Center for Food Safety
660 Pennsylvania Ave, SE, Suite 302
Washington, DC 20003

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

Science Comments - I

On the Draft Environmental Assessment of the Supplemental Request for Partial Deregulation of Sugar Beets Genetically Engineered to be Tolerant to the Herbicide Glyphosate

Center for Food Safety is submitting comments in three parts: a legal analysis and two sets of science comments. These comments address the draft Environmental Assessment (EA) primarily with respect to Roundup Ready sugar beets (RRSB), herbicide use and the evolution of herbicide-resistant weeds. The second set of science comments, to be submitted separately, address various other aspects of herbicide use with RRSB.

Weeds compete with crops for moisture, nutrients and light, and if not adequately controlled can reduce productivity. Sugar beets grow slowly, giving faster-growing weeds ample time to compete for these vital resources in the critical early phases of the crop's growth. Therefore, utilization of effective and sustainable weed control practices would be of great benefit to sugar beet farmers.

One of the most important factors that undermines sustainable weed control in sugar beets and many other crops is the evolution of herbicide-resistant weeds. 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.[1] With an estimated $7 billion spent each year on chemical-intensive weed control,[2]

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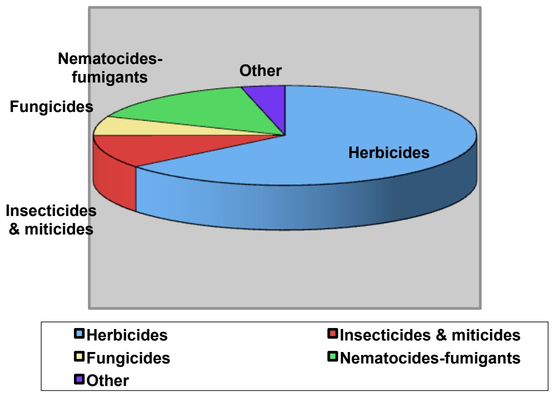
[1] USDA ARS Action Plan 2008-13-App. II. "National Program 304: Crop Protection and Quarantine Action Plan 2008-2013," Appendix II, p. 2. http://www.ars.usda.gov/SP2UserFiles/Program/304/ActionPlan2008-2013/NP304CropProtectionandQuarantineApendixII.pdf
[2] USDA ARS IWMU-1. Agricultural Research Service, Invasive Weed Management Unit, http://arsweeds.cropsci.illinois.edu/

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 1), as growers increase rates and make additional applications to kill expanding populations of resistant weeds.

Figure 1: Agricultural Pesticide Use in the U.S. by Type: 2001



Herbicides comprise by far the largest category of pesticides, defined as any chemical used to kill plant, insect or disease-causing pests. In 2001, the last year for which the Environmental Protection Agency has published comprehensive data, weedkillers (herbicides) accounted for 433 million lbs. of the 675 million lbs. of chemical pesticides used in U.S. agriculture, nearly six-fold more than the insecticides that many associate with the term "pesticide." Source: "Pesticides Industry Sales and Usage: 2000 and 2001 Market Estimates," U.S. Environmental Protection Agency, 2004, Table 3.4. http://www.epa.gov/oppbead1/pestsales/01pestsales/market_estimates2001.pdf

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Increasing the rate and number of applications, however, rapidly leads to further resistance, followed by a massive switch to another herbicide, beginning the resistance cycle all over again, just as overused antibiotics breed 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.[3]

Besides costing farmers economically via herbicide-resistant weeds, a chemical-intensive pest control regime 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 suggest that farmers in many countries, including the U.S., have higher rates of immune system and other cancers.[4] 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 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

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[3] Kilman, S. (2010). "Superweed outbreak triggers arms race," *The Wall Street Journal*, June 4, 2010. http://www.gmwatch.org/latest-listing/1-news-items/12263-superweed-outbreak-triggers-arms-race

[4] USDA ERS AREI (2000). Agricultural Resources and Environmental Indicators, USDA Economic Research Service, Chapter 4.3, Pesticides, p. 5.

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.

Roundup Ready crop systems and glyphosate-resistant weeds

Roundup Ready (RR) sugar beets represent a binary weed control system consisting of a sugar beet genetically engineered to withstand direct application of glyphosate, the active ingredient in Roundup herbicides, and multiple applications of glyphosate. This definition is borrowed from Monsanto's own description of the company's latest generation of genetically engineered soybeans, and applies equally to Roundup Ready sugar beets:

> "The utilization of Roundup agricultural herbicides plus Roundup Ready soybean, collectively referred to as the Roundup Ready soybean system…"[5]

Before addressing RRSB in particular, we provide essential background on general features of Roundup Ready crop systems, together with some of the impacts of their use as relates to weed resistance over the past 14 years.

Like other RR crop systems, RRSB is designed to dramatically simplify weed control from a diversity of weed control techniques to reliance on a single tool: post-emergence use of glyphosate. Post-emergence means application after the seedling has sprouted through some or most of the crop's life, a use pattern that is only possible with glyphosate-resistant crops, since glyphosate is toxic to virtually all conventional crops. Herbicides may also be applied before the crop seed has been planted (pre-plant) or after seeding but prior to sprouting (pre-emergence) to kill early season weeds.[6]

APHIS mistakenly describes glyphosate as a "post-emergent herbicide,"[7] while in fact it also has a broad range of pre-emergence uses in both RR and non-RR crops. For instance, glyphosate is widely used as a "burndown" herbicide to clear a field of weeds prior to planting, for instance in wheat, or for direct seeding in a no-till context.

This distinction is extremely important for several reasons. First, post-emergence glyphosate applications are much more likely than pre-emergence use to result in spray drift injury to neighbors' non-Roundup Ready crops, for the simple reason that the former (unlike the latter) occur after neighbors' crops have sprouted, and glyphosate is a broad-spectrum herbicide that kills crops as well as weeds. Steve Smith, Director of Agriculture for Red Gold, a tomato processor based in Indiana, reports that he and his 54 family farm

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[5] Monsanto (2006). "Petition for the Determination of Nonregulated Status for Roundup RReady2Yield Soybean MON 89788," submitted by Monsanto to USDA's Animal and Plant Health Inspection Service, Nov. 3, 2006, p. 4.

[6] Some herbicides are used entirely or primarily pre-plant or pre-emergence, others post-emergence, while still others like glyphosate can be used in either manner under different circumstances.

[7] EA at 92.

growers in Indiana, Ohio and Michigan have incurred over $1 million in losses over the past four years due to glyphosate drift damage to tomatoes:

> "Since the introduction of glyphosate resistant crops, the pattern of weed control in the Midwest has changed from predominantly pre-plant applications of herbicides, to almost entirely a post-plant, in-season application practice. **The effects of this paradigm shift in herbicide applications has affected our company and family growers in a very negative way, due to the potential for direct drifting of spray material onto our tomato fields from applications during windy conditions.** The majority of herbicide applications were historically made prior to the planting of most specialty crops, so the drifting of products caused little or no harm. However, the transformation to herbicide applications during the growing season in June and July has put drift prevention at the forefront of concerns to sensitive crop producers of all kinds. **Over the last four seasons, our company and growers have been involved with cropping losses exceeding a million dollars due to glyphosate drift."**[8]

Mr. Smith would probably disagree strongly with APHIS's statement that use of glyphosate with glyphosate-resistant crops has resulted in "minimal impact to adjacent non-target terrestrial plants."[9] Many other growers across the country would agree. For instance, Arkansas has seen substantial crop damage from glyphosate spray drift, occasioning years of disputes, repeated attempts to tighten regulation of spraying, and to persuade Monsanto to offer more drift-resistant Roundup formulations. Arkansas weed consultant Ford Baldwin reports that many farmers in his area originally adopted Roundup Ready corn to protect their crop from glyphosate spray drift, not from a desire to make use of the Roundup Ready trait through post-emergence applications of glyphosate. One must wonder how much farmers across the country have spent on much more expensive RR crop seeds for protection against glyphosate spray drift. It should be noted that RRSB would be grown in many states where, much more than the Midwestern Corn Belt, wheat, barley, alfalfa, beans, flax and many other small acreage crops that are not Roundup Ready are grown. Thus, the potential for spray drift damage would be considerable. APHIS does not address this important issue in the draft EA.

Second, according to weed scientist Paul Neve:

> "Glyphosate use for weed control prior to crop emergence is associated with low risks of resistance. ... Post-emergence glyphosate use, associated with glyphosate-resistant crops, ***very significantly increases risks of resistance evolution***."[10]

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[8] Oversight Hearing 9-30-2010 – Smith: "Testimony before the House Domestic Policy Subcommittee of Committee on Oversight and Government Reform," September 30, 2010, emphasis added. http://oversight.house.gov/index.php?option=com_content&view=article&id=5121:webcast-and-testimony-for-hearing-are-superweeds-an-outgrowth-of-usda-biotech-policy-part-ii&catid=66:hearings&Itemid=31.

[9] EA at 166.

[10] Neve, P. (2008). "Simulation modeling to understand the evolution and management of glyphosate resistance in weeds," Pest Management Science 64: 392-401, emphasis added.

Dr. Neve's finding is based on a simulation model that compared numerous different use patterns for glyphosate applied to parameters modeling typical weeds. His conclusion is supported by a wealth of empirical, on-the-ground evidence.

The best available source of data on herbicide-resistant (HR) weeds is known as the International Survey of Herbicide-Resistant Weeds. This Survey is an online database run by weed scientist Dr. Ian Heap, with support from pesticide companies that comprise the Herbicide Resistance Action Committee (HRAC), and members of the Weed Science Society of America (WSSA), a group of academic and industry weed scientists.

Weed scientists contribute reports of herbicide-resistant weeds they have identified in the field, but only after careful confirmation in the greenhouse in experiments that can take months to years. Only then are reports listed on the Survey website. Reporting follows a standard format, and usually includes estimates of the number of sites and the acreage infested by the resistant weed population. Because it is difficult to assess the precise extent of a resistant weed population, these estimates are given in ranges, for example 101 to 1,000 sites and 10,001 to 100,000 acres; a typical example is provided in the supporting materials (file: ISHRW Report Example.pdf). All reports can be accessed at http://www.weedscience.org/In.asp. Data on glyphosate-resistant weeds can accessed by clicking on the country or state hyperlink at http://www.weedscience.org/Summary/UspeciesMOA.asp?lstMOAID=12&FmHRACGroup=Go. Note that "Glycines" represent a category of herbicides of which glyphosate is the only member.

We have also submitted along with these comments a spreadsheet that collates data from the Survey website on all herbicide-resistant weeds in the U.S.[11] The data in the spreadsheet are current as of November 30, 2010. New reports are posted with some frequency, while existing reports are often updated to reflect changes in the number of sites or acreage infested. The spreadsheet column entitled "Report last updated" gives the relevant date, which corresponds to the entry next to "QUIK STATS" on each website report.

A chart in the supporting materials with filename Herbicide-Resistant Weeds Chart – 11-30-10 presents aggregate data derived from the spreadsheet on acreage infested by herbicide-resistant weeds in the U.S., broken down by decade of report (or update) and major families of herbicides to which weeds have evolved resistance. We first discuss glyphosate-resistant weeds, but will make briefer reference to weed populations resistant to other classes of herbicides below.

CFS first collated ISHRW data for all herbicide-resistant weeds on November 21, 2007. On four subsequent occasions we updated the GR weed data, and on November 30, 2010 collated the information for all herbicide-resistant weeds (except for GR weeds, on 12/2/10, see table below). There are now 12 GR weed biotypes in the U.S. and 20 in the world, and in the U.S. they have emerged at an average pace of one per year since the first was discovered in 1998. The draft EA, dated October 2010, is already out of date on this point, citing just 10 GR weed biotypes in the U.S. and 19 in the world.[12] APHIS's count excludes a GR perennial ryegrass population in Argentina as well as GR annual bluegrass and GR goosegrass populations in Missouri and

[11] See file entitled: HR Weeds from ISHRW – 11-30-10.xlsx.
[12] EA at 93.

Mississippi, respectively, the latter two confirmed in just the past several months.[13]

The rising number of resistant biotypes, while concerning, vastly underestimates real world consequences. As noted above, common control measures for resistant weeds include increased applications of herbicides, soil-eroding tillage operations, hand weeding, and the public health, environmental, and increased farmer expenditures entailed by these measures. These adverse impacts obviously increase in proportion to the geographic area infested by resistant weeds, not the number of biotypes. All else being equal, measures to control a resistant weed population on 1 million acres have 1,000 times the impact than such measures undertaken on 1,000 acres. This is one important reason that a recent committee of the National Research Council stated:

> "Given the rapid increase in and expansion of weeds that are resistant to glyphosate in HR [herbicide-resistant] crops, herbicide resistance management needs national attention."[14]

Glyphosate-Resistant Weeds in the U.S. (November 2007 to December 2010)

	No. of Populations	Sites (min)	Sites (max)	Acres (min)	Acres (max)
November 21, 2007	34	1,020	3,251	2,038,175	2,367,115
February 2, 2009	39	2,228	14,260	2,339,168	5,377,065
November 19, 2009	47	3,242	24,286	2,440,323	6,387,365
February 25, 2010	53	4,368	34,827	2,641,090	11,389,515
May 18, 2010	55	4,371	34,868	2,641,202	11,390,065
December 2, 2010	60	14,426	134,971	3,543,311	12,410,580

The table above shows that over just the past three years, the number of GR weed populations in the U.S. has nearly doubled, from 34 to 60. The number of sites infested has increased by a factor of from 14 (lower-bound) to over 40 (upper-bound). Acreage infested has also increased dramatically, and according to Dr. Ian Heap (who manages the ISHRW website) now lies near the upper-bound estimate of 12.4 million acres. In May of 2010 (when the upper-bound estimate was 11.4 million acres), Dr. Heap estimated the extent of GR weed infestation in the U.S. at 6% of the 173 million total acres planted to corn, soybeans and cotton, the three major RR crops, which comes to 10.4 million acres.[15]

However, these ISHRW data likely underestimate the true extent of GR weed populations, perhaps substantially, for several reasons. First, 7 of the 60 reports lack acreage infested data. Second, over three-fourths of the populations (46 of 60) are expanding in range, while only 2 of 60 have stabilized (not reported for 12 populations). Since there is no regular mechanism or timetable for updating ISHRW reports to reflect changes, and at least three-fourths of GR weed populations are expanding, some reports not recently updated may underestimate the area

[13] GR perennial ryegrass in Argentina was discovered in 2008 and posted on 5/31/10. As noted above, the "Year" designates discovery of the resistant population, but months to years can elapse before the resistance is confirmed and the report is posted on the website. The two U.S. GR biotypes not in APHIS's count are both 2010, and were posted on September 29th and December 2nd, 2010.
[14] NRC (2010). "The Impact of Genetically Engineered Crops on Farm Sustainability in the United States," National Research Council, National Academy of Sciences, 2010 (prepublication copy), p. 2-21.
[15] EA at 93, citing WSSA (2010). "WSSA supports NRC Findings on Weed Control, May 27, 2010.

infested. Third, the ISHRW reporting system is voluntary; many reports of GR and other HR weeds one finds in the published scientific literature and farm press (articles that often cite weed scientists) are not recorded by the ISHRW. This is confirmed by the NRC: "…the voluntary basis of the contributions likely results in underestimation of the extent of resistance to herbicides, including glyphosate."[16]

Another important factor is that ISHRW lists only herbicide-***resistant***, but not herbicide-tolerant weeds. The Weed Science Society of America has established official definitions of the two terms. "Herbicide resistance is the inherited ability ***of a plant*** to survive and reproduce following exposure to a dose of herbicide normally lethal to the wild type. In a plant, resistance may be naturally occurring or induced by such techniques as genetic engineering or selection of variants produced by tissue culture or mutagenesis. Herbicide tolerance is the inherent ability ***of a species*** to survive and reproduce after herbicide treatment. This implies that there was no selection or genetic manipulation to make the plant tolerant; it is naturally tolerant."[17]

In the case of herbicide resistance, herbicide application selects for more or less rare ***individual plants*** of a given species that have the genetic predisposition to withstand the herbicide; these individuals proliferate and come to dominate the population over time. In the case of herbicide tolerance, those weed ***species*** that are less susceptible to the killing effects of an herbicide will gradually supplant other more susceptible weed species in a given field over time. The latter phenomenon is known as a "weed shift." Thus, selection pressure from frequent use of a given herbicide such as glyphosate can cause both intraspecific evolution of resistant populations and weed shifts to less susceptible (tolerant) species.

Like resistance, weed shifts often trigger increased application rates of the given herbicide due to the increased prevalence of weed species less well controlled by lower doses, and/or to supplemental use of additional herbicides.[18] CFS knows of no formal survey or mechanism to record the extent of weed shifts to more herbicide-tolerant species or the increase in herbicide use that they frequently entail. However, our reading of the weed science literature suggests that weed shifts to more glyphosate-tolerant species could be responsible for a substantial burden of increased glyphosate and overall herbicide use above and beyond that occasioned by glyphosate-resistant weeds.

The best estimate of the herbicide use impacts attributable to glyphosate-resistant/tolerant crop systems is a study by Dr. Charles Benbrook, former executive director of the Board on Agriculture of the National Academy of Sciences.[19] Dr. Benbrook's meticulous study, based on analysis of gold standard USDA National Agricultural Statistics Service pesticide usage data, demonstrates that GR soybeans, corn and cotton have led to 318 million more pounds of herbicide use over the 13 years from 1996 to 2008 than would have been applied had they not been introduced. Benbrook identifies two major factors for the increase in herbicide use. First,

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[16] NRC (2010), op. cit., p. 2-12.
[17] WSSA (1998). "Technology Notes," *Weed Technology* 12(4): 789-90, emphasis added. Thus, the correct designation for crop plants is not the industry-favored "herbicide-tolerant" but rather "herbicide-resistant."
[18] Van Acker, R. (2010). Declaration of Rene Van Acker in support of plaintiffs' motion for summary judgment, Case No.: 3:08-cv-00484-JSW
[19] Benbrook, C. (2009). Impacts of Genetically Engineered Crops on Pesticide Use in the United States: The First Thirteen Years," The Organic Center, November 2009.

the higher rate herbicide glyphosate displaced many lower-rate (more potent) herbicides such as ALS inhibitors used on conventional crops (especially soybeans) in tandem with RR crop displacement of conventional versions of those crops. One important reason that farmers readily adopted Roundup Ready crops was the opportunity they offered to use glyphosate to kill massive populations of weeds that had evolved resistance to the ALS inhibitor herbicides, popular herbicides of the 1980s and early 1990s, especially in soybeans (see Herbicide-Resistant Weeds Chart – 11-30-10). This is a classic example of the pesticide treadmill referred to above. The second reason Benbrook identified for the substantial increase in herbicide use documented in USDA NASS data is glyphosate-resistant weeds. The NRC committee concurs. In a section entitled "Farmers' response to glyphosate resistance in weeds," the NRC states unambiguously that farmers are "…increasing the magnitude and frequency of glyphosate applications, using other herbicides in addition to glyphosate, or increasing their use of tillage"[20] to kill increasingly resistant weeds.

In the draft EA, APHIS inexplicably fails to discuss the crucial factor of geographic extent of glyphosate-resistant weeds, just as it failed to discuss the much greater propensity of post-emergence use of glyphosate (again, unique to GR field crop settings) vs. pre-emergence applications to foster rapid evolution of resistance. APHIS refers to the "relatively few cases" of glyphosate-resistant weeds, based solely on the number of GR biotypes, which as we have seen above is an extremely poor measure of their agronomic impact.

APHIS maintains that only 10 of the 19 species of weeds with GR biotypes worldwide (there are now 20) have evolved resistance from use of glyphosate in glyphosate-resistant crops, while the other nine evolved in non-GR crop settings.[21] This statement is grossly misleading, since it falsely suggests that GR weeds are equally prevalent in GR and non-GR systems. First, as discussed above the relevant metrics for agronomic impact are number of populations and acreage infested rather than number of species. For instance, an analysis of ISHRW data show that there are 23 populations of "GR horseweed" in the world: the great majority (16) evolved in soybeans and/or cotton (all in the U.S., where GR varieties are overwhelmingly predominant); two evolved in mixed settings involving both GR and non-GR crops; while just five evolved in non-GR crop settings (three overseas). Second, the geographic extent of these various populations varies even more dramatically. The aggregate acreage infested by the 16 populations in GR crop settings (upper-bound estimates) is 6.34 million acres, versus just 11,000 acres for mixed crop and a mere 1,100 acres for non-GR settings. Clearly, post-emergence glyphosate use in GR crops is responsible for the overwhelming majority of GR horseweed plants in the world. This holds true more generally.

Again based on upper-bound ISHRW estimates, fully 98.7% (12.58 million acres) of the area infested with GR weeds internationally is found in soybeans, corn and/or cotton in countries where GR versions of these crops are overwhelming predominant, primarily the U.S., but also Paraguay, Argentina and Brazil. Another 0.9% (0.11 million acres) is in mixed settings, with less than 60,000 infested acres (0.4%) found in exclusively non-GR crop settings. While the maximum area infested with any individual GR weed population in orchards and other non-GR crop settings is 10,000 acres, GR crops have infestations ranging up to several millions of acres.

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[20] NRC (2010), op. cit., p. 2-15.
[21] EA at 93.

The HR Weeds Chart cited above shows that glyphosate-resistant weeds have dominated the herbicide-resistant weed landscape over the past decade, followed by weeds resistant to ALS inhibitors, which we address further below.

While forecasts are always hazardous, there is no serious doubt that GR weed populations will continue to emerge and spread rapidly in the coming years. Syngenta's manager of weed resistance strategies, Chuck Foresman, predicts that ***38 million row crop acres*** could be infested with GR weeds by 2013, or one in every four acres.[22] Bayer Crop Science's Harry Strek was recently quoted as forecasting that 50% of agricultural weed species would be resistant to glyphosate by 2018.[23] The high levels of current GR weed infestation and forecasts for sharply expanding populations in the near future would seem to justify the words of eminent weed scientist Stephen Powles, who was quoted in a 2007 *Science* article as follows: "There is going to be an epidemic of glyphosate-resistant weeds. In 3 to 4 years, it will be a major problem."[24] The future is now.

In the face of this growing epidemic, it is interesting that APHIS should regard glyphosate as an herbicide to which weeds have a "low" risk of evolving resistance, presumably due to the "nature of glyphosate and its specific chemical nature as an herbicide."[25] APHIS is apparently referring to the presumed rarity of weeds with the genetic predisposition to survive treatment with glyphosate, versus the higher prevalence of weeds with mutations conferring resistance to certain other classes of herbicides, such as ACCase and ALS inhibitors. First, it should be stressed that no one knows how frequent mutations conferring resistance to glyphosate are; second, that there a number of different mechanisms (corresponding to different genetic predispositions) conferring resistance to glyphosate. APHIS states that there are three known mechanisms in the U.S.,[26] but in fact there are five, which sometimes occur individually, and other times in "stacks" of two and perhaps three.[27] In most cases, however, the mechanisms remain unknown. The potential for weak resistance mechanisms, each conferring only modest resistance, to combine for higher-level resistance, is a relatively new discovery in weed science that challenges simple probability models of weed resistance based on presumed single-mutation frequency. Nature has surprised the brightest weed researchers in the past with her ingenuity, and will certainly continue to do so in the future.[28]

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[22] Syngenta (2009).
http://www.syngentaebiz.com/DotNetEBiz/ImageLIbrary/WR%203%20Leading%20the%20Fight.pdf.

[23] Heard, G. (2010). "Smart farming essential to manage resistance," Stock and Land, July 13, 2010.
http://sl.farmonline.com.au/news/nationalrural/grains-and-cropping/general/smart-farming-essential-to-manage-resistance/1879228.aspx?storypage=0

[24] Service, R.F. (2007). "A growing threat down on the farm," Science 316: 1114-1117.

[25] EA at 87, 179.

[26] EA at 93.

[27] Powles, S.B. & Q. Yu (2010). "Evolution in Action: Plants Resistant to Herbicides," Annu. Rev. Plant Biol. 61: 8.1-8.31. The two left out by APHIS are reduced absorption of glyphosate (accompanied by reduced translocation) in Italian ryegrass from Mississippi (see reference 109 of Powles & Yu). The other is enhanced ramification after glyphosate treatment of resistant horseweed populations in several states (Dinelli, G et al (2006). "Physiological and molecular insight on the mechanisms of resistance to glyphosate in *Conyza canadensis* (L.) Cronq. Biotypes," Pesticide Biochemistry and Physiology 86: 30-41).

[28] Gressel, J. & A.A. Levy (2006). "Agriculture: The selector of improbable mutations," PNAS 103(33): 12215-16.

Much more important than mechanism, however, is the enormous selection pressure exerted by repeated post-emergence use of glyphosate and the near exclusive reliance on this single weed control tool, both of which are hallmarks of Roundup Ready crop systems such as RRSB.

> "Glyphosate has been globally and extensively used since 1974, and when reviewed in 1994, there were no reports of evolved glyphosate-resistant weeds (41). However, since first identified (132, 135), glyphosate resistance has evolved in at least 16 weed species in 14 different countries and ***is fast becoming a very significant problem in world agriculture*** (Table 4; Figure 1) (67; see Reference 129 for a review). ***A major factor accelerating the evolution of glyphosate-resistant weeds has been the advent of transgenic glyphosate-resistant crops such as soybean, maize, cotton, and canola***. These have been spectacularly adopted in North and South America. ***In these crops, glyphosate has replaced almost all other herbicides or other means of achieving weed control. From an evolutionary viewpoint, this singular reliance on glyphosate is an intense selection for any glyphosate resistance genes*** (128, 129). ***Unsurprisingly, widespread evolution of glyphosate resistance in weeds has quickly followed***…"[29]

It must be emphasized that Powles & Yu are expressing well-known truths, uncontroversial, consensus views accepted by every legitimate member of the weed science community. If we had time, we could cite dozens of statements to the same effect, which fly directly in the face of APHIS's fundamentally mistaken view that GR crop systems have little or nothing to do with GR weed evolution. We have repeatedly presented this information to APHIS in comments on various regulatory decision-making documents, and it has just as consistently been ignored.

Roundup Ready sugar beets will foster rapid evolution of glyphosate-resistant weeds

As noted above, the key factor that has fostered the extensive evolution of GR weeds in other RR crop systems is the "singular reliance on glyphosate" such that "glyphosate has replaced almost all other herbicides or other means of achieving weed control." The more a farmer relies exclusively on glyphosate, the fewer the opportunities for initially rare GR weeds to be killed by alternate weed control tactics, and thus the more rapidly they will come to dominate the fields.

Accordingly, only a diversity of weed control tactics can prevent evolution of weeds resistant to glyphosate or any other herbicide, and even then only if non-chemical weed control measures are a prominent part of the mix. One extremely promising technique that has received little support and is nowhere mentioned in the EA is green manure crops, such as oil radish, that suppress weeds as well as nematodes and perhaps disease agents in the follow-on main crop of sugar beets, and provide multiple other benefits as well.[30] Other tactics include mechanical tillage to physically uproot weeds, close row spacing to better deprive weeds of light, use of herbicides with different modes of action, and rotation to crops in which differing weed control measures (e.g. herbicide modes of action) are in fact used, as well as manual weeding.

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[29] Powles & Lu (2010), op. cit., pp. 8.11-8.12, emphasis added.

[30] Lilleboe, D. (2006). "Most Idaho growers still eyeing, not buying. Green manure crops: Amalgamated Sugar research project aims to quantify benefits in addition to nematode control."

APHIS falsely implies that RRSB cultivation does in fact involve "diversified weed management practices,"[31] which constitutes the chief basis for the claim that RRSB systems will not trigger the rapid evolution of GR weeds seen with Roundup Ready soybeans, cotton and corn cultivation. A closer examination, however, reveals that APHIS is not referring to actual farmer practice, but merely ***the availability*** of other weed control techniques, or ***recommendations*** to employ them. For instance, APHIS states that "available herbicide chemistries, etc. reduce the potential for herbicide resistant weed [sic] to develop…."[32] On the contrary, the mere availability of non-glyphosate herbicides does nothing to check the evolution of GR weeds if they are not used. In other passages, APHIS refers to multiple possible ***responses*** to weeds that have ***already*** evolved herbicide-resistance as if they constituted diverse tactics to ***prevent*** their emergence in the first place, an example of the loose reasoning that one finds throughout the EA.[33]

Abundant evidence demonstrates that RRSB growers rely solely or primarily on post-emergence glyphosate. RRSB growers recently testified that they rely solely or primarily on two to three POST applications of glyphosate for weed control.[34] University of Wyoming sugar beet expert Andrew Kniss has published research on the economics of RRSB versus conventional sugar beet cultivation in which the only weed control practice with RRSB was two or three post-emergence applications of glyphosate.[35] Mesbah & Miller published a study comparing various herbicide regimes with RRSB in which two to three POST applications of glyphosate with no other weed control measures gave the best performance, and note approvingly that RRSB will likely lead to abandonment of tillage and hand weeding.[36] This underscores the seductive nature of the single tactic, glyphosate-only RRSB system to growers, who will use it until the inevitable emergence of GR weeds renders glyphosate, like other herbicides used before it, inefficacious.

Perhaps the strongest evidence comes from Andrew Kniss and colleagues at the University of Wyoming, the same Dr. Kniss cited by APHIS for the proposition that weed control tactics in RRSB crop rotations are "diverse":[37]

> "Unavailability of currently used postemergence herbicides, hesitance to use preemergence herbicides, and reluctance to use tillage for weed control in the glyphosate resistant sugarbeet crop could potentially result in near total reliance on a single herbicide for weed management in the glyphosate resistant sugarbeet crop. ***Reliance on a single herbicide will almost surely lead to glyphosate resistant weeds***, and by the time glyphosate resistant weeds appear in Wyoming sugarbeet fields, ***growers will have few acceptable management options."***[38]

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[31] EA at 87-88.
[32] EA at 94.
[33] EA at 89.
[34] Mauch, Petersen, Schlemmer
[35] Kniss, A.R. et al (2004). "Economic evaluation of glyphosate-resistant and conventional sugar beet," *Weed Technology* 18: 388-96.
[36] Mesbah, A.O. & S.D. Miller (2004). "Weed control and glyphosate-tolerant sugarbeet response to herbicide treatments," Weed Control 41(3): p. 102.
[37] EA at 87.
[38] Kniss, A.R. et al (2010). "A novel application of the herbicide ethofumesate to increase and prolong the effectiveness of glyphosate resistant technology in sugarbeet," USDA National Institute of Food and Agriculture grant report, Project No. WYO-427-08. In supporting materials as Kniss et al 2010.

This statement appears in the summary section of a grant report for a recently completed project (January 1, 2008 through Sept. 30, 2010) led by Dr. Kniss and colleagues that was funded by USDA. It of course directly contradicts the statement Dr. Kniss made in the declaration cited by APHIS on p. 87 of the EA. It should be noted that Dr. Kniss's project is premised on the reality of "near total reliance" on glyphosate in RRSB cultivation, which he and his colleagues correctly state "will almost surely lead to glyphosate resistant weeds." Importantly, the near inevitable emergence of GR weeds will leave growers "few acceptable management options." This is due in part to the prevalence of important sugar beet weeds already resistant to other herbicides, and the likelihood that these already resistant weeds will rapidly evolve resistance to glyphosate as well, leaving growers in a worse situation than they were in before the introduction of RRSB. This is a classic example of the pesticide treadmill, where today's temporary "fix" rapidly exacerbates the problem it was supposed to solve.

APHIS relies heavily on the proposition that, even if glyphosate alone is used with RRSB, other weed control tactics used on crops that are rotated with sugar beets will succeed in preventing evolution of GR weeds, even if the only crops rotated with RRSB are also glyphosate-resistant.[39] This position directly contradicts the consensus view of the weed science community, as APHIS is well aware. The NRC Committee cited above addressed this very question, and concluded that any value of crop rotation in preventing GR weeds is largely negated by overreliance on glyphosate when all the crops in the rotation are glyphosate resistant. In a section entitled *Developing weed management strategies for herbicide-resistant crops,"* the NRC stated: "As for using crop rotations, the increasingly common practice of farmers throughout the United States of using glyphosate as the primary or only weed-management tactic in rotations of different glyphosate-resistant crops limits the application of the rotation strategy…"[40]

The imperative to rotate away from a Roundup Ready crop to a conventional one to prevent GR weed evolution has been acknowledged since the very first GR weed was documented in the late 1990s. According to Dr. Ian Heap, who has extensive knowledge of herbicide-resistant weeds by virtue of his position as organizer of the ISHRW discussed above:

> "The appearance of glyphosate-resistant rigid ryegrass should be a forewarning. The recently developed glyphosate-resistant crops will need to be used in rotation with conventional cultivars and in conjunction with non-chemical weed control and other herbicides if the selection of glyphosate-resistant weeds is to be avoided."[41]

Unfortunately, Dr. Heap's warning and those of many other agronomists have been ignored. As GR weeds are on course to expand dramatically in the coming years, APHIS continues to ignore it.

There is nothing unique about RR sugar beets that alters the situation. USDA's Agricultural Research Service recently noted that "…transgenic beets present new problems in prevention of

[39] EA at 94.
[40] NRC (2010), op. cit., pp. 2-19, 2-20.
[41] Heap, I.M. (1997). "The occurrence of herbicide-resistant weeds worldwide," Pesticide Science 51: 235-43.

weed resistance to this important herbicide, given the large number of weed species in sugar beet fields…," but unfortunately has no funding to address the issue.[42] Jeff Stachler and colleagues, in the two leading sugar beet production states of Minnesota and North Dakota, likewise have warned: "With the rapid introduction of glyphosate-resistant sugar beet and the continued use of glyphosate-resistant corn and soybean in the rotation, glyphosate-resistant common ragweed will become more challenging to control in sugar beet."[43]

Clearly, an RRSB crop rotation that involves primarily other Roundup Ready crops will foster rapid evolution of resistant weeds. To what extent, then, do RRSB growers grow other RR crops in rotation?

Corn and soybeans are major rotation crops for sugar beets in at least three of the four states with the largest annual acreage planted to sugar beets: Minnesota, North Dakota and Michigan. Table 1 of the draft EA (updated and corrected as discussed in the footnote) shows that roughly 643,000 acres of sugar beets, or a substantial 46% of sugar beet acreage, will be rotated to Roundup Ready crops.[44] North Dakota farmer Russell Mauch grows RRSB in a four-year rotation, with one year of RRSB followed by three years of corn.[45] In North Dakota, 71% of the 2010 corn crop was Roundup Ready.[46] It is thus likely that Mr. Mauch rotates RRSB to GR corn, with continual application of glyphosate throughout the four-year rotation. Michael Petersen, a farmer in southern Minnesota, grows RRSB in a five-year rotation consisting of corn/sweet corn, sugar beets, corn, soybeans and corn/sweet corn, and has experience in growing Roundup Ready crops other than RRSB.[47] In Minnesota, 74% of the corn and 93% of the soybeans were Roundup Ready in 2010. Thus, it is likely that Mr. Petersen will also rely primarily on glyphosate throughout his five-year rotation.

APHIS states that RRSB are typically given two to three POST applications of glyphosate per season. This represents frequent use compared to other GR crop systems, particularly in the early years of their adoption. When GR soybeans were first introduced in 1996, soybeans as a

[42] USDA ARS Action Plan 2008-13 – App I. "National Program 304: Crop Protection and Quarantine Action Plan 2008-2013," Appendix 1, p. 65. http://www.ars.usda.gov/SP2UserFiles/Program/304/ActionPlan2008-2013/NP304ActionPlanwithCover2008-2013.pdf.

[43] Stachler, J.M et al (2010). "Management of glyphosate-resistant common ragweed," North Central Weed Science Society Proceedings 64: 178.

[44] EA at 51, 53, Table 1. APHIS does not attribute this table, but it was put together by Monsanto, and constitutes a slightly updated version of Table VII-13 in the company's 2003 petition for deregulated status for H7-1 Roundup Ready sugar beets. Inexplicably, Monsanto excludes corn as a rotation crop for sugar beets in Minnesota (see Column C for MN), when in fact sugar beets are frequently rotated from and to corn in Minnesota. See statement by Stachler et al (2009), quoted above, and also the declaration of Michael Peterson, cited below. Monsanto also uses the outdated 2007 figure of 52% for the proportion of national corn acres, and 91% for soybeans, that are Roundup Ready. In 2010, 70% of corn and 93% of soybeans were Roundup Ready (see USDA ERS (2010) spreadsheet, cited below). The only relevant figures from this in our view intentionally confusing table are on page 53, where we learn that of the 1.411 million acres of sugar beets, 596,000 acres are likely rotated to a Roundup Ready crop. Correcting corn from 52% to 70% and soybeans from 91% to 93%, as noted above, brings the total to 643,000 acres of the 1.411 million acres. In short, a substantial 46% of sugar beet acres are rotated to a Roundup Ready crop, assuming Monsanto's assumptions are correct.

[45] Mauch Declaration (2010), para. 11.

[46] USDA ERS (2010). Adoption of Genetically Engineered Crops in the United States. See spreadsheets at: http://www.ers.usda.gov/Data/BiotechCrops/ for this and following figures.

[47] Petersen Declaration (2010), para. 5, 11.

whole received on average just 1.1 glyphosate applications per season. As more farmers began growing RR soybeans, weed resistance emerged, and they began applying glyphosate a second and sometimes a third time to achieve adequate control. This change is evidenced in USDA data showing an increase in the average number of glyphosate applications from 1.1 in 1996 to 1.7 in 2006. Unfortunately, USDA's National Agricultural Statistics Service's funding to conduct pesticide use surveys (the source of these data and those for cotton below) was cut in 2008, so we do not have more recent data (funding has since been restored).

Still more striking, glyphosate applications to cotton increased from an average of just 1.0 in 1996, the year prior to RR cotton introduction, to 2.4 in 2007,[48] when Roundup Ready cotton comprised 92% of cotton acreage.[49] It is no coincidence that glyphosate-resistant weeds have thus far been worst in Roundup Ready cotton (with RR soybeans and corn not far behind). Recall that in many cases, farmers can gain adequate control of GR weeds for a short time at least by increasing the rate and number of glyphosate applications. When this strategy proves inadequate, they generally continue applying higher rates of glyphosate, but supplemented with one or several other herbicides. As noted above, the NRC reports that farmers respond to GR weeds by "…increasing the magnitude and frequency of glyphosate applications, using other herbicides in addition to glyphosate, or increasing their use of tillage"[50]

The fact that RRSB farmers already rely solely or primarily on as many glyphosate applications as are being used now by cotton farmers beset with extremely damaging GR weeds is thus of great concern. Without diversification in weed control, including non-chemical tactics such as green manure crops, they may quickly find themselves in a dire situation. APHIS predicts that continued RRSB cultivation will eliminate or greatly reduce the need for hand weeding.[51] This has certainly not been the experience of other RR crop growers.

In 2009, half of Georgia's one million acres of cotton (the vast majority RR) had to be weeded by hand to remove glyphosate-resistant pigweed, at a cost of $11 million. Growers who until recently spent $25 per acre on weed control now find themselves spending from $60 to $100 per acre, and some face financial ruin, drawing comparisons between GR pigweed and the infamous boll weevil.[52] The sharply increasing expenditures on weed control are not only for weeding crews, but also for greater use of toxic herbicides, as in many cases these tough weeds are resistant even to herbicidal onslaughts involving six to eight different weedkillers.[53] One striking

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[48] USDA National Agricultural Statistics Service: "Agricultural Chemical Usage – Field Crops Summary," for respective years. Both soybean and cotton data are available at http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1560. For 2007 cotton data, for example, see 2008 report, entry for glyphosate on p. 14, and likewise for other years.

[49] Benbrook (2009). "Impacts of Genetically Engineered Crops on Pesticide Use: The First Thirteen Years," The Organic Center, November 2009, Table 2.2. http://www.organic-center.org/science.pest.php?action=view&report_id=159.

[50] NRC (2010), op. cit., p. 2-15.

[51] EA at 167.

[52] Haire, B. (2010). "Pigweed threatens Georgia cotton industry," Southeast Farm Press, July 6, 2010. http://southeastfarmpress.com/pigweed-threatens-georgia-cotton-industry

[53] Culpepper, A.S and J. Kichler (2009). "University of Georgia Programs for Controlling Glyphosate-Resistant Palmer Amaranth in 2009 Cotton, " University of Georgia Cooperative Extension, April 2009.

example of this is the comeback of arsenic-based weedkillers (known as organic arsenicals). The EPA, which is otherwise in the admirable process of phasing out these toxic weedkillers, reversed course by allowing their continued use in the specific case of cotton, due to the desperate need of cotton growers for additional herbicidal tools to kill glyphosate-resistant Palmer amaranth.[54]

Glyphosate-resistant pigweed and horseweed have infested in total millions of acres of cotton and soybeans in Arkansas, Tennessee, North Carolina and many other states as well (see spreadsheet), cutting cotton yields by up to one-third even with skyrocketing expenditures on weed control.[55] The return to "chopping cotton," the practice of hand-weeding that recalls the preindustrial South and has not been used for many decades, is to say the least an ironic consequence of the latest in agricultural technology, the vaunted Roundup Ready crop system.

Glyphosate-resistant weeds are also leading to a sharp increase in tillage, especially in soybeans, meaning abandonment of soil-conserving no-till practices that, ironically once again, RR crop systems are credited (falsely as we shall see below) with promoting.[56] These developments in RR soybeans and cotton, which could easily occur in RRSB systems, cast doubt on APHIS's facile prediction that the RRSB system will promote conservation and no-till practices.[57]

The adverse impacts of RR crop systems are no longer confined to the South. GR weeds are emerging rapidly in the Midwest and more northerly states as well. Illinois has a population of GR horseweed, the most prevalent GR weed, of up to 1 million acres (see spreadsheet). The weed that has Midwestern agronomists most concerned, however, is GR tall waterhemp. Despite its common name, this species of weed (*Amaranthus tuberculatus syn. rudis*) is closely related to (of the same genus as) the infamous Palmer amaranth (*Amaranthus palmeri*) discussed above. Both are pigweeds, of which there are several other species as well, including redroot pigweed (*Amaranthus retroflexus*) that is very troublesome in sugar beets. Like other pigweeds, tall waterhemp has shown a marked ability to evolve resistance to numerous herbicides. In fact, Missouri is home to a population that is resistant to at least seven different herbicide active ingredients from three very different herbicide families (glycines [= glyphosate], ALS inhibitors, and PPO inhibitors), and infests up to 1 million acres.[58] Weed scientist Patrick Tranel of Illinois recently reported a tall waterhemp biotype in his state that is resistant to ***four*** distinct classes of herbicide,[59] and which by one account infests 23 counties of the state.[60] Tranel referred to this biotype – which resists glyphosate, ALS inhibitors, PPO inhibitors as well as photosystem II inhibitors such as atrazine – as "QuadStack Waterhemp," a sardonic reference to the pesticide

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[54] EPA (2009). "Amendment to Organic Arsenicals RED," Letter from EPA's Richard P. Keigwin, Jr., Director, Special Review and Reregistration Division, EPA, to Registrant, April 22, 2009.
[55] Charlier, T. (2009). "'The perfect weed: An old botanical nemesis refuses to be rounded up," Memphis Commercial Appeal, August 9, 2009. http://www.commercialappeal.com/news/2009/aug/09/the-perfect-weed/
[56] Neuman, W. & A. Pollack (2010). "U.S. farmers cope with Roundup-resistant weeds," New York Times, May 4, 2010. http://www.nytimes.com/2010/05/04/business/energy-environment/04weed.html.
[57] EA at 166, for one of many examples.
[58] See http://www.weedscience.org/Case/Case.asp?ResistID=5269.
[59] Tranel, P. (2010). "Introducing QuadStack Waterhemp," Agronomy Day 2010, University of Illinois Extension.
[60] Roberson, R. (2010). "Herbicide resistance finding troublesome," Southeast Farm Press, January 19, 2010. http://southeastfarmpress.com/cotton/herbicide-resistance-0119/

industry's development of "stacked" crops genetically engineered for resistance to multiple herbicides as an (in our view deeply misguided) response to weeds resistant to glyphosate and other herbicides. (Like many herbicide-resistant weeds, this one has not been recorded on the ISHRW website.) Finally, still other tall waterhemp populations in Iowa and Illinois have the distinction of being the first weeds in the world to have documented resistance to a relatively new class of herbicides, 4-HPPD inhibitors, which are being counted on to manage GR and other HR weeds, and they are also resistant to atrazine and ALS inhibitor herbicides.[61]

Speaking of glyphosate-resistant weeds, Iowa State University weed scientist recently stated: "Right now, we on the edge of a precipice that we could step off in the next two years,"[62] echoing the concerns of Stephen Powles, who stated in a commentary for the Proceedings of the National Academy of Sciences: "Globally, no weed control tools are as good as glyphosate, and its potential widespread loss because of resistance is a looming threat to global cropping and food production."[63]

The many and severely adverse impacts of GR weeds that are directly attributable to unregulated RR crop systems have been addressed in many hundreds of scientific publications and farm press articles,[64] yet one searches in vain for any analysis of them in the draft EA. It would be one thing if APHIS squarely faced these experiences and impacts, and rationally discussed their relevance to RRSB, but it does not do so, preferring instead to "see no evil, hear no evil."

To the limited extent that APHIS addresses GR weeds at all, it is a wholly inadequate discussion, shot through with omissions, basic misconceptions and errors of fact. For instance, APHIS states that GR weeds generally evolve only in situations where crops are not rotated,[65] citing as the only exception "one case" of common waterhemp (some time ago officially renamed as "tall waterhemp," the weed discussed above) that evolved in a GR soybean/GR corn rotation. Yet inspection of the ISHRW database (see spreadsheet) reveals that 16 GR populations of six different weed species infest two or more crops. These include four populations of horseweed, two of giant ragweed, three of tall waterhemp, five of Palmer amaranth, and one each of GR kochia and Italian ryegrass. Most of these populations evolved in GR soybeans and GR cotton, which are commonly rotated. Three populations of GR waterhemp, including the up to one million acre Missouri infestation noted above, as well as one giant ragweed population, are present in both corn and soybeans, not the "one case" cited by APHIS. Three of the 16 populations infest three crops (2) or four (1). These facts undermine APHIS's facile assumption that rotation of RRSB with other RR crops offers protection against weed resistance.

Of the weeds cited by APHIS as problematic in sugar beets,[66] at least five include populations

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[61] Farm Industry News (2010). "Waterhemp population resistant to HPPD inhibitor herbicides," July 20, 2010. http://farmindustrynews.com/herbicides/waterhemp-population-resistant-hppd-inhibitor-herbicides. See also links at http://www.weedscience.org/Summary/UspeciesMOA.asp?lstMOAID=10&FmHRACGroup=Go.

[62] As quoted in: Gullickson, G. (2010). "Reeling from resistance," Successful Farming, January 26, 2010. http://www.agriculture.com/ag/story.jhtml?storyid=/templatedata/ag/story/data/1264542668567.xml

[63] Powles, S.B. (2010). "Gene amplification delivers glyphosate-resistant weed evolution," PNAS 107: 955-56.

[64] For one brief documented overview, see Benbrook (2009), op. cit., especially Chapter 4.

[65] EA at 94.

[66] EA at 75-76.

that have ***already*** evolved resistance to glyphosate: kochia, pigweed (as noted above, tall waterhemp is one species of the pigweed (*Amaranthus*) genus), common lambsquarters,[67] giant ragweed and common ragweed. However, there is no reason to assume, as APHIS does, that the others will not also evolve glyphosate-resistant biotypes, especially given the enormous selection pressure from repeated and near exclusive use of glyphosate in RRSB and much of the acreage it is rotated with (GR soybeans and corn). It is telling that two of the 12 GR biotypes that have emerged over the ***past 12 years*** (annual bluegrass and goosegrass) in the U.S. have been confirmed in the ***last three months.***

APHIS's treatment of herbicide-resistant sugar beet weeds, and the potential for evolution of GR and multiple herbicide-resistant biotypes, is confusing and inadequate. The most important deficiency is APHIS's failure to discuss glyphosate-resistant kochia. First, kochia has long been one of the worst weeds of sugar beet, causing major yield reductions, in part because it belongs to the same family, *Chenopodiaceae,* and so thrives under the same conditions.[68] Second, kochia is a weed species that has already demonstrated the ability to evolve glyphosate-resistant biotypes. APHIS fails to note that two kochia populations evolved resistance to glyphosate in western Kansas in 2007, though they were only confirmed as GR early this year.[69] Third, weed scientists report that glyphosate-resistant kochia has likely evolved in North and South Dakota as well.[70] This is the weed that North Dakota weed scientists most feared would evolve glyphosate resistance, because it has more impact on a state-wide basis than GR common ragweed, which is discussed by APHIS. Fourth, kochia that is already resistant to ALS inhibitors is found in nine sugar beet growing states, infesting a total of one to over three million acres (see spreadsheet). ALS inhibitors are an extremely large class of herbicides, and weeds often evolve resistance to only certain members of certain classes of ALS inhibitors (e.g. sulfonylureas, or imidazolinones). Stachler & Zollinger, however, report that ALS inhibitor resistant kochia in North Dakota and Minnesota withstand treatment with ***all*** ALS inhibitors.[71] The resistant population in North Dakota is especially large, from one to two million acres, while that in Minnesota is listed at up to 10,000 acres. Among the other seven states, Idaho and Colorado are notable for populations ranging from 10,000 to 100,000 acres each.

APHIS states that glyphosate is effective in controlling ALS inhibitor-resistant weeds in general, and kochia in particular, and on this basis even claims that RRSB cultivation may even reduce populations of ALS inhibitor-resistant kochia in RRSB rotation crops such as wheat. Yet the demonstrated ability of kochia to evolve glyphosate-resistance, including most likely in North Dakota, as well as ALS inhibitor-resistance, casts doubt on this supposition. The extremely large populations of ALS inhibitor-resistant kochia make it more likely that they contain individuals

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[67] Not yet confirmed as GR by the International Survey of Herbicide Resistant Weeds. But see Monsanto WeatherMAX Specimen Label, 2009, p. 21. Though Monsanto fails to identify many confirmed GR weeds in the list as GR, the company does indicate that there is a confirmed GR biotype of common lambsquarters.

[68] Weatherspoon & Schweizer (1969). "Competition between kochia and sugarbeet," Weed Science 17(4): 464-467, EA at 75.

[69] See kochia links at http://www.weedscience.org/Summary/UspeciesMOA.asp?lstMOAID=12&FmHRACGroup=Go.

[70] Anonymous (2010). "Weed Control in Beans," North Dakota State University, Crop and Pest Report: Weeds, 6/10/2010. http://www.ag.ndsu.nodak.edu/aginfo/entomology/ndsucpr/Years/2010/June/10/weeds.htm#STATUS

[71] Stachler & Zollinger (2009). Weed control guide for sugarbeet," Sugar Beet Education and Research Board of MN and ND.

with the rare genetic predisposition to survive glyphosate application as well. Though weed species vary greatly, it is worth noting that multiple populations of five species of weed have already evolved dual resistance to glyphosate and ALS inhibitors – common and giant ragweed, tall waterhemp, horseweed and Palmer amaranth.

Finally, herbicide-resistant kochia is of special concern because of its method of propagation. At the end of their lives, mature, seed-bearing kochia plants dry out, and are snapped off at the soil surface by wind action to disperse their seeds over very long distances as "tumbleweeds" during windstorms.[72] Since each kochia plant can produce thousands to tens of thousands of seeds, GR and multiple HR kochia could spread widely, posing problems to growers of other crops.

Michigan is the fourth largest sugar production state and has four major sugar beet weeds resistant to ALS inhibitors that either evolved in sugarbeets (kochia) or infest corn and/or soybeans that are likely to be glyphosate-resistant crop varieties (giant foxtail, lambsquarters and common ragweed). The common ragweed population is especially large, up to 100,000 acres, and infests both corn and soybeans. (APHIS for some reason omitted HR common ragweed entirely from its Table 16 of herbicide-resistant sugar beet weeds.) With over 100,000 acres of Michigan sugar beets rotated to GR soybeans or GR corn, there is great potential for continuous glyphosate selection pressure in RRSB rotations and thus emergence of GR weeds.

APHIS states in various places that RRSB have been commercially grown since 2005 or 2006,[73] yet most sources agree that they were not introduced on a widespread commercial basis until 2008, when they accounted for roughly 60% of sugar beet acreage, with at most test plantings in the previous year or two.[74] Thus, there has not been sufficient time to ascertain whether RRSB rotations select for GR weeds, as APHIS seems to imply.[75] However, APHIS is wrong to assume that "[r]esearchers have concluded that even if growers completely relied on only one herbicide, it is likely to take at least five years for a [sic] herbicide resistant weed population to develop (Kniss 2010, Beckie 2006, Neve 2008, Werth et al 2008)."[76]

APHIS is apparently unaware that the first GR weed fostered by a GR crop system evolved in just ***three*** years: "Within 3 years of using only glyphosate for weed control in continuous glyphosate-resistant soybeans, glyphosate failed to control horseweed in some fields."[77] Because RRSB have now been widely grown for two years, it is certainly possible that the first GR sugar beet weed population is coming soon. Since its emergence in the year 2000, GR horseweed has

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[72] Menalled, F.D. & R.G. Smith (2007). "Competitiveness of herbicide-resistant and herbicide-susceptible kochia (*Kochia scoparia* [L.] Schrad.) under contrasting management practices," Weed Biology and Management 7: 115-19.
[73] EA at 11, 246.
[74] USDA ERS (2009). Sugar and Sweeteners: Background, USDA ERS Briefing Room, http://transcoder.usablenet.com/tt/http://www.ers.usda.gov/Briefing/Sugar/Background.htm; Wilkins, D. (2008). "Beet growers bet on Roundup," Genetic News, 1/22/08. http://www.beetseed.com/view_article.php?id=1508. Khan, MFR (2010). "Introduction of glyphosate-tolerant sugar beet in the United States," Outlook on Pest Management, Feb. 2010.
[75] EA at 246.
[76] EA at 94, 180, 254.
[77] Van Gessel (2001). "Glyphosate-resistant horseweed from Delaware," Weed Science 49: 703-705.

become the most prevalent, and after Palmer amaranth the most financially costly, GR weed in the U.S., infesting millions of acres in 19 states. One suspected reason for its prevalence is the ability of windborne horseweed seeds to travel for many miles on the wind, and perhaps sprout in fields of distant farmers. This could mean, of course, that farmers who do not grow RR crops and had no hand in their emergence could nevertheless have their fields seeded with a costly and troublesome weed, assuming it is glyphosate-resistant.

> "Therefore, aerial transport of C. canadensis [horseweed] seeds carrying genes coding for glyphosate resistance enables seed to move tens or hundreds of kilometers in a single dispersal event, a spread rate corroborated by number of cases of reported glyphosate resistance occurrences in North America."[78]

APHIS did not analyze the potential for GR weeds fostered by RRSB systems to spread in this manner (or any other manner, since other GR weeds besides kochia have the ability to spread their seeds or cross-pollinate at considerable distances), imposing control costs on growers who had, perhaps, nothing to do with their evolution.

Of the four articles cited by APHIS for the mistaken notion that GR weeds take at least five years to develop, one in fact contradicts it. Dr. Paul Neve, cited above for his simulation model of glyphosate-resistant weed evolution, actually concluded that in certain scenarios GR weeds could evolve in as little as 4 years. We stress that this simulation model of a hypothetical weed cannot be relied upon as an exact prediction, as Dr. Neve would surely agree, and his model results are in any case trumped by the empirical observation of evolution in the three years' time frame noted above, but it is nevertheless instructive to examine the scenario (he constructed many different ones) in which his model predicted rapid evolution would occur. According to Dr. Neve:

> "In some parts of the world it is possible continuously to grow glyphosate-resistant crop varieties with little or no soil cultivation and with very heavy reliance on glyphosate. In extreme cases, five glyphosate applications (two burndown and three post-emergence) may be made during the growing season in every year. Simulations have clearly demonstrated for the present model weed species that this is an entirely unsustainable pattern of glyphosate use, leading to predicted glyphosate resistance within 4 years in 100% of model runs (Fig. 3A)."[79]

The EPA-approved label for use of Roundup formulations on RRSB would in fact permit five or even more applications of glyphosate per year. Growers are limited to no more than four post-emergence applications, but for pre-emergence use there is only a limit on the total amount that can be applied per acre, not on the number of PRE applications.[80] While this scenario of five applications may be unlikely prior to GR weed emergence, the 2-3 applications now being applied is, as we have seen, quite sufficient to foster rapid evolution of GR weeds. In the longer term (assuming the partial deregulation petition and later, perhaps a full deregulation petition, are approved), the evolution of GR weeds that could

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[78] Dauer, J.T., Mortensen, D. et al (2009). "*Conyza canadensis* seed ascent in the lower atmosphere," Agricultural and Forest Meteorology 149: 526-534.
[79] Neve (2008), op. cit., p. 396 and Figure 3 on p. 397.
[80] Roundup WeatherMAX Specimen Label, 2009, Section 12.9, p. 20.

well occur at any time would likely spur growers to follow the practices of RR soybean and cotton growers, namely, to increase the number of glyphosate applications in response.

In a close reading of the Beckie (2006) paper cited by APHIS, no reference whatsoever was found to "at least five years" for GR weeds to evolve in any scenario. However, Dr. Beckie does contradict APHIS's false assumption that rotating from RRSB to other Roundup Ready crops constitutes a GR weed prevention strategy.

> "The potential value of crop rotation to delay or manage HR weeds will not be realized unless accompanied by diversification or reduction in herbicide use. ***Repeated use of herbicides with the same site of action will negate the weed-suppression benefits associated with crop rotation.*** Crop rotations had little influence on occurrence of ACCase inhibitor–HR wild oat in the northern Great Plains because farmers frequently applied these herbicides to cereal, oilseed, and annual legume crops that dominate cropping systems (Legere et al. 2000). … Similarly, ***despite diversity in crop rotations in Western Australia, repeated triazine use in different crops selected for triazine resistance in wild radish*** (Hashem et al. 2001b)."[81]

There is nothing special about glyphosate in this respect, as should be evident by now given the epidemic emergence of glyphosate-resistant weeds in crop rotations comprised only of GR crops (whether a single GR crop or several).

APHIS's citation of Werth et al (2008) for the "at least five years for a GR weed population to evolve" opinion is extremely puzzling. The paper is entitled: "Managing the risk of ***Australian*** glyphosate-resistant cotton production systems." Is APHIS not aware that there is much more to learn about the risks of GR cotton production systems in the United States? Apparently not. There appears to be no discussion in the EA at all of the GR cotton in the U.S., or the extremely serious and costly resistant weed problem it has generated. The reference to the declaration of Dr. Kniss (2010) is less persuasive than it might have been, had he not contradicted it in the USDA grant report discussed above. In short, APHIS has no credible backing whatsoever to assert that GR weeds will not emerge quite rapidly, perhaps next year, rather than in at least five years.

APHIS plays a strange comparison game in many parts of the draft EA which contributes nothing to an understanding of whether unregulated use of RRSB systems is sustainable, or, as we have argued in these comments, it is not. For instance, APHIS cites a Dr. Wilson for the proposition that GR weeds account for 5% of HR weed biotypes, while ALS inhibitor resistant weeds comprise 31%.[82] It is true that there are many more biotypes of the latter than the former, but this has absolutely no bearing on the sustainability (or lack thereof) of RRSB systems. What it does indicate is that there are two very serious agronomic problems facing American farmers, rather than just one, and that neither the USDA nor the EPA have done anything to help farmers confront them. In fact, however, it should be pointed out that the majority of weeds resistant to ALS inhibitor herbicides (as properly measured by acreage infested) evolved in the 1980s and

[81] Beckie, H.J. (2006). "Herbicide-Resistant Weeds: Management Tactics and Practices," Weed Technology 20: 793-814.
[82] EA at 87.

early 1990s, as is evident from the HR Weeds chart and the spreadsheet, and GR weeds have been predominant in the past decade. There is an irony in Dr. Wilson's comparison, however, which we alluded to above. This is the well-known fact that the massive emergence of ALS inhibitor resistant weeds in the 1980s and early 1990s eroded the effectiveness of this mode of action considerably (especially in soybeans), and helped set the stage for eager adoption of Roundup Ready crops beginning in 1996.

> "The evolution of resistance to ALS-inhibiting herbicides has been widespread in agroecosystems where these herbicides are used. The adoption of herbicide-resistant crops, particularly glyphosate-resistant crops, had little direct impact on the widespread evolution of ALS-inhibiting-herbicide resistance. However, ALS-inhibiting-herbicide resistance likely fueled the adoption of herbicide-resistant crops because growers determined that control of the resistant biotypes would be better with glyphosate-based systems."[83]

Once again, this is a classic example of the pesticide treadmill, the next turn of which is rapidly bringing us new HR crops resistant to older, more toxic herbicides, to control weeds that have evolved resistance to glyphosate, ALS inhibitors, and the increasing number that are resistant to both. There are dozens of such crops in the works, with pesticide companies investing hundreds of millions of dollars in their development.[84] Dow AgroSciences is already awaiting USDA approval of corn and soybeans it has engineered for resistance to extremely high rates of 2,4-D, a component of the Vietnam War defoliant Agent Orange. Monsanto is also seeking approval of soybeans resistant to large doses of dicamba, a close chemical cousin to 2,4-D known for its extreme volatility, and its propensity to drift long distances and damage vineyard grapes, tomatoes, soybeans and most other broadleaf (non-cereal) crops and native plants.[85] Steve Smith, the Director of Agriculture for Indiana-based tomato processing company Red Gold, is extremely concerned that these dicamba-resistant soybeans will lead to a huge increase in dicamba use,[86] and with it perhaps devastating consequences for his company and his tomato growers.[87]

Another example of APHIS's meaningless comparison game is calculating the percentage of glyphosate used on RR sugar beets to total agricultural use, and even to the amount used by gardeners and homeowners.[88] The estimate of 233 million lbs. for agricultural use of glyphosate is likely close to the mark. But what is the point that APHIS is trying to make here? The

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[83] Owen, MKD & IA Zelaya (2005). "Herbicide-resistant crops and weed resistance to herbicides," Pest Management Science 61: 301-311.
[84] Kilman (2010), op. cit.
[85] For USDA's list of GE crops pending deregulation (approval), including these 2, see http://www.aphis.usda.gov/biotechnology/not_reg.html.
[86] Mortensen, D. (2010). Testimony before the House Domestic Policy Subcommittee of Committee on Oversight and Government Reform, July 28, 2010. Available at: http://oversight.house.gov/index.php?option=com_content&view=article&id=5054:are-superweeds-an-outgrowth-of-usda-biotech-policy&catid=66:hearings&Itemid=31.
[87] Testimony before the House Domestic Policy Subcommittee of Committee on Oversight and Government Reform, September 30, 2010. http://oversight.house.gov/index.php?option=com_content&view=article&id=5121:webcast-and-testimony-for-hearing-are-superweeds-an-outgrowth-of-usda-biotech-policy-part-ii&catid=66:hearings&Itemid=31.
[88] EA at 85.

interesting and important question that APHIS should be trying to answer is this: How much of this enormous quantity of glyphosate is being applied in response to increasingly glyphosate-resistant weeds that proper regulation on the part of APHIS and the EPA might have prevented,[89] or at least mitigated? What is the financial burden of these expenditures on U.S. farmers? We remind APHIS that its sister agency, the Agricultural Research Service, has estimated that up to 25% of pest (including weed) control expenditures are spent to manage pesticide (which includes herbicide) resistance, perhaps $1.7 billion. This is to say nothing of the potential environmental, agronomic and human health harms that may be caused by this large amount of herbicide. Also of more relevance than gardeners' use is the estimated 20-fold increase in glyphosate use on RRSB from the pre-RRSB era,[90] and the increased selection pressure this represents for resistant weeds.

APHIS appears to be convinced that Monsanto is taking all the necessary steps to ensure that RRSB systems will not foster evolution of resistant weeds. This is extremely puzzling, given the ongoing epidemic emergence of GR weeds attributable to the company's three major RR cropping systems: cotton, soybeans and corn. One would think, perhaps, that the Company's failure to stem the epidemic thus far would argue for a somewhat greater degree of skepticism.

The chief bulwark against GR weeds appears to be Monsanto's Technology Use Agreement (TUG), which APHIS cites repeatedly throughout the draft EA. APHIS cites the TUG for Monsanto ***recommendations*** to growers to use "mechanical weed control/cultivation and/or residual herbicide" with RRSB, where appropriate, and "additional herbicide modes of action/residual herbicides and/or mechanical weed control ***in other Roundup Ready crops***" rotated with RRSB.[91]

The first recommendation is unobjectionable, mechanical tillage and residual herbicides being sound measures to diversify weed control practices away from a glyphosate-only approach. However, the second recommendation is disappointing, as it provides tacit support to the notion that farmers should rotate from RRSB to another Roundup Ready crop, which as we have seen is a seductive invitation to rely excessively on glyphosate, in some cases throughout a three to five year crop rotation. As we have discussed at some length above, prevention of glyphosate-resistant weeds requires rotating ***away*** from an RR crop system ***to*** a conventional crop, where post-emergence use of glyphosate is not possible. We repeat the warning of Dr. Ian Heap:

> "The recently developed glyphosate-resistant crops will need to be used in rotation with ***conventional cultivars*** and in conjunction with non-chemical weed control and other herbicides if the selection of glyphosate-resistant weeds is to be avoided."[92]

While the measures Monsanto recommends as accompanying the rotation from RRSB to another RR crop might help to a small degree for growers who take them seriously, they will not be

[89] We note that Dr. Neve believes glyphosate-resistant weeds can be prevented, not just mitigated. Neve (2008), op. cit.
[90] EPA (2008). "Screening Level Estimates of Agricultural Uses of The Case Glyphosate," November 26, 2008. EPA estimates that 100,000 lbs. of glyphosate were used on conventional beets, versus USDA's estimate of roughly 2 million lbs. EA at 84.
[91] EA citing to Monsanto (2010) at 86, 89, 95, all with precisely the same language.
[92] Heap, I.M. (1997). "The occurrence of herbicide-resistant weeds worldwide," Pesticide Science 51: 235-43.

nearly as effective as the conventional crop option, where post-emergence glyphosate will be absent, rather than merely supplemented. The NRC Committee, in the passage quoted above, appears to concur, stating that "the increasingly common practice of farmers throughout the United States of using glyphosate as ***the primary*** or only weed-management tactic in rotations of different glyphosate-resistant crops limits the application of the rotation strategy…" as a means to forestall GR weed evolution.[93] In short, minor supplementation of glyphosate with another mode of action or tillage is simply not enough. A complete break from POST applications of glyphosate, which applications as Dr. Neve reminds us "***significantly increase risks of resistance evolution***"[94] vs. pre-emergence uses, is called for. The bottom line must also be considered. Monsanto has made such recommendations for some years now, and if they had worked and were working, the GR weed problem would not be growing ever more intractable.

It might be argued that it is unreasonable to ask Monsanto, a profit-seeking business like any other, to sacrifice some revenue by recommending that farmers purchase, at least periodically, a conventional seed variety. Not at all. If Monsanto were truly serious about glyphosate stewardship, this is precisely what the company would do. In any case, the loss would not have to be great. Surely Monsanto, the largest seed firm in the world, does or could still offer conventional varieties that it could recommend to farmers for the purpose of rotation with its RRSB (and other RR crop varieties).

There is precedent. The German chemical company BASF and Oregon State University together developed a non-GM wheat variety (ORCF-103) that is resistant to imazamox, an ALS inhibitor herbicide of the imidazolinone class, in cooperation with USDA's Agricultural Research Service. Because many weeds have shown a proclivity to evolve resistance to ALS inhibitor herbicides, as to glyphosate, and wheat can hybridize with jointed goatgrass, which in the case of ORCF-103 would create an imazamox-resistant hybrid weed, Oregon State University and BASF have worked out a stewardship guide to extend the life of the herbicide-resistant technology, which is known as CLEARFIELD. A short description follows:

> "Herbicide resistance management is a key consideration when utilizing CLEARFIELD technology. Maintaining the utility of ALS-inhibiting Group 2 herbicides in wheat production cropping systems is crucial for increasing the longevity of this production technology. Thus, Oregon State University strongly advocates that growers follow the BASF stewardship recommendations outlined in the CLEARFIELD Wheat Stewardship Guide. These recommendations include:
>
> • ***Do not plant ORCF-103 or any other CLEARFIELD wheat variety continually and apply Beyond or Clearmax more than 2 out of every 4 years.***
> • Limit the reliance on ALS-inhibiting Group 2 herbicides. When applicable, use herbicides with different modes of action.
> • Properly manage weeds in wheat-fallow-wheat rotations.
> • Treat the entire field with a labeled rate of Beyond or Clearmax for jointed goatgrass control.
> • Control jointed goatgrass in fencerows, road ditches, and pastures around

[93] NRC (2010), op. cit., pp. 2-19, 2-20, emphasis added.
[94] Neve, P. (2008). "Simulation modeling to understand the evolution and management of glyphosate resistance in weeds," Pest Management Science 64: 392-401, emphasis added.

> CLEARFIELD wheat fields."[95]

Two things stand out. BASF recommends that farmers "limit the reliance on" the herbicides the crop is resistant to, not merely, like Monsanto, to "supplement" glyphosate with other herbicides. Second and even more important, BASF unambiguously tells farmers NOT TO PLANT its HR crop every year, and to abstain from use of the associated herbicide at least two of every four years. Though CFS has not seen the actual Stewardship Guide, based on this description it would appear to be a sound and ***serious*** stewardship plan.

The same cannot be said of Monsanto's TUG. Another recommendation in the TUG, this one not cited by APHIS, is: "Start clean with tillage and follow-up with a burndown herbicide, such as Roundup WeatherMAX, if needed prior to planting."[96]

Monsanto must know that RRSB growers typically apply two to three post-emergence applications of glyphosate, with the option to apply up to four, with for the most part no other weed control measures. A burndown application of glyphosate would increase the typical number of applications to three to four, with a clear possibility for five, dangerously near the "extreme case" of Dr. Neve's scenario, which resulted in a hypothetical weed evolving weed resistance in just four years in 100% of model runs. Unlike BASF, there is no admonition to "limit reliance on" the HR crop-associated herbicide.

However, the worst recommendation is one listed near the beginning of the TUG, rather than in the RRSB section, so it applies to all of the company's RR crop systems:

> "Rotation to other Roundup Ready crops will add opportunities for introduction of other modes of action."[97]

This recommendation can only be called Orwellian. Rotation to other Roundup Ready crops does ***not*** add opportunities for using non-glyphosate herbicides. Monsanto (and the EPA) need to explain how rotating from one RR crop to another RR crop opens up opportunities for using herbicides that could not be used on a conventional rotation crop. The only way this could be so would be if the rotational RR crop were not an RR crop, but a crop resistant to some other herbicide that a conventional crop does not already tolerate. It would seem that Monsanto misses no opportunity to "add opportunities" for further sales revenue.

The Roundup WeatherMAX specimen label,[98] and presumably other glyphosate formulations the company sells as well, has similar self-serving misinformation. Section 6.1, entitled General Weed Management, purports to tell farmers how to "minimize the occurrence of glyphosate-resistant biotypes." While most of the recommendations are unexceptional, one stands out:

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[95] OSU (2010). "ORCF-103: CLEARFIELD Soft White Winter Wheat," Oregon State University Extension Service, EM 9006-E, April 2010, emphasis added.
http://ir.library.oregonstate.edu/xmlui/bitstream/handle/1957/15319/em9006.pdf;jsessionid=8F819B416348023B77D1EC84212F4912?sequence=1.
[96] Monsanto (2010) TUG, Technology Use Guide, p. 40.
[97] Monsanto (2010) TUG, Technology Use Guide, p. 10.
[98] Roundup WeatherMAX specimen label, EPA Reg. No. 524-537, 2009-1.
http://www.cdms.net/LDat/ld5UJ064.pdf, last visited Dec. 6, 2010.

> "One method for adding other herbicides into a continuous Roundup Ready system is to rotate to other Roundup Ready crops."

The very same recommendation serves double-duty for Section 6.2: Management of Glyphosate-Resistant Biotypes, where it is a "good agronomic practice [that] can reduce the spread of confirmed glyphosate-resistant biotypes." Apparently, growers should do exactly the same thing to prevent and manage glyphosate-resistant weeds as they did to trigger their emergence in the first place. While it is deplorable that Monsanto should offer such a counterproductive sales pitch in the form of a stewardship recommendation, familiarity with the company's practices make this less than surprising. What is surprising and inexcusable is that the EPA should approve such a misguided label recommendation – the same EPA that exempted organic arsenical herbicides from the general phase-out for special use on cotton due to the severity of the resistant pigweed threat confronting cotton growers.

The same section contains the following disclaimer:

> "Since the occurrence of new glyphosate-resistant weeds cannot be determined until after product use and scientific confirmation, Monsanto Company is not responsible for any losses that may result from the failure of this product to control glyphosate-resistant weed biotypes."

CFS believes that Monsanto deserves to be held accountable for all losses associated with glyphosate-resistant weeds as long as the recommendation discussed above remains on its label.

APHIS not only relies on Monsanto's deficient TUG recommendations as if they somehow constituted a serious GR weed prevention strategy, in at least two passages it treats such recommendations as if they were legally binding obligations:[99] "Indeed, H7-1 growers are required to follow Monsanto's TUG, including its recommendation for adopting growing practices aimed at reducing the development of glyphosate-resistant weed populations."

The "required recommendations" listed on page 10 of the TUG include: scout your fields before and after herbicide application; start with a clean field, using either a burndown application or tillage; control weeds early when they are small; add other herbicides … and cultural practices … as part of your Roundup Ready cropping system ***where appropriate***; rotate to other Roundup Ready crops to add opportunities for introduction of other modes of action; use the right herbicide at the right rate and the right time; control weed escapes and prevent weeds from setting seeds; clean equipment before moving from field to field to minimize spread of weed seed; use new commercial seed that is as free from weed seed as possible.

Clearly, Monsanto is not going send employees into farmers' fields to make sure they

[99] EA at 89, 254.

control weeds early when they are small or clean their equipment before moving from field to field; and it is difficult to imagine how a contractual obligation to "use the right herbicide at the right rate and the right time" could be enforced.

The reason we bring this up is that these passages seem to epitomize APHIS's posture throughout the EA, as if it were an onlooker rather than the governmental agency with the statutory authority to critically analyze, set conditions, make demands, occasionally perhaps even say no rather than passively say yes to the registrant's views and proposals. It almost seems as if APHIS believes that Monsanto, through contractual agreements with growers, is in charge of American agriculture, not the USDA itself, with its statutory authority under the Plant Protection Act to protect "the interests of American agriculture."

The other provisions APHIS regards as sufficient to prevent or at least mitigate the emergence of GR weeds are as deficient as Monsanto's TUG. For instance, "a high level of awareness about the potential for glyphosate resistant weeds" among growers and "many readily available resources to assist growers with management strategies"[100] has not stopped or even slowed the emergence of GR weeds in the past, and it will not likely do so in the case of the RRSB system. While an unpublished survey (in press) of 350 farmers cited by APHIS on page 88 of the EA (a survey reported by the Weed Science Society of America)[101] that appears to indicate an increase in the proportion of those taking proactive steps to minimize the potential for GR weeds to develop would be nice to believe, the continuing rapid emergence of GR weeds, as recorded by the ISHRW and in the published literature, casts doubt on the results. And other studies have arrived at more disappointing results.

A telephone survey of 1200 farmers from Illinois, Indiana, Iowa, Mississippi, Nebraska and North Carolina (200 from each state) was conducted from November 2005 to January 2006. It was described as "one of the few robust and wide-scale assessments of the implications of farmer knowledge and attitudes on weed management in GE GR crops in U.S. agriculture."[102] The authors describe what they call three "alarming" observations. First, only 30% or less of all farmers thought GR weeds were, or could become, a serious problem. A second finding was that a majority of the farmers surveyed thought that following the glyphosate label rate recommendation was the most effective strategy for reducing or preventing GR weeds, while very few thought that tillage and not using a GE GR crop would be effective strategies. Finally, the authors observed that farm press publications were farmers' most important source of information, and that the recommendations found in those publications, which contain the results of research from both land grant university studies and those from biotechnology companies, is not consistent and leads to confusion among farmers about the most appropriate strategies to use to manage glyphosate resistance in GE GR crop systems.

[100] EA at 254.
[101] EA at 88.
[102] Johnson, W.G. et al (2009). "U.S. farmer awareness of glyphosate-resistant weeds and resistance management strategies," Weed Technology 23(2): 308-312.

It is interesting to note that Monsanto has long recommended to farmers using the full label rate of glyphosate as its keystone glyphosate-resistant weed prevention strategy. In 2004, Monsanto sponsored an "advertorial" in a farm press publication that featured University of Nebraska weed scientist Dr. Bob Wilson.[103] Dr. Wilson reported on the results of a seven-year study comparing the efficacy of various herbicide regimes involving glyphosate and non-glyphosate herbicides on various Roundup Ready crops at five small field test sites in four states. Based on the lack of resistant weeds in the continuous Roundup Ready crop rotations, Dr. Wilson concluded that there was "no benefit in rotating glyphosate" as a means to forestall glyphosate-resistant weeds as long as the full label rate of glyphosate was used. He stated:

> "The important finding is that telling growers to use glyphosate one year and not the next year has no advantage over using glyphosate every year at recommended rates. … The concept of rotating glyphosate with alternative chemistries hasn't proven any more effective than just properly applying glyphosate."

This advertorial, and one accompanying it featuring Monsanto's Corn Technology Manager, Dr. Rick Cole, were criticized in a joint article by 12 leading Midwestern weed scientists, and again by Dr. Bob Hartzler of Iowa State University. Their chief criticism of Dr. Wilson's study was that it was conducted on far too few acres to serve as a meaningful test of the potential for glyphosate-resistant weed evolution. This is because genetic mutations conferring glyphosate resistance are presumably rare, so that it would be highly unlikely for resistant weeds to be present in Dr. Wilson's small field test sites; and if not present, they could not be selected for, regardless of the particular herbicide regime. Dr. Cole's accompanying advertorial underscored the importance of using the full label rate of glyphosate, with the observation that: "The goal is to kill all the weeds, because we know that dead weeds will not become resistant."

Interestingly, at the time of the advertorial GR horseweed was already quite extensive, infesting several states, and GR common ragweed had just been confirmed. Dr. Hartzler remarked that Dr. Cole seemed not to understand the principle that glyphosate-resistant weeds are simply not killed by glyphosate. Dr. Hartzler inducted both ads into his "Herbicide Ad Hall of Shame" as proffering advice at odds with the principles of integrated weed management.

It should be noted that APHIS relies on declarations by both Dr. Wilson and Monsanto's Dr. Cole in the draft EA. In addition, it would seem that APHIS's and Monsanto's position that farmers can grow RRSB in rotation with other Roundup Ready crop systems continuously, with continual strong selection pressure from repeated glyphosate applications over three to five years without risk of glyphosate-resistant weed evolution, is essentially the same as the discredited views of Dr. Wilson and Dr. Cole.

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[103] See file entitled Roundup Hall of Shame – Hartzler 12-7-04.docx in supporting documents for the material in the following discussion.

Conclusion

Like other RR crops systems, RRSB is extremely attractive, even seductive, to agronomists and growers alike. Setting aside resistance, glyphosate is a very effective, broad-spectrum herbicide. The post-emergence use of glyphosate enabled by RR crops provides growers with flexibility and convenience in weed control and saves labor (though it must be said this latter facet is a double-edged sword, as American farms become ever more consolidated into larger units, aided in part by labor-saving RR crops). While elsewhere in these comments CFS has presented a discussion of recent scientific research into Roundup's/glyphosate's potential adverse impacts on amphibians, on soil microbiota/plant health, and on human health – research which deserves fair, objective assessment, free of "glyphosate exceptionalism" thinking – we nevertheless agree that glyphosate is probably less impactful than many other pesticides. And this is precisely the reason that strong measures must be taken to slow and if possible stop the continuing erosion of its efficacy by way of glyphosate-resistant weeds. These two positions – that Roundup/glyphosate may have adverse effects but must be saved from inefficacy – are not contradictory. It may well be that ***moderate*** use of glyphosate-based formulations avoids both the likely adverse effects of its present, wildly excessive use, while at the same time reducing the tremendous selection pressure that is eroding its efficacy via evolution of glyphosate-resistant weeds. The alternatives are not attractive – large increases in the use of 2,4-D, dicamba and other more toxic herbicides with their associated HR crops as the temporary "fix" to GR weeds – which in turn will drive weed resistance to synthetic auxins while polluting the environment, etc.

CFS believes that some sort of mandatory glyphosate-resistance management program, modeled on EPA's insect resistance management program for Bt crops, needs to be implemented for RRSB as for other GR crop systems. "Singling out" glyphosate and GR crops here is no more objectionable than singling out Bt for resistance management. To the extent that glyphosate really is safer than alternatives, it seems strongly advisable for USDA and EPA to jointly take action on this front, using the ample statutory authority provided by the Plant Protection Act and FIFRA. Since the Bt spatial model will not work, a temporal approach is needed. The program might involve limitations on the frequency with which glyphosate-resistant crops can be grown over years through the PPA, and/or restrictions on post-emergence use of glyphosate at field or farm-scale (one year on, one year off) through FIFRA. There are likely other possibilities.

A program such as this should be accompanied by renewed commitment to integrated weed management that gives higher priority to cultural and biological methods of weed control, and deemphasizes somewhat the herbicidal approach. CFS is excited by the possibilities of cover cropping and the many benefits it provides beyond weed control, such as the nematode control and perhaps disease suppression demonstrated by Hafez's work with oil radish green manures with sugar beets, discussed above. Stanley Culpepper in Georgia, the USDA ARS's Andrew Price, and Matt Liebman of ISU are among those doing exciting work with cover crops and other cultural and biological weed control. As EPA well knows, cover cropping in the Chesapeake Bay watershed is helping limit nitrogenous runoff, and one shouldn't assume such practices are infeasible in the Midwest. Interestingly, it is the scourge of glyphosate-resistant Palmer amaranth that is opening minds like Dr. Culpepper's to the potential of cover crops to make a real contribution to weed control in cotton.

CFS is of course a strong supporter of organic agriculture, and we do insist that those who choose to farm organically be accorded the respect they deserve, and not be made to bear the entire burden of maintaining their chosen way of farming. But we also support more sustainable approaches to biotech and conventional agriculture.

Sincerely,

Bill Freese, Science Policy Analyst
Center for Food Safety