § 346a(1).
[21] 21 U.S.C. § 321(r) defines "raw agricultural commodities" as "any food in its raw or natural state, including all fruits that are washed, colored or otherwise treated in their unpeeled natural form prior to marketing."
[22] 21 U.S.C. § 342a(2)(A) (emphasis added); *see also* 40 C.F.R. § 180.1(f).
[23] 21 U.S.C. § 346a(2)(A)(ii).

mechanism of toxicity."[24] The Act further requires that, in determining the "safe" tolerance level, EPA must specifically consider potential routes of exposure to infants and children, and apply additional margin of safety for the pesticide residue and other sources of exposure to ensure that the tolerance level will be safe for infant and children.[25]

The 1996 passage of the Food Quality Protection Act ("FQPA"), Pub. L. No. 104-170, 110 Stat. 1489, amended EPA's statutory duties under both FIFRA and the FFDCA. Specifically, the FQPA mandates that EPA gives extra consideration to account for risks to infants and children from pesticide exposure.[26] As such, the FFDCA directs that in determining the tolerance level, "an additional tenfold margin of safety for the pesticide residue and other sources of exposure shall be applied … with respect to exposure to toxicity to infants and children."[27] However, the presumptive 10X FQPA safety factor is not always required; the FFDCA provides that the EPA "*may* use a different margin of safety for the pesticide chemical residue," but "only if, on the basis of reliable data, such margin will be safe for infants and children."[28]

Endangered Species Act

As recognized by the Supreme Court, the ESA is "the most comprehensive legislation for the preservation of endangered species ever enacted by any nation."[29] The ESA's statutory scheme "reveals a conscious decision by Congress to give endangered species priority over the 'primary missions' of federal agencies."[30] Federal agencies are obliged "to afford first priority to the declared national policy of saving endangered species."[31]

Section 7(a)(2) of the ESA requires every federal agency to consult the appropriate federal fish and wildlife agency—Fish and Wildlife Service (FWS), in the case of land and freshwater species and the National Marine Fisheries Service (NMFS) in the case of marine species—to "insure" that the agency's actions are not likely "to jeopardize the continued existence" of any listed species or "result in the destruction or adverse modification" of critical habitat.[32]

The ESA's implementing regulations broadly define agency action to include "all activities or programs of any kind authorized, funded or carried out … by federal agencies," including the granting of permits and "actions directly *or* indirectly causing modifications to the land, water or air."[33] The scope of an action, or "action area," is also broadly defined,

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[24] 21 U.S.C. § 346a; *see Natural Res. Def. Council v. Whitman*, No. C 99-03701-WHA, 2001 WL 1221774 (N.D. Cal. Nov. 7, 2001).
[25] 21 U.S.C. § 346a(c).
[26] *See* 21 U.S.C. § 346a(b)(2)(C).
[27] *Id.*
[28] *Id.* (emphases added).
[29] *Tenn. Valley Authority v. Hill*, 437 U.S. 153, 180 (1978).
[30] *Id*. at 185.
[31] *Id.*
[32] 16 U.S.C. § 1536(a)(2); *see also* 50 C.F.R. § 402.01(b).
[33] 50 C.F.R. § 402.02 (emphasis added).

and includes "all areas to be affected directly or indirectly by the federal action and not merely the immediate area involved in the action."[34] The potential "effects" of an action that an agency must consider are similarly broad, and include both "direct" and "indirect" effects of the action and all activities "interrelated or interdependent" with that action.[35] Finally, a species' "critical habitat" includes those areas identified as "essential to the conservation of the species" and "which may require special management considerations or protection."[36]

FWS and NFMS have adopted joint regulations governing the Section 7(a)(2) consultation process. Every federal agency, using the "best scientific and commercial information available,"[37], must first determine whether its actions—here, EPA's proposed registration of dicamba use on dicamba-resistant GE cotton and soybean—"may affect" any listed species or designated critical habitat, and if so initiate a Section 7(a)(2) consultation with NMFS or FWS.[38] The threshold for a "may affect" determination is very low, and includes "any possible effect, whether beneficial, benign, adverse, or of an undetermined character."[39]

The ESA requires each federal agency that plans to undertake an action to request information from the expert agency "whether any species which is listed or proposed to be listed [as an endangered species or a threatened species] may be present in the area of such proposed action."[40] If FWS/NMFS advises the agency that listed species or species proposed to be listed may be present, the agency must then prepare a biological assessment for the purpose of identifying any such species that are likely to be affected by the proposed agency action.[41] If, based on a biological assessment, an agency determines that its proposed action may affect any listed species and/or their critical habitat, the agency generally must engage in consultation with FWS/NMFS.[42]

ESA consultation may in some cases be informal.[43] If, after informal consultation, the expert federal wildlife agency concurs in writing that the action is "not likely to adversely affect" any listed species or critical habitat, the process ends.[44] Otherwise, the agency must enter formal consultation.[45] Formal consultation "is a process between the Service and the [f]ederal agency that commences with the [f]ederal agency's written request for consultation under section 7(a)(2) of the Act and concludes with the Service's issuance of

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[34] *Id.*
[35] *Id.*
[36] 16 U.S.C. § 1532(5)(A).
[37] 16 U.S.C. § 1536(a)(2).
[38] 50 C.F.R. § 402.14(a).
[39] *See* 51 Fed. Reg. 19,926, 19,949 (June 3, 1986) (Codified at 50 C.F.R. pt. 402).
[40] 16 U.S.C. § 1536(c)(1); *see also* 50 C.F.R. § 402.12(c).
[41] *Id.*
[42] 50 C.F.R. § 402.14.
[43] 50 C.F.R § 402.13(a).
[44] 50 C.F.R. § 402.14(b).
[45] 50 C.F.R. § 402.14(a).

the biological opinion under section 7(b)(3) of the Act."[46] At the end of the formal consultation, FWS/NMFS must provide the agency with a "biological opinion" detailing how the proposed action will affect the threatened and endangered species and/or critical habitats.[47] If FWS/NMFS concludes that the proposed action will jeopardize the continued existence of a listed species or result in the destruction or adverse modification of critical habitat, the biological opinion must outline "reasonable and prudent alternatives" to the proposed action that would avoid violating ESA section 7(a)(2).[48]

Pending the completion of formal consultation with the expert agency, an agency is prohibited from making any "irreversible or irretrievable commitment of resources with respect to the agency action which has the effect of foreclosing the formulation or implementation of any reasonable and prudent alternative measures."[49]

Migratory Bird Treaty Act

The Migratory Bird Treaty Act (MBTA) implements the obligations of the U.S. under several international treaties and conventions for the protection of migratory birds.[50] The MBTA mandates that proposed projects must avoid the take of migratory birds entirely and must minimize the loss, destruction, and degradation of migratory bird habitat.[51] The vast majority of U.S. native birds are protected under the MBTA, even those that do not participate in international migrations.[52] Under the MBTA, "[n]o person may take, possess, import, export, transport, sell, purchase, barter, or offer for sale, purchase, or barter, any migratory bird, or the parts, nests, or eggs of such bird except as may be permitted under the terms of a valid permit."[53]

COMMENTS

As analyzed in detail below and CFS's previously-submitted comments and supporting documents to Docket No. EPA-HQ-OPP-2012-0841, EPA's proposed new use registration of dicamba for use on Monsanto's dicamba-resistant GE cotton and soybean mark a significant departure from existing use patterns of dicamba on existing varieties of cotton and soybean. The novelty of the proposed new use on two widely planted agricultural crops in the United States demands that EPA carefully consider all of the "economic, social, and environmental costs" against any purported benefits associated with the proposed new uses in its risk assessments.[54] Under FIFRA, EPA cannot approve the proposed new use of dicamba on dicamba-resistant GE cotton and soybean if the Agency's assessment reveals that the proposed registration may result in unreasonable adverse

[46] 50 C.F.R. Id. § 402.02.
[47] 16 U.S.C. § 1536(b); 50 C.F.R. § 402.14.
[48] 16 U.S.C. § 1536(b)(3)(A).
[49] 16 U.S.C. § 1536(d).
[50] 16 U.S.C. § 701.
[51] *Id.* § 701–12.
[52] *See* 50 C.F.R. § 10.13.
[53] *Id.* § 21.11.
[54] 7 U.S.C. §136(bb).

effects on the environment. EPA must also ensure that "there is a reasonable certainty that no harm to humans, including sensitive populations, will result from aggregate exposure" to dicamba.[55]Separately, the ESA requires that EPA consult the appropriate federal expert agency to "insure" that the agency's actions are not likely "to jeopardize the continued existence" of any listed species or "result in the destruction or adverse modification" of critical habitat.[56] The MBTA mandates that proposed projects must avoid the take of migratory birds entirely and must minimize the loss, destruction, and degradation of migratory bird habitat.[57] EPA's current assessments fail to meet these statutory duties. To the contrary, EPA's assessments demonstrate that the proposed new uses of dicamba would result in unreasonable adverse effect on the environment, to the detriment of threatened and endangered species and their critical habitats. EPA must revise and supplement its current risk assessments, and conduct the requisite ESA consultation, before moving forward with the proposed approval of dicamba use on dicamba-resistant GE cotton and soybean.

I. EPA's Assessment of the Impacts to Threatened and Endangered Species from the Proposed New Uses of Dicamba on Dicamba-Resistant GE Cotton and Soybean Is Legally Deficient.

EPA's assessment of the potential risks to federally listed threatened and endangered species from the proposed approval is legally deficient, in violation of the ESA and FIFRA. EPA's current assessment is unlawful because the Agency improperly assumed that some level of effect to listed species is acceptable. Despite initially finding that exposure to the proposed new uses of dicamba carried great risks for numerous federally listed and threated species, the Agency unilaterally eliminated its "may affect" finding and instead switched to "no effect" determinations by narrowing the "action area" and relying on unrealistic mitigation measures such as buffer zones. EPA's approach here violates the ESA, as well as the agency's stated approach in assessing pesticide risks to listed species. EPA also failed to adequately consider various direct and indirect effects to non-target species, including listed species, such as exposure to dicamba from drift, volatilization, other forms of dicamba degradation and contamination of the environment, as well as synergistic effects of dicamba toxicity when used with other pesticides.[58] EPA's lack of sufficient analysis violates the Agency's duty under the ESA and FIFRA.

First, EPA's current approach to considering potential impacts to threatened and endangered species is legally deficient, in violation of the ESA. EPA uses "levels of concern" and "risk quotients" to determine if listed species will be effected throughout its ESA risk assessments, from screening level through more refined assessments. For example, "EPA determines that there is "no effect" on listed species if, at any step in the screening level assessment, no levels of concern are exceeded. If, after performing all the steps in the screening level assessment, a pesticide still exceeds the Agency's levels of concern for listed

[55] 21 U.S.C. § 346a.
[56] 16 U.S.C. § 1536(a)(2); *see also* 50 C.F.R. § 402.01(b).
[57] *Id.* § 701–12.
[58] *Id.*

species, EPA then conducts a species-specific refined assessment to make effects determinations for individual listed species…."[59] At the species-specific level, EPA also uses "levels of concern" and "risk quotients" based on modeling exposure to predicted environmental exposure.[60]

These determinations are not based on whether there is any effect at all, but on whether any effects predicted are of concern to EPA. This is contrary to the ESA's definition of "may affect," which is broadly defined to include "any possible effect, whether beneficial, benign, adverse, or of an undetermined character."[61] EPA's current approach, relying on "risk quotients" and "levels of concern," falls short of the agency's duty under the ESA.

Second, EPA's current approach is also unlawful because EPA improperly switches from a "may affect" to a "no effect" finding after unilateral analysis. EPA's own policy provides that where a screening level assessment shows the risk threshold is exceeded for a listed species, EPA may conduct further refined analysis, but such refined analysis will not determine "no effect" and avoid consultation. Instead, the agency's refined assessment is only used to make the "not likely to adversely affect"/"likely to adverse effect" determination, which then can be used to allow EPA to forego formal consultation, but only if the expert wildlife agency concurs in writing with EPA's determination after informal consultation. [62]

Here, EPA's initial assessments of the various states concluded that there are numerous species that may be directly or indirectly affected by dicamba use. EPA switched to "no effect" findings after the agency's unilateral further analyses with three "refined endangered species assessments" for soybean and cotton, for 3 different sets of states. In these documents, EPA drills down to particular listed species and their habitats and requirements to determine ESA "no effect" or "may effect" designations:

- In the Addendum Assessment for 16 states, 183 listed species were identified as occurring in counties where soybeans and cotton are grown. At the screening level, EPA concluded that 10 of these species would be expected to occur on the fields themselves where they would be exposed to dicamba and its metabolites, triggering a "May Affect" determination under the ESA. Yet, EPA proceeded with unilateral further refined analysis, whereby EPA reverted to "no effect" findings for 9 of the species. EPA only gave 1 of these

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[59] EPA, *Addendum to Dicamba Diglycolamine Salt (DGA) and its Degradate, 3,6-dichlorosalicylic ac id (DCSA) Section 3 Risk Assessment: Refined Endangered Species Assessment for Proposed New Uses on Herbicide-Tolerant Soybean and Cotton in 16 states (Arkansas, Illinois, Iowa, Indiana, Kansas, Louisiana, Minnesota, Mississippi, Missouri, Nebraska, North Dakota, Ohio, Oklahoma, South Dakota, Tennessee, and Wisconsin)* 2-3 (Mar. 24, 2016) [hereinafter *Addendum Assessment for 16 States*].
[60] *See, e.g.*, EPA, *Addendum Assessment for 16 States*, at 7.
[61] *See* 51 Fed. Reg. 19,926, 19,949 (June 3, 1986) (Codified at 50 C.F.R. pt. 402).
[62] EPA, *Overview of the Ecological Risk Assessment Process in the Office of Pesticide Programs, U.S. Environmental Protection Agency. Listed and Threatened Species Effects Determinations* (2004); *see also* EPA, *Assessing Pesticides under the Endangered Species Act,* http://www2.epa.gov/endangered-species/assessing-pesticides-under-endangered-species-act.

species a "May Affect" determination, and "Likely to Adversely Affect": Spring Creek Bladderpod, found only in Wilson County, TN.[63]

- For its assessment of risks to listed species in the 7 states (Alabama, Georgia, Kentucky, Michigan, North Carolina, South Carolina, and Texas),[64] of 307 listed species in cotton and soybean counties, EPA concluded that 10 species would be expected to occur on the fields themselves and thus be exposed and may be affected. During refined assessments, EPA gave all but 1 "No effect" determinations.[65] The Eskimo Curlew (bird) was given a "May Affect" determination, and although potentially found in 23 counties in Nebraska and 1 in Texas, is "presumed extinct," so was designated "Not Likely to Adversely Affect."

- For its assessment of risks to listed species in 11 states (Arizona, Colorado, Delaware, Florida, Maryland, New Mexico, New Jersey, New York, Pennsylvania, Virginia and West Virginia),[66] of 322 listed species in cotton and soybean counties, EPA concluded that 14 species would be expected to occur on the fields themselves and thus be exposed and may be affected. During refinement, all but 1 were given "No effect" determinations by EPA.[67] The Audubon Crested Caracara (bird) was given a "May Affect" and "Not Likely to Adversely Affect" determination for Palm Beach County in Florida, only.

- For all three ESA refined assessments, all critical habitats were given a "No Modification" determination. Most "No Modification" determinations were based EPA's assessment that the associated listed species did not use cotton or soybean fields and hence cannot be impacted by on-field exposure to dicamba DGA. For the few critical habitats of species that EPA determined do use cotton or soybean fields, EPA first assumed there may be modification, then unilaterally arrived at a "No Modification" determination after a more refined analysis that focused on the species' exposure to dicamba within cotton and soybean fields, and that assumed there would be an acceptable

[63] EPA, *Addendum Assessment for 16 States*, at 3-4.
[64] EPA, *Addendum to Dicamba Diglycolamine Salt (DGA) and its Degradate, 3,6-dichlorosalicylic acid (DCSA) Section 3 Risk Assessment: Refined Endangered Species Assessment for Proposed New Uses on Herbicide-Tolerant Soybean and Cotton in 7 states (Alabama, Georgia, Kentucky, Michigan, North Carolina, South Carolina, and Texas)* 3-4 (Mar. 24, 2016) [hereinafter *Addendum Assessment for 7 States*].
[65] *Id.*
[66] EPA, *Addendum to Dicamba Diglycolamine Salt (DGA) and its Degradate, 3,6-dichlorosalicylic ac id (DCSA) Section 3 Risk Assessment: Refined Endangered Species Assessment for Proposed New Uses on Herbicide-Tolerant Soybean and Cotton in 11 states (*Arizona, Colorado, Delaware, Florida, Maryland, New Mexico, New Jersey, New York, Pennsylvania, Virginia and West Virginia) 4 (Mar. 24, 2016) [hereinafter *Addendum Assessment for 11 States*].
[67] *Id.* at 4.

threshold of impact based on the Agency's "risk quotients" and "levels of concern."[68]

EPA cannot unilaterally undo a "may affect" finding as it did here in refining assessments. EPA's most-recent guidance on assessing pesticide risks to listed species notes that "any species or critical habitat that overlaps with the action area *will be considered a 'May Affect.'*"[69] The guidance confirms unequivocally: "For species and critical habitats that do overlap with the action area, the call *will be 'May Affect,'* and the analysis *will proceed* with [informal consultation with FWS]." [70] Here, EPA reached "may affect" findings for 24 unique listed species based on habitat co-occurrence with dicamba use on cotton and soybean fields and did not consult the expert agencies, in contravention of the ESA's legal triggers and the Agency's own guidance on ESA assessments.

In addition, EPA determined that there would be no effect on almost all of the hundreds listed species identified at the screening level as co-occurring in counties where cotton and soybeans are grown by unrealistically narrowing the "action area" to only within GE cotton or GE soybean fields that had been sprayed with dicamba DGA. EPA similarly concluded that there would be no modification to listed species' critical habitats solely based on the fact that the species did not use cotton or soybean fields. EPA's approach is unlawful under the ESA.

As detailed below, EPA's approach is arbitrary and capricious, and scientifically indefensible, in violation of the agencies' duties under ESA and FIFRA.

1. Exposure to listed species from off-site movement of dicamba

EPA's rationale for limiting the potential impacts of dicamba on listed species to within the boundaries of treated fields is based on putting mitigation measures in the label language that EPA states will result in no direct dicamba exposure outside of those fields (terrestrial species), or exposure below EPA's level of concern (critical habitats, aquatic species) .[71]

EPA's rationale is faulty. EPA's own calculations of movement of dicamba do in fact predict that this registration action will result in off-site dicamba transport, and thus potentially expose those listed species and critical habitats that occur outside of treated fields, requiring a "may effect" finding for more species than EPA has so far determined.

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[68] EPA, *Addendum Assessment for 7 States*, at 29-31; EPA, *Addendum Assessment for 11 States*, at 25-26; EPA, *Addendum Assessment for 16 States*, at 100-101.
[69] EPA, *Interim Approaches for National-Level Pesticide Endangered Species Act Assessments Based on the Recommendations of the National Academy of Sciences April 2013 Report*, at 4, *available at* http://www2.epa.gov/sites/production/files/2015-07/documents/interagency.pdf.
[70] *Id.*
[71] EPA, *Addendum Assessment for 11 States*, at 6.

For example, in the Proposed Registration Document,[72] EPA describes how the proposed buffer distances were determined, and concludes that "[u]sing these buffers, expected residues at the field's edge from spray drift would be below apical endpoints for the most sensitive tested species (i.e. NOAEC for soybean plant height)."

For volatilization, EPA admits that it doesn't have enough information to determine if the proposed in-field buffers are sufficient.[73] Rather than require more data before taking this registration action, and ignoring incident data showing injury to sensitive crops well beyond its chosen buffer distances, EPA is going to reconsider the efficacy of the buffer distances "if" it receives more volatility data.[74] In the meantime, listed species far away from application sites may be affected by exposure to dicamba from volatilization. This violates EPA's duties under both ESA and FIFRA.

EPA finds that dicamba residues will leave treated fields into surrounding waterways via runoff, where many kinds of aquatic and semi-aquatic organisms could be directly exposed,[75] and also terrestrial plants[76] Terrestrial animals also may come into contact with dicamba-contaminated runoff.

In fact, EPA shows over and over throughout the environmental assessments in the docket,[77] that even with mitigation measures in place, some dicamba is expected outside of field boundaries due to spray drift, volatilization and runoff.[78] Stating categorically that terrestrial species outside of field boundaries are "not expected to be directly exposed to dicamba DGA" is thus at odds with EPA's own models and calculations - assessments EPA has done for this very registration action, and is contrary to the agency's legal mandates under the ESA.

For aquatic organisms, EPA's rationale for "no effect" determinations based on exposures below levels of concern is unlawful, as discussed above, since EPA does estimate particular levels of dicamba in runoff. In addition, EPA has estimated an environmental

[72] EPA, *Proposed Registration of Dicamba on Dicamba-Tolerant Cotton and Soybean* 17 (Mar. 31, 2016) [hereinafter *Proposed Registration Document*].
[73] *See* EPA, *Proposed Registration Document*, at 17; EPA, *Dicamba DGA: Second Addendum to the Environmental Fate and Ecological Risk Assessment for Dicamba DGA Salt and Its Degradates, 3,6-dichlorosalicylic acid (DCSA) for the Section 3 New Use on Dicamba-Tolerant Soybean* 10 (Mar. 24, 2016) [hereinafter *Second Addendum to Ecological Risk Assessment for Dicamba Use on Dicamba-Tolerant Soybean*].
[74] EPA, *Proposed Registration Document*, at 17.
[75] *See* EPA, *Second Addendum to Ecological Risk Assessment for Dicamba Use on Dicamba-Tolerant* Soybean, at 21, 31-33; EPA, *Ecological Risk Assessment for Dicamba DGA Salt and Its Degradates, 3,6-dichlorosalicylic acid (DCSA), for the Proposed Post-Emergence New Use on Dicamba-Tolerant Cotton (MON87701)* 14 (Mar. 24, 2016) [hereinafter *Ecological Risk Assessment for Dicamba Use on Dicamba-Tolerant Cotton*].
[76] EPA, *Addendum Assessment for 16 States* at 6.
[77] *See* EPA, *Second Addendum to Ecological Risk Assessment for Dicamba Use on Dicamba-Tolerant Soybean* at 2-11 (especially, using new data on drift and volatilization)
[78] *See* EPA, *Proposed Registration Document*, at 16-18.

concentration for surface waters from dicamba applications to dicamba-resistant cotton[79] that is much higher than concentrations shown to cause endocrine effects in fish.[80]

Besides offsite movement of dicamba admitted by EPA, there are deficiencies in EPA's assumptions about off-field exposure to dicamba and dicamba metabolites that lead to underestimates of exposure for both terrestrial and aquatic species.

For example, EPA assumes that terrestrial mammals and birds will only ingest DCSA, a toxic metabolite of dicamba, if those animals are within sprayed fields: "Based on the available plant metabolism data for DCSA on non-DT plants, EFED assumed that any exposure for terrestrial vertebrates occurs as a result of feeding solely on DCSA in DT soybean and no exposure to DCSA is expected for terrestrial vertebrates feeding off the field, even if dicamba residues should occur following spray drift or volatilization. This is because the conversion of dicamba to DCSA in plants is only expected to occur in crops modified to be tolerant to dicamba."[81]

EPA does not consider exposure to dicamba and DCSA from ingestion of dicamba-resistant crop material that leaves the field via wind or runoff, even though detritus from crop fields is well known to move away from fields and to persist in the environment, and to serve as a reservoir of pesticides and metabolites in aquatic and terrestrial areas.[82] This is a serious omission, and may affect both terrestrial and aquatic animals.

Insects and other arthropods that have fed on dicamba-resistant crop tissues and thus are contaminated with dicamba and DCSA[83] could be consumed by animals outside of the field boundaries. Many insects come and go from crop fields. EPA did not include this likely occurrence when assessing risks to listed species. Both terrestrial and aquatic animals that eat insects may be affected.

Increases in total dicamba usage are likely, and will result in higher levels of exposure to more listed organisms.[84] This is a cumulative impact that EPA did not adequately consider, as it is not taken into account in EPA's risk assessment models. For example, rivers and streams in watersheds where dicamba is used on dicamba-resistant crops are likely to have higher dicamba contamination levels, but this is not taken into account.

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[79] EPA, *Ecological Risk Assessment for Dicamba Use on Dicamba-Tolerant Cotton*, at 14.
[80] Zhu et al. 2015.
[81] *See* EPA, *Second Addendum to Ecological Risk Assessment for Dicamba Use on Dicamba-Tolerant Soybean* at 14; *see also* EPA, *Proposed Registration Document* at 20.
[82] *See, e.g.,* Tank et al. 2010 and other studies of Bt in corn detritus cited in CFS's previously-submitted comments.
[83] *See* EPA, *Proposed Registration Document* at 20.
[84] *See* Exhibit B, at 74 (attached) (01/18/2013 CFS's Science Comments to EPA's Notice of Receipt of Application to Register New Use of Dicamba on Monsanto's Dicamba- and Glufosinate-Resistant MON 88701 Cotton, Docket No. EPA-HQ-OPP-2012-0841).

Dicamba contamination is already widespread in surface waters in the US and EPA must consider the cumulative impacts on both terrestrial and aquatic species of increased dicamba use in watersheds where it is already applied to other crops.[85]

For all these reasons, EPA's assumption that exposure of terrestrial and aquatic species will be confined to fields where applications occur is scientifically indefensible and legally erroneous.

2. EPA's fails to adequately consider effects to listed species of using dicamba formulations on dicamba-resistant cotton and soybeans because toxicity of all the components of likely end-use products has not been considered.

In addition to the toxicity of the each ingredient, EPA must consider possible additive and synergistic effects from various components of the end-use product formulation. If synergy is present, there can be greater effects from the same exposure to the pesticide than predicted, and thus effects at longer distances from the application site.

Although EPA is only considering registration of Monsanto's dicamba DGA salt formulation in this action, it is well known that Monsanto plans to combine dicamba with glyphosate, and perhaps with other herbicides such as glufosinate, to apply in fields planted with crops that have multiple herbicide resistance traits. Monsanto is already marketing such crops for 2016. Therefore EPA needs to consider impacts of likely mixtures of herbicide active ingredients now in order to understand complete costs and benefits.

Synergy can result from combining any of the components in the formulation, including synergy from combining different active ingredients and also between inerts (surfactants and other components added to the formulation before sale), adjuvants (surfactants and other components added to the formulation by applicators, as in tank mixes), and other components of the formulation and the active ingredient(s).

Synergy concerns are not limited to premixes and tank mixes where the components are applied to fields simultaneously. It is also relevant for pesticides applied on the same field before or after dicamba formulations are applied. For example, in a patent, Monsanto describes synergy between dicamba and glyphosate applied at different times:[86]

> In accordance with the invention, methods and compositions for the control of weeds are provided comprising the use of plants exhibiting tolerance to glyphosate and auxin-like herbicides such as dicamba. As shown in the working examples, <u>dicamba and glyphosate allow use of decreased amounts of herbicide to achieve the same level of control of glyphosate-tolerant weeds</u> and thus this embodiment

[85] *See* Exhibit A (attached), at 54-55 (09/21/2012 CFS's Science Comments to EPA's Notice of Receipt of Application to Register New Use of Dicamba on Dicamba-Resistant Soybean, Docket No. EPA-HQ-OPP-2012-0841); Exhibit B, at 62-63.
[86] Feng and Brinker 2014, at 9.

> provides a significant advance for the control of herbicide tolerance in commercial production fields. In one embodiment, a tank mix of glyphosate and dicamba is applied pre- and/or post-emergence to plants. Glyphosate and dicamba may additionally be applied separately. In order to obtain the ability to use decreased amount of herbicide, the glyphosate and dicamba are preferably applied within a sufficient interval that both herbicides remain active and able to control weed growth.
>
> This embodiment therefore allows use of lower amounts of either herbicide to achieve the same degree of weed control as an application of only one of the herbicides.

EPA admits that there are uncertainties regarding impacts of mixtures of different herbicide active ingredients, and has added a mitigation measure to compensate for the uncertainty: a requirement that no other herbicides be tank-mixed with dicamba DGA.[87] However, this is an inadequate mitigation measure for several reasons: 1) other types of pesticides than herbicides, such as insecticides and fungicides, could also interact synergistically in the formulation and are not included in the tank mixing restriction, 2) adjuvants that do not increase spray drift are allowed to be tank mixed without consideration of synergistic toxicity even though adjuvants are often chosen specifically because they synergistically enhance toxicity of the active ingredient,[88] and 3) synergism can occur between pesticides that are applied before or after each other in addition to being applied concurrently.[89]

EPA's failure to consider synergistic effects between dicamba and other chemicals is unlawful in light of the Agency's recognition that the proposed new use would be used concurrently with glyphosate and other pesticides on soybean and cotton. Under FIFRA, EPA must consider "any unreasonable risk to man or the environment, taking into account the economic, social, and environmental costs and benefits of the use of any pesticide" prior to approving a pesticide use. Here, EPA improperly segmented its cost-benefit analysis and neglected to consider the environmental costs associated with the use of the dicamba on GE soybean and cotton resistant to both dicamba and glyphosate. As a result of EPA's improper segmentation, EPA fails to consider the increased costs associated with the synergistic and additive effects of using both glyphosate and dicamba together.

3. EPA's conclusion that the proposed buffer zones would effectively reduce exposure of listed species to dicamba is unsupported

[87] EPA, *Proposed Registration Document* at 22; M1691 Herbicide DT Cotton Label M1691 EPA Reg. No. 524-582, EPA Docket ID EPA-HQ-OPP-2016-0187-0014, at 22; M1691 Herbicide DT soybean Label - EPA Reg. No. 524-582, EPA Docket ID EPA-HQ-OPP-2016-0187-0015, at 4.
[88] Sun 2012.
[89] Feng and Brinker 2014 at 9.

Finally, assumptions EPA used to design mitigation measures—buffer zones—to reduce exposure of listed species to dicamba DGA are unrealistic.[90] For example, EPA does not analyze how often applicators are likely to spray when wind speeds are greater than allowed, when weather conditions are unpredictable, or how often rain events occur when not forecast. Nor does EPA assess the likelihood that nozzles will be adjusted improperly, or buffer zone distances miscalculated. Without a realistic assessment of mitigation measures, risks cannot be predicted accurately and are likely to be underestimated.

II. EPA's Assessment Neglects Any Potential Impacts on Migratory Birds.

Based on the same reasoning above, EPA's current risk assessment is also unlawful under the MBTA. EPA's own risk assessments acknowledged that the proposed registration of dicamba use on dicamba-resistant, GE cotton and soybean poses potential risks to avian species, including numerous listed migratory avian species, yet EPA failed to properly consider and disclose its obligations to migratory birds, never even mentioning its responsibilities under the MBTA. The MBTA prohibits the take of migratory birds entirely and mandates that the loss, destruction, and degradation of migratory bird habitat must be minimized. Under EPA's proposed approval, dicamba would be used in fields visited by hundreds of species of birds protected under the MBTA. Rather than determining whether the proposed use of dicamba on dicamba-resistant GE cotton and soybean would have adverse effects on species protected under the MBTA, EPA simply ignores this significant issue. EPA must cure this defect by conducting a new risk assessment.

III. EPA's Current Assessment Does Not Adequately Consider Unreasonable Adverse Effects and Potential Risks to Pollinator Species.

EPA's current assessments regarding potential adverse effects to honey bees, other bees and pollinator species, and other beneficial terrestrial invertebrates, is also legally deficient under FIFRA. A recent study of dicamba impacts on nectar resources found that very low levels of dicamba, such as occur during drift of dicamba into areas adjacent to treated fields, caused reduced and delayed flowering and fewer visits by honey bees to the dicamba-injured plants.[91] Given the importance and imperilment of beneficial invertebrates such as pollinators, EPA needs to do a full assessment before taking this registration action instead of delaying until the upcoming dicamba registration review that won't be completed for several years.[92]

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[90] For detailed analysis, see previous comments for similar mitigation measures in Exhibit C (attached) (01/30/2014 CFS's comments to EPA on the Proposed New Use of Enlist Duo on 2,4-D-Resistant Crops, Docket No. EPA-HQ-OPP-2014-0195), and Exhibit D (attached) (12/15/2014 CFS's comments to EPA on the Proposed New Use of Enlist Duo on 2,4-D-Resistant Crops in Ten Additional States, Docket No. EPA-HQ-OPP-2014-0195).

[91] Bohnenblust et al. 2016.

[92] EPA, *Second Addendum to Ecological Risk Assessment for Dicamba Use on Dicamba-Tolerant Soybean* at 16-17.

EPA's own *Guidance for Assessing Pesticide Risks to Bees* sets out a risk assessment process for assessing potential risks to honey bees and other pollinators.[93] Here, EPA admitted that the initial 2011 risk assessment for the proposed uses "included no quantitative analysis of the risks" to beneficial insects and pollinators, and recognized that since then, EPA itself has "identified additional honeybee life stage testing and longer duration effects tests for adults [bees]…as potentially important to the risk assessment process."[94] Nonetheless, EPA fails to adhere to its current guidance and require all the necessary data and studies in order to adequately assess the potential risks to honey bees and other insects, including pollinators and federally listed terrestrial invertebrates, as part of the current risk assessment. Without these data and studies, EPA cannot ascertain that the proposed use of dicamba would not have "unreasonable adverse effects to the environment" or that it would not affect listed terrestrial invertebrates, in violation of FIFRA and the ESA.

For assessment of impacts to pollinators, there are important data gaps. For example, there are no data on levels of dicamba residues and metabolites in parts of the crops that pollinators use, such as pollen, nectar, or guttation fluids, without which no risk assessment can be meaningfully conducted.[95] There are no data on toxicity of the major metabolite of dicamba in dicamba-resistant crop tissues, glucosylated DCSA, which has not been tested for toxicity to any species. Also, toxicity data from studies of surrogate species used by EPA are unreliable because of vastly different life histories.[96]

These and other deficiencies in EPA's pollinator risk assessments are discussed by CFS for dicamba use with dicamba-resistant soybean and cotton at length in previous comments.[97]

IV. EPA's Current Assessment Entirely Fails to Consider Toxicity of Conjugated Metabolites of Dicamba.

All of EPA's risk assessments that involve animals, including listed animals, which may ingest dicamba-treated, dicamba-resistant crop tissues are deficient because toxicity of the major metabolite of dicamba is unknown and unaccounted for.

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[93] EPA, *Guidance for Assessing Pesticide Risks to Bees* (2014), *available at* https://www.epa.gov/sites/production/files/2014-06/documents/pollinator_risk_assessment_guidance_06_19_14.pdf
[94] EPA, *Second Addendum to Ecological Risk Assessment for Dicamba Use on Dicamba-Tolerant Soybean* at 16.
[95] *See, e.g.,* EPA, *Second Addendum to Ecological Risk Assessment for Dicamba Use on Dicamba-Tolerant Soybean* at 20, where EPA uses levels of DCSA in seeds instead.
[96] *See, e.g.,* EPA, *Second Addendum to Ecological Risk Assessment for Dicamba Use on Dicamba-Tolerant Soybean* at 18 - 20, where aquatic invertebrates are used as surrogates for chronic effects of dicamba exposure, and then this assessment is extended to all terrestrial invertebrates.
[97] *See* Exhibit A (attached), at 62-64; Exhibit B (attached), at 70-73; Exhibit E (attached), at 15-23 (10/10/2014 CFS's Science Comments to USDA'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, Docket No. APHIS 2013-0043).

By far the most common metabolite present at the highest level after spraying dicamba on dicamba-resistant soybeans or cotton is a conjugate of DCSA that has been modified by the addition of a sugar: glucosylated (also called glycosylated) DCSA (. This metabolite is a novel addition to the food supply for both humans and animals that eat dicamba-treated, dicamba-resistant crops, particularly forage and fodder, and also perhaps other plant-derived foods such as nectar, pollen, guttation fluids.[98]

EPA does not report any toxicology studies of glucosylated DCSA for any kind of organism. Based on studies with other conjugated metabolites, during digestion toxic DCSA could be released as the sugar is cleaved from the glucosylated form. CFS discusses this in previous comments.[99]

Given the novelty of glucosylated DCSA in the food and feed supply, and the fact that it is the major metabolite of dicamba in dicamba-resistant crops, EPA's risk assessments are incomplete, and may significantly underestimate adverse effects.

V. EPA Lacks Sufficient Information to Make the No "Unreasonable Adverse Effects" Finding Required Under FIFRA.

The Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) mandates that EPA can register a pesticide use only if it can ensure that the use will not cause unreasonable adverse effects on man or the environment, taking into account the economic, social, and environmental costs and benefits of the pesticide's use.[100] Here, EPA has failed to assess and account for several significant economic and social costs of the proposed uses, in violation of FIFRA.

1. EPA's assessment of dicamba resistance in Weeds

EPA acknowledges that weeds resistant to glyphosate and other heavily used herbicides have imposed "yield and economic losses" on farmers. In fact, the chief benefit claimed for the proposed uses of dicamba is to facilitate better control of these resistant weeds.[101]. However, EPA also acknowledges that these new uses on dicamba-resistant soybeans and cotton could lead to "expansion of dicamba-resistant weeds and the development of [dicamba] resistance by some additional weed species."[102] Dicamba-resistant weeds, like those resistant to glyphosate, would impose costs on growers. Therefore, EPA must assess any potential benefits of the new uses (i.e. controlling

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[98] *See* EPA, *Dicamba. Section 3 Registration for the Amended Use of Dicamba on Dicamba-Tolerant Cotton. Summary of Analytical Chemistry and Residue Data* 19 (Mar. 29, 2016); *Second Addendum to Ecological Risk Assessment for Dicamba Use on Dicamba-Tolerant Soybean* at 14.
[99] *See* Exhibit A (attached), at 58-61; Exhibit B (attached), at 65-70; Exhibit E (attached), at 26-28.
[100] *See* 7 U.S.C. § 136a(c)(5).
[101] EPA, *Review of Benefits as Described by the Registrant of Dicamba Herbicide for Postemergence Applications to Soybean and Cotton and Addendum Review of the Resistance Management Plan as Described by the Registrant of Dicamba Herbicide for Use on Genetically Modified Soybean and Cotton* 2 (Mar. 20, 2016) [hereinafter *Benefits Analysis*].
[102] *Id.* at 4.

glyphosate-resistant weeds) and weigh them against costs (emergence of dicamba resistance).

However, EPA's Benefits Analysis that is supposed to address weed resistance is deficient in several respects. In brief:

1) It only describes purported benefits, not costs;
2) The treatment of weed resistance is extremely cursory and descriptive in nature, erroneous in certain respects, and entirely lacking any quantitative or semi-quantitative analysis of the dicamba-resistant weed threat;
3) EPA explicitly limits itself to the registrant's viewpoints and information, neglecting relevant scientific literature, a key assessment by the US Department of Agriculture, and public comments that EPA was aware of;
4) EPA's failure to properly assess the dicamba-resistant weed threat has led it to propose an herbicide resistance management plan that will be ineffective and unworkable.

EPA's description of the purported benefits of the new dicamba uses is just six pages (minus appendices), with no accounting of costs.[103] It is explicitly keyed to "benefits as described by the registrant" and "Monsanto's submitted information." Only two peer-reviewed studies on weed resistance are cited, and a handful of farm press articles and extension publications. Even in those few instances where EPA cites non-registrant studies or data, it does so in a way that inexplicably minimizes resistance issues. For instance, EPA cites Godar et al. (2015) and Sandell et al. (2012) for the statement that "glyphosate-resistant kochia populations have been identified in Kansas … and Nebraska." However, Godar et al. (2015) actually report glyphosate-resistant [GR] kochia not just in Kansas and Nebraska, but in ten states and three Canadian provinces: "As of 2014, presence of GR kochia populations has been reported in ten Great Plains states (Colorado, Idaho, Kansas, Montana, Nebraska, North Dakota, Oklahoma, Oregon, South Dakota, and Wyoming) and three Canadian provinces (Alberta, Saskatchewan, and Manitoba).[104]

EPA provides no discussion of the resistance-promoting features of herbicide-resistant crop systems in general or the news uses with dicamba-resistant soybeans or cotton in particular. EPA also fails to provide any quantitative or semi-quantitative assessment of the factors conducing to weed resistance, or of the extent or costs of dicamba-resistant weeds that the proposed uses would foster. Though EPA makes regular use of quantitative projections and modeling in assessing new uses of pesticides, and has done so in certain respects with dicamba,[105] such analysis is entirely lacking here with respect to weed resistance.

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[103] EPA, *Benefits Analysis* at 1-6.
[104] Godar et al. 2015. EPA's citation to this study (*see EPA Benefits Analysis* at 12, with first author's name misspelled as "Bodar") specifies the abstract "(abstr.)." Thus, EPA may have missed the statement quoted here, which appears in the body of the paper, by scanning only the title and abstract.
[105] For instance, EPA used drift modeling software to provide quantitative estimates of how far and what concentrations dicamba would drift.

This cursory treatment contrasts sharply with the approach taken by others to assess the issue of herbicide- and dicamba-resistant weeds. For instance, weed scientist Paul Neve has created a quantitative simulation model to assess how rapidly weed resistance would evolve under various herbicide usage scenarios.[106] Neve found that using an herbicide as it is typically used with an herbicide-resistant crop "very substantially increases risks of resistance evolution" relative to typical uses of the same herbicide with conventional crops. While the cited paper focuses on glyphosate, the model is applicable to other herbicides.

The U.S. Department of Agriculture (USDA) provided a detailed, quantitative assessment of dicamba use in its Environmental Impact Statement on Monsanto's petition to deregulate dicamba-resistant (DR) soybeans and cotton, based in part on data provided by Monsanto.[107] This assessment is highly relevant to the dicamba-resistant weed threat posed by the new uses on DR crops. USDA's assessment was based on quantitative estimates of acreage planted to dicamba-resistant soybeans and cotton and sprayed with dicamba; the number of dicamba applications per season to each DR crop, and the rate (i.e. lbs./acre) at which dicamba would be applied. Based on these projections, tens of millions of acres of DR crops would receive two to three applications of dicamba per season. Because resistance risk generally rises with the frequency of application, and most herbicides are applied just once per season, dicamba-resistant weeds are likely to emerge rapidly on millions of acres of DR cropland (see analysis in Exhibit F[108]). USDA deregulated DR soybeans and cotton without restriction despite its conclusion that doing so would increase selection pressure for dicamba-resistant weeds.[109] USDA took this action in the expectation that EPA was "thoroughly analyzing" the weed resistance impacts of the proposed new uses of dicamba, and would establish effective weed resistance management requirements as part of its registration.[110] Yet EPA makes no reference to this clearly relevant USDA assessment, despite the fact that the two agencies are supposed to be collaborating to address weed resistance risks associated with herbicide-resistant crop systems.

Mortensen et al. (2012) discuss many implications of the introduction of soybeans genetically engineered for resistance to dicamba (Monsanto) and 2,4-D (Dow). They provide quantitative projections of DR/2,4-D-resistant soybean acreage and associated

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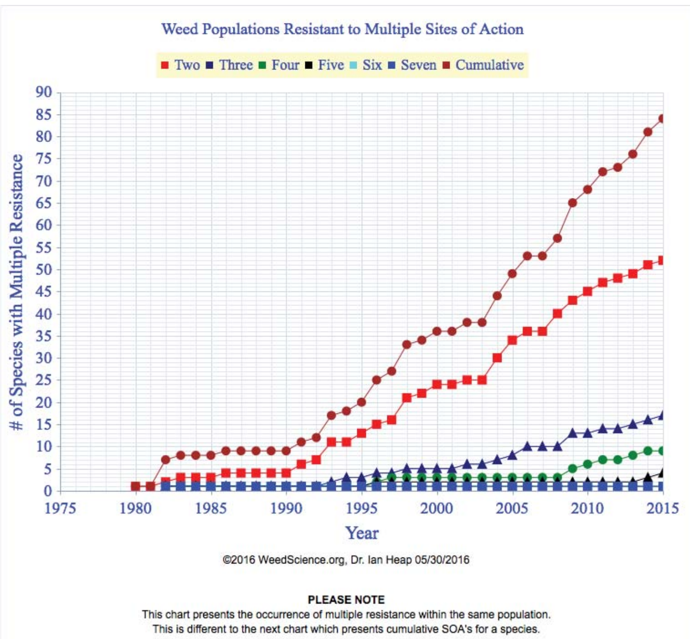
[106] Neve 2008.
[107] USDA, *Monsanto Petitions (10-188-01p and 12-185-01p) for Determinations of Nonregulated Status for Dicamba Resistant Soybean and Cotton Varieties Final Environmental Impact Statement* (December 2014), *available at* https://www.aphis.usda.gov/brs/aphisdocs/dicamba_feis.pdf. [hereinafter *USDA Dicamba FEIS*].
[108] Exhibit F (attached) (10/10/2014 CFS's Science I 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, Docket No. APHIS-2013-0043).
[109] USDA, *Record of Decision, Monsanto Petitions (10-188-01p and 12-185-01p) for Determinations of Nonregulated Status for Dicamba Resistant Soybean and Cotton Varieties 20* (2015), *available at* https://www.aphis.usda.gov/brs/aphisdocs/dicamba_feis_rod.pdf. [hereinafter *USDA Dicamba ROD*].
[110] *USDA Dicamba ROD*, at 21.

usage of dicamba/2,4-D. They discuss the weed resistance risk posed by introduction of these crops. Among their relevant findings are that weeds resistant to dicamba and/or 2,4-D (closely related "auxin" herbicides) are more common than generally recognized, and that the new uses of dicamba (and 2,4-D) pose a high risk of generating dicamba/2,4-D-resistance in weeds already resistant to glyphosate, resulting in weeds resistant to both herbicides. They also discuss the dramatically increasing prevalence of such multiple herbicide-resistant weeds in U.S. and world agriculture (see graph below), which increases weed control costs as much as six-fold.[111] Additional dicamba-resistance in weeds already resistant to glyphosate (and sometimes other herbicides) will limit weed management options for farmers,[112] are often more difficult and costly to control, and more likely to be managed with soil-eroding tillage, as discussed below.



Source: International Survey of Herbicide Resistant Weeds.
http://www.weedscience.com/Graphs/MultipleResistance.aspx, 3/30/16.

EPA's cursory review makes no reference to this much-cited study; nor does it provide any assessment of the threat posed or costs imposed by multiple herbicide-resistant weeds generated by the proposed uses. In fact, EPA appears unaware that populations of the damaging weed kochia that have evolved resistance to dicamba in Kansas (mentioned at EPA Benefits Analysis on page 4) already have multiple resistance to glyphosate and other classes of herbicide as well as dicamba[113], illustrating EPA's general failure to consider the threat of multiple herbicide-resistant weeds.

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[111] Service 2013.
[112] Following Monsanto, EPA states that registration of dicamba "would expand weed management options for growers by providing an additional MOA [mode of action] in the growing season" (EPA Benefits Analysis, t 2). However, EPA fails to discuss the limitation of weed management options that will result with the evolution of dicamba- and multiple-herbicide resistant weeds.
[113] HR Kochia 1 & 2 (2015).

Finally, EPA itself has provided careful quantitative projections of the resistance risks associated with toxins introduced into first-generation genetically engineered corn and cotton that target above-ground pests like European corn borer. EPA conducted rigorous analysis, and consulted independent scientific literature in making these projections, and in establishing mandatory insect resistance management plans to prevent (or greatly delay) emergence of insect pest resistance to these toxins.[114] Weed resistance shares many characteristic features with insect resistance, yet EPA has provided nothing approaching this level of analysis of weed resistance risks in its cursory "benefits" memorandum or its proposed registration. As discussed below, EPA has also failed to require effective measures to prevent or greatly delay emergence of dicamba resistance.

Dicamba-resistant weeds that evolve with the proposed uses will likely spread to the fields of other farmers via seed dispersal and cross-pollination, including farmers who use other forms of dicamba on non-DR crops. This spread of dicamba resistance would likely impose increased weed control costs on such farmers, costs which EPA has not assessed or even mentioned. For instance, wheat growers who use dicamba may be forced to replace/supplement dicamba use with more costly/additional herbicides. EPA has failed to assess this issue. In contrast, USDA provided a quantitative assessment of such costs imposed on other farmers in a precisely analogous case: that is, costs associated with the projected spread to wheat farmers' fields of 2,4-D-resistant weeds fostered by the use of Enlist Duo on 2,4-D-resistant corn and soybeans.[115]

The discussion above is far from comprehensive, and is meant only to suggest the wealth of relevant resources and facts that EPA ignored in its cursory description of weed resistance, and to highlight assessment approaches and factors that EPA must employ or consider in projecting the costs of dicamba-resistant weeds under the proposed uses.

2. EPA's assessment failure undermines proposed herbicide resistance management plan

EPA has proposed an herbicide resistance management plan that will very likely be ineffective and unworkable, a predictable outcome given the Agency's failure to assess the very problem it purports to address, as discussed above. CFS has provided a detailed discussion of the flaws of EPA's herbicide-resistance management plan for the new uses, based on the Agency's plan for Enlist Duo, upon which the dicamba plan is closely modeled.[116] We provide a brief summary of these comments below, and also address elements that are new and specific to EPA's proposed herbicide-resistance management plan for the new dicamba uses.

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[114] *See, e.g.* EPA IRM 2001.
[115] USDA, *Final Environmental Impact Statement on Dow AgroSciences Petitions (09-233- 01p, 09-349-01p, and 11-234-01p) for Determinations of Nonregulated Status for 2,4-D-Resistant Corn and Soybean Varieties* (2014), *available at* https://www.aphis.usda.gov/brs/aphisdocs/24d_feis.pdf, [hereinafter *USDA 2,4-D FEIS*].
[116] Exhibit F (attached), at 32-35.

1) EPA fails to require any effective measures to prevent or substantially delay emergence of weed resistance to dicamba. The most effective measures would involve reducing selection pressure by limiting the frequency with which dicamba is applied, in a single season and/or over years, in line with the recommendations of many weed scientists. In the analogous case of inhibiting evolution of glyphosate resistance, scientists recommend annual rotation between a Roundup Ready and non-Roundup Ready crop, with glyphosate applied every other year instead of every year.[117] Syngenta's Chuck Foresman similarly recommended limiting glyphosate use to two applications in a two-year period.[118] EPA does not discuss or even mention the possibility of placing limits on the frequency of dicamba use as a condition of the proposed registration.

2) EPA's plan relies on farmers detecting weed resistance once it has already occurred by scouting their fields both before and after application of dicamba. It is unreasonable to expect busy growers who often farm thousands of acres to make the substantial time commitment thorough scouting would entail; to the extent such scouting occurs, it is often difficult to detect resistance until it is far advanced, and too late to effectively control.

3) EPA delegates most authority for implementing this plan to the registrant; yet Monsanto has failed to properly implement a very similar insect resistance management plan for genetically engineered Bt corn targeting corn rootworm, resulting in broad emergence of resistant pests. To the limited extent the plan has value, it is unlikely to be properly implemented due to the registrant's conflicts of interest.

4) EPA's resistance management recommendations rely heavily on use of dicamba sequentially with different types of herbicide, which are supposed to inhibit evolution of dicamba resistance. However, use of multiple herbicides is increasingly ineffective with the rapid emergence of multiple herbicide-resistant weeds (e.g. kochia resistant to two and four herbicide modes of action in Kansas, discussed above), which EPA fails to consider. For a fuller discussion of this issue, including examples of the failure of the multiple herbicide approach to forestalling weed resistance.[119]

5) EPA relies heavily on a recommendation that growers of DR crops use non-dicamba pre-emergence herbicides with residual activity to kill emerging weeds six to eight weeks after application to help forestall dicamba resistance.[120] However, this is extremely unlikely to occur in the case of DR soybeans, for several reasons:

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[117] *See, e.g.*, Heap 1997.
[118] NGSF I 2004, at 26.
[119] *See* Exhibit F (attached), at 15-30; *see also* Mortensen et al. (2012).
[120] EPA, *Benefits Analysis*, at 3.

a. Soybean farmers have already shifted away from use of pre-emergence herbicides with residual activity in favor of reliance on glyphosate, which does not have residual activity;
b. USDA's more robust assessment of DR soybeans directly contradicts EPA's assumption on this point. USDA projects that "....substantive PRE [pre-emergence] non-glyphosate applications ***will likely be eliminated***, as may more than half of POST non-glyphosate applications."[121] The upshot of USDA's analysis is that most DR soybean farmers will rely entirely on dicamba and glyphosate[122] (to which DR soybeans are also resistant), generating intense selection pressure for evolution of dicamba resistance, often in weeds already resistant to glyphosate.
c. EPA fails to appreciate that dicamba has (limited) residual activity, as indicated by the waiting intervals for its pre-emergence use on conventional crops,[123] and is thus a likely choice for those growers who choose to make pre-emergence applications. This is also indicated by the fact that the proposed registration permits one or more pre-emergence applications of dicamba.
d. EPA's failure to conduct a proper real-world assessment of herbicide use practices and consult USDA's more robust assessment has led it to rely heavily on an herbicide resistance management method that will for the most part not be implemented.

6) EPA has proposed a minimum rate of 0.5 lb./acre per application of dicamba for post-emergence (in-crop) use as a resistance management measure for both DR soybeans and DR cotton.[124] Normally, the Agency prescribes only maximum pesticide rates. However, there is disagreement in the scientific literature on the utility of using "full herbicide rates" to inhibit weed resistance. In a comprehensive review of the effects of using reduced herbicide rates, Blackshaw et al. (2006) found that "reduced doses of herbicides are likely to have a neutral effect on weed resistance development, especially if used within an integrated weed management system." Beckie & Kirkland (2003) found that reducing ACCase inhibitor herbicide rates "decreased the proportion of resistant [wild oat] individuals in the population," especially when reduced rates were combined with increasing crop competition with a higher seeding rate. This suggests that prescribing a high minimum dicamba rate of 0.5 lb./acre might actually exacerbate rather than reduce resistance problems. Using the label-recommended (full rate) of glyphosate with Roundup Ready crops has always been Monsanto's chief recommendation for reducing the emergence of glyphosate-tolerant and glyphosate-resistant weeds, but

[121] *USDA Dicamba FEIS*, at 143 (emphasis added). For detailed discussion, *see* Exhibit F (attached).
[122] These two herbicides are not permitted to be used together in a tank mix, according to the proposed registration, but there is no bar to a farmer using them sequentially.
[123] Waiting intervals of two to four weeks between application of dicamba and planting of conventional soybeans and cotton are imposed for pre-emergence uses to allow dicamba to degrade or dissipate to levels that will not kill or damage the emerging crop (EPA, *Benefits Analysis*, Table 1). This same residual activity provides some level of weed control during these intervals.
[124] EPA, *Proposed Registration Document*, at 3.

many weed scientists disagree with this approach. At the National Glyphosate Stewardship Forum, a meeting convened specifically to address the emerging threat of glyphosate-resistant weeds, Iowa State University weed scientist Micheal Owen found that "reduced glyphosate rates, at times, may increase returns without increased weed problems."[125] In addition, glyphosate-resistant weeds have emerged in epidemic fashion despite Monsanto's "full rate" exhortations, and despite steadily increasing glyphosate use rates. Thus, prescribing a minimum rate of dicamba would be unlikely to inhibit emergence of dicamba resistance, and could exacerbate the problem.

7) USDA data show that dicamba, to the very limited extent it is used in soybeans, is currently applied to soybean fields on average at less than half the minimum rate proposed by EPA (0.1 to 0.2 lbs./acre).[126] Prescribing more than double the usual rate for post-emergence new use applications would likely increase farmer dicamba use and expenditures beyond, and perhaps well beyond, what they would otherwise be. The rate of herbicide needed to provide acceptable weed control varies dramatically in particular regions and fields based on numerous factors: which weed species are present, the number and size of the weeds, environmental factors like weather, crop production practices (tillage, seeding rate, etc.), which other herbicides (if any) are used, and the farmer's "tolerance" for weed presence. Weed scientists find that reduced herbicide rates are consistent with maintaining yield and increased overall production returns, even in cases where there is increased weed seed production.[127] This is particularly true when reduced rates are part of an integrated weed management program that involves cultural practices like higher crop seeding rates, diverse crop rotations, specific fertilizer placement and cover crops.[128] Thus, prescribing a high minimum rate of dicamba would likely increase farmer production costs and reduce farmer returns, without accomplishing the intended purpose of inhibiting resistance. In addition, this high minimum rate would also likely have negative environmental costs, for instance reductions in populations of field-edge flowering plants, given dicamba's propensity to drift and high efficacy on broadleaf weeds.

8) EPA's resistance management plan relies heavily on inclusion of various items of information and directions regarding weed resistance management on the dicamba label. However, weed resistance management statements similar though less extensive than those recommended now by EPA have been included on herbicide product labels since at least 2004,[129] and have obviously been ineffective, especially with respect to inhibiting glyphosate-resistant weed development. Participants at

[125] NGSF I 2004, at 18.
[126] *See* https://quickstats.nass.usda.gov/results/2513DF3C-9C21-3487-A36B-BA460678756C#0DC606AB-2494-3C85-8F7E-1C6920C4BA7A. One reason for the low rate is that dicamba is sometimes applied in mixtures with other herbicides.
[127] Hamill et al. 2004.
[128] Beckie & Kirkland 2003, Blackshaw et al. 2006.
[129] NGSF I 2004, at 36-37.

the second National Glyphosate Stewardship Forum, which included weed scientists, farmers and representative of commodity groups and industry, found that resistance management statements on labels have "low impact" at inhibiting resistance to glyphosate.[130] EPA provides no empirical evidence to support the efficacy of label statements concerning resistance management, and no empirical assessment of the factors (e.g. economic, time constraints) that influence farmers' real-world herbicide choices and the degree to which they do or do not implement herbicide resistance management directions. For instance, as discussed above several recommendations involve use of additional herbicides that represent additional production costs that growers may find excessive, or scouting for potential resistance that many farmers will not have time for.

9) EPA proposes a "5-year time limited registration … so that any unexpected weed resistance issues that may result from the proposed uses can be addressed before granting an extension…."[131] This time period is too long. Weed resistance to dicamba will likely emerge within this five-year time limit, and perhaps on an extremely widespread basis that inflicts significant costs on growers. Two considerations support this. First, EPA is greatly overestimating the efficacy of the herbicide resistance management plan, as discussed above. Second, weed resistance is known to evolve very rapidly when an herbicide is used as part of an herbicide-resistant crop system. For instance, glyphosate-resistant horseweed emerged within just three years in Delaware fields planted continuously to glyphosate-resistant soybeans treated with glyphosate.[132] Similarly, glyphosate-resistant (GR) horseweed was first reported in Tennessee cotton and soybean fields in 2001, and by 2004, just three years later, it had infested an estimated 1.5 million acres of Tennessee cropland.[133] Stahlman et al. (2013) found that "[g]lyphosate-resistant kochia spread rapidly ***throughout the central U.S. Great Plains within 4 years of discovery***" (emphasis added). These examples illustrate how quickly resistant weeds have evolved and spread in glyphosate-resistant crop systems, and suggest a similar potential for rapid and widespread evolution of resistance with the new uses of dicamba. EPA provides no rationale for choosing a 5-year time limit, and provides no assessment of the speed or extent of resistant weed evolution or spread, as modeled for example by Neve (2008).

3. Dicamba-Resistant Cotton Will Compromise Boll Weevil Eradication Efforts

Both volunteer cotton and cotton stalks remaining after harvest can harbor boll weevil larvae. Thus, cotton growers in several states (e.g. Texas, Tennessee) are legally required to control cotton volunteers and destroy cotton stalks as part of boll weevil eradication efforts. Agronomists have found this task to be more difficult with the advent of glyphosate- and glufosinate-resistant cotton varieties, and anticipate still greater problems

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[130] NGSF I 2004, at 36-37.
[131] EPA, *Proposed Registration* Document, at 28.
[132] VanGessel 2001.
[133] NGSF I 2004, at 60.

with the introduction of Monsanto's dicamba, glyphosate- and glufosinate-resistant cotton and Dow's 2,4-D-, glyphosate- and glufosinate-resistant cotton. This is because glyphosate, 2,4-D, dicamba and glufosinate are among the few herbicides that provide effective control of volunteer cotton and cotton stalks. Registration of the new dicamba use on cotton would encourage farmer adoption of DR cotton, and hence potentially compromise boll weevil eradication efforts, or substantially increase the associated costs. This subject is addressed in more detail, with citations, in the attached Exhibit B, at 38-40. EPA did not address this issue in its proposed registration documents.

4. Increased tillage and soil erosion

Typical herbicide use patterns with herbicide-resistant crops foster rapid evolution of herbicide-resistant weeds, which in some cases are controlled through the use of tillage. Tillage in turn renders the soil more prone to erosion. A National Research Council committee reported increased use of tillage by farmers to control glyphosate-resistant weeds fostered by Roundup Ready cropping systems.[134] Many farmers employed tillage to control glyphosate-resistant horseweed infesting 1.5 million acres of Tennessee cropland, leading to a dramatic 50% reduction in the use of conservation tillage in Tennessee cotton, and a 30% reduction in the state as a whole.[135] Reduced use of conservation tillage due to GR weeds has also been reported in Missouri and Arkansas. A decline in no-till acreage in U.S. cotton and corn from 2007-2010 and in soybeans from 2008-2010 was attributed to greater use of tillage to control glyphosate-resistant weeds.[136] USDA reported a drop in the use of conservation tillage in soybeans from 2006 to 2012, which likely reflects more tillage to combat glyphosate-resistant weeds.[137]

As weeds with resistance to multiple herbicides continue to emerge and expand, herbicidal management options will continue to decline, meaning more and more farmers will turn to tillage for weed control. For instance, Godar & Stahlman (2015) report higher than expected use of tillage in Kansas to control kochia, which "might indicate failure to control kochia with herbicides." They report that the efficacy of glyphosate + dicamba on kochia has declined dramatically since 2007, as confirmed by reports of kochia with verified resistance to dicamba, glyphosate and other herbicides in Kansas.[138]

By promoting the emergence of weed resistance to dicamba (often in combination with resistance to glyphosate and other herbicides), registration of the proposed new uses will exacerbate the trend to increased use of tillage and soil erosion in American agriculture. Soil erosion on U.S. cropland is already occurring at rates far above soil formation rates,[139] meaning an ongoing loss of valuable topsoil that poses an extremely

[134] NRC 2010.
[135] NGSF I 2004, at 60.
[136] Owen 2011, Table 1.
[137] Based on USDA Agricultural Resource Management Surveys (ARMS). Data accessible at: http://www.ers.usda.gov/data-products/arms-farm-financial-and-crop-production-practices/tailored-reports-crop-production-practices.aspx.
[138] HR Kochia 1 & 2 (2015).
[139] Montgomery 2007, USDA NRCS 2015.

serious long-term threat to American agriculture and American society more broadly. The increased soil erosion expected with the new dicamba uses are significant social costs that EPA has not considered in its assessment of the proposed registration.

5. Dicamba, DR crops and land consolidation

Economists have found that herbicide-resistant crop systems tend to reduce labor needs on the farm.[140] USDA agricultural economists MacDonald et al. agree: "HT [herbicide-tolerant] seeds reduce labor requirements per acre."[141] MacDonald's team examined factors responsible for the continuing increase in farm size in American agriculture. They found that innovations like herbicide-resistant seeds that reduce the amount of labor required for field operations allow farming more acres. Large growers of herbicide-resistant crops are generally in a better position to absorb the costs of buying or leasing additional land for expansion, and so outcompete small and medium-size growers, who are thereby put at a competitive disadvantage and potentially out of business. Thus, MacDonald et al. find that herbicide-resistant seeds are a likely contributor to increased consolidation among field crop farmers since 1995.[142]

EPA should assess the impacts of the proposed new uses of dicamba on labor, farm size, land consolidation, welfare of small to medium-size farmers, and the economic health of rural communities. The discussion above suggests that registration of the new uses could have significant social costs.

Under FIFRA, EPA cannot approve a proposed registration or proposed use if there would be "unreasonable adverse effects on the environment" from the pesticide use, defined as "any unreasonable risk to man or the environment, taking into account the economic, social, and environmental costs and benefits of the use of any pesticide." Yet, EPA's Benefits Analysis fails to affirm or assess Monsanto's claimed benefits, and entirely fails to show that the purported benefits outweigh the unreasonable adverse effects of the proposed use. Instead, as explained above, EPA's assessment fails to critically assess numerous unreasonable adverse effects of approving the proposed use. EPA also failed to quantitatively or meaningfully assess the significant environmental and economic costs of these adverse effects against the purported benefits of the propose use. EPA's Benefits Analysis failed to make the requisite legal finding that the benefits of the proposed approval would outweigh its risks such that approving the proposed dicamba use on dicamba-resistant cotton and soybean would not have "unreasonable adverse effects on the environment." EPA must critically reassess the potential benefits of the proposed use against its numerous significant environmental and economic costs.

VI. EPA's Assessment of Human Health Risks Violates FIFRA and the FFDCA.

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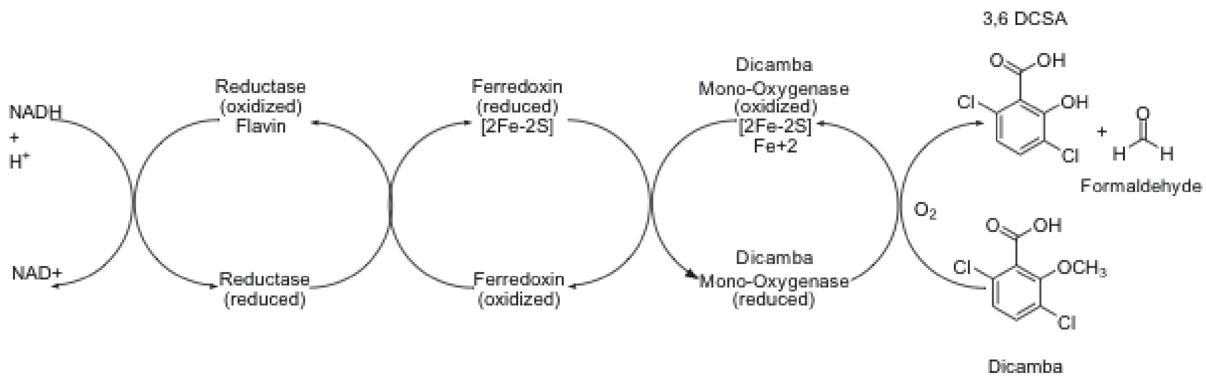
[140] Gardner et al. 2009.
[141] MacDonald et al. 2013, p. 28.
[142] MacDonald et al. (2013).

Monsanto's genetically engineered, dicamba-resistant soybeans and cotton enable the entirely novel uses of dicamba that EPA has proposed to register: spraying the herbicide at high levels directly on growing dicamba-resistant soybeans or cotton to kill nearby weeds throughout the growing season. Because of dicamba's toxicity to conventional soybeans and cotton, it is little used in conventional production of these crops. When used, it is applied primarily "pre-emergence" to clear a field of weeds prior to crop "emergence" to avoid crop injury.

Dicamba resistance is conferred by genetically engineering a gene encoding an enzyme, dicamba mono-oxygenase (DMO), into dicamba-resistant (DR) soybeans and cotton. This DMO enzyme, derived from a soil bacterium, is expressed in the DR crops and demethylates dicamba to form metabolites, chiefly 3,6-dichlorosalicylic acid (DCSA) and formaldhyde, that are generated at levels that are not toxic to the plant, as depicted below. DCSA is not found, or only at extremely low levels, in conventional crops that come into contact with it.



<u>EPA's Assessment of the Carcinogenicity of Dicamba</u>

Animal experiments

EPA describes two animal studies (rat and mouse) on the potential carcinogenicity of dicamba.[143] In the rat study, four groups of 60 animals of each sex were either untreated (control) or fed one of three doses of dicamba for 115 (male) or 117 (female) weeks. Seven percent (4 of 60) of the male rats in each of the two higher-dose groups contracted malignant lymphomas, while no lymphomas were found in the control group or low-dose group (each 0 of 60). In addition, 0/60, 2/60 and 5/60 male rats in the low, medium, and high-dose groups, respectively, contracted thyroid parafollicular cell carcinomas, along with 1/60 males in the control group.

[143] EPA, Dicamba and Dicamba BAPMA Salt: Human Health Risk Assessment for Proposed Section 3 New Uses on Dicamba-tolerant Cotton and Soybean 74-76 (Mar. 29, 2016) [hereinafter *Human Health Risk Assessment*].

EPA notes that: "The Cochran-Armitage trend test showed a statistically significant ($p \leq 0.05$) tendency for the proportion of animals with tumors to increase steadily with increase in dose." Thus, for two forms of cancer, the study exhibited "dose-response," an important indicator that the tumors are related to the treatment (dicamba) rather than due to chance. However, EPA dismissed the statistically significant trends for both cancers because a second statistical test involving pairwise comparisons did not show statistical significance.

EPA followed accepted practice in analyzing the carcinogenicity data with a trend test, and the Cochran-Armitage test is most commonly used for this purpose. It is also accepted practice to make a pairwise comparison of the incidences of animals with tumors in the high dose and control groups.[144] However, the highest dose used in the study should be based on the "maximum tolerated dose,"[145] which was not the case here. In the context of carcinogenicity experiments, the maximum tolerated dose (MTD) is defined as "[t]he highest dose … which, when given for the duration of the chronic study, is just high enough to elicit signs of minimal toxicity without significantly altering the animal's normal lifespan due to effects other than carcinogenicity."[146]

However, no toxicity other than cancers was observed in this experiment. EPA notes that the rats treated with dicamba did not exhibit ***any*** signs of systemic toxicity,[147] that the animals would likely have tolerated substantially higher doses, and that "an MTD was not achieved." Thus, EPA's dismissal of the statistically significant trend of increasing number of tumors with increasing dose of dicamba based on lack of statistical significance in the pairwise comparison of control and high-dose groups is not legitimate, because the study did not incorporate a maximum tolerated dose as demanded by accepted protocol for animal carcinogenicity experiments with chemicals.

In the mouse study, five groups of mice of each sex were either untreated (control group) or received one of four doses of dicamba for 89 (males) or 104 (females) weeks. Of the 10 groups (5 male, 5 female), EPA reports the number of animals with tumors for only two. Eight of the 52 female mice (15%) that were fed the second-lowest dose of dicamba contracted lymphosarcomas, compared to only 2 of 52 (4%) in the control group. The pairwise comparison of these two groups shows a statistically significant increase in lymphosarcomas, but EPA dismissed this finding due to a lack of dose-response (the presence of which was dimissed in the rat study), and because different groups of untreated control mice from entirely different studies tended to have a higher incidence of the tumor than the control group in this study (concurrent control). As in the rat study, the mouse study did not incorporate a maximum tolerated dose. EPA notes that in 1995, its RfD/Peer Review Committee had found that this "mouse carcinogenicity study was not tested at a high enough doses [sic] to evaluate carcinogenicity in the mouse." However, this

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[144] Rahman & Armitage 2012.
[145] NRC 1993;FDA 2008; Rahman & Armitage 2012.
[146] FDA 2008 (citing the U.S. Interagency Staff Group on Carcinogens, 1986).
[147] "Treatment had no adverse effect on survival, body weight, body weight gain, food consumption, hematology, clinical chemistry, urinalysis, organ weights or gross pathology."

determination was overturned here, without explanation, and the study will not be repeated.

Both studies revealed statistically significant evidence of carcinogenicity. EPA dismissed the significant dose-response trend of increasing tumors with increasing dicamba dose in male rats because pairwise comparisons were not significant. A significant pairwise comparison result in the mouse study was dismissed because dose-response was not significant. Neither study incorporated a maximum tolerated dose, which is critical for legitimate application of the pairwise comparison test. Unless or until studies that incorporate maximum tolerated doses are conducted and their results definitively refute the present findings, based on existing evidence EPA should properly find that dicamba is carcinogenic.

Human evidence

Epidemiological studies have associated dicamba exposure with increased incidence of a number of cancers in pesticide applicators. In 1992, epidemiologists with the National Cancer Institute (NCI) found that Iowa and Minnesota farmers who were first exposed to dicamba prior to 1965 had increased incidence of non-Hodgkin's lymphoma (NHL) relative to controls, with an odds ratio of 2.8.[148] A subsequent study in Canada also found an association between exposure to dicamba and NHL.[149] A study of cancer in Iowa farmers associated exposure to benzoic herbicides[150] with increased risk of multiple myeloma,[151] which has since been identified as a subtype of non-Hodgkin's lymphoma.[152] A comprehensive meta-analysis of epidemiology assessing non-Hodgkin's lymphoma and exposure to agricultural pesticides also found an association with dicamba exposure.[153]

Exposure to pesticides has long been suspected as a risk factor in non-Hodgin's lymphoma due to a striking fact. While farmers are generally healthier, and have lower ***overall*** cancer rates than the general population, they have higher than average risk of contracting NHL and several other cancers.[154] This fact lends weight to epidemiology studies that find correlations between these cancers and and specific pesticides, such as dicamba. EPA does not discuss the increased incidence of NHL or any other cancer in farmers or pesticide applicators.

EPA fails to assess these studies, though CFS brought most of them to the Agency's attention several years ago.[155] Neither does EPA remark on or assess the commonality in cancer type (lymphatic system) in animal experiments and epidemiology: malignant lymphomas (male rats), lymphosarcomas (female mice), and non-Hodgkin's lymphoma

[148] A 2.8-fold higher risk of cancer than the unexposed control group. *See* Cantor et al 1992, Table 6.
[149] McDuffie et al 2001.
[150] Dicamba is the most widely used benzoic acid herbicide.
[151] Burmeister 1990.
[152] Schinasi and Leon 2014.
[153] Schinasi and Leon 2014.
[154] Blair & Zahm 1995.
[155] *See* Exhibit B (attached).

(pesticide applicators). This may well indicate that dicamba has a common mechanism of action targeting the lymphatic system in animals and humans.

The only epidemiology study assessed by EPA in its six-sentence treatment of epidemiology data.[156] is from the Agricultural Health Study,[157] Samanic et al. found found suggestive associations between dicamba exposure and both lung and colon cancer, with statistically significant exposure-response trends in both cases.[158] EPA's cursory review of Samanic et al. (2006) is biased, incomplete and erroneous, failing to report even the specific types of cancer – lung and colon – for which the authors found dicamba dose-response trends when the referent group was low-exposed applicators. EPA reports that they found a significant trend (p = 0.02), failing to specify this trend was between dicamba exposure and **lung** cancer. Contrary to EPA, this lung cancer trend was ***not*** "largely due to elevated risk at the highest exposure level." The authors identified a still more significant trend for **colon** cancer (p = 0.002), and it is this trend that was largely due to elevated risk at the highest exposure level. Samanic et al. describe their results in part as follows:

> "When the reference group comprised low-exposed applicators, we observed a positive trend in risk between lifetime exposure days and lung cancer (p = 0.02), but none of the individual point estimates was significantly elevated. We also observed significant trends of increasing risk for colon cancer for both lifetime exposure days and intensity-weighted lifetime days, although these results are largely due to elevated risk at the highest exposure level."

EPA also fails to assess a previous Agricultural Health Study[159] that likewise found "a positive trend in risk for lung cancer with lifetime exposure days for dicamba…" (as quoted in Samanic et al. 2006).

Samanic et al. find that "the patterns of association observed for lung and colon cancers warrant further attention" and propose to re-examine dicamba "when larger numbers will allow for a more comprehensive evaluation of lung and colon cancer, as well as additional cancer cites." With registration of the proposed new uses, many more farmers would be exposed to higher levels of dicamba than ever before, providing epidemiologists with additional cancer cases to analyze.

EPA has failed to properly assess either animal or human evidence of dicamba's potential carcinogenicity, or to consider the implications of the common cancer types (lymphatic system) found in animal studies and human epidemiology studies.

EPA's Assessment of the Chronic Toxicity of Dicamba and its Metabolites

Point of Departure based on the DSCA study

[156] EPA, *Human Health Risk Assessment*, at 29-30,
[157] Samanic et al. 2006.
[158] Weichenthal et al 2010.
[159] Alvanaja et al. 2004.

EPA assessed a number of animal feeding studies with dicamba and its major metabolite (DCSA) in dicamba-resistant soybeans and cotton to establish a purported "safe" level of chronic (long-term) human dietary exposure. The studies were submitted by the registrant, and involved long-term administration of dicamba or DCSA to rats, rabbits or dogs at various levels to assess potential reproductive, developmental or neurological toxicity, among other endpoints.[160] Consistent with its standard practice, EPA chose the registrant-submitted study that revealed adverse effects at the lowest dose as its "point of departure" for calculating the highest level of long-term dietary exposure to dicamba that is presumed "safe" for human beings, known as the chronic reference dose (cRfD).

The "point of departure" study chosen by EPA was a two-generation rat reproduction study involving DCSA. In this study, following pre and/or post-natal exposure, rat pups exhibited signs of toxicity (decreased body weight) at levels of DSCA that were approximately ten-fold lower than did adult rats.[161] EPA established the lowest observed adverse effect level (LOAEL) at 37 mg/kg/day, and the no observed adverse effect level (NOAEL) at 4 mg/kg/day.[162] After applying the standard 100X uncertainty factor to the NOAEL for application of these findings to humans (10X for interspecies extrapolation; 10X for intraspecies variation), EPA established a chronic reference dose (cRfD) of 0.04 mg/kg/day. Even though rat pups were 10-fold more sensitive to DCSA than adults, EPA did not apply the additional 10X safety factor demanded by the Food Quality Protection Act (FQPA) when toxicology tests demonstrate that the young are more susceptible than adults. Thus, based on the findings in the DCSA point of departure study, EPA should have applied the FQPA safety factor and set the cRfD at 0.04 x 0.1 = 0.004 mg/kg/day rather than 0.04 mg/kg/day.

Point of Departure based on beagle study not considered by EPA

EPA failed to consider another study in its database that the Agency once used to establish a still lower cRfD. In this study, beagle dogs were administered dicamba in their diets for two years at three different doses, in addition to an untreated control group. The doses of 5, 25 or 50 ppm corresponded to 0.125, 0.625 or 1.25 mg/kg/day. Based on the observation of reduced body weight in males at the 25 ppm = 0.625 mg/kg/day dose, EPA identified an NOAEL of 5 ppm = 0.125 mg/kg/day based on this study. After application of a standard uncertainty factor of 100X, EPA established a chronic reference dose of 0.0013 mg/kg/day.[163] A National Research Council committee recommended a very similar acceptable daily intake (ADI) level (equivalent to cRfD) for dicamba of 0.00125 mg/kg/day,[164], as noted by EPA.[165]

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160 EPA, Human Health Risk Assessment, Tables A.2.4, A.2.5, A.2.6.
161 EPA, *Human Health Risk Assessment*, at 21.
162 EPA, *Human Health Risk Assessment*, at 21, 25.
163 EPA 1987.
164 NRC 1977.
165 EPA 1987.

EPA provides no assessment of this study in any of the registration documents, though it was brought to the Agency's attention three years ago by CFS.[166]

Estimated exposure relative to alternative cRfD values

EPA provides estimates of human dietary exposure (food + water) to dicamba and its metabolites that greatly exceed both alternative cRfD values discussed above. Chronic dietary exposure to dicamba is estimated at 0.006319 mg/kg/day for the general U.S. population and 0.016988 mg/kg/day for the most highly exposed subgroup, children 1-2 years of age.[167] Below we compare these exposure levels to the alternative cRfD values.

Population	Dietary exposure	DCSA study (adj. 10X FQPA)		Beagle study (EPA 1987)	
		cRfD	% exceedance	cRfD	% exceedance
General U.S.	0.006319	0.004	58%	0.0013	386%
1-2 yrs. old	0.016988	0.004	325%	0.0013	1207%

Based on the DSCA study with application of the 10X FQPA safety factor and EPA's estimates of human dietary exposure to dicamba, the general U.S. population and children 1-2 years old are exposed to levels of dicamba that exceed the cRfD by 58% and 325%, respectively. Based on the beagle study that EPA used to set a chronic reference dose in 1987, the estimated exposure of the U.S. population and 1-2 year old children to dicamba is nearly 400% and 1200% greater than the cRfD, respectively. Thus, Americans' exposure to dicamba as estimated by EPA is far above the level the Agency formerly regarded as safe.

Unfortunately, this would not be the first time the Agency has sharply increased the level of exposure to a pesticide it regards as safe, based on unexplained dismissal or dubious reinterpretation of old studies in favor of newer ones that sharply raise the "safe" level of exposure. For instance, EPA radically and unjustifiably altered its interpretation of a key study on the herbicide 2,4-D to accommodate the greatly increased use and exposure that would result from rising use of 2,4-D on corn and soybeans engineered to resist it.[168] In the case of glyphosate, EPA has raised the maximum "safe" level of exposure 17.5-fold since just 1983.[169]

Formaldehyde exposure

Formaldehyde is generated as a byproduct when dicamba is metabolized in DR soybeans and cotton to DCSA (see figure above). EPA should consider potential human health impacts from exposure to formaldehyde in food or feed derived dicamba-resistant soybeans and cotton that has been treated with dicamba.

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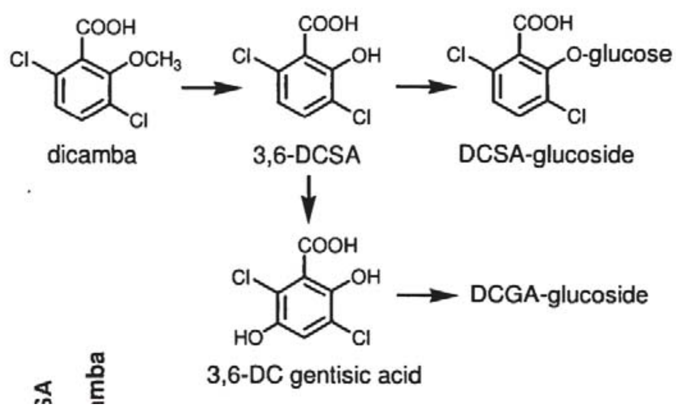
[166] *See* Exhibit B (attached).
[167] EPA, *Human Health Risk Assessment*, at 37 Table 5.4.6.
[168] Callahan 2015.
[169] EPA 1983; *see also* CFS 2015, *Glyphosate and cancer risk: frequently asked questions*, *available at* http://www.centerforfoodsafety.org/files/glyphosate-faq_64013.pdf.

Metabolites of dicamba

When dicamba is applied to dicamba-resistant soybeans and cotton, the herbicide is absorbed and translocated internally to various plant tissues. The novel DMO enzyme expressed in DR soybeans and cotton converts dicamba to 3,6-DSCA and formaldehyde, as discussed above. DCSA in turn undergoes a process known as conjugation – the attachment of sugar molecules to the chemical to form compounds known generically as glycosides. When the sugar molecule that is attached is glucose, the "conjugates" are known glucosides. In dicamba-resistant soybeans, a metabolism study using radioactively labeled dicamba shows that the major dicamba metabolite is DCSA-glucoside (see figure below).

> "A new metabolism study submitted by the registrant on dicamba resistant soybean shows that the identified dicamba metabolites were DCSA glucoside (60.32-74.48% of TRR), which was the major component in dicamba-tolerant soybean, DCSA HMGglucoside (1.14-7.62% of TRR), DCGA glucoside (0.75-4.32%), DCGA malonylglucoside (0.73-5.46% of TRR), DCSA (1.54- 4.08% of TRR), in addition to two minor un-identified metabolites characterized as mixtures of unknown DCSA and DCGA conjugates, each constituted less than 2.0% of the TRR."[170]



Source: Feng, PCC (2013). Methods and composition for improving plant health. U.S. Patent 2013/0217576 A1, August 22, 2013. Figure 11: Metabolism of 14C-dicamba to DCSA and conjugation to glucoside in whole plant studies.

DCSA glucoside represents roughly 60-74% of the total recovered radioactivity (TRR); that is, 60-74% of the radioactively labeled dicamba that was applied to the plant and recovered when the plants were analyzed. In contrast, DCSA in its unconjugated or free form represents just 1.5-4% of the TRR, on the order of 20- to 40-fold less than DCSA glucoside.

170 EPA, *Human Health Risk Assessment*, at 30.

It is well known that intestinal bacteria have the general capacity to split off the glucoside component of conjugated chemicals like DCSA glucoside, thus liberating the non-glucoside component (here, DCSA).[171] Thus, there is a clear potential for animals or human beings that consume feed or food derived from dicamba-resistant soybeans to be exposed not only to the relatively small amount of free DCSA they contain, but also to the much larger amount of DCSA that may be liberated from the DCSA-glucoside conjugate upon ingestion. The same is true of other conjugated metabolites of dicamba (e.g. DCGA-glucoside).

Thus, EPA must consider the potential exposure to DCSA and other metabolites of dicamba that are released from glucoside-conjugated forms of these metabolites when animals or humans consume food or feed derived from dicamba-resistant soybeans and cotton that have been treated with dicamba. This issue is also discussed in the context of potential environmental impacts in the section of our comments addressing potential risks to threatened and endangered species.

CFS addresses additional potential health concerns of the proposed new uses of dicamba in prior comments submitted to the Agency.[172]

CONCLUSION

For the reasons described above and discussed in detail in the attached exhibits and CFS's previously submitted comments, CFS requests EPA comply with FIFRA, FFDCA, MBTA, and the ESA by critically considering the effects to listed species and their critical habitats, as well as the numerous unreasonable adverse human health, environmental, and socioeconomic effects stemming from proposed new uses of dicamba on dicamba-resistant, GE cotton and soybean.

Submitted by,
Center for Food Safety

[171] Stella 2007.
[172] *See* Exhibits A-B (attached).

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USDA Dicamba FEIS (2014). Final Environmental Impact Statement for Monsanto Petitions (10-188-01p and 12-185-01p) for Determinations of Nonregulated Status for Dicamba-Resistant Soybean and Cotton Varieties. US Department of Agriculture, December 2014.

Exhibit A

Center for Food Safety Comments
Docket No. EPA-HQ-2016-0187
Submitted May 31, 2016

The impact of the proposed registration on evolution of herbicide-resistant weeds

Summary

U.S. agriculture's undue reliance on single-tactic, chemical-intensive weed control generates huge costs in the form of herbicide-resistant weeds – costs that could be avoided or greatly lessened with sustainable integrated weed management techniques that emphasize non-herbicidal tactics. Herbicide-resistant crop systems promote more rapid evolution of resistant weeds than do other (non HR crop) uses of the pertinent herbicide(s). This is clearly demonstrated by the history of glyphosate-resistant weeds, which have emerged almost exclusively in the Roundup Ready crop era. Weeds resistant to synthetic auxin herbicides, the class to which dicamba belongs, are already numerous, indicating that auxin-resistance is prevalent in the plant world. The proposed registration would facilitate greatly increased dicamba use on weeds already resistant to glyphosate and other herbicides, leading to still more intractable, multiple herbicide-resistant weeds. Clear evidence of cross-resistance and/or tolerance to auxin herbicides among weed species exacerbates the threat. Multiple herbicide-resistant weeds lead to increased selection pressure for resistance to evolve to the ever fewer remaining effective herbicidal control options. In light of these considerations, weed scientists have recently called for mandatory stewardship practices to address the likely emergence of auxin-resistant weeds with auxin-resistant crop systems. Volunteer HR soybeans with resistance to multiple herbicides may become ever more problematic weeds. Monsanto's stewardship recommendations for MON 88708 are entirely inadequate. Because herbicide-resistant weeds, once evolved, can spread their resistance traits via cross-pollination and seed dispersal, stewardship recommendations that focus on persuading individual growers to "do the right thing" are ineffective, and risk undermining the utility of valuable herbicides for non HR crop uses. Regulation is a rational response to this "tragedy of the commons" dilemma, in which the susceptibility to weeds is the common resource rapidly being squandered.

Weed management vs. weed eradication

Weeds can compete with crop plants for nutrients, water and sunlight, and thereby inhibit crop growth and potentially reduce yield. While less dramatic than the ravages of insect pests or disease agents, weeds nevertheless present farmers with a more consistent challenge from year to year. However, properly managed weeds need not interfere with crop growth. For instance, organically managed corn has been shown to yield as well as conventionally grown varieties despite several-fold higher weed densities (Ryan et al. 2010). Long-term cropping trials at the Rodale Institute reveal that average yields of organically grown soybean were equivalent to those of conventionally grown soybean, despite six times greater weed biomass in the organic system (Ryan et al. 2009). Weeds can even benefit crops – by providing ground cover that inhibits soil erosion and attendant loss of soil nutrients, habitat for beneficial organisms such as ground beetles that consume weed seeds, and organic matter that when returned to the soil increases fertility and soil tilth (Liebman 1993). These complex interrelationships between crops and weeds would seem to call for an approach characterized by careful management rather than indiscriminate eradication of weeds.

Farmers have developed many non-chemical weed management techniques, techniques that often provide multiple benefits, and which might not be utilized specifically or primarily for weed control (see generally Liebman & Davis 2009). For instance, crop rotation has been shown to significantly reduce weed densities versus monoculture situations where the same crop is grown each year (Liebman 1993). Cover crops – plants other than the main cash crop that are usually seeded in the fall and killed off in the spring – provide weed suppression benefits through exudation of allelopathic compounds into the soil that inhibit weed germination, and when terminated in the spring provide a weed-suppressive mat for the follow-on main crop. Common cover crops include cereals (rye, oats, wheat, barley), grasses (ryegrass, sudangrass), and legumes (hairy vetch and various clovers. Intercropping – seeding an additional crop amidst the main crop – suppresses weeds by acting as a living mulch that competes with and crowds out weeds, and can provide additional income as well (Liebman 1993). One common example is intercropping oats with alfalfa. Higher planting densities results in more rapid closure of the crop "canopy," which shades out and so inhibits the growth of weeds. Fertilization practices that favor crop over weeds include injection of manure below the soil surface rather than broadcast application over the surface. Techniques that conserve weed seed predators, such as ground beetles, can reduce the "weed seed bank" and so lower weed pressure. In addition, judicious use of tillage in a manner that does not contribute to soil erosion is also a useful means to control weeds.

Unfortunately, with the exception of crop rotation and tillage, such techniques are little used in mainstream agriculture. This is in no way inevitable. Education and outreach by extension officers, financial incentives to adopt improved practices, and regulatory requirements are just a few of the mechanisms that could be utilized to encourage adoption of more integrated weed management systems (IWM) that prioritize non-chemical tactics (Mortensen et al. 2012). Meanwhile, the problems generated by the prevailing chemical-intensive approach to weed control, exacerbated by the widespread adoption of herbicide-resistant crops, are becoming ever more serious.

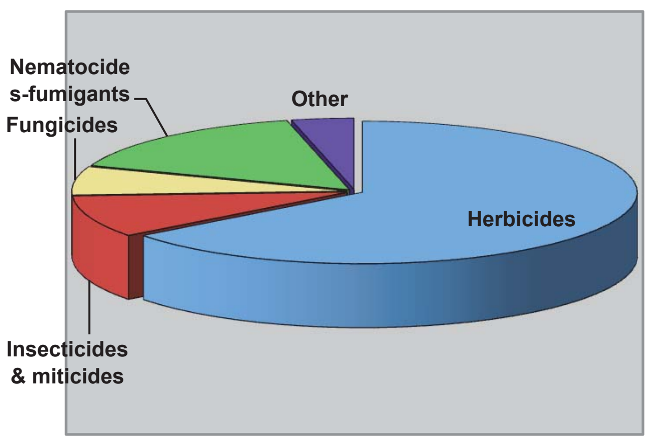
The high costs of herbicide-only weed control

In 2007, U.S. farmers spent $4.2 billion dollars to apply 442 million lbs of herbicide, and uncounted billions more on technology fees for herbicide-resistance traits in major crops. Overall, the U.S. accounts for one-quarter of world herbicide use (EPA Pesticide Use 2011, Tables 3.1, 5.2, 5.6). Surely this intensive herbicidal onslaught should make American fields among the most weed-free in the world. But such is not the case. As farmers gradually came to rely more on herbicides as the preferred and then often the sole means to control weeds, herbicide-resistant weeds have become increasingly severe and costly.

The first major wave of herbicide-resistance came in the 1970s and 1980s as weeds evolved resistance to the heavily used triazines, such as atrazine (see Benbrook 2009a for this discussion). The next major wave of resistance comprised weeds resistant to ALS inhibiting herbicides in the 1980s and 1990s. Just five years intervened between introduction of the first ALS inhibitor herbicide in 1982 and the first resistant weed population (1987). One of the major factors persuading farmers to adopt Roundup Ready, glyphosate-resistant crops was the prevalence of weeds resistant to ALS inhibitors. Weeds have evolved resistance at least 21 "modes of action," or herbicide classes, in the world (ISHRW HR Weed Ranking 9/20/12).

According to the USDA's Agricultural Research Service, up to 25% of pest (including weed) control expenditures are spent to manage pesticide (including herbicide) resistance in the target pest (USDA ARS Action Plan 2008-13-App. II). With an estimated $7 billion spent each year on chemical-intensive weed control (USDA ARS IWMU-1), herbicide-resistant weeds thus cost U.S. growers roughly $1.7 billion (0.25 x $7 billion) annually. These expenditures to manage resistance equate to tens and perhaps over 100 million lbs of the over 400 million lbs of agricultural herbicide active ingredient applied to American crops each year (see figure below), as growers increase rates and make additional applications to kill expanding populations of resistant weeds

Agricultural Pesticide Use in the U.S. by Type: 2007



Herbicides comprise by far the largest category of pesticides, defined as any chemical used to kill plant, insect or disease-causing pests. In 2007, the last year for which the Environmental Protection Agency has published comprehensive data, weedkillers (herbicides) accounted for 442 million lbs of the 684 million lbs of chemical pesticides used in U.S. agriculture, nearly seven-fold more than the insecticides that many associate with the term "pesticide." Source: "Pesticides

Industry Sales and Usage: 2006 and 2007 Market Estimates," U.S. Environmental Protection Agency, 2011, Table 3.4 (EPA Pesticide Use 2011 in supporting materials).

Increasing the rate and number of applications, however, rapidly leads to further resistance, followed by adding additional herbicides into the mix, beginning the resistance cycle all over again, just as overused antibiotics breed resistant and then multiple-drug resistant bacteria. This process, dubbed the pesticide treadmill, has afflicted most major families of herbicides, and will only accelerate as U.S. agriculture becomes increasingly dependent on crops engineered for resistance to one or more members of this by far largest class of pesticides (Kilman 2010).

Besides costing farmers economically via herbicide-resistant weeds, the chemical-intensive pest control regime of HR crop systems also has serious public health and environmental consequences. Various pesticides are known or suspected to elevate one's risk for cancer, neurological disorders, or endocrine and immune system dysfunction. Epidemiological studies of cancer demonstrate that farmers in many countries, including the U.S., have higher rates of immune system and other cancers (USDA ERS AREI 2000). Little is known about the chronic, long-term effects of exposure to low doses of many pesticides, especially in combinations. Pesticides deemed relatively safe and widely used for decades (e.g. cyanazine) have had to be banned in light of scientific studies demonstrating harm to human health or the environment. Pesticides also pollute surface and ground water, harming amphibians, fish and other wildlife.

Herbicide-resistant weeds thus lead directly to adverse impacts on farmers, the environment and public health. Adverse impacts include the increased costs incurred by growers for additional herbicides to control them, greater farmer exposure to herbicides and consumer exposure to herbicide residues in food and water, soil erosion and greater fuel use and emissions from increased use of mechanical tillage to control resistant weeds, environmental impacts from herbicide runoff, and in some cases substantial labor costs for manual weed control. These are some of the costs of unsustainable weed control practices, the clearest manifestation of which is evolution of herbicide-resistant weeds.

Why herbicide-resistant crop systems promote rapid evolution of resistant weeds

Herbicide-resistant (HR) crop systems such as MON 87708 soybeans involve post-emergence application of one or more herbicides to a crop that has been bred or genetically engineered to survive application of the herbicide(s). These HR crop systems promote more rapid evolution of herbicide-resistant weeds than non-HR crop uses of the associated herbicides. This is explained by several characteristic features of these crop systems.

HR crops foster more ***frequent*** use of and ***overreliance*** on the herbicide(s) they are engineered to resist. When widely adopted, they also lead to more ***extensive*** use of HR crop-associated herbicide(s). Herbicide use on HR crops also tends to occur ***later in the season***, when weeds are larger. Each of these factors contributes to rapid evolution of resistant weeds by favoring the survival and propagation of initially rare individuals that have genetic mutations lending them resistance. Over time, as their susceptible brethren are killed off, these rare individuals become more numerous, and eventually dominate the weed population.

High frequency of use means frequent suppression of susceptible weeds, offering (at frequent intervals) a competition-free environment for any resistant individuals to thrive. Overreliance on the HR crop-associated herbicide(s) means little opportunity for resistant individuals to be killed off by alternative weed control methods, thus increasing the likelihood they will survive to propagate and dominate the local weed population. Widespread use of the HR crop system increases the number of individual weeds exposed to the associated herbicide(s), thus increasing the likelihood that there exists among them those individuals with the rare genetic predisposition that confers resistance. The delay in application fostered by HR crop systems means more weeds become larger and more difficult to kill; thus, a greater proportion of weeds survive to sexual maturity, and any resistant individuals among them are more likely to propagate resistance via cross-pollination of susceptible individuals or through deposition of resistant seeds in the seed bank; in short, a higher likelihood of resistance evolution.

Below, we discuss these resistant weed-promoting features of HR crop systems in more detail, with particular reference to systems involving glyphosate-resistance (Roundup Ready) and auxin-resistance.

GE seeds in general, including HR seeds, are substantially more expensive than conventional seeds (Benbrook 2009b). Their higher cost is attributable to a substantial premium (often called a technology fee) for the herbicide-resistance trait. This premium constitutes a financial incentive for the grower to fully exploit the trait through frequent and often exclusive use of the associated herbicide(s), and a disincentive to incur additional costs by purchasing other, often more expensive herbicides.

> The cost of RR [Roundup Ready] alfalfa seed, including the technology fee, is generally twice or more than that of conventional alfalfa seed. Naturally, growers will want to recoup their investment as quickly as possible. Therefore, considerable economic incentive exists for the producer to rely solely on repeated glyphosate applications alone as a weed control program. (Orloff et al. 2009, p. 9).

To our knowledge, Monsanto has not revealed its pricing for MON 87708 seed, but it is likely to be considerably more expensive than currently available GE varieties.

Overreliance is especially favored when the associated herbicide(s) are effective at killing a broad range of weeds, which tends to make other weed control practices less needed, at least until weed resistance emerges. Glyphosate is such a broad-spectrum herbicide; dicamba provides control of most broadleaf weeds. Applied together or sequentially, glyphosate and dicamba would initially provide broad-spectrum control of soybean weeds, making use of other weed control measures unnecessary until the inevitable rapid evolution of auxin resistance, often in populations already resistant to glyphosate and/or other herbicides. Greater use of non-chemical weed control tactics is the only way to avoid the evolution of increasingly intractable, multiple HR weeds.

Frequent use and overreliance are also fostered when the HR crop-associated herbicide(s) are inexpensive relative to other herbicides. Monsanto lowered the price of Roundup herbicide (active ingredient: glyphosate) in the late 1990s to encourage farmers to adopt Roundup Ready crop systems and rely exclusively on glyphosate for weed control (Barboza 2001),[13] and the price has fallen further since then. Dicamba is even cheaper than glyphosate, and in fact is one of the least inexpensive herbicides on the market (U of Tenn 2011, p. 94). As suggested by Orloff et al. (2009), quoted above, overreliance on HR crop-associated herbicide(s) is particularly favored when the HR trait premium is high and the price of the associated herbicide(s) is low, the likely scenario with MON 87708 soybeans. Any price premium for a dicamba product registered for use on MON 87708 would encourage farmers to use cheaper and more drift-prone formulations.

One of the key changes wrought by herbicide-resistant crop systems is a strong shift to post-emergence herbicide application, which generally occurs later in the season on larger weeds, versus early-season use on smaller weeds or prior to weed emergence that is more characteristic of conventional crops. It is important to understand that facilitation of post-emergence herbicide use as the sole or primary means of weed control is the *sine qua non* of HR crop systems, not an incidental feature. Early-season uses include soil-applied herbicides put down around the time of planting; these herbicides have residual activity to kill emerging weeds for weeks after application. The Roundup Ready soybean system has practically eliminated use of soil-applied, or indeed of any herbicide other than glyphosate.

Weed scientist Paul Neve has simulated the rate at which weeds evolve resistance to glyphosate under various application regimes (Neve 2008). His results show unambiguously that the post-emergence use of glyphosate unique to glyphosate-resistant crop systems fosters resistant weeds much more readily than traditional uses ("prior to crop emergence") typical of conventional crops. This is consistent with the massive emergence of glyphosate-resistant weeds only after glyphosate-resistant crops were introduced (see below):

> Glyphosate use for weed control prior to crop emergence is associated with low risks of resistance. These low risks can be further reduced by applying glyphosate in sequence with other broad-spectrum herbicides prior to crop seeding. Post-emergence glyphosate use, associated with glyphosate-resistant crops, very significantly increases risks of resistance evolution. (Neve 2008)

Glyphosate-resistant crop systems have fostered later post-emergence applications than many agronomists anticipated, which increases the potential for resistant weed evolution.

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[13] Monsanto has greatly increased the price of RR seed to compensate for reduced income from sale of Roundup.

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> Growers rapidly adopted glyphosate-resistant crops and, at least initially, did not have to rely on preventive soil-applied herbicides. Growers could wait to treat weeds until they emerged and still be certain to get control. ***Many growers waited until the weeds were large in the hope that all the weeds had emerged and only one application would be needed. Today, experts are challenging this practice from both an economic and a sustainability perspective.*** (Green et al. 2007, emphasis added)

> Following the widespread adoption of glyphosate-resistant soybean, ***there has been a subtle trend toward delaying the initial postemergence application longer than was once common***. Because glyphosate provides no residual weed control and application rates can be adjusted to match weed size, ***producers hope that delaying the initial postemergence application will allow enough additional weeds to emerge so that a second application will not be necessary.*** (Hagar 2004, emphasis added)

University of Minnesota weed scientist Jeff Gunsolus notes that: "Larger weeds are more apt to survive a postemergence application and develop resistance." (as quoted in Pocock 2012). University of Arkansas weed scientist Ken Smith notes that application of Ignite (glufosinate) to cotton plants with dual resistance to glyphosate and glufosinate (Widestrike varieties) in order to control large glyphosate-resistant weeds risks generating still more intractable weeds resistant to both herbicides (as quoted in Barnes 2011, emphasis added):

> Many growers who use Ignite on WideStrike varieties do so after they discover they have glyphosate-resistant weeds, according to Smith. To combat this, ***growers will make an application of Ignite on weeds that, on occasion, have grown too big to be controlled by the chemistry. This creates a dangerous scenario which could possibly encourage weeds to develop resistance to glufosinate***, the key chemistry in Ignite. ***The end-result, according to Smith, would be disastrous***.

It should be noted that Dr. Smith's concern is that weeds will evolve resistance to the same two herbicides to which the HR crop is resistant, which both undermines the utility of the crop and creates a potentially noxious HR weed that becomes extremely difficult to control. As discussed further below, this tendency for weeds to mimic the herbicide resistances in the crop is a general feature of HR crop systems, and sets up a futile and costly chemical arms race between HR crops and weeds.

Overview of glyphosate-resistant crops and weeds

A discussion of glyphosate-resistant (GR) crops and weeds is important for two reasons. First, the rapid emergence of GR weeds in RR crop systems is evidence of the resistant weed-promoting effect of HR crop systems in general, as discussed above, and provides insight into the risks of resistant weed evolution in the context of the MON 87708 soybean system. Second, the prevalence of glyphosate-resistant weeds is the motivating factor in Monsanto's introduction and farmers' potential adoption of MON 87708 under the proposed registration.

Glyphosate-resistant crops represent by far the major HR crop system in American and world agriculture, and provide an exemplary lesson in how HR crop systems trigger HR weeds (see Benbrook 2009a for following discussion). Glyphosate was first introduced in 1974. Despite considerable use of the herbicide, for the next 22 years there were no confirmed reports of glyphosate-resistant weeds. A few small and isolated populations of resistant weeds – mainly rigid and Italian ryegrass and goosegrass – emerged in the late 1990s, attributable to intensive glyphosate use in orchards (e.g. Malaysia, Chile, California) or in wheat production (Australia).

Significant populations of glyphosate-resistant weeds have only emerged since the year 2000, four years after the first Roundup Ready (RR) crop system (RR soybeans) was introduced in 1996, followed by RR cotton & canola in 1997 and RR soybean in 1998. According to the International Survey of Herbicide-Resistant Weeds (ISHRW), multiple populations of 23 weed species are resistant to glyphosate in one or more countries today; of these, 26 populations of ten species are also resistant to herbicides in one to three other families of chemistry in addition to glyphosate (ISHRW GR Weeds 4/22/12).[14] Based on acreage infested, GR weeds have emerged overwhelmingly in soybeans, cotton and soybean in countries, primarily the U.S., where RR crop systems predominate (see CFS RRSB 2010, which has further analysis of GR weeds).

The first glyphosate-resistant (GR) weed population confirmed in the U.S., reported in 1998, was rigid ryegrass, infesting several thousand acres in California almond orchards (ISHRW GR Weeds 4/22/12). Beginning in the year 2000 in Delaware, glyphosate-resistant horseweed rapidly emerged in Roundup Ready soybeans and cotton in the East and South. Just twelve years later, glyphosate-resistant biotypes of 13 species are now found in the U.S., and they infest millions of acres of cropland in at least 27 states (ISHRW GR Weeds 4/22/12).[15]

Based on Center for Food Safety's periodic compilation of data from the ISHRW website over the past four years, glyphosate-resistant weeds in the U.S. have evolved at an accelerated rate in recent years. As of November 2007, ISHRW recorded eight weed species resistant to glyphosate, covering up to 3,200 sites on up to 2.4 million acres. By Sept. of 2012, as many as 440,000 sites on up to 18,700,000 acres were documented to be

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[14] A population of one additional weed species (for 24 total) has evolved resistance to glyphosate since the cited 4/22/12 list was compiled, spiny amaranth in Mississippi. See http://www.weedscience.org/Case/Case.asp?ResistID=5682.

[15] Now 14 weed species, in at least 30 states. GR weeds have been documented in three additional states since this 4/22/12 list was compiled. For South Dakota and Wisconsin, see list at http://www.weedscience.org/Summary/UspeciesMOA.asp?lstMOAID=12&FmHRACGroup=Go. For Montana, see AgNews (2012). Thus, all 10 major soybean growing states how have GR weeds.

infested by glyphosate-resistant weeds (CFS GR Weed List – 9/20/12). This astonishing proliferation of resistant weeds – an over 130-fold increase in number of sites and 8-fold increase in acreage – is portrayed in the figure at the end of this section.

However, the true extent of GR weeds is much greater than even the maximum figures shown in the graph, because "...the voluntary basis of the contributions [to ISHRW] likely results in underestimation of the extent of resistance to herbicides, including glyphosate" (NRC 2010, p. 2-12). Many examples could be cited to illustrate to what extent ISHRW underestimates the extent of GR weed populations, but one will suffice. Illinois weed scientist Bryan Young recently reported 5-6 million acres of Illinois cropland infested with glyphosate-resistant waterhemp (as quoted in Lawton 2012, confirmed with Dr. Young, personal communication). Yet ISHRW lists GR waterhemp as infesting just 100 acres in Illinois (ISHRW Illinois Waterhemp). Inclusion of this single updated report in the ISHRW system would raise the GR weed infested acreage by one-third. It appears that much or all of this waterhemp is resistant to ALS inhibitors as well, with a significant portion also resistant to PPO inhibitors and/or triazine herbicides (Tranel 2010).

Dr. Ian Heap, who manages the ISHRW website cited above, confirms that: "The survey is definitely too low because researchers report the first cases and enter in the area infested. Often they don't return in subsequent years to keep updating the survey." Dr. Heap estimates that "there are about 40 million acres affected by glyphosate-resistant weeds," but notes that if one accounts for "overlapping acres" infested with more than one GR weed, "the estimate probably comes down to about 30 million actual acres" (Heap 2012). Dow has an even higher estimate of GR weed-infested acreage of 60 million acres (Bomgardner 2012). Thus, actual acreage infested with glyphosate-resistant weeds is double to triple the 18.7 million acres reported by ISHRW and shown in the figure below. However, the figure can be assumed to accurately capture the extremely rapid pace of GR weed emergence.

Early on, most resistant weed populations were driven by intensive glyphosate use associated with RR soybeans and RR cotton. However, adoption of corn with the Roundup Ready trait has increased sharply in recent years, from 20% to 72% of national corn acres from just 2004 to 2011. The increasing reliance on glyphosate associated with the growing use of RR soybean/RR corn rotations is the major factor driving the rapid emergence of resistant weeds in the Midwest and Northern Plain states. In general, more GR weeds are emerging on agricultural land planted to several crops that are predominantly Roundup Ready in the U.S., which since 2008 includes sugar beets. The most recent example is the emergence of GR common waterhemp on land planted to soybeans, corn and sugar beets in North Dakota (ISHRW GR Weeds 4/22/12).

Populations of some glyphosate-resistant weeds, such as GR Palmer amaranth, GR horseweed, GR kochia, and GR common waterhemp, are properly regarded as noxious weeds. The increased use of herbicides and increased use of soil-eroding tillage operations to control them cause harm to the environment and natural resources (e.g. loss of soil and increased runoff of agricultural chemicals). When not properly managed due to the difficulty of controlling them, these noxious weeds can sharply reduce yields, while successful control efforts often involve a several-fold increase in weed control costs, in either case harms to the interests of agriculture. A brief, documented overview of these harms is provided in Benbrook (2009a, Chapter 4).

Synthetic auxin-resistant crops and weeds

Synthetic auxin herbicides like dicamba act by mimicking plant growth hormones such as indole acetic acid. Monsanto maintains that "there is a low potential for dicamba-resistant broadleaf weed populations to arise from the use of dicamba applied to MON 87708 integrated into the Roundup Ready soybean system," and gives the following reasons for this opinion (Monsanto 2010, p. 601).

1) Dicamba will be used together with glyphosate, with recommended use of a soil residual herbicide, and such use of multiple modes of action "is a primary way to delay the development of resistance;"
2) Resistance to auxin herbicides has developed slowly, hypothetically due to multiple sites of action within plants, suggesting that resistance is determined by multiple genes as a quantitative trait;
3) Only four broadleaf weeds have confirmed as resistant to dicamba in the U.S., while relatively low numbers of weed species have confirmed resistance to synthetic auxin herbicides in general; and
4) Confirmed dicamba- and auxin-resistant weeds are found primarily in the West rather than in major soybean production regions, and weeds with known dicamba resistance are not major soybean weeds.

There are several serious flaws in these arguments, which were persuasively rebutted by Mortensen et al. (2012). First, Monsanto's two points regarding past history of auxin- and dicamba-resistant weed emergence have little bearing on the future course of resistance with introduction of MON 87708 under the proposed registration. As explained above, use of an herbicide in the context of an HR crop system very significantly elevates the risk of resistant weed emergence relative to non-HR crop uses of the same herbicide. Monsanto officers cannot fail to understand this, given the history of glyphosate-resistant weeds with their RR crops, but apparently prefer to ignore the lesson.

However, even to the limited extent that past resistance is relevant, Monsanto is in error. The ISHRW website lists 50 biotypes[16] of 30 different weed species with resistance to synthetic auxin herbicides internationally (ISHRW SynAux Weeds 9/20/12). Of the 21 herbicide modes of action to which weeds have evolved resistance, synthetic auxin-resistant weeds rank fourth in terms of number of resistant species, in the top quintile (ISHRW HR Weed Ranking 9/20/12). Contrary to Monsanto, this is a quite high number of resistant species relative to other modes of action. While this is in no way determinative of which weed species will evolve resistance in the future, it does indicate that the genetic

[16] We use the term "biotype" to refer to a single listing on the ISHRW website. For instance, four biotypes of the single species kochia have evolved auxin resistance in four different states.

predisposition to survive auxin treatment is quite prevalent in the plant world. Moreover, five new auxin-resistant biotypes and 1 new species have been recorded by ISHRW over just the past five months,[17] indicative of continuing and perhaps accelerated emergence of auxin-resistant weeds.

Nine biotypes of five different weed species have confirmed resistance to dicamba: lambsquarters (1), common hempnettle (1), kochia (4), prickly lettuce (1) and wild mustard (2) (see ISHRW SynAux Weeds Table 9/20/12 for following discussion). One other biotype highly resistant to 2,4-D also exhibits reduced sensitivity to dicamba (common waterhemp in Nebraska, discussed further below). Interestingly, four biotypes of four species have confirmed resistance to dicamba and other auxin herbicides, while one other population has multiple resistance to dicamba and several ALS inhibitors. The cross-resistance of dicamba-resistant weeds to other auxin herbicides is troubling, because it removes alternative weed control options, and could undermine the utility of both auxin-resistant soybean varieties. Many auxin-resistant weeds have not been tested for dicamba resistance, so there could be considerably more weed species and biotypes that are immune to the herbicide.

The argument that auxin-resistant weeds have developed slowly due to multiple sites of action in the plant is also specious. In most cases, scientists have not elucidated the precise mechanisms by which weeds evolve resistance, making predictions about the likelihood of weed resistance on this basis extremely hazardous. This is particularly true of auxin resistance, the precise mechanisms of which have yet to be elucidated. Monsanto scientists likewise predicted very little chance of glyphosate-resistant weed evolution in the 1990s (Bradshaw et al. 1997), and for much the same reasons: dearth of resistance from past use of glyphosate, and the molecular nuances of glyphosate's mode of action.[18] These predictions were of course disastrously wrong, but they did help quell concerns about GR weed evolution and forestall efforts to establish mandatory weed resistance management programs as Monsanto was introducing its Roundup Ready crops. Interestingly, only one GR weed had been identified by the time the first RR crop was introduced in 1996 (ISHRW GR Weeds 4/22/12), in contrast to the 30 weed species with biotypes resistant to auxins today.

The experience with glyphosate-resistant weeds demonstrates that neither a narrow focus on the biochemical nuances of resistance mechanisms, nor the frequency of resistance evolution in the past, provide an accurate basis for forecasting what will happen when the herbicide in question is used in the context of an herbicide-resistant crop system. What it does demonstrate is that the characteristic ways in which HR crop systems are used in the field, as discussed above, make them far more likely to trigger evolution of resistant weeds than non-HR crop uses of those same herbicides.

[17] 45 biotypes and 29 species when CFS last recorded these data (compare ISHRW SynAux Weeds 4/22/12 to ISHRW SynAux Weeds 9/20/12).

[18] Interestingly, another reason put forward by Monsanto scientists Bradshaw and colleagues for the unlikelihood of GR weed evolution was Monsanto's past failures in multiple attempts to engineer glyphosate-resistant plants, the arrogant presumption being that Nature could certainly not accomplish what had proven so difficult for Monsanto's scientists.

Monsanto's third argument, that use of both dicamba and glyphosate on MON 87708 soybean stacked with glyphosate resistance will hinder evolution of weeds resistant to either one, also lacks merit. This argument ignores the obvious fact that the huge extent of existing GR weed populations – with many billions of individual weeds on 30 to 60 million infested acres – make it near certain that some among them will have the rare genetic mutations conferring resistance to dicamba ***as well***. Mortensen et al. (2012) provide the mathematical exposition (emphasis added):

> First, when an herbicide with a new mode of action is introduced into a region or cropping system in which weeds resistant to an older mode of action are already widespread and problematic, the probability of selecting for multiple target-site resistance is not the product of two independent, low-probability mutations. In fact, the value is closer to the simple probability of finding a resistance mutation to the new mode of action within a population already extensively resistant to the old mode of action. For instance, in Tennessee, an estimated 0.8–2 million ha of soybean crops are infested with glyphosate-resistant horseweed (C. canadensis) (Heap 2011). Assuming seedling densities of 100 per m^2 or 10^6 per ha (Dauer et al. 2007) and a mutation frequency for synthetic auxin resistance of 10^{-9}, ***this implies that next spring, there will be 800–2000 horseweed seedlings in the infested area that possess combined resistance to glyphosate and a synthetic auxin herbicide*** ((2×10^6 ha infested with glyphosate resistance) x (10^6 seedlings per ha) x (1 synthetic auxin–resistant seedling per 10^9 seedlings) = 2000 multiple-resistant seedlings). In this example, these seedlings would be located in the very fields where farmers would most likely want to plant the new stacked glyphosate- and synthetic auxin–resistant soybean varieties (the fields where glyphosate-resistant horseweed problems are already acute). Once glyphosate and synthetic auxin herbicides have been applied to these fields and have killed the large number of susceptible genotypes, these few resistant individuals would have a strong competitive advantage and would be able to spread and multiply rapidly in the presence of the herbicide combination.

The upshot is that dicamba-resistant crop systems like MON 87708 soybean will very likely foster rapid evolution of weeds resistant to dicamba and glyphosate. In those cases where the GR weed populations in dicamba-treated crop fields already have resistance to one or more additional modes of action, the result will be evolution of still more intractable weeds with multiple-herbicide resistance, including to dicamba and glyphosate.

Multiple herbicide-resistant crops and weeds

Mortensen et al. (2012) note that there are currently 108 biotypes of 38 weed species possessing simultaneous resistance to two more classes of herbicide, and that 44% of them have appeared since 2005. Since herbicide-resistant weeds began to emerge in a significant way around 1970 (triazine-resistant weeds),[19] this means that nearly half of multiple HR weed biotypes have emerged in just the past seven years of our 40-year history of significant weed resistance. This global trend is also occurring in the U.S., where acreage infested with multiple HR weeds has increased by 400% over just the three years from November 2007 to November 2010 (Freese 2010, p. 15). There are at least 12 biotypes of weeds resistant to glyphosate and one or more other herbicide families in the U.S. (11) and Canada (1) that are attributable to RR crop systems, all but one having emerged since 2005 (CFS GR Weed List 9/20/12).

The progressive acquisition of resistances to different herbicide classes has the insidious effect of accelerating evolution of resistance to those ever fewer herbicides that remain effective. This is well-expressed by Bernards et al. (2012) with reference to multiple-herbicide-resistant waterhemp, though it applies more generally:

> The accumulation of multiple-resistance genes within populations and even within individual plants is of particular concern. This resistance stacking limits chemical options for managing waterhemp 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.

There is already evidence that the scenario of dicamba resistance evolving in weeds already resistant to one or more herbicide classes, as depicted by Mortensen et al. (2012), will occur with four especially problematic species of weeds: horseweed, Palmer amaranth, waterhemp and kochia. These are the four weed species deemed most likely to evolve problematic populations of dicamba-resistant weeds by weed scientists (Crespo 2011).

i. Horseweed

Horseweed, or marestail, is the most prevalent GR weed. First discovered in 2000 in Delaware, GR horseweed has emerged in just over a decade to infest up to 8.4 million acres in 20 states (CFS GR Weed List 9/20/12[20]), up from 3.3 million acres in 16 states in February 2009 (Benbrook 2009a, p. 35). It is particularly prevalent in Tennessee, Kansas and Illinois, with populations infesting up to 5 million, 2 million and 1 million acres, respectively. GR horseweed in Mississippi is also resistant to paraquat, the first time multiple resistance to these two herbicides has been documented, while in California a population of horseweed's Conyza relative, hairy fleabane, with dual resistance to glyphosate and paraquat was recently reported to infest up to 1 million acres. Ohio has glyphosate/ALS inhibitor-resistant[21] horseweed.

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[19] A few auxin-resistant biotypes emerged in the 1950s and 1960s.

[20] Consult this chart for data in the following discussion. It should also be noted that these acreage-infested estimates are highly conservative, in view of the underreporting in the ISHRW system, as discussed above.

[21] CFS suspects that GR weeds that are also resistant to ALS inhibitor herbicides are greatly underreported by ISHRW; this is certainly the case with waterhemp (see discussion below).

Weed scientists regard GR horseweed as a "worst-case scenario" in RR cropping systems because this weed is well adapted to no-tillage planting systems popular among GR crop growers. It also produces up to 200,000 seeds per plant, and its seeds can disperse extremely long distances in the wind (Owen 2008), which may partly explain the prevalence of GR horseweed.

GR horseweed can reduce cotton yields by 40 to 70% (Laws 2006), and is also problematic in soybeans. In 2003, Arkansas weed scientist Ken Smith estimated that Arkansas growers would have to spend as much as $9 million to combat glyphosate-resistant horseweed in 2004 (AP 2003). An uncontrolled outbreak of GR horseweed in Arkansas could reduce the income of cotton and soybean farmers by nearly $500 million, based on projected loss in yield of 50% in 900,000 acres of cotton and a 25% yield loss in the over three million acres of soybeans (James 2005). Tennessee is especially hard hit, with up to 5 million acres of both cotton and soybeans infested with GR horseweed.

Because GR horseweed is often controlled with tillage, it has led to abandonment of conservation tillage practices on substantial cotton acreage in Tennessee and Arkansas, with similar trends reported in Mississippi and Missouri (Laws 2006) and perhaps other states. This in turn increases soil erosion. An NRC committee reported that increased tillage and increased herbicide use are common responses to glyphosate-resistant weeds (NRC 2010). Evolution of multiple herbicide-resistance reduces options for chemical control and so increases the chances for still more soil-eroding tillage.

The many farmers with GR and multiple-HR horseweed would be prime candidates for MON 87708. Yet Purdue University weed scientists have flagged horseweed as a plant with the genetic "plasticity" to readily evolve resistance to multiple herbicides:

> Multiple-resistant and cross-resistant horseweed populations have evolved to various combinations of the previous herbicide modes of action in Israel, Michigan, and Ohio (Heap 2009), providing evidence for the plasticity of this weed. (Kruger et al. 2010a).[22]

These same 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 in the context of heavy postemergence use enabled by the proposed registration:

> "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

[22] As noted above, horseweed has also evolved dual resistance to glyphosate and paraquat in Mississippi; in California, a glyphosate/paraquat-resistant biotype of the closely related *Conyza* weed hairy fleabane was recently reported to infest up to 100,000 fields on as much as 1 million acres. See http://www.weedscience.org/Case/Case.asp?ResistID=5250.

> 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, suggesting that the proposed registration might more readily lead to auxin-resistant horseweed than would other forms of dicamba.

Kruger et al 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 above, 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 RR 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). But 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 than were similar recommendations made for glyphosate with Roundup Ready crops.

Cultivation of MON 87708 under the proposed registration is quite likely to promote rapid evolution of horseweed resistant to dicamba and perhaps 2,4-D as well, often in combination with glyphosate-resistance. 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.

ii. Waterhemp

Waterhemp is regarded as one of the worst weeds in the Corn Belt. It grows to a height of 2-3 meters, and emerges late into the growing season. Controlled trials in Illinois demonstrated that late-season waterhemp reduced corn yields in Illinois by 13-59%, while waterhemp emerging throughout the season cut yields by up to 74% (Steckel & Sprague 2004).

ISHRW lists 12 biotypes of GR waterhemp, all of which have emerged since 2005 in corn, soybeans, cotton and/or sugar beets, almost certainly all in RR crop systems (CFS GR Weed List 9/20/12). While ISHRW records up to 1.1 million acres infested with GR waterhemp, this is a vast underestimate. As noted above, Illinois weed scientist Bryan Young estimates a substantial 5-6 million acres infested with GR waterhemp in his state.

Waterhemp has an astounding ability to evolve resistance to herbicides. Biotypes resistant to one to four herbicide families have been identified in several Midwest and Southern states, from North Dakota to Tennessee (see CFS GR Weed List 9/20/12 for those resistant to glyphosate). Triple herbicide-resistant waterhemp infests up to one million acres in Missouri, while populations resistant to four herbicide classes, sardonically called "QuadStack Waterhemp" (Tranel 2010), have arisen in Illinois. Tranel's investigations suggest that the 5-6 million acres of GR waterhemp in Illinois noted above are all resistant to ALS inhibitors, with some additionally resistant to PPO inhibitors and/or triazines.

Tranel states that multiple herbicide-resistant waterhemp "appears to be on the threshold of becoming an unmanageable problem in soybean," and is quite concerned that if already multiple herbicide-resistant waterhemp evolves resistance to additional herbicides, "soybean production may not be practical in many Midwest fields" (Tranel et al 2010). Corn is often rotated with soybeans, and so could be similarly affected.

In early 2011, waterhemp was identified as the first weed with resistance to a relatively new class of herbicides, HPPD inhibitors, the fifth mode of action to which waterhemp has evolved resistance (Science Daily 2011), prompting weed scientist Aaron Hagar to comment that "we are running out of options" to control this weed. Populations of waterhemp in Iowa and Illinois are resistant to HPPD inhibitors and two other modes of action (ISHRW Waterhemp 2012).

Just months later, a waterhemp population highly resistant to 2,4-D and with significantly reduced sensitivity to dicamba was discovered (Bernards et al 2012), and it is potentially resistant to the popular corn herbicides atrazine and metolachlor as well, which would make it particularly difficult to manage (UNL 2011). The weed scientists who discovered this resistant weed population clearly understand the likelihood that auxin-resistant crops – "if used as the primary tool to manage weeds already resistant to other herbicides," the hallmark of these systems – will lead to still more intractable, multiple herbicide-resistant weeds:

> 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)

In a peer-reviewed publication about this same waterhemp population, these scientists call for mandatory weed resistance prevention measures for MON 87708 soybean and other auxin-resistant crops:

> ***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 close reading of this paper helps explain their concerns. First, the 2,4-D-resistant waterhemp population is resistant to extremely high rates of 2,4-D, with some plants surviving application of 35,840 grams/hectare of 2,4-D, equivalent to 32 lbs/acre, or 32 times the maximum single 2,4-D application rate in the proposed label for 2,4-D use on MON 87708 soybean. Second, this population also has significantly reduced sensitivity to dicamba. This is important because it suggests that waterhemp has the capacity to evolve simultaneous resistance to both 2,4-D and dicamba, even without application of dicamba (no dicamba use was reported on the field where this weed evolved 2,4-D resistance); and because the elimination of 2,4-D as an effective control option is compounded by the elimination or at least erosion of the efficacy of a second important control tool, dicamba. Third, as noted above, waterhemp is one of the most damaging weeds in the Corn Belt, and multiple herbicide-resistance makes it still more damaging and expensive to control.

It is interesting to note that the field where this waterhemp evolved resistance to 2,4-D and tolerance to dicamba had also been regularly treated with atrazine and metolachlor: "Since

1996, atrazine, metolachlor, and 2,4-D were applied annually to control annual grasses and broadleaf weeds" (Bernards et al. 2012). This suggests the possibility of resistance to atrazine and/or metolachlor as well: "Research is underway at UNL to determine whether this waterhemp population has developed resistance to additional herbicide mechanisms-of-action" (UNL 2011).

Use of multiple herbicides is supposed to forestall evolution of resistance to any single herbicide. At least in the case of this waterhemp population, this strategy apparently did not work. Atrazine-resistant waterhemp has been reported in Nebraska and other states, and is particularly prevalent in Kansas, with up to 1 million infested acres reported.[23] Thus, it is possible that this population had previously evolved resistance to atrazine, demonstrating the potential for "resistance-stacking." 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.[24] Monsanto's recommendation that farmers use a soil residual herbicide in addition to dicamba and glyphosate with MON 87708 will most likely not be followed, as explained above. However, this waterhemp population suggests that the herbicidal onslaught approach may not always be successful even if utilized. In addition, Bernards and colleagues' call for mandatory stewardship practices suggests that HR crops, as explained above, are particularly prone to foster rapid evolution of weed resistance.

iii. Palmer amaranth

Perhaps the most destructive and feared weed in all of U.S. agriculture is glyphosate-resistant Palmer amaranth (see Benbrook 2009a, Chapter 4). Second only to GR horseweed in prevalence, GR Palmer amaranth is estimated to infest 112,000 to over 220,000 fields covering up to 7.0 million acres in 12 states, all but one in corn, cotton and/or soybeans (CFS GR Weed List 9/20/12). Best known for plaguing cotton and soybean growers in Southern states, this weed is rapidly emerging in Corn Belt states like Illinois and Missouri; populations have recently been reported in Michigan (ISHRW GR Weed List 4/22/12) and Ohio (Ohio Farmer 2012). In California, a population of GR Palmer amaranth has just been reported infesting three predominantly Roundup Ready crops (alfalfa, corn, cotton) as well as orchards, vineyards, roadways and fencelines.[25] Palmer amaranth is feared especially because of its extremely rapid growth – several inches per day – which means it can literally outgrow a busy farmer's best attempts to control it while still small enough to be killed. It also produces a huge number of seeds, so just one mature weed can ensure continuing problems in future years by pouring hundreds of thousands of resistant weed seeds into the "weed seed bank." Left unchecked, its stem can become baseball bat breadth, and is tough enough to damage cotton pickers. Glyphosate-resistant Palmer amaranth can dramatically cut yields by a third or more, and occasionally causes

[23] See entries for "photosystem II inhibitors," the class of herbicides to which atrazine belongs, at http://www.weedscience.org/Summary/USpeciesCountry.asp?lstWeedID=219&FmCommonName=Go.

[24] http://www.weedscience.org/Summary/UspeciesMOA.asp?lstMOAID=18&FmHRACGroup=Go

[25] http://www.weedscience.org/Case/Case.asp?ResistID=5690.

abandonment of cropland too weedy to salvage. In Georgia, Arkansas and other states, farmers have resorted to hiring weeding crews to manually hoe this weed on hundreds of thousands of acres, tripling weed control costs (Haire 2010). Herbicide regimes of six to eight different chemicals, including toxic organic arsenical herbicides such as MSMA otherwise being phased out (EPA 2009, p. 3), are recommended to control it (Culpepper and Kichler 2009).

At least three states (Mississippi, Georgia and Tennessee) have Palmer amaranth resistant to both glyphosate and ALS inhibitors; the most recent one, reported in 2011, infests over 100,000 sites covering up to 2 million acres in Tennessee (CFS GR Weed List 9/20/12). Palmer amaranth belongs to the same genus as common waterhemp (*Amaranthus*), and to some extent can interbreed with it. Both have considerable genetic diversity. The demonstrated ability of waterhemp to evolve resistance to auxin herbicides suggests that a similar potential likely exists in Palmer amaranth. Growers with GR and multiple HR Palmer amaranth would be prime candidates to adopt MON 87708, and utilize them under the proposed registration. Palmer amaranth must be judged a high-risk weed for evolution of resistance to dicamba and other auxin herbicides, which would undermine the efficacy of existing, pre-emergence use of dicamba in battling this serious weed threat.

iv. Kochia

Kochia is a fourth serious weed, described further at CFS (2010). It has evolved widespread resistance to many different herbicides, and is on the ISHRW's list of the top ten most important herbicide-resistant weed species (ISHRW Worst HR Weeds). Limited populations of glyphosate-resistant kochia first emerged in Kansas in 2007, but recent reports suggest that it is now likely prevalent in the entire western third of Kansas, as well as parts of Colorado (Stahlman et al. 2011). A second population identified in Nebraska (2009) was first listed on ISHRW in December of 2011; a third in South Dakota (2011) infests up to 10,000 acres and was first listed in May of 2012; while a fourth infesting up to 1,000 acres in North Dakota was first listed in August of 2012. Kochia resistant to both glyphosate and ALS inhibitors was recently identified in Alberta, Canada (2012).[26] All of the US populations emerged in corn, soybeans and/or cotton (almost certainly RR versions), while the Canadian population emerged in cereals and "cropland" that may also include RR crops.

Stahlman et al. (2011) state that the original four populations in Kansas likely evolved glyphosate-resistance independently, but the rapid emergence across such a broad swath of the state suggests the potential for spread of the original populations, perhaps by resistant seed dispersal, as kochia "tumbleweed" can disperse seeds at considerable distances (see CFS 2010). CFS (2010) also documents that kochia is a serious weed of both alfalfa and sugarbeets, Roundup Ready versions of which have been recently introduced and are widely grown. GR kochia infesting these RR crops would seriously impair the efficacy of the RR trait; likewise, selection pressure from glyphosate use with these crop

[26] See entries under Kochia at http://www.weedscience.org/Summary/UspeciesMOA.asp?lstMOAID=12&FmHRACGroup=Go.

systems (especially in rotation with other RR crops, as seen particularly with RR sugar beets, which are frequently rotated with RR corn and/or RR soybeans) could rapidly lead to still more extensive emergence of GR kochia.

Four biotypes of kochia have also evolved resistance to dicamba in Montana, Idaho, North Dakota, and most recently Nebraska. The Nebraska population first emerged in corn in 2010, and Nebraska is a major soybean producing state. Nearly half of all confirmed dicamba-resistant weed populations in the world are kochia biotypes, which may suggest a genetic proclivity in this species to evolve resistance to this herbicide. The extremely rapid emergence of GR biotypes in RR crop systems may induce growers to adopt MON 87708 to control it; and kochia's demonstrated propensity to evolve resistance to dicamba make it a prime candidate to evolve multiple resistance to dicamba, glyphosate and other herbicides.

Stewardship

It is highly doubtful whether Monsanto's stewardship plan for MON 87708 soybean will be effective in forestalling weed resistance to 2,4-D. For at least 15 years, companies and weed scientists have touted voluntary stewardship guidelines and best management practices as the chief bulwark against evolution of resistant weeds in the context of HR crop systems. These programs and exhortations have demonstrably failed with Roundup Ready crops, or there would not be an epidemic of glyphosate-resistant weeds. A critical assessment of Monsanto's failed stewardship messages, practices and actions with Roundup Ready crops is essential to inform its current plans with respect to the use of MON 87708 under the proposed registration.

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). Many weed scientists were not convinced, and called for serious measures to forestall evolution of GR weeds (Freese 2010, question 1). Monsanto introduced its RR crops as "RR crop systems" designed for sole reliance on glyphosate for weed control. Even several years after GR weeds first emerged in RR soybeans and then 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 farmers 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 glyphosate-only, RR corn ad campaign was to promote glyphosate-only weed control programs in RR corn/RR soybean rotations. (Up to that time, most corn/soybean farmers had rotated RR soybeans with conventional corn, utilizing primarily non-glyphosate herbicides with the latter.) 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 2005. 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.

As discussed above, dicamba use on non-dicamba-resistant corn will likely increase considerably with significant adoption of MON 87708 under the proposed registration. This will result in more acres treated every year with dicamba in popular corn/soybean rotations. Monsanto's planned introduction of dicamba-resistant corn in a few years would greatly exacerbate matters, since the elimination of corn injury concerns will make dicamba-resistant corn a more attractive option for farmers.

Monsanto's recommendation to use a soil residual herbicide in addition to dicamba and glyphosate with MON 87708 will not be followed by the majority of growers, and as discussed above in relation to waterhemp is of questionable value for those who do. If Monsanto were a responsible steward of dicamba-resistant technology, the company would strongly advise growers of MON 87708 to abstain from dicamba use when rotating to corn (or small grains crops like wheat); and it would not have developed dicamba-resistant corn at all, which if introduced will almost surely lead to tens of millions of acres treated with dicamba each year in rotations of dicamba-resistant corn and soybeans, and thus to massive evolution of dicamba-resistant weeds.

Dow's introduction of competing 2,4-D resistant crops may not offer much help in terms of diversifying selection pressure, due to clear emerging evidence that resistance to either auxin herbicide may often confer resistance or at least increased tolerance to the other. Two weed populations have confirmed resistance to both dicamba and 2,4-D (prickly lettuce in Washington, and wild mustard in Canada, see ISHRW SynAux Weeds Table 9/20/12). The recently discovered 2,4-D-resistant waterhemp in Nebraska has significantly decreased sensitivity to dicamba as well. And preliminary research strongly suggests that horseweed populations with increased tolerance to 2,4-D also have increased tolerance to dicamba. Finally, it is interesting to note that MON 87708 itself possesses increased tolerance to three tested phenoxy herbicides – 2,4-D, MCPA and 2,4-DB (Monsanto 2010 at 76-77). While the precise mechanisms of auxin resistance in weeds have not been fully elucidated, the evidence presented above suggests strongly that cross-resistance among auxin herbicides is a frequent occurrence.

This suggests the need to consider the cumulative impacts of all auxin-resistant crops together for purposes of assessing their potential for fostering auxin-resistant weeds. This is surely the reasoning that prompted Bernards et al. (2012) to call for "mandatory stewardship practices" for "soybean, cotton and corn resistant to 2,4-D and dicamba." Furthermore, the demand for "mandatory" practices is an implicit acknowledgement of the failure of voluntary programs such as Monsanto's.

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[27] 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.

[27] 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.

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.

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.

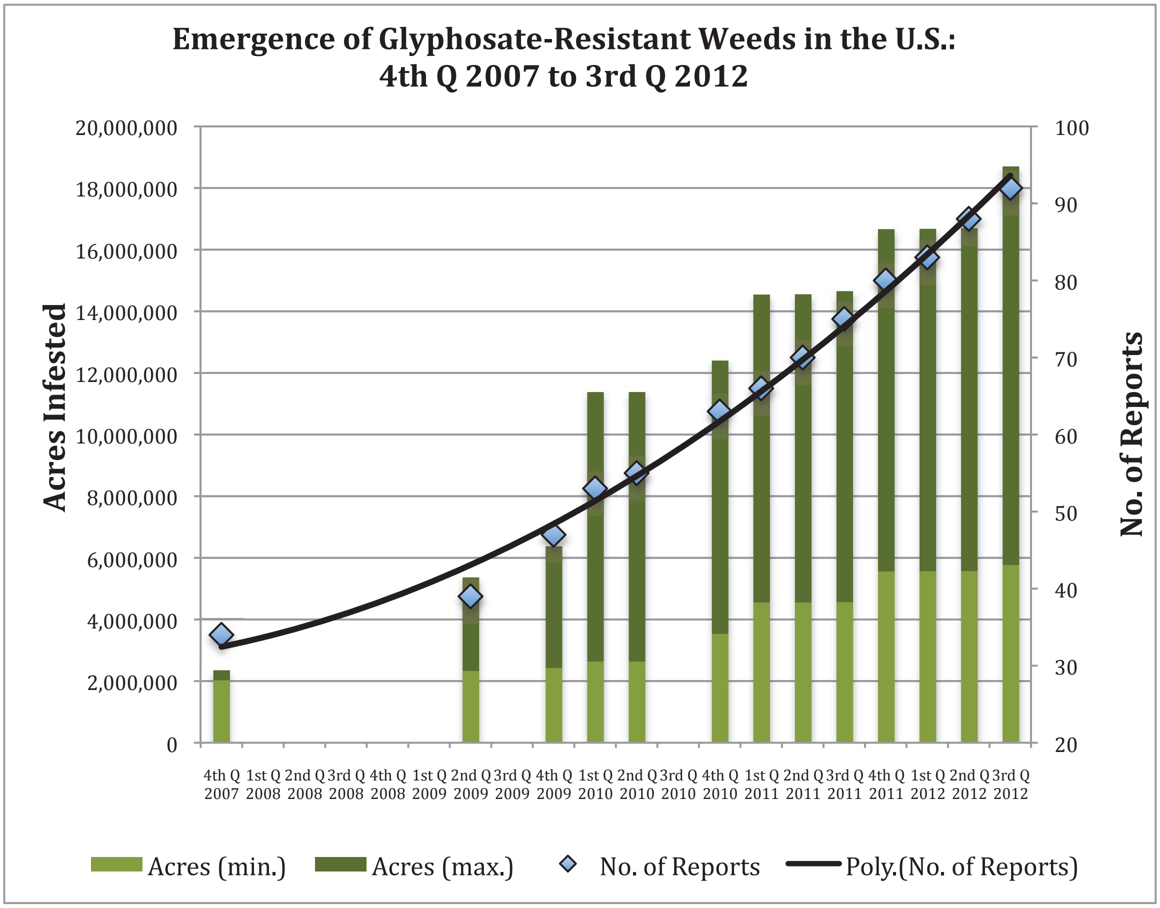
MON 87708 soybean volunteers (stacked with Roundup Ready) would possess resistance to dicamba as well glyphosate, eliminating dicamba and glyphosate and reducing the efficacy of 2,4-D as herbicidal control options. These volunteer soybeans weeds would thus be still more of a management challenge than 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, three other HR soybean events are presently pending deregulation by USDA: Dow's 2,4-D- and glufosinate-resistant soy, BASF's isoxaflutoleresistant soy, and Bayer's imidazolinone-resistant variety.[28] 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.

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



Legend: This chart plots data on glyphosate-resistant weeds in the U.S. compiled from the International Survey of Herbicide-Resistant Weeds (ISHRW) as of September 20, 2012. See CFS GR Weed List (2012) for the data upon which this chart is based. The ISHRW lists reports of confirmed herbicide-resistant weeds submitted by weed scientists.[29] Each report normally contains the year of discovery, the number of sites and acreage infested by the resistant weed population, the crop or non-crop setting where the weed was found, whether or not the population is expanding, and date the report was last updated. Note that months to several years can elapse before a putative resistant weed population is confirmed as resistant and listed on the website. ISHRW reports sites and acreage infested in ranges due to the difficulty of making precise point estimates. CFS aggregated ISHRW data for all glyphosate-resistant weed reports on 13 dates – 11/21/07, 2/2/09, 11/19/09, 2/25/10, 5/18/10, 11/30/10, 1/6/11, 7/5/11, 9/28/11, 12/31/11, 3/28/12, 7/2/12 and 9/20/12 – corresponding to the 13 bars in the graph above. The bars were assigned to the appropriate quarterly period on the x-axis. The minimum and maximum acreage values represent the aggregate lower- and upper-bound acreage infested by all glyphosate-resistant weeds listed by ISHRW on the given date. The number of reports is plotted on the secondary y-axis. The figures shown here are very conservative, because ISHRW is a voluntary reporting system and many GR weed populations are never reported, or if reported are often not updated to account for expansion. ISHRW organizer Dr. Ian Heap concedes that these figures are "way too low," and in August 2012 estimated that 40 million acres were infested with a GR weed (30 million if overlapping acres infested with more than one GR weed are counted just once) (see Heap 2012). As noted in the text, Dow estimates 60 million GR weed-infested acres. This suggests that GR weed prevalence is roughly

[29] Each report may be accessed by (and corresponds to) a link at: http://www.weedscience.org/Summary/UspeciesMOA.asp?lstMOAID=12&FmHRACGroup=Go.

twice to three times the upper-bound estimates shown here. Even so, this graph provides a sense of the rapid course of GR weed emergence in the U.S.

Exhibit F

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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.

Comment of SOCC - Docket No. EPA-HQ-OPP-2016-0187

COMMENT OF:
SAVE OUR CROPS COALITION
[Docket No. EPA-HQ-OPP-2016-0187]

May 31, 2016

ELECTRONIC SUBMISSION

Re: Dicamba: New Use on Herbicide Tolerant Cotton and Soybeans

The Save Our Crops Coalition (SOCC) is a grassroots coalition of farm interests organized for the specific purpose of preventing injury to non-target crops from exposure to 2,4-D and dicamba. SOCC does not oppose advances in plant technology, particularly genetic modification, but does oppose actions that would result in substantial injury to non-target crops and to the habitats necessary for their pollinators.

Non-target plant damage associated with herbicide spray drift and volatilization is a major concern for specialty crop growers and processors. Credible estimates project significant increases in the amount of dicamba that will be applied upon the introduction of dicamba-tolerant crops. Dicamba, because of its potential to drift and volatilize, has proven to be one of America's most dangerous herbicides for non-target plant damage.

Thus, SOCC respectfully submits the following comment regarding EPA's proposed registration of dicamba on dicamba-tolerant cotton and soybeans. This comment requests the Environmental Protection Agency (EPA) withhold registration until EPA: (a) adopts residue tolerances for common food crops, (b) adopts the additional registration restrictions as suggested below, and (c) undertakes a classification review of pesticide products with the active ingredient dicamba.[1]

Commenter

SOCC represents nearly every segment of American agriculture, from growers to processors, both conventional and organic. All SOCC growers cultivate specialty crops, but they also cultivate significant acreages of major agronomic crops, like corn and soybeans.

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[1] EPA, *Posting EPA-HQ-OPP-2016-0187 to Regulations.gov for Public Access* ("*Posting EPA-HQ-OPP-2016-0187*"), (March 31, 2016), at: https://www.regulations.gov/#!documentDetail;D=EPA-HQ-OPP-2016-0187-0001

SOCC is over 2,000 growers strong, including grower organizations such as the Indiana Vegetable Growers Association and the Ohio Produce Growers and Marketers Association, and is supported by major processors like Red Gold.

Factual Background

Drift and Volatilization

Due to the potential for crop injury, pesticide spray drift and volatilization from agronomic crops is a major concern for specialty crop growers and processors. Spray drift is the airborne movement of pesticide spray particles to a non-target site. Spraying during windy conditions or using nozzles or pressures that result in the creation of fine spray particles increase the risk of spray drift. Volatilization is the airborne movement of pesticide vapor to a non-target site. Volatilization occurs when a pesticide is applied to a target site, subsequently evaporates, and moves off-target. The calm windless conditions that minimize drift, ironically, only increase the potential for volatilization.

All pesticides may have harmful effects on non-target crops if they drift or volatize away from their intended areas of application; however, dicamba has proven especially prone to cause damage.[2] A survey of state pesticide control officials listed dicamba as the pesticide third most commonly involved in drift incidents for two years in a row.[3] This incidence of drift damage far outpaces the relative use of dicamba. Dicamba does not even make the list of the top 25 most commonly applied pesticide active ingredients.[4] Drift concerns have led some states to enact safeguards, such as requiring the use of lower volatility formulations, restrictions on application timing, and even bans on use.[5] Thus, SOCC regards dicamba as one of America's most dangerous herbicides for non-target plant damage.

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[2] Sciumbaro, Audie S., et al. *Determining Exposure to Auxin-Like Herbicides. I. Quantifying Injury to Cotton and Soybean*, Weed Technology, Vol. 18, 1125-1134 (2004).
[3] *2005 Pesticide Drift Enforcement Survey Report*, Association of American Pesticide Control Officials (2005), available at: http://aapco.ceris.purdue.edu/doc/surveys/DriftEnforce05Rpt.html
[4] *Pesticides Industry Sales and Usage: 2006 and 2007 Market Estimates*, EPA (Feb. 2011) available at: http://www.epa.gov/opp00001/pestsales/07pestsales/market_estimates2007.pdf.
[5] 4 Tex. Admin. Code § 7.50 (2011); Or. Admin. R. 603-057-0301 (2012); Wash. Admin. Code 16-228-1250 (2012)

Dicamba-tolerant crops heighten drift and volatilization concerns. The introduction of dicamba-tolerant crops is anticipated to increase the amount of dicamba that will be used, especially in soybean producing regions. Because these regions also produce substantial acreages of broadleaf crops that are sensitive to dicamba, the environmental impacts in these regions are anticipated to be especially intense.

The introduction of dicamba-tolerant crops would also permit applications of dicamba weeks later in the growing season. Applications at this time of year occur when other crops are 'leafed out,' further increasing the risk of non-target damage.[6] High temperatures also substantially increase the potential for herbicide volatilization.[7] These risks are particularly alarming in the case of dicamba, because dicamba causes substantial plant damage effects at very low application rates, and is prone to volatilize at high temperatures.

Dicamba Drift Has Substantial Harmful Effects at Very Low Application Rates

Researchers at the Ohio State University Department of Horticulture and Crop Science conducted a study on the effect of simulated dicamba drift and volatilization on tomatoes grown for processing.[8] Their objective was to quantify the impact of low rates of dicamba on broadleaf crops with respect to plant injury and the potential for yield losses.

Their conclusions are startling. Simulated dicamba drift and volatilization caused tomato bloom to "abort." Applications of dicamba at levels as low as 1/300th of the soybean field rate caused statistically significant losses of tomato crops. The late drift of dicamba, during bloom, caused a 17-77% reduction in marketable fruit when applied at 1/100th of the field rate. *See* Figure 1, below.

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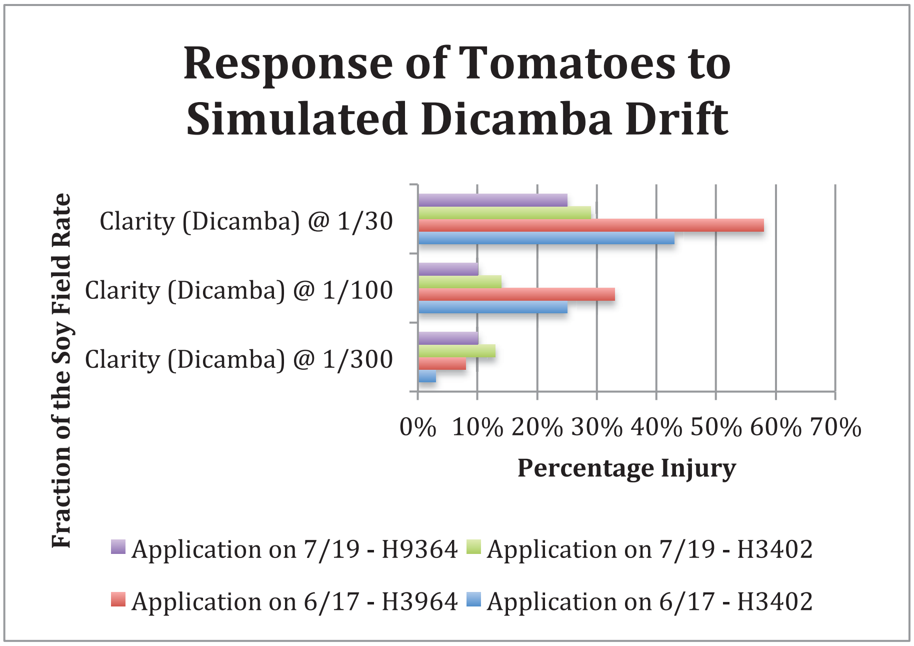
[6] *Determining Exposure to Auxin-Like Herbicides. I. Quantifying Injury to Cotton and Soybean.*
[7] Atkins, Peter and Loretta Jones, *Chemical Principles: The Quest for Insight*, 310-311 (4th ed. 2008).
[8] Doohan, Doug and Koch, Tim, *Effect of Simulated Dicamba and 2, 4-D Drift on Processing Tomatoes*, Ohio State University/OARDC (2010).

Figure 1.



Effect of Dicamba-tolerant Crops on the Use of Dicamba

The rationale presented by Monsanto for dicamba-tolerant crops, is that they would provide another weed management tool for farmers, because they would offer, "... an option to delay or prevent further resistance to glyphosate and other critically important soybean herbicides, in particular, herbicides in the ALS and PPO class of chemistry..."[9] Thus, dicamba-tolerant crops represent a replacement for, or complement to, glyphosate tolerant crops, because the widespread use of glyphosate has contributed to glyphosate resistant weed populations.

Monsanto's own petitions to USDA for non-regulated status of dicamba-tolerant crops have indicated that, upon peak adoption, dicamba use will approximately double its 1994 peak historical use level, or reach about 25 million pounds annually.[10] However, it should be noted that the use of dicamba has declined precipitously from its peak levels. Monsanto's petitions omit describing the intensity of the rate of sudden change in dicamba

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[9] *Monsanto Petition for Determination of Nonregulated Status of Event MON 87708*, APHIS (Jul. 13, 2012), available at: http://www.regulations.gov/#!documentDetail;D=APHIS-2012-0047-0002, at 5.
[10] *Monsanto Petition for Determination of Nonregulated Status of Event MON 87708*, at 210-211.

use from current use levels. The latest figures place the amount of dicamba applied at about 2.7 million pounds annually.[11] Monsanto's projected use pattern would represent an approximately 925% increase in pounds applied over current levels, an almost 250% increase in the total acreage treated, and a 5660% increase in soybean acreage treated.[12] Such an increase would represent a dramatic shift in the utilization of an herbicide both in total pounds applied and in total acreage treated. Even the increase in the use of glyphosate upon the introduction of glyphosate tolerant crops, an increase of almost 600% in pounds applied, would be eclipsed by this shift in use.[13]

Proximity of Agronomic Crop Acreage to Broadleaf Crop Acreage in the Midwest

The map, below, produced by USDA's CropScape, is a close-up of a portion of Monroe County, Michigan.[14] Growers in Monroe County cultivate fruit and vegetable crops in proximity to major agronomic crops like soybeans. This proximity is representative of the Midwest generally. The large grey-pink portion in the middle of the map is a tomato field surrounded by corn and soybean fields. Tomatoes are a broadleaf crop. *See* Figure 2.

As noted above, dicamba has substantial harmful effects on unmodified broadleaf crops even at very low applications rates, and because dicamba-tolerant crops will be grown in such close proximity to unmodified broadleaf crops, such as tomatoes, the potential for non-target plant damage caused by drift and volatilization is tremendous.

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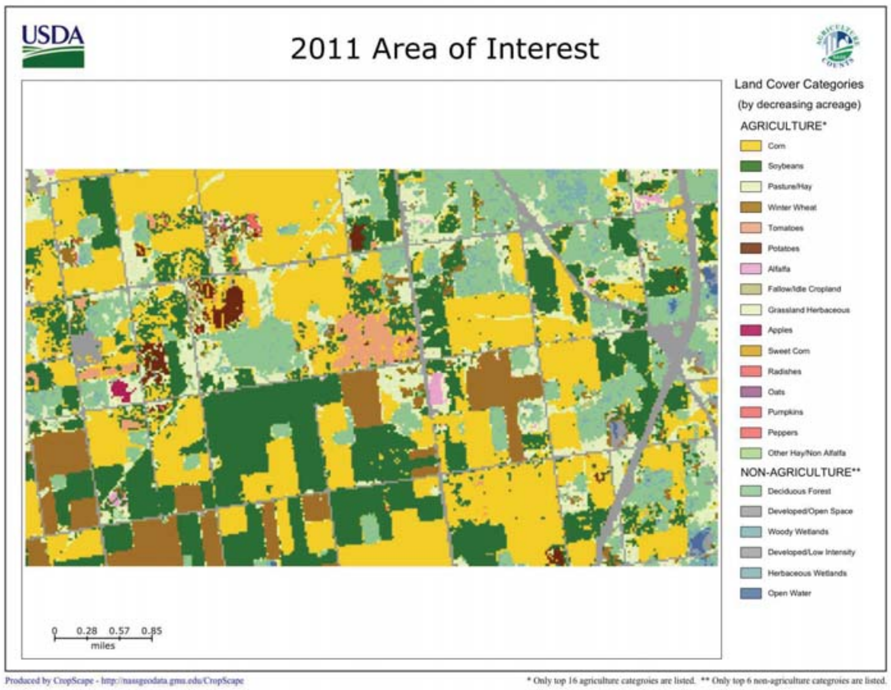
[11] *Monsanto Petition for Determination of Nonregulated Status of Event MON 87708*, at 198.
[12] *Monsanto Petition for Determination of Nonregulated Status of Event MON 87708*, at 223-224.
[13] Gianessi, L. P. and N. Reigner, *Pesticide Use in U.S. Crop Production: 2002 with Comparison to 1992 and 1997*, (2006) available at: http://www.croplifefoundation.org/Documents/PUD/NPUD%202002/Fung%20&%20Herb%202002%20Data%20Report.pdf
[14] *2011 Area of Interest*, USDA/NASS (Apr. 14, 2012) available at: http://nassgeodata.gmu.edu/CropScape/

Figure 2.



Discussion

Statutory and Regulatory Authority

The Federal Insecticide Fungicide and Rodenticide Act (FIFRA) requires EPA to regulate the sale and use of pesticides in the United States through registration and labeling of pesticide products.[15] The sale of any pesticide is prohibited unless it is registered and labeled.[16] EPA is directed to restrict the use of pesticides as necessary to prevent unreasonable adverse effects on people and the environment.[17] Pursuant to FIFRA, "unreasonable adverse effects on the environment" is defined as "(1) any unreasonable risk to man or the environment taking into account the economic, social, and environmental costs and benefits of the use of any pesticide, and (2) a human dietary risk from residues that result from a use of a pesticide in or on any food inconsistent with the standard under 408 of the Federal Food, Drug, and Cosmetics Act."[18]

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[15] 7 U.S.C. § 136, *et seq.*
[16] 7 U.S.C. §§ 136a(a), 136a(c)(5)(B).
[17] 7 U.S.C § 136a(a).
[18] 7 U.S.C § 136(bb).

If EPA is not satisfied that a pesticide "will perform its intended function without unreasonable adverse effects on the environment" or "when used in accordance with widespread and commonly recognized practice it will not generally cause unreasonable adverse effects on the environment," EPA may refuse to register said pesticide.[19]

The Federal Food, Drug, and Cosmetics Act (FFDCA) prohibits the shipment, in interstate commerce, of "adulterated food."[20] A food is considered adulterated "if it bears or contains a pesticide chemical residue that is "unsafe."[21] A pesticide is "unsafe" unless (1) EPA has established a tolerance for the pesticide on a particular commodity or in a particular food, and the pesticide residue is within that tolerance, or (2) with respect to a particular commodity or processed food, EPA has exempted the pesticide from the requirement for a tolerance.[22] Therefore, before agriculture commodities containing pesticide residues can be sold or distributed, EPA must adopt a "tolerance," a permissible level of residue, or an exemption.[23]

SOCC Petition for Residue Tolerances

On December 18, 2012, SOCC petitioned EPA to establish tolerances for dicamba residues on certain specialty crops anticipated to be grown in close proximity to the dicamba-tolerant crops. The very next day, December 19, 2012, EPA noticed receipt of petitions requesting the establishment of regulations for residues of dicamba in or on dicamba-tolerant cotton.[24] EPA published its proposal to register dicamba on dicamba-tolerant cotton and soybeans on March 31, 2016.[25] To date, more than three years after receipt of said petitions, EPA has not established tolerances for common food crops, like tomatoes, that are likely to be grown in close proximity to dicamba-tolerant crops.[26]

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[19] 7 U.S.C §§ 136a(c)(5), 136a(c)(6).

[20] 21 U.S.C. §331

[21] 21 U.S.C. §342(a)(2)(B)

[22] 21 U.S.C. §346a(a)(1)

[23] 21 U.S.C. §§346a, 346a(c)(2)(A)

[24] *Notice of Receipt of Several Pesticide Petitions Filed for Residues of Pesticide Chemicals in or on Various Commodities*, EPA, 77 Fed. Reg. 75082 (Dec. 19, 2012), available at: http://www.gpo.gov/fdsys/pkg/FR-2012-12-19/pdf/2012-30450.pdf

[25] *Posting EPA-HQ-OPP-2016-0187*, at 1.

[26] 40 CFR §180.227

Failure to establish tolerances for food crops is likely to have an "unreasonable adverse [Effect] on the environment"

In its proposed registration, EPA states, "Permanent tolerances for dicamba are established under 40 CFR §180.227 for a wide variety of crops and livestock commodities."[27] Unfortunately, this is just not the case. Any fair reading of 40 CFR § 180.227 would indicate that the proscribed residue tolerances for dicamba in and on food crops are *very narrow*. Residue tolerances have been established for only the following crops: Asparagus, Barley, Corn, Grass, Millet, Oats, Rye, Sorghum, Soybeans, Sugarcane, Teff, and Wheat.[28]

This situation may be tolerable for a grower of asparagus or one of the major agronomic crops listed above, however, for the growers and processors of the food crops listed in Federal Crop Groups 8 (fruiting vegetables) and 9 (cucurbit vegetables), which are likely to be grown in close proximity to dicamba-tolerant cotton and soybeans, as noted above, this situation poses an unacceptable threat.[29]

Specifically, EPA has not established residue tolerances for the food crops listed within Federal Crop Groups 8 and 9, which SOCC requested in its petition to EPA, dated December 18, 2012. More than three years ago as of the date of this comment. It may be worth noting that the U.S. Department of Health and Human Services (HHS) and USDA suggest a daily intake for Americans of at least two and one-half cups of vegetables.[30] Below please find a list of the food crops for which SOCC requested tolerances:

- Grape (Vitis spp.)
- Eggplant (Solanum melongena)
- Groundcherry (Physalis spp.)
- Pepino (Solanum muricatum)
- Pepper (Capsicum spp.) (includes bell pepper, chili pepper, cooking pepper, pimento, sweet pepper)
- Tomatillo (Physalis ixocarpa)
- Tomato (Lycopersicon esculentum)

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[27] *Posting EPA-HQ-OPP-2016-0187*, at 9.
[28] 40 CFR § 180.227
[29] 40 CFR § 180.41
[30] *U.S. Department of Health and Human Services and U.S. Department of Agriculture. 2015 – 2020 Dietary Guidelines for Americans*, 8th Edition, (December 2015). *See*: http://health.gov/dietaryguidelines/2015/guidelines/.

- Chayote (fruit) (Sechium edule)
- Chinese waxgourd (Chinese preserving melon) (Benincasa hispida)
- Citron melon (Citrullus lanatus var. citroides)
- Cucumber (Cucumis sativus)
- Gherkin (Cucumis anguria)
- Gourd, edible (Lagenaria spp.) (includes hyotan, cucuzza); (Luffa acutangula, L. cylindrica) (includes hechima, Chinese okra)
- Momordica spp. (includes balsam apple, balsam pear, bitter melon, Chinese cucumber)
- Muskmelon (hybrids and/or cultivars of Cucumis melo) (includes true cantaloupe, cantaloupe, casaba, crenshaw melon, golden pershaw melon, honeydew melon, honey balls, mango melon, Persian melon, pineapple melon, Santa Claus melon, and snake melon)
- Pumpkin (Cucurbita spp.)
- Squash, summer (Cucurbita pepo var. melopepo) (includes crookneck squash, scallop squash, straightneck squash, vegetable marrow, zucchini)
- Squash, winter (Cucurbita maxima; C. moschata) (includes butternut squash, calabaza, hubbard squash); (C. mixta; C. pepo) (includes acorn squash, spaghetti squash)
- Watermelon (includes hybrids and/or varieties of Citrullus lanatus)

In failing to adopt residue tolerances, EPA has flipped its statutory mandate, to prevent "unreasonable adverse effects," on its head. EPA is directed to restrict the use of pesticides as necessary to prevent unreasonable adverse effects on people and the environment.[31] "Unreasonable adverse effects on the environment" are defined to include "…(2) a human dietary risk from residues that result from a use of a pesticide in or on any food inconsistent with the standard under 408 of the Federal Food, Drug, and Cosmetics Act."[32] Presently, if even just a trace amount of dicamba is found on a food crop without a tolerance, such crop is unmarketable, and must be thrown away. EPA may have avoided true consideration of its statutory mandate to prevent "human dietary risk" by not considering residue tolerances for the various food crops that are likely to be grown in close proximity to dicamba on dicamba-tolerant cotton and soybeans, however, having done so, EPA has itself created an "(1) unreasonable risk to man or the environment taking

[31] 7 U.S.C § 136a(a).
[32] 7 U.S.C § 136(bb).

into account the economic, social, and environmental costs and benefits of the use of any pesticide," another basis upon which EPA should withhold this proposed registration.[33]

The use of dicamba on dicamba-tolerant cotton and soybeans without tolerances for most food crops presents an "unreasonable adverse effects on the environment," because it presents an "unreasonable risk" to food crop growers and processors and to the Americans who eat their crops, when taking into account the economic, social, and environmental costs and benefits of the use of dicamba.[34] Because dicamba on dicamba-tolerant cotton and soybeans cannot "perform its intended function without unreasonable adverse effects on the environment," EPA should withhold its proposed registration, until such time as EPA is able to promulgate food tolerances on common specialty crops, such as those listed within Federal Crop Group 8 (fruiting vegetables) and Group 9 (cucurbit vegetables). [35]

Proposed registration is likely to have an "unreasonable adverse effect on the environment"

Notwithstanding the failure of EPA to provide dicamba residue tolerances on food crops, this proposed registration of dicamba on dicamba-tolerant crops would significantly increase the risk of unreasonable adverse effects on the environment, as identified in the "Factual Background" section above.[36]

SOCC appreciates the work that EPA has done to prepare its proposed registration and its willingness to engage in a dialogue with SOCC regarding its concerns. However, SOCC still regards additional measures as necessary to mitigate the potential for drift and volatilization damage to non-target plants caused by this new pattern of use. Below SOCC suggests several modifications to the proposed registration, which would mitigate the risks of unreasonable adverse effects on the environment.[37]

SOCC would suggest modifying the "B. Labeling Requirements" in the following way:[38]

1. As a matter of emphasis, at "4. Spray Drift Management; Wind Speed," SOCC recommends striking "Drift potential is lowest between wind speed of 3 to

[33] 7 U.S.C § 136(bb).
[34] 7 U.S.C § 136(bb)
[35] 7 U.S.C §§ 136a(c)(5), 136a(c)(6); 40 CFR § 180.41
[36] 7 U.S.C § 136(bb)
[37] 7 U.S.C § 136(bb)
[38] *Posting EPA-HQ-OPP-2016-0187*, at 33-34.

10 miles per hour" and replacing said labeling with "There is less risk of drift between 3 to 10 miles per hour." SOCC believes that applicators could claim that, if they applied when the "Drift potential is lowest," they were operating under 'safe haven' established by EPA. SOCC is certain EPA would agree that it is best to express label language in terms of risk, instead of relative safety.

2. At "5. Protection of Sensitive Areas, a. Buffer," SOCC would strongly recommend that EPA follow the example set by the Arkansas Plant Board and adopt a buffer of 400 feet. Although EPA has already specifically considered this question in its proposed registration decision, SOCC would respectfully request EPA to reconsider its approach.[39] Arkansas has created a reasonable restriction based on observable evidence of damage. The language of the proposed registration indicates that EPA may be unwilling to consider the practical knowledge of its colleagues in the states, simply because those state pesticide officials did not use the same methodology as EPA. This is unfortunate. SOCC is appreciative of the work these officials do to investigate and resolve claims, and believes the precautionary approach outlined by the Arkansas Plant Board is appropriate given the risks of non-target plant damage outlined above.

SOCC is certain that EPA would agree that it is just as important for EPA to mitigate the potential for drift and volatilization damage to non-target plants caused by this new pattern of use. Thus, SOCC would suggest modifying the "C. Registration Terms," in the following way:[40]

1. By including "EPA has determined that certain registration terms are needed to ensure that likely spray drift concerns as discussed in Section III, A., 4."
2. By including "1a. Spray Drift Management Plan," which would state, "Monsanto must have a Spray Drift Management Plan for M1691 Herbicide developed and approved by EPA before final registration can be issued. Such Plan must focus on educating applicators on the appropriate use of the M1691 Herbicide. EPA is requiring that such Spray Drift Management Plan include the following measures, which may assist in reducing the risk of adverse impacts on the environment."

[39] *Posting EPA-HQ-OPP-2016-0187*, at 17-18.

[40] 40 CFR § 152.115(3)(c); *Posting EPA-HQ-OPP-2016-0187*, at 29-33.

3. By including "1a. Spray Drift Management Plan, a. Investigation and Remediation," which would state, "Monsanto or its representative must investigate reports of spray draft and volatilization incidents, when requested by an interested person, and assist interested persons in the diagnosis and resolution of alleged non-target claims."
4. By including "1a. Spray Drift Management Plan, b. Recordkeeping," which would state, "Monsanto must commit to include terms within its Technology Use Agreements for dicamba-tolerant crops that require growers and applicators to keep accurate records of the locations where dicamba tolerant crops are planted and where dicamba is applied, and to retain invoices for all dicamba-tolerant seed and dicamba herbicide purchases. Further, Monsanto must commit to include language in its Product Use Guide for use of dicamba on dicamba tolerant crops that recommends applicators keep accurate spray records, including application location, timing, and wind speed."
5. By including at "1a. Spray Drift Management Plan, c. Auditing," which would state, "Monsanto commits to utilize an independent third party to collect seed and pesticide sales data that will help identify applicators that use any form of dicamba that has not been labeled for use on dicamba tolerant crops."
6. At "2. EPA's Continued Control over the Registration," by including in the first clause of the first sentence, "…and because the issue of spray drift and volatilization is an extremely important issue to keep under control and can be very fast moving," and noting in the second sentence that EPA can work to address any unexpected spray drift in volatilization issues that may result from "the proposed uses before granting an extension or allowing the registration to terminate, if necessary," as well.

As demonstrated by the "Factual Background" section, above, "(a) Without [the additional registration terms listed above, the M1691 Herbicide] when used in accordance with warnings, cautions and directions for use or in accordance with widespread and commonly recognized practices of use may cause unreasonable adverse effects on the environment; and (b) The decrease in risks as a result of [additional registration terms] would exceed the decrease in benefits as a result of [additional registration terms]."[41] Thus, EPA's own regulations give it the authority to impose additional registration terms. In the interest of the thousands of growers and processors of SOCC, and, more broadly, for the

[41] 40 CFR § 152.171

welfare of American agriculture, EPA should act to mitigate the potential for drift and volatilization damage to non-target plants caused by this new pattern of use.

Notwithstanding the failure of EPA to provide dicamba residue tolerances on food crops, this proposed registration of dicamba on dicamba-tolerant crops, without modification, would significantly increase the risk of unreasonable adverse effects on the environment. In order to mitigate the risks of unreasonable adverse effects on the environment identified above, prior to finalizing its registration, EPA should adopt the suggested modifications to its proposed registration, as listed in this section.

SOCC Petition To Conduct a Classification Review of Products with Active Ingredient Dicamba

As requested in SOCC's petition to EPA, prior to finalizing this proposed registration, EPA should undertake a classification review to determine whether many, if not all, products with the active ingredient dicamba, without additional regulatory restrictions, when applied in accordance with its directions for use, warnings and cautions and for the uses for which it is registered, or in accordance with a widespread and commonly recognized practice, may cause unreasonable adverse effects on the environment.[42] Classifying certain forms of dicamba as restricted use, including a requirement that only certified applicators apply such forms of dicamba and records of such application are kept, could mitigate the potential for unreasonable adverse effects on the environment.

Conclusion

On September 11, 2012, SOCC announced the successful conclusion of discussions with Dow AgroSciences (Dow) regarding its 2,4-D tolerant cropping system. SOCC was satisfied that Dow had adopted effective measures to protect against non-target plant damage associated with the introduction of 2,4-D tolerant crops. SOCC was also impressed with Dow's 2,4-D choline salt formulation. Only 2,4-D choline salt, the lowest volatility 2,4-D formulation available, would be approved for use on 2,4-D tolerant crops, and Dow has committed to strongly discourage the unlawful use of older, cheaper, highly volatile generic formulations on 2,4-D tolerant crops. Unfortunately, SOCC has not been able to reach a similar agreement with Monsanto. EPA has a responsibility to American agriculture to use

[42] Save Our Crops Coalition, *Citizen's Petition to Classify Pesticides with Active Ingredient Dicamba as Restricted Use*, (May 24, 2016), available at: http://saveourcrops.org/wp-content/uploads/2016/05/FINAL-SOCC-Petition-RUP-Generic-Dicamba-160524.pdf.

its authority to protect those growers and processors of food crops throughout the country, and, therefore, in this instance, EPA must act.

SOCC hopes that EPA will recognize that SOCC is requesting only reasonable accommodations to avoid what are likely unreasonable consequences -- accommodations that the competitors of Monsanto and BASF have already agreed are in the best interests of American agriculture. In light of the foregoing, SOCC requests that, prior to final registration, EPA adopt residue tolerances for food crops, adopt SOCC's suggested modifications to the proposed registration, and undertake a classification review of pesticide products with the active ingredient dicamba.

Respectfully submitted,

__________/s/_____________

Steve Smith
Chairman, Save Our Crops Coalition
P.O. Box 83
Elwood, Indiana 46036

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Anonymous public comment

The is a Comment on the **Environmental Protection Agency** (EPA)
Other: **Public Participation for Dicamba: New Use on Herbicide-Tolerant Cotton and Soybean**

For related information, **Open Docket Folder**

Comment Period Closed
May 31 2016, at 11:59 PM ET

ID: EPA-HQ-OPP-2016-0187-0837

Tracking Number: 1k0-8pxp-1d90

Document Information

Date Posted:
Jun 10, 2016

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Comment

Oliver Winery grows 60 acres of wine grapes in northwest Monroe County, Indiana. We respectfully oppose the labeling of Dicamba for use on Dicamba resistant soybeans without the greatest degree of protection provided to Dicamba sensitive crops such as wine grapes. Our vineyard lies immediately adjacent to two fields commonly planted in soybeans. These fields are to the south, and west of our vineyard and this fact is of an important point in our opposition to the labeling of Dicamba containing herbicides for use on Dicamba resistant soybeans. Winds are most commonly from the south, southwest and west during the summer months.
We have in our twenty one year history had two instances of significant herbicide drift damage to our vineyard. One resulted in a complete crop loss. Both were caused by 2,4,d herbicide. We continue to see 2,4d symptoms on a nearly annual basis due to volatilization drift.
Widespread use of Dicamba later in the season due to broad use on soybeans will no doubt compound an already tenuous situation.
While new formulations of Dicamba are less volatile and could in theory reduce (but not eliminate) volatilization drift issue, older highly volatile formulations are available to farmers. It is imperative that these older formulations become restricted use pesticides and not labeled for use on Dicamba resistant soybeans.
The current proposal of a 400' buffer distance between Dicamba application and sensitive crops is insufficient. Our prior drift injury included significant damage to plants well beyond a 400' distance from the sprayed field. I propose a minimum 1000' protection zone around sensitive crops in which Dicamba will not be allowed for use.
Of additional concern is the presence of Dicamba residue in our grapes and our finished product, wine. As the EPA has no current threshold for allowable Dicamba residue in grapes or wine, any amount detected will render these products unfit for sale. I additionally urge the EPA to set limits on the allowed limit of Dicamba in grapes and wine.
Wine grapes are a high value, value added crop. Their cultivation should be encouraged and supported by federal departments. The prospect of mid-season application of Dicamba near wine grapes only

serves to undermine this growing industry. Not providing the highest level of protection for grapes and other sensitive crops only serves to perpetuate the current near monoculture of beans and corn on Midwestern farm ground. I urge the EPA to place the highest consideration to the protection of other crops.

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Comment submitted by J. R. Paarlberg

The is a Comment on the **Environmental Protection Agency** (EPA)
Other: **Public Participation for Dicamba: New Use on Herbicide-Tolerant Cotton and Soybean**

For related information, **Open Docket Folder**

Comment Period Closed
May 31 2016, at 11:59 PM ET

ID: EPA-HQ-OPP-2016-0187-0832

Tracking Number: 1k0-8pxd-fdtq

Comment

James R Paarlberg, Paarlberg Farms

Attachments (1)

Comment

View Attachment: DOC PDF

Document Information

Date Posted:
Jun 10, 2016

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Dear EPA,

My son's and I are corn, soybean and specialty crop producers, including processing tomatoes in Indiana. We are opposed to the registration as it reads today of dicamba use, on dicamba tolerant cotton and soybeans until the EPA (1) Adopts residue tolerances for common food crops, (2) Adopts additional restrictions on the use and (3) reclassify all dicamba AI products to restricted use.

The reason there is a need of this technology is because of the resistance to glyphosate. I see comments already made by grain organizations, state Farm Bureaus, PhD's, crop advisors, farmers, etc… all widely stating we must have another "tool" in our tool box of chemistry because we have resistance. The "new tool" (dicamba) is a "old tool" we already had for crops already on it's label. I believe all could agree, we have resistance because the end user over used one tool and now has consequences.

The "new tool" dicamba since it has been an "old tool" has documented risk associated with it's use. I have personal experience with it moving onto my crops causing damage. So I ask the EPA to help protect the off target crops, those that grow them and those that process them. The economic damage has the potential to be devastating to the producer, processor, insurance companies, applicator and farmer.

1. Today it states "0 residue tolerance for common foodcrops". Please do not register until a tolerance is established. Wide use of this "new tool" will likely create residue. Who will pay for such lose? Manufacture? Processor? Applicator? As it stands today applicators do not have enough liability coverage to cover the probable losses. And how could it be traced?
2. Additional restrictions for the "new tool" uses are needed before registration. The buffer zone should be at least 400 feet to help mitigate the risk of volatilization to off target crops. Winds should be away from off target crops. Applied by a certified applicator. Apply only after consulting the "Driftwatch" website where specialty crop fields are registered. And maybe register it's use.
3. Reclassify all dicamba AI products to restricted use so all would have to follow the application rules. There is a likelihood that applicators and farmers will be tempted to use a cheaper old formulation of dicamba that presents greater risk to moving off target. Monsanto and BASF could step up and be proactive to help ensure the effective use of the "new tools" and protect us from the old formulations.

I again ask the EPA to delay the registration until these issues are evaluated for the risks they pose. The unintended consequences to off target crops could potentially cause total loss of that crop. So who would pay for that Monsanto, BASF, PhD's, crop advisors, insurance companies, applicators, farmers? Me and our family farm!

Thank you for consideration.

James R Paarlberg, Paarlberg Farms

PAN
PESTICIDE ACTION NETWORK • NORTH AMERICA

RECLAIMING THE FUTURE OF FOOD AND FARMING

May 31, 2016

US EPA/OSCPP/OPP 7505P
Environmental Protection Agency
1200 Pennsylvania Ave. NW
Washington DC 20460

RE: Docket No. EPA-HQ-OPP-2016-0187, Dicamba: proposed new use on herbicide resistant cotton and soybeans

ELECTRONIC SUBMISSION via www.regulations.gov

Pesticide Action Network North America (PANNA) submits the following comment regarding EPA's proposed registration of dicamba for use on genetically engineered dicamba-resistant cotton and soybeans.

PANNA is a non-profit, public interest organization representing the concerns of over 100,000 supporters across the country, including farmers, farmworkers, health professionals, members of sustainable agriculture, labor, environmental and consumer groups and individuals concerned with the safety, sustainability, fairness and integrity of our food and agricultural system.

Our members are deeply concerned about the serious social, economic, environmental and health harms to farmers, workers and rural communities that would accompany EPA registration of dicamba for use on genetically engineered dicamba-resistant crops. We therefore urge EPA to reject Monsanto's petition for use of dicamba on these crops.

Drift damage to vulnerable crops, farmers' livelihoods and ecosystems

Dicamba products on the market today are highly volatile. Dicamba has been identified by the Association of American Pesticide Control Officials as the third most commonly involved herbicide in drift occurrences.[1] Volatilization leading to drift occurs more readily at higher temperatures (e.g. midseason, when dicamba could still be applied to Monsanto's dicamba-resistant varieties). Mechanical spray drift alone (e.g. when the herbicide is applied during commonly occurring wind conditions or with incorrect farm equipment) readily causes damage to vulnerable crops and adds to the threat of volatilization drift.

Dicamba residues are also difficult to remove from pesticide applicators' equipment. Because miniscule, residual amounts left in a sprayer can harm crops that are subsequently sprayed with other herbicides, the likelihood that vulnerable crops treated by an applicator's dicamba-contaminated equipment will be harmed increases.

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[1] Association of American Pesticide Control Officials (AAPCO). "2005 AAPCO Pesticide Drift Enforcement Survey Report." 2005. On file and available at http://aapco.ceris.purdue.edu/doc/surveys/DriftEnforce05Rpt.html. Accessed May 3, 2013.

Dicamba is also highly toxic to broadleaf plants. Incidences of both mechanical spray and volatilization drift, as well as unintended contamination of spray equipment, are likely to rise sharply, and because of the herbicide's high toxicity, threatens growers of specialty crops and non-dicamba-resistant commodity crops with severe crop damage and yield loss. Highly sensitive crops include nearly all fruits, vegetables, seed and nut crops, such as grapes, beans, lettuce, tomatoes, soybeans, sunflower, cotton and peanuts, among others. The specialty crop industry as well as seed and vegetable oil and fiber production, would be seriously impacted.

With USDA's 2015 deregulation of dicamba-resistant cotton and soybean, followed by its 2016 deregulation of dicamba-resistant corn, the window for dicamba spraying will be significantly widened, with more dicamba applications likely to occur mid-season when temperatures are warmer and volatilization occurs more readily and when vulnerable crops have leafed out and are extremely susceptible to dicamba damage. The acreage on which dicamba will be applied will also increase from current levels, as farmers begin to cultivate dicamba-resistant crops. The likelihood of dicamba drift causing crop injury and severe harm to specialty crop and organic farmers, as well as non-target species, poses a severe and unacceptable risk for thousands of American farmers.

Other non-crop broadleaf plants e.g. in hedge rows, at field-edge or throughout the larger landscape, are also likely to be harmed, destroying critical habitat, food and reproductive sites for birds and other beneficial species critical to agroecosystem health (pollinators, natural enemies). Commodity growers' efforts to diversify their farms with perennials and other crops, support agriculturally critical ecosystem services, reduce wind and water erosion and diversify sources of farm income, would be undermined.

Herbicide resistance and weed management

U.S. farmers are facing an unprecedented crisis in the spread of herbicide-resistant weeds. USDA's approval and the subsequent widespread planting of Monsanto's Roundup Ready varieties have led directly to the current weed crisis, in which glyphosate-resistant weeds now cover over 70 million acres of farmland. With the expected surge in dicamba use that USDA and Monsanto both acknowledge will accompany cultivation of Monsanto's dicamba-resistant cotton and soybean varieties, farmers are likely to face the spread of intractable dicamba-resistant weed populations.

Already several weed species are resistant to dicamba, and with resistance in the case of at least two weed species conferred by a single dominant allele, that resistance could spread swiftly. [2] Furthermore, a number of weed species have developed multiple resistance (to more than one herbicide) and/or cross-resistance (in which a metabolic adaptation in a weed species enables it to degrade several different herbicide modes of action at once).

The spread of weed populations resistant to dicamba, the evolution of dicamba resistance in weed species and the emergence of volunteer dicamba-resistant corn and soybean plants all pose serious threats to the future of American farming.

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[2] Mortensen, David et al. 2012. Navigating a critical juncture for sustainable weed management. BioScience 62(1): 75-84.

An EPA registration decision will spur a dramatic increase in use of an already problematic herbicide, exacerbate the weed problem by escalating the emergence and spread of resistant weeds, further trapping farmers on an out-of-control pesticide treadmill, and pushing many struggling family farmers out of business. This trajectory represents the polar opposite of the direction that American farming should be headed, namely that of ecologically-based, biodiversified, resilient farming that relies on least-toxic ecological approaches to insect and weed pest management.

Economic harm from loss of inter-state and global commerce

Economic harm due to crop damage and product loss caused by dicamba drift has been discussed above. Organic farmers whose crops are drifted on by dicamba face the additional possibility of losing organic certification of their crops.

The absence of established tolerances for dicamba on many fruit and vegetable crops also threatens interstate commerce in these crops. This exposes specialty crop growers to risk of enforcement action by FDA, since interstate commerce is prohibited for produce lacking tolerances or exemptions. These enforcement actions could include crop confiscation and destruction, with the economic loss — whether due to crop destruction or simply to loss of market value — borne by the specialty crop growers themselves.

Finally, conventional soybean and cotton growers may find themselves under extreme pressure to buy Monsanto's dicamba-resistant varieties, so that their own crops are not destroyed by dicamba drift. Those who have been exporting clean, non-GE soybean and cotton product to non-GE markets in Europe or Japan may find themselves unable to maintain their non-GMO production due to dicamba drift damage. The loss of these export markets will be devastating to their businesses.

Health harms to farmers, workers and rural communities

Adverse health effects associated with exposure to dicamba provide additional reason to reject Monsanto's proposed uses. Epidemiology studies have linked dicamba to increased rates of cancer—including non-Hodgkin's lymphoma and multiple myeloma— in pesticide applicators and farmers.[3] Preconception exposure to dicamba has also been linked to increased risk of birth defects in farmers' male offspring, in the Ontario Farm Family Health Study.[4] Dicamba has also been listed in the U.S. Toxic Release Inventory as a developmental toxin. Because dicamba has moderate persistence in the environment, is frequently detected in surface waters, and is expected to be applied more frequently throughout the growing season, the general population will also likely be more frequently exposed to dicamba than under current practice, rendering the increased risk of adverse health effects wholly unacceptable.

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[3] Schinasi, L and M. Leon, 2014. Non-Hodgkin lymphoma and occupational exposure to agricultural pesticide chemical groups and active ingredients: a systematic review and meta-analysis. Int J Environ Res Public Health. 2014 Apr 23;11(4):4449-527. doi: 10.3390/ijerph110404449.

[4] Arbuckle, T., Z. Lin and L. Mery, 2001. An exploratory analysis of the effect of pesticide exposure on the risk of spontaneous abortion in an Ontario farm population. Environ Health Perspect. 2001 Aug; 109(8): 851–857.

Conclusion

In sum, we call on EPA to reject Monsanto's petition for new uses of dicamba on genetically engineered dicamba-resistant crops. EPA must protect the public against severe harms that would be exacerbated by continued and increased use of dicamba in these cropping systems. These harms include:

- *economic harms* to farmers' businesses and livelihoods caused by dicamba drift damage to vulnerable crops as well as crop loss, the cost of managing spread of intractable dicamba-resistant weeds, the emergence of dicamba-resistant soybean and cotton plants as noxious weeds themselves, restrictions on inter-state commerce, loss of organic certification for drift-damaged organic farmers and loss of access to valuable export markets;
- *environmental harm* from increased dicamba application accompanying the planting of dicamba-resistant cotton and soybean, including reduction in farm- and landscape-scale plant diversity that provide alternative income sources as well as protection from wind and water erosion; loss of habitat and food and reproductive resources for birds, beneficial arthropods and other species; and loss of critical ecosystem services such as pollination and natural pest control;
- *health harm* from exposure of pesticide applicators, farmers and rural communities to dicamba, including potential increased risks of cancers such as non-Hodgkin's lymphoma and multiple myeloma, birth defects and developmental toxicity; and
- *socio-cultural harm* to rural communities arising from increased conflict between neighboring farmers around issues of drift, crop damage and liability.

We therefore urge EPA to prioritize the public interest and reject Monsanto's registration petition for use of dicamba on dicamba-resistant crops.

Thank you for your consideration.

Sincerely,

Marcia Ishii-Eiteman, PhD

Senior Scientist