THE CENTER FOR FOOD SAFETY

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These comments were revised by Center for Food Safety on September 1, 2013, both to correct some inadvertent errors and to incorporate new material. Most of the revisions were to the herbicide-resistant weed section (Section 6).

Comments to USDA APHIS on Draft Environmental Assessment and Draft Plant Pest Risk Assessment for "Bayer Petition 09-328-01 Determination of Non-regulated Status of Double Herbicide-tolerant Soybean (*Glycine max*) Event FG72": isoxaflutole- and glyphosate-resistant soybean

Center for Food Safety, Science Comments

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These comments submitted by Center for Food Safety are one of two sets of comments from our organization. Legal comments are also being submitted. The references cited have been uploaded as supporting materials. The filenames for these documents match the citations in the text, and are all incorporated as such (e.g. Benbrook 2012). Full citations are included at the end.

1. Table of Contents

2. The impact of approval of FG72 soybean on herbicide use 3
  b. Introduction 4
  c. Herbicide use is part of the FG72 soybean system 4
  d. Specific herbicides that are part of the FG72 soybean system 5
    i. Herbicides that FG72 soybean can withstand because of transgene expression 5
    a) Isoxaflutole 5
    b) Mesotrione and other HPPD-inhibitor herbicides? 7
    e) Glyphosate 8
    ii. Herbicides that are likely to used in FG72 soybean because of “stacked” resistance traits 9
    a) Glufosinate 9
  e. Changes in herbicide amounts and use patterns 9
    i. Isoxaflutole 9
    ii. Glyphosate 13
    iii. Glufosinate 13
  f. Cumulative impacts of FG72 approval 15
    i. More non-point sources of isoxaflutole and DKN pollution 15
    ii. Isoxaflutole appliations in sequence 16

3. Environmental effects of increased herbicide use and changes in herbicide use patterns with approval of FG72 soybean 17
  a. Injury to plants and other non-target organisms via spray drift 17
  b. Injury to plants and other non-target organisms via off-site soil movement 18
  c. Injury to plants and other non-target organisms via runoff 19
  d. Herbicide use patterns with FG72 soybean result in greater risk to non-target species 23
    i. Timing of isoxaflutole applications in the growing season 24
    ii. Total use of isoxaflutole at landscape level 24
  e. Injury to non-target crops and wild plants from change in use patterns of associated herbicides 24
  f. Herbicides can directly and indirectly affect pests and pathogens of non-target plants 25
  g. Increased ingestion of isoxaflutole residues and degradates puts animals at risk, including pollinators, and threatened and endangered species 26
  h. Impacts to biodiversity 26
    i. Biodiversity in soybean fields 27
    ii. Biodiversity around soybean fields 30

4. Threatened and endangered species 32
  a. Impacts of increased herbicide use and changes patterns of use on listed species 32
  b. Ingestion of FG72 soybean by listed species 34

5. Human health and approval of FG72 soybean 34
  a. Impacts on farmers 34
  b. Health risks from isoxaflutole 35

c. Health risks from glufosinate 36
6. Herbicide-resistant weeds and approval of FG72 soybean 36
a. Summary 36
b. Isoxaflutole- and HPPD-inhibitor-resistant weeds 37
c. Weed management vs. weed eradication 41
d. The high costs of herbicide-only weed control 42
e. Why herbicide-resistant crop systems promote rapid evolution of resistant weeds 44
f. Overview of glyphosate-resistant crops and weeds 46
g. Multiple herbicide-resistant crops and weeds 52
i. Horseweed 52
ii. Waterhemp 54
iii. Palmer amaranth 55
iv. Kochia 56
h. Potential for glufosinate resistant weeds 57
i. Stewardship 58
j. Spread of weed resistance and tragedy of the commons 59
k. Volunteer FG72 soybean 61
7. Conservation tillage and environmental concerns 62
a. Overview of environmental impacts related to tillage 62
b. Herbicide resistant crops not responsible for increased conservation tillage 63
i. Correlation in question 64
ii. Conservation tillage leads to HR seeds, not vice versa 67
iii. Reductions in soil erosion come to an end during the decade of herbicide-resistant crop adoption 67
iv. Federal farm policy triggered sharp declines in soil erosion prior to HR crop adoption 71
v. Weakening enforcement of farm conservation plans brings soil erosion reductions to an end 71
c. Environmental impacts of conservation tillage 74
i. Soil and water 74
ii. Climate change 75
8. Transgenic contamination of conventional and organic soybean varieties by FG72 soybean 77
9. Conclusion 78
10. References Cited 79

2. The impact of approval of FG72 soybean on herbicide use

APHIS must assess FG72 soybean as Bayer CropScience intends it to be used, as a weed control system. No isoxaflutole is presently used in soybean production because it causes severe damage to soybeans. FG72 soybean eliminates this risk of crop injury. If FG72 soybean is widely adopted, isoxaflutole use could increase 4-fold over current use in U.S. agriculture. Glufosinate use could increase 16-fold in soybeans and 5-fold in U.S. agriculture overall. Glyphosate would also likely continue to be used at high levels, such that overall herbicide use on soybeans would increase. FG72 soybean would also substantially alter herbicide use patterns, with isoxaflutole being used more extensively in the landscape, longer during the season, and sequentially on the same acreage. The consequences of these substantial changes in farming practice are addressed elsewhere in these comments. The draft EA (DEA) is undermined by fundamental errors of fact, ommision, and interpretation; lacks any quantitative assessment of changes in herbicide use aside from speculative and conclusory statements; neglects to consider quality data from APHIS' USDA sister agencies; and excludes important considerations. As a result, the DEA does not meet the "sound science" standard demanded by NEPA for environmental assessments.

b. Introduction

Bayer CropScience has genetically engineered soybeans with resistance to the broad-spectrum herbicides containing isoxaflutole (Balance Flexx) and glyphosate (Roundup and other brands). Bayer CropScience has developed FG72 soybean in response to the epidemic of glyphosate-resistant (GR) weeds fostered by widespread use of GR crops, with the idea that isoxaflutole will be able to control GR weeds in soybean (DEA at 42 – 43, Petition at 15). It expects growers to continue using glyphosate in conjunction with isoxaflutole to help manage non-GR weeds (Petition at 15). It is foreseeable that FG72 soybean will be stacked with Bayer CropScience's glufosinate resistance trait, as well, as we discuss below.

APHIS is now considering whether to approve Bayer CropScience's petition for non-regulated status (Petition) for FG72 soybean, and has prepared a draft Plant Pest Risk Assessment (DPPRA) and draft Environmental Assessment (DEA) that are open for public comments. We appreciate the opportunity to participate in this process.

c. Herbicide use is part of the FG72 soybean system

FG72 soybean is a weed control system that includes the genetically engineered crop and use of the herbicides that the crop has been engineered to withstand. According to APHIS and Bayer, the purpose of the FG72 soybean system is give farmers herbicidal options to manage difficult weeds, in particular weeds that have evolved resistance to glyphosate herbicides (DEA at 42, Petition at 15 - 16). The target species of the FG72 soybean system are thus weeds of soybean.[1]

In this respect, FG72 soybean is the same as other herbicide-resistant (HR) crops: they are weed control systems involving one or more post-emergence applications of the HR crop-associated herbicide(s). Dow describes its pending 2,4-D- resistant corn and

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[1] See DPPRA at 12 for APHIS' untenable view that there are no 'target' species for FG72 soybean.

soybean in precisely these terms, as the "Enlist Weed Control System" (DAS 2011a), with the brand name "Enlist" referring to both the HR trait and Dow's 2,4-D herbicide. Monsanto describes its HR crops in similar terms: "The utilization of Roundup agricultural herbicides plus Roundup Ready soybean, collectively referred to as the Roundup Ready soybean system..."[2]

This purposed use of FG72 soybean cannot be assessed without careful consideration of the herbicidal components of the system, any more than an automobile can properly be assessed without putting gasoline in the tank and subjecting it to a road test. APHIS' failure to assess Monsanto's glyphosate-resistant, Roundup Ready (RR) crop varieties as HR crop systems led to unregulated cultivation, which as discussed later, generated the glyphosate-resistant weed epidemic that is now the rationale for Bayer CropScience's FG72 soybean. APHIS' preferred alternative in the DEA – full deregulation – would repeat this same mistake with the FG72 soybean system, triggering unacceptable impacts.

Therefore, APHIS must assess both FG72 soybean in its own right and as a component of an HR soybean system, in which isoxaflutole and glyphosate would be used in different amounts and in altered patterns by virtue of the genetically engineered resistance to these herbicides in FG72 soybean seed. The anticipated use of glufosinate via stacked traits must also be assessed. APHIS must determine how approval of the FG72 soybean system will change associated herbicide use in order to properly assess impacts of approval on agronomic practices, human health, the environment, threatened and endangered species, and socioeconomic factors – both in the short- and long-term. As shown in these comments, APHIS has failed to provide an adequate assessment of the FG72 soybean system.

d. Specific herbicides that are part of the FG72 soybean system

i. Herbicides that FG72 soybean can withstand because of transgene expression

a) Isoxaflutole

FG72 soybean is the first crop genetically engineered to be resistant to isoxaflutole, or to any herbicide in its class. Isoxaflutole is a relatively new herbicide, first used in the US in 1999, which kills plants by disrupting photosynthesis, resulting in bleaching and then death. Isoxaflutole is a pro-herbicide that is activated when it degrades or is metabolized to DKN (a diketonitrile derivative) within the plant or in the environment. It is classified as an HPPD inhibitor – interfering with the enzyme

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[2] From: "Petition for the Determination of Nonregulated Status for Roundup Ready2Yield Soybean MON89788," submitted to USDA by Monsanto on June 27, 2006 (revised November 3, 2006), APHIS Docket No. APHIS-2006-0195, p. 4).

hydroxyphenolpyruvate dioxygenase (US EPA 1998). Other members of this herbicide class include mesotrione (Callisto), tembotrione (Laudis), and topramezone (Impact) (AgWeb 2012).

Currently, no isoxaflutole is used in soybeans because soybeans are very sensitive to it, and would be killed along with the weeds. Isoxaflutole is used only in corn to kill weeds, and is applied before the crop is planted (pre-plant), after planting but before the corn emerges (pre-emergence), until the corn is 2" high (very early post-emergence) (Bayer CropScience 2011a). It can remain active in the soil for months, killing weeds that germinate after rains later in the season (Bayer CropScience 2011b)

Isoxaflutole is applied at very low doses compared to other commonly used herbicides – about 10-fold less herbicide per acre – because it is so toxic to plants (DEA at 31). Corn and some other grasses are less sensitive than other plants (Swarcewicz et al. 2002). Still, growers risk injuring their corn when they use isoxaflutole (US EPA 2011 at 15), particularly at high enough doses to control all weeds, and under certain environmental conditions (Wicks et al. 2000, 2007).

Isoxaflutole has been controversial from the start because it is classified by EPA as a "probable human carcinogen", is toxic to some aquatic organisms and to non-target plants, and it and its degradates and metabolites contaminate water easily (Wisconsin Department of Agriculture 2002). These concerns have resulted in restrictions on its use. It is a federally "Restricted Use Pesticide" (RUP), meaning that it can only be applied by certified applicators, and only in some of the corn growing states (Bayer CropScience 2011a).

In fact, it is not registered for use in the corn growing states of Wisconsin, Michigan and Minnesota because these states enacted more restrictive conditions than federal ones based on their own environmental impact studies (AP 2003; Hemphill 2003; US Water News; Wisconsin Department of Agriculture 2002). Bayer, opting not to play by the stricter rules, refused to offer it to them (Bergquist 2002). Environmentalists in Wisconsin have vowed to sue if isoxaflutole ever does go on sale there (Bergquist 2002).

In states where isoxaflutole is registered, the label requires that applicators determine the structure and organic matter of their soil, how high the water table is, and how close applications will be to wells before they use the product in order to determine application rates and restrictions (Bayer CropScience 2011a).

Also, because isoxaflutole has residual soil activity, growers must wait up to 18 months before planting some rotation crops, depending on the crop and the amount of rain that has fallen (Bayer CropScience 2011). In Australia where isoxaflutole is used in chickpea fields, growers have to wait even longer – up to 21 months – before planting some rotation crops (Bayer CropScience 2005).

In spite of all of these restrictions and the risk of injury to the crop, isoxaflutole is used on about 7% of total corn acres (USDA NASS 2011). Because it has a different mode of action than other major herbicides used in corn, it is marketed as a long-lasting alternative for killing many of the weeds that are resistant to those other herbicides, including GR weeds.

And even though it is used at low doses on just 7% of corn acres, isoxaflutole and its degradates are disproportionately detected in water samples long after applications (Scribner et al. 2006). No Maximum Contaminant Level (MCL) has been set for isoxaflutole and its degradates in water, but there is a Drinking Water Level of Concern of 3.1 ppb, and that level has been greatly exceeded in some surface water monitoring studies (Wisconsin Department of Agriculture 2002) .

It is against this backdrop of controversy over the toxicity of and water contamination by isoxaflutole as currently used on corn that Bayer CropScience is requesting nonregulated status for its FG72 soybean. If approved, this will be the first herbicide-resistant cropping system involving a potent, restricted use herbicide that is classified as a probable human carcinogen; and that remains herbicidally active in soil and water for a long period of time.

b) Mesotrione and other HPPD-inhibitor herbicides?

It is logical to expect that there might be some cross-resistance to other HPPD inhibitor herbicides based on expression of the transgene for isoxaflutole resistance in FG72 soybean, and APHIS conjectures that it is foreseeable that one of these, mesotrione, might be used on FG72 soybean (DEA at 51). They present this possibility when discussing cumulative impacts of approving FG72 soybean (DEA at 51 – 56), although if FG72 soybean is in fact resistant to mesotrione because of a transgene, APHIS should deal with this as a primary rather than a cumulative impact, in the DPPRA and in the DEA.

However, APHIS does not present convincing evidence that FG72 soybean is indeed resistant to mesotrione, or that mesotrione is being registered for use as part of the FG72 soybean system.

First, Bayer CropScience does not mention cross-resistance in its Petition, and in fact lists mesotrione as an herbicide that could be used to control FG72 volunteers, an indication that it would be effective in killing FG72 soybean (Petition at 77). APHIS cites a Bayer newsletter article for evidence that mesotrione can be applied to FG72 soybean (Bay News 2011, as cited in DEA at 51,52), but this news report is most likely referring to future HPPD-inhibitor-resistant crops in the pipeline, that will be developed in collaboration with Syngenta, the maker of mesotrione (Johnson 2011; Miller et al. 2012).

And APHIS implies that Syngenta's application for residue tolerances of mesotrione on soybeans in general is related to intention to use mesotrione on FG72 (74 FR 67119, as cited in DEA at 51, 52), citing the current Callisto label as well (Syngenta 2011, as cited in DEA at 51, 52). However, no instructions for use of mesotrione on soybeans are listed there.

Finally, APHIS cites an EPA memorandum – "Mesotrione; Human-health Risk assessment for Section 3 New Use on Soybeans" – as an indication that Syngenta is planning to use a specific mesotrione application regime on FG72, when in fact this is an assessment for use of mesotrione on an un-named mesotrione-resistant soybean likely to be for a different event. Indeed, press reports indicate that Syngenta and Bayer are collaborating on a non-FG72 mesotrione-resistant soybean with resistance derived from an oat gene: "Because of glyphosate-resistant weed concerns occurring in the United States, Syngenta and Bayer CropScience are co-developing a hydroxyphenyl pyruvate dioxygenase (HPPD) herbicide tolerance trait for soybeans. Used in Callisto brand products, mesotrione, a HPPD herbicide, is tolerated by corn. The HPPD genetically engineered trait in soybeans was created using a naturally present gene in oats that was moved to soybeans. Numerous trials from 2008 to 2011 have confirmed consistent HPPD tolerance in soybeans from pre-emergence through post-emergence applications. The companies are continuing with the regulatory approval process and commercialization, with projected launch between 2015 and 2020."(Johnson 2011).

The issue needs to be cleared up, because cross-resistance of FG72 soybean to other HPPD-inhibitor herbicides would indeed have impacts in the context of both the DEA and DPPRA. If FG72 soybean can withstand applications of other herbicides and Bayer CropsScience did not disclose this in its Petition, that is a serious omission of information necessary for approval. APHIS should have directly queried Bayer about this possibility, and then should have included a documented, definitive answer and a risk assessment of potential use for public comment.

e) Glyphosate

Glyphosate is by far the most commonly applied herbicide in soybeans due in large part to the fact that 93% of soybean varieties planted in the US carry a genetically engineered glyphosate-resistance trait (NRC 2010). Therefore, APHIS contends: "…cultivation of FG72 soybean is unlikely to change current glyphosate use patterns…" (DEA at 54). However, glyphosate use on non-FG72 soybean may begin to decline in response to GR weeds, in which case FG72 soybean will prolong the dominance of glyphosate in soybean production, particularly if Bayer CropScience markets a premix of isoxaflutole and glyphosate and growers are encouraged to use both herbicides together. APHIS thus needs to assess the impacts of maintaining high glyphosate use with approval of FG72 soybeans.

Also, the GR trait in FG72 soybean may confer resistance to higher levels of glyphosate, or later in the season, than currently approved GR soybean traits, allowing a different application regime. APHIS must procure this information in order to assess impacts.

ii. Herbicides that are likely to used in FG72 soybean because of "stacked" resistance traits

a) Glufosinate

It is foreseeable that Bayer CropScience will "stack" its flagship Liberty Link glufosinate-resistance traits with FG72 soybean so that glufosinate can be used along with glyphosate and isoxaflutole to control weeds in soybean. They have already announced that an HPPD-inhibitor-resistant soybean combined with glufosinate resistance is being developed for the future (Miller et al. 2012), and thus are likely to see stacking as an expedient interim measure to obtain the same result. Therefore, APHIS should assess cumulative impacts of increased glufosinate use with FG72 soybean, instead of claiming that there is "uncertainty in the development of that particular product" (DEA at 9).

e. Changes in herbicide amounts and use patterns

i. Isoxaflutole

Approval of FG72 soybean will result in a different pattern of isoxaflutole use throughout the season (later in the summer), over the years (in successive years on the same acreage), and across the landscape (in both corn and soybean fields in a region) than occurs now. These changes will result in a very large increase in isoxaflutole use in American agriculture, with attendant impacts.

APHIS states: "The use of IFT [isoxaflutole] in U.S. soybean production may increase under the Preferred Alternative. This is an expected outcome, as IFT was not previously utilized in U.S. soybean production (EPA, 2011d)" (DEA at 30). However, APHIS provides no estimate, however rough, of the magnitude of the expected increase in use of isoxaflutole. In addition, they surmise that adoption of FG27 soybean will be low, based on unsubstantiated assumptions, thereby downplaying the use of isoxaflutote and thus its impacts.

First, APHIS claims that the restricted use status of isoxaflutole will "potentially preclud[e] its common and widespread use…" because isoxaflutole will have to be applied by certified applicators, in particular environments and in a limited number of states (DEA at 30). This argument does not hold water. Although isoxaflutole use will be limited to certain states, the states in which it will be allowed include the biggest producers of soybeans. Adding up the acreage planted to soybeans in 2010 (DEA at 113 – 114) in the states APHIS has determined will be allowed to use isoxaflutole on

FG72 soybean (DEA at 101), there would have been 50,485,000 soybean acres potentially available for planting FG72 soybean and applying isoxaflutole, or 66% of the US soybean acres. Even if half of this acreage is unsuitable due to soil type or water table constraints[3], that still leaves a lot of room for isoxaflutole use to expand. And soybean growers - most of whom are also corn growers – have demonstrated a willingness to apply restricted use herbicides on a large scale when the advantages outweigh the disadvantages: atrazine, another restricted use herbicide, is used on over 60% or corn acres today, as we discuss in more detail below.

Second, APHIS does not have reliable, detailed information about the application window of isoxaflutole on FG72 soybean. They describe it as a "pre-emergent/early post-emergent herbicide", only applied once at the beginning of the season using a low rate, based on information in DEA Appendix A that shows a label for use of isoxaflutole on "experimental use" FG72 soybean (DEA at 30). APHIS specifically uses this "short window and low rate" argument to say that the total weight of herbicide used in soybeans is not likely to increase much. However, in the case of an extremely potent herbicide such as isoxaflutole, the number of acres it is used on and the span of use during the season are more important for assessing impacts than total weight.

Bayer CropScience should have clearly laid out its plan for labeled use of isoxaflutole in FG72 soybean in its Petition, but it did not. APHIS should require this information. However, Bayer CropScience does provide a clue in its experimental design for herbicide tolerance testing (Petition at 59). In these tests, Bayer CropScience subjects FG72 soybean to herbicide treatments that mimic "typical production practices" in order to collect agronomic information: "Regimen C represents the intended weed control practice in which event FG72 plots were sprayed with **IFT at a target rate of 70 grams ai/Ha** and GLY at a target rate of 1060 grams ai/Ha. Herbicide applications were made to the Regimen C plants as a foliar spray at about the **V4-V5 plant growth stage**." (Petition at 59, emphases added). The application rate of 70 g ai/Ha is similar to the average rate that isoxaflutole is applied on corn today (USDA NASS 2011). The V4 – V5 stage of soybean development is when the 4th or 5th trifoliate leaf unfolds, and often corresponds to the 4th or 5th week after planting, depending on conditions (Casteel 2010).

APHIS depends on information in Appendix A for isoxaflutole application details (DEA at 30), taken from a Supplemental Label, EPA Reg. No.: 264-600, "For use on Isoxaflutole-tolerant soybean grown for research, field trials and seed production only, including USDA regulated plantings or seed production" (Bayer 2011a, as cited in DEA at 30). This label states that isoxaflutole can be used from preplant until "early postemergence", but gives no definition of the specific soybean stage of development for "early postemergence". This is unusual, because labels for herbicides used on HR

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[3] In Wisconsin's FEIS for isoxaflutole use on corn (2002), they estimated that 21% of their total corn acres would be ineligible to receive a Balance Pro application due to soil type, organic matter or depth of water table (p.24), so our choice of 50% ineligible soybean acres may underestimate impacts.

crops are very specific about plant developmental stages related to applications. Perhaps this label is meant to imitate the corn label where corn can be sprayed until the 2nd leaf stage, for purposes of FG72 soybean experimentation, until a full review can be made. Or maybe Bayer CropScience gave individual instructions to growers on when to make the postemergence application in these trials. APHIS then cites an EPA human-health risk assessment for isoxaflutole that provides directions for its use, but this source is also based on growing FG72 soybean in experimental conditions only (EPA 2011b, as cited in DEA at 102). In any case, APHIS should not assume that the details of application to FG72 soybean if it is approved will correspond to experimental use conditions, particularly since Bayer CropScience did not explicitly state such details in its Petition, and in fact used a postemergence application later than "early postemergence" in its tolerance tests that were said to represent likely practices.

It is important to know the window of application in assessing risks, because herbicides applied later in the growing season are likely to impact non-target crops and wild organisms in different ways, as we discuss in more detail later. Many plants are more sensitive to herbicides during reproductive stages, for example. Also, drift and runoff are affected by weather, likely to differ later in the season. In the case of isoxaflutole with its residual soil activity, later applications may push the limits of possible rotation crops.

Use of isoxaflutole in FG72 soybeans will result in later applications than now occur on corn. First, soybeans can be planted later than corn without as much risk of yield loss (Edwards 2012; Pedersen 2008). In fact, soybeans are often planted a month or more later than corn, so even preplant or preemergence use of isoxoflutole is likely occur weeks later in the season on FG72 soybean than on corn. Second, as discussed above, isoxaflutole may be used for over a month after planting with FG72 soybean (following the tolerance test details in the Petition), whereas with corn it can only be used for a few weeks after planting, further extending the difference in application window between FG72 and corn. It is conceivable that with late-planted FG72 soybeans the isoxaflutole application would be in mid August, compared to early July for late-planted corn, for example. This is a substantial difference in the pattern of use.

Finally, APHIS doesn't think that isoxaflutole will be used much with FG72 soybean because it currently isn't used much in corn (DEA at 30), focusing on the total number of pounds applied. However, extrapolating from use of isoxaflutole in corn to FG72 soybean is not appropriate. Because Bayer's soybean has been engineered to be resistant to isoxaflutole it is unlikely to suffer injury from field applications under any conditions, unlike the situation with non-engineered corn. Corn is naturally tolerant of isoxaflutole at certain levels, but FG72 is genetically engineered to be resistant to isoxaflutole. Biological constraints removed, growers will be more comfortable using the herbicide on the enginnered FG72 soybean than on conventional corn.

For purposes of risk assessment, APHIS must assume that FG72 soybean will be a success (Petition at 16). Bayer is targeting growers who have glyphosate-resistant and ALS-inhibitor-resistant weeds as its most likely market (Petition at 15 – 16, 80, 186, 190). It is estimated that one or more glyphosate-resistant weeds now infest 30 million acres of U.S. cropland, with acreage infested growing rapidly, mostly in soybeans and cotton (see discussion of resistant weeds in these comments). Several years ago, Syngenta projected that GR weeds will infest 38 million acres by 2013 (Syngenta 2009b). This doesn't take into account U.S. acreage infested with ALS inhibitor-resistant weeds, which CFS estimates at over 20 million acres based on reports listed in the International Survey of Herbicide-Resistant Weeds. If soybean growers with resistant weeds are likely adopters of FG72 soybean, then a high rate of adoption with accompanying isoxaflutole use is certainly a possibility.

In fact, use of isoxaflutole on FG72 soybean may be more akin to the use of atrazine on corn than isoxaflutole on corn. Like isoxafutole, atrazine has a broad spectrum of activity against weeds, it is "restricted use" so must be applied by certified applicators, is only registered in some states, has rotation crop restrictions due to soil residual activity, and cannot be sprayed near waterways (Kentucky Department of Agriculture 2007). In other words, it is as much of a hassle to use as isoxafutole. However, atrazine is still one of the most popular corn herbicides, and is applied to about 60% of corn acres (USDA NASS 2011). The difference is that atrazine rarely injures corn, even when applied to corn that is 12" tall, as allowed on the label (Syngenta 2009a); whereas injury to corn from isoxaflutole is unpredictable (US EPA 2011c; Wicks et al. 2000, 2007) and it cannot be used past the 2-leaf stage (Bayer CropScience 2011a). As with atrazine on corn, FG72 soybean growers will be able to apply isoxaflutole from pre-plant until the soybeans are several inches tall (Petition at 59) without fear of injury to the crop.

Finally, for projecting changes in isoxaflutole use, it is likely that more acres of corn will be treated with isoxaflutole if FG72 soybean is approved. Now, when growers choose to use isoxaflutole on corn they are limiting the timing and kinds of rotation crops that can follow (Bayer CropScience 2011a). FG72 soybean can follow corn treated with isoxaflutole without any waiting period, making the decision to do so quite simple. We will assume that corn acreage treated with isoaflutole may increase to 10% of total corn acres.

Taking all of these points into consideration, we can make a projection of isoxaflutole use if FG72 soybean is approved. Assuming that 25,242,500 soybean acres are suitable for isoxaflutole applications (half of soybean acres located in states where isoxaflutole will be registered for use with FG72 soybean) and that 60% of soybean acres in those locations will eventually be planted to FG72 soybean (the percentage of corn acres treated with atrazine), there would be 15,145,500 new isoxaflutole applications to soybeans per year – one application per acre (the maximum allowed by label, and the average number used in corn). The average application rate per acre is likely to be the same as for corn, since corn is grown on the same acreage in other years and thus fields will have the same characteristics that determine rate: 0.07 lb/acre (USDA NASS 2011). An estimate of the total isoxaflutole that will eventually be applied to FG72 soybean is 1,060,150 lb/yr.

Current use on corn is 399,000 lb/yr ((USDA NASS 2011), and if isoxaflutole applications increase to 10% of corn acres, that would be 570,000 lb/yr after FG72 soybean adoption.

According to our estimate, then, if FG72 soybean is approved there may be a 4-fold increase in isoxaflutole use in American agriculture (1,060,150 lb/yr on FG72 soybean + 570,000 lb/yr on corn, divided by 399,000 lb/yr currently used in corn).

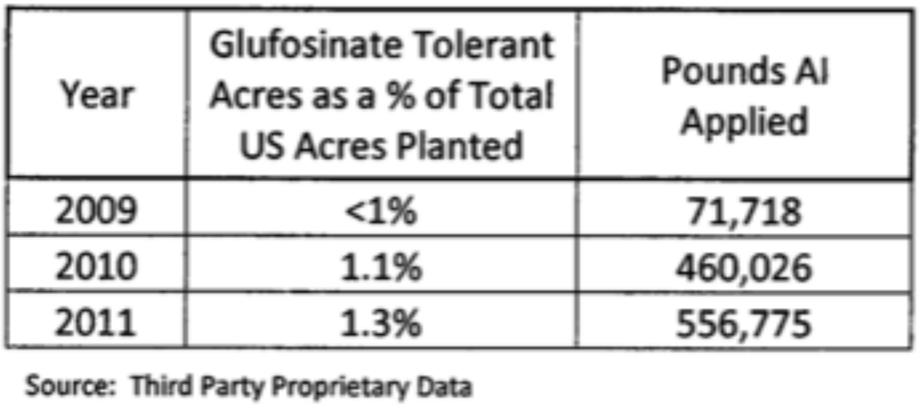
ii. Glyphosate

We assume that glyphosate use will accompany isoxaflutole use in FG72 soybean acres, especially if Bayer CropScience markets a premix containing both herbicides. APHIS points out that glyphosate is already used on most soybeans, so approval of FG72 soybean will not have a big impact on glyphosate use overall. Bayer CropScience does not say whether their new GR trait will tolerate more glyphosate, or applications longer in the season, than do the current GR soybean events. APHIS should procure this information and determine potential impacts of greater glyphosate use if the tolerance is better.

However, the exponential increase in the use of glyphosate as a result of the deregulation of glyphosate-resistant crops has resulted in numerous significant environmental impacts. The continued use of glyphosate on FG72 soybean would contribute to the same environmental harms, including but not limited to the overapplications of glyphosate, the development and spread of glyphosate-resistant weeds, and harms to wildlife, including threatened and endangered species, from applications of glyphosate.

iii. Glufosinate

Glufosinate has traditionally been used very little on soybeans. The latest USDA NASS report on soybean herbicide use (2006) does not list glufosinate among the 37 herbicides used nationally on soybeans. EPA’s latest estimate indicates annual use of glufosinate on soybeans of just 10,000 lbs per year (EPA 2007). However, Bayer CropScience introduced glufosinate-resistant, LibertyLink soybeans in 2009. According to “third party proprietary data” provided to the EPA by Dow, glufosinate use has increased sharply with rising adoption of LL soybeans.



Year	Glufosinate Tolerant Acres as a % of Total US Acres Planted	Pounds AI Applied
2009	<1%	71,718
2010	1.1%	460,026
2011	1.3%	556,775

Source: Third Party Proprietary Data

From: DAS (2011h). "Supplementary documentation in support of draft environmental assessment: Glufosinate use on soybeans," Dow AgroSciences, Nov. 16, 2011.

The table below shows that glufosinate was used on glufosinate-resistant soybeans at annual rates of 0.54 and 0.57 lbs/acre in 2010 and 2011, respectively.

Year	Glufosinate-Resistant Soy as % Total Soy Acres	Total Soybean Acres (thousands)	Glufosinate-Resistant Soybean Acres (thousands)	Pounds Glufosinate Applied (a.i.)	Pounds glufosinate per acre (a.i.)
2009	< 1%	77,451		71,718	
2010	1.1%	77,404	851	460,026	0.54
2011	1.3%	75,208	978	556,775	0.57

Source: DAS (2011h); USDA NASS for soybean acreage figures.

If Bayer includes glufosinate resistance as a stacked trait with FG72 soybean, it is likely to be subject to the same label limits as growers of LibertyLink (LL) soybeans, which prescribe a seasonal maximum rate of 1.2 lbs ai/acre (Bayer CropScience 2012). Growers of LL soybeans are presently utilizing nearly half of the maximum permitted by the label (0.57 of 1.2 lbs/acre/year). Based on this usage rate and the FG72 soybean adoption scenario presented in the isoxaflutole calculations, glufosinate use with FG72 soybean could increase to 8.6 million lbs (15,145,500 acres FG72 soybean X 0.57 lb/acre). This would represent a roughly 16-fold increase over current use of glufosinate on soybeans.

EPA's latest estimate of overall glufosinate use in American agriculture is 1.36 million lbs per year, with corn (900,000 lbs) and cotton (300,000 lbs) accounting for the vast majority (EPA 2007). Because this estimate is based on crop years 2001-2006, it does not account for glufosinate use on LL soybeans, discussed above, which brings total agricultural use of glufosinate to 1.92 million lbs. (1.36 + 0.56 million). Thus, FG72 soybean has the potential to increase overall agricultural use of glufosinate by five-fold

(10.5/1.92, based on average current (2011) use on LL soybeans and the isoxaflutole adoption scenario of 15,145,500 FG72 soybean acres.

To summarize, if FG72 soybean is approved, use of isoxaflutole and glufosinate in U.S. agriculture has the potential to increase an estimated 4-fold and 5-fold, respectively. Glyphosate use is likely to stay at about the same high level. Although the increase in isoxaflutole use would not represent a large percentage of total herbicides based on weight (DEA at 30), APHIS needs to assess impacts of the increase in number of applications and acres treated based on the potency of this herbicide, as we discuss later in these comments.

f. Cumulative impacts of FG72 approval

APHIS defines a cumulative impact as "…an effect on the environment which results from the incremental impact of the proposed action when added to other past, present, and reasonably foreseeable future actions" (DEA at 51). They recognize that impacts of stacking traits are cumulative impacts, but do not think that specific stacked traits are foreseeable. We have already commented on the likelihood of Bayer CropScience adding glufosinate-resistance to FG72 soybean, concluding that APHIS should assess impacts of increased glufosinate use. APHIS also includes the "…use of a pesticide with a similar mode of action to that of the intended pesticide described in the petition for nonregulated status" under cumulative impacts, and makes a case for assessing the HPPD-inhibitor herbicide mesotrione (DEA at 51). If indeed FG72 soybean is resistant to mesotrione because of the genetically engineered transgene that confers resistance to isoxaflutole, then mesotrione use should be addressed as an "impact", not as a cumulative one. Also, APHIS should require Bayer CropScience to include information about cross-resistance in their Petition, as we have discussed. APHIS' assessment of mesotrione use is actually appropriate as a cumulative impact if Bayer CropScience is likely to stack mesotrione-resistance with FG72 soybean in the future, but that possibility is not addressed by APHIS. For weed resistance issues, use of mesotrione now in corn added to projected isoxaflutole use with FG72 soybean qualifies as a cumulative impact because weeds are already developing cross-resistance to these two herbicides, as we discuss later.

APHIS fails to analyze the most obvious cumulative impacts of FG72 soybean approval: 1) the application of isoxaflutole on both FG72 soybean and on corn in the same locale in any given year, and 2) the application of isoxaflutole on the same acreage in successive years as FG72 soybean is rotated with corn.

i. More non-point sources of isoxaflutole and DKN pollution

Most of U.S.' corn and soybeans are grown in rotation with each other (DEA at 8), and thus on the same plots of ground. Also, corn and soybean are grown in roughly equal amounts, although the particular proportion varies with commodity prices, weather, region, and other factors. In a given corn-and-soybean region, then, the landscape is a patchwork of fields of corn intermixed with soybean fields, with some fields of other crops depending on the region. Currently, isoxaflutole can only be used on cornfields. With approval of FG72 soybean, isoxaflutole will be used on both corn and soybeans. If experimental use labels for isoxaflutole in resistant soybeans are a good indication, the rate of application, number of applications, and amount allowed to be applied per season will be similar for corn and FG72 soybean, although the pattern of application will differ. If FG72 soybean is adopted for use on the same number of acres as isoxaflutole is used on corn – 7% - then use of isoxaflutole at the landscape level will double. (We estimate that adoption of FG72 soybean will be much higher than that, and that use on corn will also increase, so that 4 times more isoxaflutole is possible, as we have discussed.) The point here is that even if the amount of isoxaflutole is the same with FG72 soybean as it now is in corn – same number of acres, same application rate, same number of applications – twice the amount isoxaflutole will be used in regions where both are grown.

This landscape-level increase in isoxaflutole use is likely to have impacts on water quality. Within a watershed draining corn and soybean fields there will be twice the load of isoxaflutole entering the system. Basically, the number of agricultural non-point sources for isoxaflutole pollution will increase (DEA at 12). We discuss all of these impacts later in thesthe comments: isoxaflutole, and particularly its degradates, enter surface water through runoff and leaching for quite a while after it is are applied, and can persist and accumulate in water at levels that are harmful to non-target organisms, including threatened and endangered species. Biodiversity may thus be diminished. These increased loads may also affect drinking water, and human health. The propensity of isoxaflutole applications to contaminate water with risk of harm to non-target plants is the reason for its restricted use status (DEA at 35, 93 – 95). A greater portion of the landscape sprayed with isoxaflutole may also accelerate weed resistance. APHIS must assess the cumulative impacts from isoxaflutole use on corn and FG72 soybean in the same landscape.

ii. Isoxaflutole appliations in sequence

Corn – FG72 soybean rotations on the same acreage with isoxaflutole applied in succession also may have cumulative impacts, as we discuss below: isoxaflutole has residual activity in soil, killing germinating seedlings after rains for weeks; and requiring waiting periods of months to a year and a half, accompanied by specified amounts of rainfall, before other crops can be planted. Drought results in increased soil retention of isoxaflutole residues and its degradates, possibly increasing the waiting times, too. Under some conditions, isoxaflutole may be applied in the second year on top of residual isoxaflutole from the year before, perhaps leading to higher contamination of water, or to unexpected injury in other rotation crops. Non-target wild plant populations, including threatened and endangered species, that are particularly sensitive to isoxaflutole may be more adversely affected by use of isoxaflutole in successive years than from intermittent applications. Biodiversity may thus be diminished. Also, use of herbicides with the same mode of action on the same acreage in successive years is a risk factor for promotion of resistant weeds, including isoxaflutole resistance and resistance to multiple herbicides. APHIS needs to consider the cumulative impacts of rotating corn with FG72 soybean.

3. Environmental effects of increased herbicide use and changes in herbicide use patterns with approval of FG72 soybean

APHIS' failure to adequately assess the changes in amounts and patterns of use of isoxaflutole and other potential herbicides to which FG72 is resistant needs to be redressed. Without a reasonable projection of herbicide use, environmental, health, economic and agronomic impacts of approval of FG72 soybean cannot be determined. Assessing impacts on endangered species also hinges on realistic projections and descriptions of isoxaflutole and other herbicide use.

Isoxaflutole is an extremely potent, broad-spectrum herbicide, toxic at very low levels to non-target plants via drift and runoff. It retains herbicidal activity in some soils for over a year, becoming activated after rains. In dry years, dust from isoxaflutole-treated fields may pose a hazard to non-target plants. Therefore an increase in isoxaflutole use and change in its pattern of use will impact non-target crops and wild plants, including endangered plants, with consequences for biodiversity. No other herbicides that have "restricted use" status are used on more than 1% of soybean acres in the U.S. (USDA NASS 2007).

a. Injury to plants and other non-target organisms via spray drift

Injury to organisms from isxoaflutole applications have been recorded in EPA's Ecological Incident Information System (EIIS), and other databases (US EPA 2011c) at 15. Most of the 460 incidents in the EIIS were of injury to corn itself after direct application. A few incidents involved injury to sugar beet and soybean that were planted in rotation with treated corn via residual soil activity. There were also more than 8000 "minor plant incidents" between from 1999 to 2010 from herbicides containing isoxaflutole, but no more details are provided. Some of these incidents could have resulted from spray drift. With wider use if FG72 soybean is approved, drift events that injure adjacent non-resistant crops and wild plants will no doubt occur more frequently.

It is likely that crop injury from pesticide drift is significantly under-reported:

> When crops are damaged by off-target movement of herbicides, the affected growers may settle their differences without the intervention of government enforcement agencies or courts. However, in the absence of a damage report to a state agency or court settlement, there are no records of their occurrence, due to lack of a centralized herbicide incident reporting system in the United States. For incidents that are more contentious or serious, a likely sequence of events arising from herbicide damage to non-target crops may include: 1) a complaint to a state agency over damage cause[d] by an herbicide, 2) an ensuing investigation that may uncover a violation (but which may not resolve the economic loss by the farmer whose crop is affected), and 3) lawsuits that use the investigation as evidence of harm…However, the majority of lawsuits are settled out of court with the stipulation that the plaintiffs not divulge the contents of the settlement to anyone including the government. (Olszyk et al. 2004, p. 225)

When only wild plants are harmed, injury may not be noticed or reported at all. Therefore, most information about risks of herbicide exposure for wild plants and ecosystems comes from experimental studies and comparative surveys rather than from incident reports (discussed later in these comments).

Glufosinate is a broad-spectrum contact herbicide, so non-target plants are at risk of injury from drift (Reddy et al. 2011). An EFSA report on glufosinate use in various agricultural scenarios identified drift injury to non-target plants as a critical area of concern that "requires risk mitigation measures such as a 5 m buffer zone." (EFSA 2005, p. 42). As glufosinate use increases with approval of FG72 soybean, due to foreseeable stacking, more injury to non-target plants can be expected.

b. Injury to plants and other non-target organisms via off-site soil movement

Due to the widespread drought this summer in much of the U.S., weed scientists are cautioning farmers that label-recommended waiting times before planting sensitive crops after isoxaflutole use in corn may be too short (Hartzler and Owen 2013) , a reminder that isoxaflutole and DKN are quite stable in soil the absence of rain. This property of soil retention has prompted concern that such soil containing bound isoxaflutole and/or DKN will move away from treated fields in drought conditions, potentially injuring crops and wild plants at some distance away from the application (US EPA 2002):

> Based on the observations, EFED recommends that the use of isoxaflutole be limited or disallowed in regions that are subject to frequent drought. It is possible that soil contaminated with isoxaflutole (i.e., soils from which the chemical has not dissipated into surface waters because of inadequate rainfall) could dry out and become airborne. The contaminated dust could land on

> sensitive crops and cause damage. The recent incident with Oust herbicide in Idaho is an example of this scenario.

This incident with Oust in Idaho occurred after the Bureau of Land Management (BLM) applied herbicide containing sulfometron methyl to SW Idaho BLM lands in 1999 and 2000. Nearby crops, including potatoes, sugar beets, grains and other crops sustained severe injury for a few years afterwards, and 135 farmers blamed BLM and DuPont for damages, winning a bellwether case but losing awarded damages on procedural ground (Hull 2011; Paez 2011). Soil contaminated with sulfometuron methyl was swept away in wind erosion after drought. The contaminated soil landed in irrigated fields, releasing the herbicide to be taken up by the sensitive crops.

Drought in corn and soybean regions of the U.S. is likely to become a more frequent occurrence with climate change, according to some models. APHIS needs to evaluate the impacts of increased isoxaflutole use with FG72 soybean on crop injury from off-site soil movement, including changes in risk from climate change.

c. Injury to plants and other non-target organisms via runoff

It is the ability of isoxaflutole and its herbicidally active degradate DKN (a diketonitrile derivative) to injure plants via uptake in water through both their roots and shoots (Bayer CropScience 2005) that results in isoxaflutole's status as a federally "restricted use pesticide" (DEA at 35, 68). In fact, Bayer CropScience touts this characteristic of isoxaflutole as a selling point: a grower can apply isoxaflutole before planting and kill emerged weeds with spray droplets and soil uptake, but then as the season progresses, weed seeds that germinate after rains will take up "reactivated"residual isoxaflutole and DKN and many will die (Bayer CropScience 2005, 2011b). According to a recent USDA study, this is a special property of isoxaflutole: "… IFT [isoxaflutole] fate changes more profoundly with water content than for most herbicides, with resurgence of activity reported for subsequent rainfall events. This has been linked to the hydrophobic nature of the parent herbicide, which appears to be protected from transformation to DKN at low water content" (Sims et al. 2009, internal citations omitted).

The same rains that reactivate isoxaflutole carry it and its herbicidal degradate DKN into surface and shallow ground water. DKN is more mobile in water and has a much longer half-life, so is detected at higher levels in the environment (Lin et al. 2004, 2007; Sims et al. 2009). Plants in the environment can take up a lot of DKN, ending up with DKN concentrations in their tissues that are greater than soil or water levels (Lin et al. 2007).

In 2010, US EPA completed an ecological risk assessment for use of isoxaflutole on Bayer CropScience's isoxaflutole soybeans grown under experimental conditions.[4] They determined that the Level of Concern is exceeded for terrestrial non-target plants from runoff and spray drift. Both the parent isoxaflutole and the herbicidal degradate DKN are likely in runoff from resistant soybean or from cornfields, and at levels that "may exceed the Agency's LOC for non-target plants by up to 310X" (DEA at 94 -95). Thus, runoff water used for irrigation may kill crops.

Instructions for use of isoxaflutole on corn prohibit runoff water for irrigation of crops (Bayer CropScience 2011a), but runoff by its nature leaves the area and is free to kill non-target wild plants. The increased use of isoxaflutole with FG72 soybean will therefore increase the risk of injury to plants in the affected watersheds.

Just how sensitive are terrestrial plants to isoxaflutole and DKN in soil and water? EPA studies show growth is reduced in the most sensitive species by a dose that is ~10,000X lower than the application rate (application rate ~0.1 lb a.i./acre, EC25 for vegetative vigor 0.00001 lb a.i./acre) (US EPA 2011c at 13). The degradate DKN gives similar results (at 15):

> Seedling emergence and vegetative vigor data are available from a toxicity study where 10 species of terrestrial plants were exposed to technical isoxaflutole. Overall, vegetative vigor endpoints are more sensitive when compared to seedling emergence. Of the dicot species, the turnip was the most sensitive, with EC25 values of 0.00047 and 0.00001 lb a.i./A for effects to seedling emergence and vegetative vigor, respectively. Of the monocot species, onion was the most sensitive for seedling emergence with an EC25 of 0.01576 lb a.i./A, while oat was the most sensitive for vegetative vigor with an EC25 of 0.0021 lb a.i./A. Additional studies are available where terrestrial plants were exposed to formulated products containing isoxaflutole; however, the endpoints generated from these studies were less sensitive.

Sims et al. (2009) studied the amount of DKN in soil that would keep weed seeds from germinating, and found that ~4 ug DKN per liter of solution[5] was effective:

> Control approached 100% herein (for each of the four weeds effectively controlled by the herbicide) at an estimated dose of 0.0035 μg DKN mL−1 solution. This compares favorably with approximately 0.0065–0.008 μg DKN mL−1 solution (assuming no degradation) predicted to achieve GR80 for the test species and soil (estimated Kd = 1.01 L kg−1) used by Swarcewicz et al. Predicted solution concentrations for this study and that for GR80 reported by Swarcewicz et al. would thus be nearly identical if similar degradation rates

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[4] Note that EPA's assessment assumes application details and other conditions that may be different from commercial regimens if FG72 soybean is approved.

[5] ppb = μg/liter

> were assumed. The concentration of DKN in solution thus may be a useful parameter for predicting the biologically effective dose of the herbicide (Sims et al. 2009 at 109)

Based on these results, the levels of isoxaflutole and/or DKN measured in surface water after simulated rain events and runoff studies, and in drainage tiles around corn fields are sometimes high enough to injury or kill non-target plants, even months after the application. The State of Wisconsin prepared a Final Environmental Impact Statement in 2002 to address impacts of allowing isoxaflutole use in corn. This is their analysis of potential environmental effects from surface water contamination:

> Surface Water
> Isoxaflutole has been detected in surface water reservoirs at total residue concentrations up to 2,394 ppt (2.4 ppb) as long as 10 months after application. Results of drain-tile studies have a bearing on both surface water and groundwater. DKN (the primary degradate) concentrations in tile drain water of one study exceeded 1000 ppt (1.0 ppb) on 34 days. Continued sampling of drain tiles have shown peaks of up to 70,000 ppt (70 ppb). These levels are similar to concentrations produced in runoff simulations (50 ppb). Large spikes in DKN are well correlated with rainfall events.
>
> These and other studies (see Chapter 2) suggest that within 3 years of use, isoxaflutole will 1) be widespread in surface waters, 2) may accumulate in surface water from year to year, and 3) may exceed levels considered toxic to aquatic organisms (see Table 8 below). Aquatic toxicity tests also do not take into consideration the effects of longer-term chronic exposures and potential changes in ecosystem structure and function, which could occur by placing certain species at an ecological disadvantage. Overland flow of isoxaflutole could potentially impact terrestrial plants or crops. (FEIS at 25)

When plants are injured, ecosystems are at risk: "… terrestrial ecosystems potentially at risk could include the treated field and immediately adjacent areas that may receive drift or runoff. Areas adjacent to the treated field could include cultivated fields, fencerows and hedgerows, meadows, fallow fields or grasslands, woodlands, riparian habitats, and other uncultivated areas" (Bayer CropScience 2011a).

The most recent monitoring studies, from 2004, indeed find pervasive water contamination by isoxaflutole and DKN. USGS has measured isoxaflutole's degradate DKN in corn-growing watersheds of Iowa in more samples than one might predict based on the amount of isoxaflutole applied, an indication of how easily it contaminates water after commercial applications (Scribner et al. 2006). In 2004, these USGS scientists collected monthly samples at 10 sites near the mouth of major rivers draining the Missouri and Mississippi rivers in Iowa, where a lot of corn is grown. Isoxaflutole was found in very few of the samples, which was not surprising given how quickly it is converted to DKN. DKN, however, was found in 56 out of 75 of the water samples, at a maximum concentration of 0.552 µg/L. Although isoxaflutole was applied during preplanting in March and April, the highest concentrations of both isoxaflutole and DKN were detected in samples during the postplanting period of May and June. By late summer, only DKN was detected. DKN was detected year-round. Other herbicides and their breakdown products were measured, too, including atrazine. Atrazine was detected in 64 of 67 samples.

Scribner et al. (2006) conclude: "Isoxaflutole is applied in Iowa at a rate that is 8 percent of the rate of atrazine application and 4 percent of the rate of metolachlor application and is only applied to 24 percent of the number of acres to which atrazine is applied (U.S. Department of Agriculture, 2004). Thus the frequent detection of the herbicidally active degradation product of isoxaflutole, diketonitrile, and its degradation product, benzoic acid [not herbicidally active], was unexpected."

Given the results of these plant sensitivity and water monitoring studies, APHIS needs to assess impacts to non-target plants of FG72 approval with rigor. Instead, APHIS deals with the issue of plant-toxic water from isoxaflutole on FG72 soybean in the DEA by comparing the environmental profile and leaching potential of isoxaflutole to other soybean herbicides, as presented on a chart derived from the New York State Integrated Pest Management Program (DEA at 36): "Relative to other herbicides applied to U.S. soybean fields, IFT and its degradates fall within the range of environmental impact quotient (EIQ) for several parameters related to water resources, such as leaching potential, and effects on fish, birds, beneficial organisms, and ecology (Table 6). Indeed, when compared to other herbicides applied on soybean, IFT appears to possess an average leaching potential (Table 6)" (DEA at 35). APHIS concludes: "Given that the leaching potential of IFT is not substantially higher than many currently-registered soybean herbicides (Table 6), it is unlikely that IFT poses any more of a risk to non-target plants than the herbicides that would otherwise be utilized under the No Action Alternative" (DEA at 42)."

Comparing Environmental Impact Quotients and leaching potentials from this secondary source is not a rigorous scientific assessment of the likelihood that non-target plants will be at more risk from isoxaflutole in runoff from FG72 soybean. APHIS needs to weigh the value of relying on these EIQs against the numerous caveats inherent in their use, and determine if the methods used in calculating these EIQ values are a good predictor of injury to non-target plants, in particular (e.g. Levitan 1997 at 37-41 for detailed critique of EIQ methodology)(Levitan 1997). Nor does APHIS convey how "leaching potential" is calculated in the EIQ, and whether it is a good predictor of the levels of herbicides in runoff and shallow groundwater. For example, does this "leaching potential" of isoxaflutole include the much more mobile and stable DKN (Sims et al. 2009), or not? If not, it will fail to predict plant injury. A cursory look at studies of pesticide contamination show that the potential for a molecule to leach based on its physical properties is only one factor in how that molecule behaves in water of agricultural fields and surrounds (e.g. Kellogg et al. 2000). Finally, isoxaflutole is the restricted use herbicide that will increase in use by an estimated 4-fold with approval of FG72 soybean, not the other herbicides on this list.

It is surprising that APHIS dismisses the impacts of water contamination from isoxaflutole applications so easily, given that the propensity for isoxaflutole and DKN to contaminate water has made it a pesticide of special concern to many parties. For example, the State of Wisconsin prepared a Final Environmental Impact Statement in 2002 to address impacts of allowing isoxaflutole use in corn (Wisconsin Department of Agriculture 2002). Based on these analyses, and also on uncertainty about human health impacts (discussed later in these comments), Wisconsin decided that restrictions over and above the federal label were necessary to protect the environment and public health in their state: "DATCP has concerns about isoxaflutole's environmental fate characteristics, its phytotoxicity to other non-target plants at very low concentrations, and its potential to cause cancer in humans. DATCP is proposing three measures to limit adverse affects related to the use of Balance Pro in Wisconsin: 1) a label for use in Wisconsin that is more stringent than the federal label, 2) groundwater monitoring at 15 fields where the isoxaflutole is used, and 3) a requirement that the manufacturer conduct stewardship training for dealers and growers on the appropriate handling, use and disposal of Balance Pro" (Wisconsin Department of Agriculture 2002 at 2-3). In their proposed label, Wisconsin also identified areas of the state that would be off limits to isoxaflutole applications, limited the window of application to between April 15 and July 31, and required irrigation management to reduce over-watering; all measures designed to reduce movement of isoxaflutole and DKN into waterways.

Michigan and Minnesota, two other corn –growing states, also decided to require more restrictive conditions on the use of isoxaflutole in corn, following public concern about the new herbicide (AP 2003; Hemphill 2003; US Water News).

According to press accounts, the company's response (Aventis was the manufacturer at the time) was to leave Michigan, Wisconsin and Minnesota off of the list of states on the federal label for Balance herbicide, saying that the extra restrictions were too onerous (Hemphill 2003). These states are still missing from the federal label, and no isoxaflutole is used on corn.

d. Herbicide use patterns with FG72 soybean result in greater risk to non-target species

Because FG72 soybean has been engineered to withstand isoxaflutole, thus removing biological constraints, this herbicide can be used from preplant through postemergence, until the FG72 soybean has 4 to 5 trifoliate leaves expanded (Petition at 59). It is therefore likely that isoxaflutole applications will occur later in the season when used with FG72 than with corn. As we have described, these applications on FG72 soybeans may occur as late as mid-August, whereas the last likely applications of isoxaflutole on corn would be in July (depending on planting dates, crop varieties, weather, and so on).

i. Timing of isoxaflutole applications in the growing season

Herbicide applications are more likely to coincide with life-stages of plants that are the most sensitive to injury because the FG72 soybean itself is less sensitive to injury during spring and summer than is corn. This is a general outcome of herbicide-resistant crop systems: "Increased use of herbicide-resistant technology by producers creates the possibility of off-site movement onto adjacent conventional crops. The role of total postemergence programs to control grass and broadleaf weeds has expanded with the development of herbicide-resistant crops. Because of the diversity of cropping systems in the United States, it is not uncommon for herbicide-resistant crops to be planted near susceptible conventional crops. Postemeregence application of a herbicide to a genetically-modified (GM) crop often occurs when non-GM plants are in the early reproductive growth stage and most susceptible to damage from herbicide drift….Consequently, most drift complaints occur in spring and summer as the use of postemergence herbicide applications increase." (Lee et al. 2005, p. 15) Plants – both crop and wild species –are often most sensitive to herbicide injury as pollen is forming (Olszyk et al. 2004).

ii. Total use of isoxaflutole at landscape level

Another way that the FG72 soybean will increase isoxaflutole use is by increasing the total number of acres that are treated with these herbicides. Within a given year, both corn and FG72 soybean acres will be sprayed, as we show in our comments on herbicide use. Also, since corn and soybeans are often rotated on the same acreage within a region. And because of the corn-soybean rotation, the likelihood that isoxaflutole will be used on the same acreage year after year is greater as well.

At a landscape level this change in isoxaflutole's use pattern will result in a larger number of individuals of a wider array of species in proximity to FG72 soybean and thus isoxaflutole, with attendant impacts. Drift injury will be more likely, and runoff from the greater area may result in higher levels of isoxaflutole in water bodies.

e. Injury to non-target crops and wild plants from change in use patterns of associated herbicides

Herbicide use in agriculture results in injury to non-target crops and wild plants, and approval of FG72 soybean that will result in increased herbicide use and changes in herbicide use patterns will increase this risk, as we have discussed in detail.

In soybeans, herbicide use, including drift, volatilization and runoff from such herbicide use, can cause poor seedling emergence, yellowing of leaves, necrotic lesions, and cupped leaves, similar to the injuries from pests or pathogens (Shumway and Scott 2012; UW Agronomy). For example, cupped leaves in soybeans, a symptom of injury from auxinic herbicides such as 2,4-D and dicamba, can also be caused by Soybean mosaic virus, bean pod mottle virus and alfalfa mosaic virus (Legleiter et al. 2012).

Similarly, herbicide drift causes injuries to tomato like those from pathogen damage: "Cucumber mosaic virus and herbicide injury are almost identical. Cucumber mosaic virus causes tomato plants to yellow and become bushy and stunted. Leaves may be mottled."(Edmunds and Pottorff 2009).

As explained in detail, crop injury from herbicide use is a significant issue associated with the increased use of over-the-top applications of herbicides accompanying the cultivation of the FG72 soybean system. In the PPRA, then, APHIS needs to consider – as a plant pest risk – the injury to non-target plants from increased herbicide use and different patterns of herbicide use as part of the FG72 soybean system, and ways to prevent such injury.

f. Herbicides can directly and indirectly affect pests and pathogens of non-target plants

Herbicides can have direct effects on plant pathogens, either stimulating or suppressing the growth of particular bacteria and fungi (Duke et al. 2007; Sanyal and Shrestha 2008). Indirect effects on plant diseases are also common, and involve a variety of mechanisms: "Another potential indirect effect is alteration of plant metabolism or physiology in a way that makes it more susceptible or resistant to plant pathogens. For example, induction of higher levels of root exudate (e.g., Liu et al., 1997) or altered mineral nutrition (proposed by Neumann et al., 2006)." (Duke et al. 2007).

Herbicide dosage is important for the effects, and sometimes drift levels can stimulate the growth of pathogens, whereas full application rates suppress the same pathogens. Thus non-target plants may be at higher risk for diseases than the treated crop itself from herbicide applications: "It is not unusual for low rates of herbicides to stimulate in vitro pathogen growth (e.g., Yu et al., 1988). Hormesis (the stimulatory effect of a subtoxic level of a toxin) is common with both fungicide effects on fungi and herbicide effects on plants (Duke et al., 2006). Thus, dose rates are likely to be highly important in both direct and indirect effects of herbicides on plant disease"(Duke et al. 2007).

There may also be indirect effects on plant pests and pathogens due to the simplification of rotation crop sequences with FG72 soybean, as we discuss below regarding biodiversity within soybean fields.

Therefore, in the PPRA, APHIS must consider the changes in pests and pathogens of non-target plants as a result of increased herbicide use and different patterns of herbicide use with the FG72 soybean system, and they did not do so.

g. Increased ingestion of isoxaflutole residues and degradates puts animals at risk, including pollinators, and threatened and endangered species

Postemergence applications with FG72 soybean may result in higher levels of isoxaflutole residues and degradates or metabolites in FG72 soybean tissues than were present on corn. Also, there may be more wild food plants that take up isoxaflutole and DKN from contaminated water and soil at higher levels if FG72 soybeans are approved.

APHIS uses the fact that food and feed safety data on FG73 soybean has cleared the FDA assessment process to support the idea that ingestion of FG73 soybean will have no impacts on wild animals: "Furthermore, BCS [Bayer CropScience] has submitted food and feed safety data to FDA as part of a voluntary consultation process. Based on the food and feed safety data, lack of toxicity and allergenicity of introduced gene products, APHIS concludes that feeding of Event FG72 soybean plant or seed by mammals and other nontarget organisms is unlikely to cause any adverse impact on their survival and reproduction (DPPRA at 13)." They repeat this reasoning for risks to threatened and endangered species (DEA at 11).

Food safety assessment for humans are not appropriate for wildlife. Humans eat the seeds and processed products from seeds of soybean, whereas wild animals may eat any part of the plant, including pollen and nectar (pollinators). Herbicide residues and degradates or metabolites in seeds are almost always much lower than in vegetative tissues, partly because applications are made so much earlier than seed development; and also because seeds are not contacted directly by herbicides, being covered by the pod. Feed for livestock, such as hay and forage, is likely to have much higher herbicide residues than do seeds, but it is assessed for safety after the approved waiting time post-application, whereas wild animals may eat the these vegetative tissues immediately after applications and thus receive a much higher dose. Pollen and nectar used by pollinators – organisms beneficial to agriculture – are not taken into account in food and feed assessments, either.

APHIS needs to reconsider potential increased risks to wild animals of various types from eating FG72 soybean tissues or drinking runoff in the DEA and DPPRA in light of herbicide use projections, taking into account the difference between human or livestock exposure vs. wild animal exposure.

h. Impacts to biodiversity

According to APHIS, there are no potential impacts from approval of FG72 soybean, because agronomic practices will remain the same as before. However, APHIS did not fully consider the impacts of the substantial changes in herbicide use amounts and patterns that are part of the FG72 soybean system.

Under cumulative impacts, though, APHIS says:

> The use of GE soybean varieties containing herbicide-tolerant traits may improve biological diversity by providing growers the opportunity to use conservation tillage practices (Bonny, 2011; NRC, 2010). Incorporation of herbicide tolerance in the crop facilitates the grower adoption of conservation and no-till strategies, improved soil porosity, enhancing soil fauna and flora (CTIC, 2010), increasing the flexibility of crop rotation, and facilitating strip cropping (Fernandez-Cornejo et al., 2002). Each of these contributes to the health of the faunal and floral communities in and around soybean fields thereby promoting biodiversity (Palmer et al., 2010) (DEA at 60).

We will address the link between GE soybeans, conservation tillage and biodiversity in a later section.

i. Biodiversity in soybean fields

An example of harm to biodiversity in corn fields from an herbicide-resistant crop system is the recent decline in milkweed populations in Midwestern fields with probable impacts on monarch butterflies, as described in a series of studies (Hartzler and Buhler 2000, Hartzler 2010, Brower et al. 2011, Pleasants and Oberhauser 2012). The basic conclusions are well stated in the abstract of the most recent publication by Pleasants and Oberhauser (2012):

> Abstract. 1. The size of the Mexican overwintering population of monarch butterflies has decreased over the last decade. Approximately half of these butterflies come from the U.S. Midwest where larvae feed on common milkweed. There has been a large decline in milkweed in agricultural fields in the Midwest over the last decade. This loss is coincident with the increased use of glyphosate herbicide in conjunction with increased planting of genetically modified (GM) glyphosate-tolerant corn (maize) and soybeans (soya).
>
> 2. We investigate whether the decline in the size of the overwintering population can be attributed to a decline in monarch production owing to a loss of milkweeds in agricultural fields in the Midwest. We estimate Midwest annual monarch production using data on the number of monarch eggs per milkweed plant for milkweeds in different habitats, the density of milkweeds in different habitats, and the area occupied by those habitats on the landscape.
>
> 3. We estimate that there has been a 58% decline in milkweeds on the Midwest landscape and an 81% decline in monarch production in the Midwest

> from 1999 to 2010. Monarch production in the Midwest each year was positively correlated with the size of the subsequent overwintering population in Mexico. Taken together, these results strongly suggest that a loss of agricultural milkweeds is a major contributor to the decline in the monarch population.
>
> 4. The smaller monarch population size that has become the norm will make the species more vulnerable to other conservation threats.

Here, 16 years after the introduction of Roundup Ready soybeans, major impacts of their widespread adoption are just now surfacing, with only a handful of researchers doing this kind of "post-market" ecological research. APHIS needs to consider these kinds of harms, and how to prevent them, before rather than after approval of FG72 soybean.

The FG72 soybean system will result in a new use of isoxaflutole on soybeans, also a systemic herbicide, and likely to be used in addition to full rates of glyphosate, and glufosinate. It is also reasonably foreseeable that in the future FG72 soybean will be treated with isoxaflutole and glyphosate, in rotation with corn similarly treated, as we have commented. Weed biodiversity, such as small populations of milkweed, within these fields will be diminished. Tolerant and resistant weeds will come to dominate, simplifying the number of plant species in the fields, and this by definition is a decrease in biodiversity. Also, with specialist herbivores, such as the monarch butterfly that rely completely on particular plant species, other kinds of plants will not substitute for their requirements.

Isoxaflutole has residual activity in soil, as well, so changes in pattern of use may cause unique harms to biodiversity, preventing seed germination of a variety of wild plants within or on the edges of fields that may not be considered problem weeds and were thus tolerated by farmers.

Biodiversity may also be increased by diverse rotation sequences that include a variety of types of crops, providing different kinds of food and habitat for beneficial insects or for birds, for example (Chappell and LaValle 2009). FG72 soybean is likely to simplify rotation sequences, reinforcing the dominant corn – soybean alternation. APHIS thinks that current rotation will be maintained:

> … similar to the No Action Alternative, a determination of nonregulated status of FG72 soybean is unlikely to substantially change current patterns of soybean crop rotation because it exhibits similar agronomic performance relative to its nontransgenic parent variety, Jack (Bayer, 2011c). In particular, no differences in phytopathology were generally observed between FG72 and its nontransgenic parent variety (Jack) in experimental plots (USDA-APHIS, 2012b). These similar measures of disease susceptibility suggest that FG72 soybean would benefit from currently-practiced soybean rotation strategies. Furthermore, cultivation of FG72 soybean and potential corresponding IFT use may not restrict common corn/soybean rotation, as the rotation interval for

> corn following IFT use is 0 months (Bayer, 2011b). Due to this general benefit from crop rotational strategy on disease mitigation and an unlikely disruption with common soybean rotational crops, a determination of nonregulated status of FG72 soybean is likely to continue current patterns of rotation in U.S. soybean production (DEA at 28).

Since isoxaflutole can be applied to both FG72 soybean and corn, after FG72 soybean, corn is an easy follow-on crop because there is no waiting period – no need to be concerned about herbicide carry-over injuring the next crop. We think the same will be true of FG72 soybean following corn.

Integrated Pest Management (IPM, including Integrated Weed Management, or IWM) strategies rely on diversifying rotation crops beyond the corn – soybean axis to reduce pests and pathogens, manage soil characteristics, increase yields, etc. (Liebman 1993, Liebman and Davis 2009, Liebman et al. 2009). The corn – soybean rotation used alone no longer protects against rootworm in parts of the corn belt, for example (O'Neal et al. 2002). Wheat, cotton, rice, sorghum, barley, oats and dry beans are some of the crops currently rotated with soybeans, other than corn (DEA at 8). All of these have some rotational interval after isoxaflutole before they can be planted. Cotton and rice require 10 months, dry beans require 10 – 18 months, depending on region, and at least 15 inches of cumulative precipitation between the application and planting of the rotational crop in addition (Bayer CropScience 2011a). Presumably, leguminous cover crops would also require long rotational intervals. Thus, FG72 soybean may be at odds with implementation of IPM, and also result in lower biodiversity over time.

APHIS misunderstands the meaning of herbicide half-life in relation to rotation intervals required before crops other than corn can be planted after isoxaflutole applications:

> …the estimated half-life of DKN is 61 days, facilitated by aerobic soil metabolism (EPA, 1998). DKN is the bioactive principle of IFT, and thus, may be responsible for non-target plant injury that may result from growth on the treated soil. However, EPA label use restrictions on IFT formulations places minimum limits on when another crop may be planted following IFT application. These intervals, ranging from 4-18 months, exceed the half-life of DKN and are designed to mitigate any incidental plant injury from the soil (Bayer, 2011b) (DEA at 34).

The half-life of DKN is not a fixed property, like molecular weight. How quickly DKN is broken down depends on many other factors, from types of microbes to soil structure and weather (Sims et al. 2009; Swarcewicz et al. 2002). In drought conditions, for example, DKN and isoxaflutole (that has a much shorter average half-life) can remain un-degraded for a much longer than in hydrated soil (US EPA 2002), raising concerns of toxicity to plants beyond the labeled rotation interval (Hartzler and Owen 2013). Also, half-life means that half of the parent molecule has degraded or been metabolized, but half is still there. That half that is present may still be enough to kill or injure plants.

Although the recommended rotation intervals are designed to mitigate injury, they do not remove all risk of injury.

Besides the direct toxicity of the increased herbicides used on FG72 soybean to plant population diversity within soybean fields and ramifications for animals from changes in plant diversity, there will also be an increase in herbicide exposure from residues and their degradates or metabolites in FG72 soybean tissues. A wide variety of animals feed on soybean leaves, flower parts, and seeds, including many beneficial organisms such as honeybees and wild pollinators, as discussed in our comments on gene flow, below.

Also, some animals may be over-sprayed during applications of herbicides, and others may brush against newly sprayed foliage, receiving higher herbicide doses in FG72 soybean with possible toxic impacts (US-EPA 2009, Freemark and Boutin 1995).

APHIS needs to assess potential impacts to animals in fields of FG72 soybean in light of the foreseeable increase in exposure to isoxaflutole and its degradates or metabolites, based on realistic use scenarios and a wide range of relevant independent scientific studies in order to compare alternatives.

ii. Biodiversity around soybean fields

EPA has identified the types of ecosystems likely to be impacted by isoxaflutole use: "… terrestrial ecosystems potentially at risk could include the treated field and immediately adjacent areas that may receive drift or runoff. Areas adjacent to the treated field could include cultivated fields, fencerows and hedgerows, meadows, fallow fields or grasslands, woodlands, riparian habitats, and other uncultivated areas." (US EPA 2011 at 15).

APHIS does briefly acknowledge that there is biodiversity to protect in agroecosystems: "Although soybean production fields are cultivated as plant monocultures to optimize yield, the adjacent landscape may harbor a wide variety of plants and animals" (DEA at 46), but they do not take into account the impacts that increased isoxaflutole use and changes in pattern of application in FG72 soybean would have on those nearby habitats because they do not develop a realistic analysis of changes in herbicide use, and defer to EPA on pesticide use anyway (DEA at 60)/ Thus they are unable to properly compare their proposed alternatives.

Increased drift and runoff from use of isoxaflutole with the FG72 soybean is likely to alter the very habitats important for biodiversity in agroecosytems (Freemark and Boutin 1995, Boutin and Jobin 1998, Olszyk et al. 2004). Particular species of plants are more or less sensitive to these herbicides, and at different times of the year, so that a specific drift event is likely to change the population dynamics in affected areas (Olszyk et al. 2004). These impacts may result in long-term changes in the mix of plant species, favoring annual weeds over native plants, for example (Boutin and Jobin 1998, Boutin et al. 2008). And if there are herbicide resistant plants in these habitats, they will of course be better able to withstand drift and may become more abundant (Watrud et al. 2011).

These herbicide-induced changes in plant populations can then indirectly impact "microbial communities, occurrence of plant pathogens, or diminished insect populations. Both direct and indirect effects could lead to numerous negative impacts on ecosystem services including wildlife habitat, nutrient cycling, control of soil erosion, recreation, timber or pulp production, livestock grazing, control of noxious plant species and aesthetics…." (Olszyk et al. 2004).

There are studies of species composition in field margins (Kleijn and Snoeijing 1997) and hedgerows that border conventional fields compared with fields managed organically without herbicides (Boutin et al. 2008) showing differences in plant populations that indicate just these sorts of species shifts from herbicide exposure. Also, "[i]n controlled experiments with plant communities, Pfleeger and Zobel (1995) demonstrated that variable species responses to herbicide exposure may alter the competitive interactions within a community. Such shifts in a community could result in changes in frequency and production and even extinction of desired species…" (Olszyk et al. 2004).

Recent experiments have shown that drift levels of the broad-spectrum herbicide glyphosate alter population structures of plants that include some herbicide-resistant individuals, favoring an increase in those with the glyphosate-resistance trait. Differences in the populations persist years after the last "drift" incident, affecting the kinds of beneficial soil fungi present and growth of subsequently planted species, for example (Watrud et al. 2011).

Animals depend on plant biodiversity for most of their needs, so it would be surprising if herbicide induced changes in plant populations had no effects on animal biodiversity around cornfields. Freemark and Boutin (1995) reviewed the literature on how herbicide use has affected wildlife, and found that, as expected, biodiversity has been affected in areas adjacent to sprayed crop fields, including types and abundance of small mammals and birds.

It is clear, then, that increased use of herbicides with the FG72 soybean are likely to have negative impacts on biodiversity around soybean fields, perhaps at some distance, and thus APHIS should prepare an Environmental Impact Statement that assesses these impacts.

4. Threatened and endangered species

APHIS needs to take into account the increase in use of herbicides with FG72 soybean, instead deferring to the EPA (DEA at 62 - 63).

a. Impacts of increased herbicide use and changes patterns of use on listed species

All of the harms from increased use of herbicides on FG72 soybean systems to plants, animals, and other organisms, and to their habitats, discussed above, apply to species that are at risk of extinction. Endangered species near fields planted to FG72 soybean will be at increased risk from exposure to herbicides via drift of particles and runoff, accidental over-spraying, and recently sprayed plant parts and soil. Their habitats will be at higher risk of being altered from changes in plant populations with attendant impacts.

However, the stakes of herbicide exposure are higher, especially for plants: "Determination of herbicide effects to threatened and endangered plant species in native plant communities is especially critical. In the US, the federal government has listed over 500 plant species as threatened and endangered and the Nature Conservancy considers 5,000 of the 16,000 native species to be at risk. Almost 50% of these species are annuals that are dependent on seed production or the seed bank for survival, thus any reproductive effects of herbicides could affect their survival." (Olszyk et al. 2004).

The new use of isoxaflutole on soybeans should have been a red flag for APHIS to consult with FWS about endangered species because they cite concerns to listed species from EPA registration review documents (DEA at 13).

Recently, 2,4-D, a widely used herbicide, was evaluated in a Pesticide Effects Determination by EPA (US-EPA 2009) and Biological Opinion from the National Marine Fisheries Service (NMFS 2011), both finding adverse impacts to several specific endangered species.

Specifically, the EPA evaluated the risks of 2,4-D use to the threatened California red-legged frog (CRLF) and Alameda whipsnake (AW) and their critical habitats. This frog lives in both coastal and interior mountain ranges, using both water bodies and riparian and upland sites; and eats wide variety of plant and animal foods during its aquatic and terrestrial phases, including insects, other amphibians and an occasional small mammal. The Alameda whipsnake is found in scrub and chaparral, as well as riparian areas, grasslands and savannas; also has a varied diet that includes insects, amphibians, other reptiles, small mammals and birds (US-EPA 2009, p. 55).

Just about all of these habitats and prey types are potentially impacted by use of 2,4-D at agricultural rates, either directly or indirectly (US-EPA, summary of effects p. 11 – 25). Looking at specific use of 2,4-D applied with ground equipment on field corn or popcorn, for example, the "level of concern" is exceeded for direct effects on the terrestrial habitat of CRLF and with aerial applications for AW. "Level of concern" is exceeded for indirect effects on prey, including terrestrial invertebrates and plants, frogs, small mammals (CRLF and AW), and also for birds (AW). Small mammals were also likely to be directly impacted, based on incident reports. After going through the whole assessment process, EPA concluded that use of 2,4-D in a variety of scenarios, including on corn, was "likely to adversely affect" both the CRLF and AW via indirect effects on prey, and was likely to modify critical habitat (US-EPA 2009, p. 175 – 179). They initiated a formal consultation with FWS based on these conclusions.

Many threatened and endangered animals share the basic food and habitat requirement of CRLF and AW, including other amphibians and reptiles, but also mammals and birds. In particular, the ability of 2,4-D to alter habitat by injuring plants, and thus changing plant populations is relevant to the potential for isoxaflutole to do the same.

The only EPA consultation over 2,4-D impacts on threatened and endangered species that has proceeded to the "biological opinion" stage is for Pacific salmonid fishes (NMFS 2011). These are fish species that spawn in the floodplains of the Pacific coast, and then go to sea for a few years before returning up rivers and creeks to their original spawning ground to begin again. Here the NMFS concluded that agricultural uses of 2,4-D were "likely to adversely modify" critical habitat because of injury to plants. They expressed concern about toxicity to plants from agricultural applications near riparian zones in the floodplains, for example (NMFS 2011, p, 540 – 543). Riparian vegetation "provides shade, bank stabilization, sediment, chemical and nutrient filtering, and provides a niche for the terrestrial invertebrates that are also salmon prey items…We believe the a.i. [2,4-D] will have a detrimental effect on riparian vegetation…" (NMFS 2011, p. 627 – 628).

Again, many threatened and endangered aquatic species will have similar habitat requirements for water quality and prey, including some that are in habitats near soybean cultivation and thus could be impacted by the increased use of isoxaflutole on FG72 soybean.

Yet, EPA has not even gone through a "pesticide effects determination" for any listed species and isoxaflutole, or glufosinate, although they are in the process of reviewing the registration of these herbicides where they are addressing endangered species (US EPA 2011a). Based on ecological studies in Europe, we expect non-target plants – listed and non-listed – to be at risk from drift and runoff of glufosinate, as well, with possible consequences for listed animals. Some animals may also be at direct risk from glufosinate exposure (EFSA, 2005).

b. Ingestion of FG72 soybean by listed species

Finally, APHIS did not take into account the potential toxicity of FG72 soybean to listed species that might eat leaves, roots, stems, or flower parts. Migrating birds, for example, eat parts of the soybean plant. Bees consume the pollen and nectar, and presumably other insects do as well. Soybean detritus washes into wetlands.

If any listed species do consume soybean APHIS must consider the differences in composition between FG72 soybean and its conventional counterparts, including pesticide residues. Again, food and feed safety studies do no provide "sound science" for wild animals (see comments above).

APHIS should initiate consultations with FWS and NMFS concerning the approval of the FG72 soybean.

5. Human health and approval of FG72 soybean

a. Impacts on farmers

Farmers are in many ways healthier than the general population. They have lower mortality from heart disease; cancers of the lung, bladder, liver, colon, esophagus, rectum and kidney; as well as from all cancers combined. However, farmers from many countries experience higher rates of certain cancers – leukemia, non-Hodgkin's lymphoma, multiple myeloma, soft-tissue sarcoma, and cancers of the skin, lip, prostate, brain and stomach (Blair and Zahm 1995). The excess of certain cancers in farmers is striking in light of their lower mortality from most other causes. Which factors in the farming life might explain the fact that farmers are more likely to contract and die from certain cancers?

Several lines of evidence suggest that exposure to pesticides is one important factor. In broad terms, increased cancer risk coincides with pesticide use in time and space. The overall incidence of cancer in the U.S. population has risen sharply over the period of extremely rapid growth in the use of pesticides and other industrial chemicals, by 85% from 1950 to 2001 (Clapp et al. 2006). Significant associations have been found between agricultural chemical use and cancer deaths in 1,497 rural U.S. counties (Steingraber 2010, p. 64).

Because direct human experimentation is unethical, the chief means to determine whether exposure to pesticides has adverse health effects is epidemiological studies. The rate or incidence of a disease in a population exposed to a particular pesticide is compared to that of a reference population of those not exposed to it. Any excess disease in the exposed population suggests that the pesticide is a risk factor that increases the likelihood of contracting the disease.

Where epidemiological studies have not been done, research on animals provides important information about pesticide safety.

b. Health risks from isoxaflutole

One reason use of isoxaflutole in corn has been controversial is that it has classified as "likely to be a human carcinogen" by the Health Effects Division at the US EPA. For example, Wisconsin determined they needed to do an FEIS partly based on this classification: "DATCP [Department of Agriculture, Trade and Consumer Protection] has concerns about isoxaflutole's environmental fate characteristics, its phytotoxicity to other non-target plants at very low concentrations, and its potential to cause cancer in humans"(Wisconsin Department of Agriculture 2002). And:

> …Approximately 70% of Wisconsin residents rely on groundwater for their drinking water supply. The EPA has listed isoxaflutole as a probable (B2) human carcinogen. Because of the potential for isoxaflutole to leach to groundwater and the fact that it is a B2 carcinogen, there is a potential for this action to cause unsafe drinking water in areas where it is used. However, EPA concludes that there is a reasonable certainty that no harm will result from aggregate exposure to isoxaflutole residues (Wisconsin Department of Agriculture 2002).

This is the statement in the Human Health Scoping Document in the current docket for registration review: "Isoxaflutole was negative in a variety of genotoxicity screening assays. However, in carcinogenicity studies, isoxaflutole induced liver and thyroid tumors in rats and liver tumors in mice. Based on the tumor findings, the HED Carcinogenicity Peer Review Committee (CPRC; 1997) classified isoxaflutole as "likely to be a human carcinogen""(US EPA 2011b).

As discussed above, isoxaflutole use is projected to increase dramatically with introduction and adoption of FG72 soybean, and within watersheds, the increased number of non-point pollution sources from FG72 soybean fields interspersed with corn fields may increase water levels of isoxaflutole and DKN. APHIS needs to address the possibility that cancer risks could increase, impacting human health. Instead, APHIS does not even acknowledge in the DEA that isoxaflutole has been classified as a probable human carcinogen, or that the public has concerns about this issue. APHIS should prepare an Environmental Impact Statement where the impact of the FG72 soybean system is assessed in light of herbicide use projections.

c. Health risks from glufosinate

APHIS also needs to assess the health impacts glufosinate based on the possibility of increased use of glufosinate with FG72 soybean. We project a 16-fold increase over current use of glufosinate on soybeans, and a 5-fold increase in glufosinate use in agriculture as a whole if FG72 soybean is approved, as discussed our herbicide use section of these comments. This means that more people are likely to be exposed to glufosinate, more often.

Exposure of mixers, loaders and applicators to glufosinate is of particular concern. In 2005, the European Food Safety Authority (EFSA) reviewed glufosinate ammonium and found that it's use in agriculture poses a risk to various animals, including humans. Operators using glufosinate on genetically engineered corn were at risk of unsafe exposures in spite of taking precautions, such as wearing protective clothing (EFSA 2005, p. 20).

Studies in laboratory animals showed that glufosinate caused premature deliveries, abortions and dead fetuses in rabbits, and pre-implantation losses in rats (EFSA, p. 13 – 14). These analyses led to precautionary language on the Material Safety Data Sheet for glufosinate ammonium, warning users that it is a "[s]uspected human reproductive toxicant", and that "[i]t may cause damage to organs through prolonged or repeated exposures". It also is tagged as causing a "[p]ossible risk of harm to the unborn child." (Glufosinate EU MSDS 2010).

In fact, glufosinate is one of 22 pesticides that has been identified by the EU as a reproductive, carcinogenic or mutagenic chemical and thus will not have its registration renewed in 2017 (EFSA 2005).

APHIS says that "[g]lufosinate-ammonium is classified as not likely to be a human carcinogen and has no mutagenicity concern…", but fails to mention these international concerns over reproductive toxicity (DEA at 59).

Given the dramatic increases in use that will be brought about if FG72 soybean is approved, APHIS should explore these impacts in an Environmental Impact Statement.

6. Herbicide-resistant weeds and approval of FG72 soybean

a. Summary

U.S. agriculture's undue reliance on single-tactic, chemical-intensive weed control generates huge costs in the form of herbicide-resistant weeds – costs that could be avoided or greatly lessened with sustainable integrated weed management techniques that emphasize non-herbicidal tactics. Herbicide-resistant crop systems promote still more rapid evolution of resistant weeds. The history of glyphosate-resistant weed emergence must be carefully heeded, yet APHIS has provided little assessment of it.

Multiple herbicide-resistant weeds are a rapidly growing threat. Some existing populations of resistant weeds already rate the designation "noxious," and they will be made still more intractable and costly if they evolve additional resistance to other modes of action, such as HPPD-inhibitor herbicides, as is already occurring in common waterhemp and Palmer amaranth, two extremely problematic weeds. Volunteer FG72 soybean may become a problematic "resistant weed" in its own right, by virtue of its resistance to two to three herbicides, and perhaps still others with cross-pollination by other HR soybean varieties. Stewardship strategies proposed by Bayer are quite similar to those of Monsanto with Roundup Ready crops, which have completely failed to prevent resistant weed emergence.

Weed scientists recently called for "mandatory stewardship practices" to accompany 2,4-D and dicamba-resistant crops, and APHIS has initiated environmental impacts statements for each of these crop systems to assess the weed resistance threats they pose. Similar measures are necessary for FG72 soybeans. APHIS's assessment of weed resistance in the draft EA (DEA) was deeply flawed, and it provided no assessement of an alternative involving mandatory weed resistance management. Under the preferred alternative, the increase in use and change in pattern of use of isoxaflutole accompanying FG72 soybean combined with continued use of glyphosate will very likely trigger rapid emergence of increasingly intractable, multiple herbicide-resistant weeds that will harm farmers, the environment, and the interests of American agriculture.

b. Isoxaflutole- and HPPD-inhibitor-resistant weeds

Bayer CropScience's rationale for developing FG72 soybean is to add an herbicide, isoxaflutole, with a mechanism of action not used before in soybeans to control weeds that have become resistant to glyphosate and other herbicides. However, this advantage of isoxaflutole only operates as long as weeds do not develop resistance to it, too.

A few years after isoxaflutole was introduced, weeds resistant to triazine and ALS inhibitor herbicides were then the major problem in corn: "Balance Pro also has the advantage that it controls certain herbicide-resistant weed biotypes such as triazine-resistant pigweed, lambsquarters, and velvetleaf and ALS-resistant waterhemp, eastern black nightshade, and ragweed. Balance Pro is an HPPD-inhibiting herbicide. Currently there are no reported cases of HPPD-resistant weed biotypes in the world, but this mode of action has not been used extensively. The lack of current cases of resistance does not preclude development of resistance problems in the future" (Wisconsin Department of Agriculture 2002).

Since then, glyphosate-resistant weeds have become a major problem throughout the corn and soybean growing regions, and, as the Wisconsin DoA predicted, HPPD-resistant weed biotypes have indeed appeared in cornfields. Since 2009, six HPPD-resistant biotypes (4 common waterhemp and 2 Palmer amaranth) have emergend in cornfields; at least one of the common waterhemp biotypes has been found in soybeans as well as corn.[6]

APHIS's assessment of the impact of FG72 soybeans on evolution of weed resistance to isoxaflutole is vitiated by numerous factual errors and much faulty analysis. First, it must be said that APHIS (once again) unaccountably misreports the extent of glyphosate-resistant weeds by at least 15-fold (DEA at 42, citing Hubbard 2008). APHIS cites an outdated figure for glyphosate-resistant infested acreage of "approximately two million acres of farmland in the U.S." (DEA at 42). As discussed below, the true figure is indisputably at least 30-40 million acres.[7]

Below, we reproduce the key passages in which APHIS discusses current HPPD inhibitor-resistant weed populations, and assesses the potential for FG72 soybeans to foster more resistant HPPD-resistant biotypes. Passages in the DEA with errors, omissions and/or faulty analysis are underlined, followed by our explanatory comments (bolded and italicized).

> "Since 2009, four populations of common waterhemp in Illinois, Iowa, and Nebraska corn fields were reported to be resistant to 4-HPPD inhibitors (Heap, 2011b). While three of these biotypes were resistant to the triketone family of 4-HPPD inhibitors, cross-family resistance to IFT [isoxaflutole] may be possible. One example of this was found in 2011 in a common waterhemp biotype from Iowa that displayed cross-family resistance to triketone-based 4-HPPD inhibitors as well as IFT (Heap, 2011b)." (DEA at 43).
>
> ***The 2011 common waterhemp biotype referred to here is resistant not only to IFT (isoxaflutole) and at least one triketone HPPD inhibitor (mesotrione), but also to two other modes of action: glyphosate and ALS inhibitors (see record on next page). The significance of this omission is discussed below.***
>
> "Since 2009, four populations of common waterhemp in Illinois, Iowa, and Nebraska were reported to be resistant to 4-HPPD inhibitors (Heap, 2011b). Despite the four reported cases, only one waterhemp population (Mclean County, IL) was studied in detail (Hausman et al., 2011; Syngenta, 2010). In the Mclean County population (which also possessed non-target site atrazine resistance), development of 4-HPPD resistance was generally linked to seed corn production and its respective management strategies that precluded the application of pre-emergent and broad-spectrum

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[6] See http://www.weedscience.org/Details/Case.aspx?ResistID=5576. Note that this biotype emerged in corn and soybeans (apparently field corn/soybeans), not seed corn production fields; and also that the two Palmer amaranth biotypes were first reported in December of 2012, after the April 2012 date of the draft EA.

[7] APHIS made precisely the same error in its Environmental Impact Statement for Roundup Ready alfalfa, and was corrected by CFS, yet this significant error is repeated.

herbicides.” As a result, 4-HPPD inhibitors were used without MoA rotation over the course of seven growing seasons (2003 – 2009) (Hausman et al., 2011).“ (DEA at 58)

First, three of the four HPPD-resistant waterhemp biotypes (including the McLean County population) are resistant to three modes of action: ALS inhibitors (omitted by APHIS) in all 3 cases; atrazine in two; and glyphosate in the third (also omitted, the 2011 Iowa biotype noted above). Second, APHIS misreports the study it cites, Hausman et al (2011). Table 1 of that paper clearly states that two pre-emergence herbicides with differing modes of action (S-metolachlor + simazine) were used in every year from 2003 to 2009, directly contradicting APHIS's contention that use of “pre-emergent” herbicides was “precluded.” (Two post-emergence herbicides were also used in every year.) Third, Hausman (2012) (not consulted by APHIS) reports experiments confirming that the McLean County population was not controlled by S-metolachlor, demonstrating that this biotype has at least substantial tolerance to this fourth mode of action (chloracetamides) in addition to resistance to three others.

Last updated	**December 9, 2011**
Common Name	**Common Waterhemp**
Species	*Amaranthus tuberculatus (syn. rudis)*
Group	ALS inhibitors (**B/2**) 4-HPPD inhibitors (**F2/27**) Glycines (**G/9**)
Herbicides	chlorimuron-ethyl, glyphosate, imazamethabenz-methyl, isoxaflutole, mesotrione, and thifensulfuron-methyl
Location	United States
Year	2011
Situation(s)	Corn (maize), and Soybean
Contributors	Micheal Owen

Source: http://www.weedscience.org/Details/Case.aspx?ResistID=5576, last visited 8/31/13.

“The conditions leading to the advent of at least one of these reported cases is not likely to be common in FG72 soybean fields. In the Illinois biotype found in 2009, an absence of crop and herbicide rotation in the corn seed production field contributed to the development of 4-HPPD resistance (Hausman et al., 2011). Unlike seed corn production fields, however, the majority of soybean production fields are rotated with another crop (USDA-ERS, 2011b). FG72 soybean fields are not anticipated to be any different. Under the Preferred Alternative, FG72 soybean will permit the pre-emergent use of both glyphosate and IFT; pre-emergent use of an herbicide was sufficient to control this population of 4-HPPD resistant waterhemp (Syngenta, 2010)." (DEA at 43)

First, as noted above APHIS focuses on only one of four HPPD-resistant waterhemp populations, one that evolved in continuous seed corn production. Two of the four, however, apparently evolved in field corn, which is commonly rotated with soybeans;[8] thus, both crop and herbicide rotation was not effective in forestalling resistance in these cases.

Second, although FG72 soybeans would likely be rotated "with another crop," the other crop will in most cases be corn, to which isoxaflutole and other HPPD inhibitors are often applied (in 2010, 26% of corn acres were treated with an HPPD inhibitor, 7% with isoxaflutole[9]). Thus, in many cases where FG72 soybeans are grown, HPPD inhibitors will be applied every year on both FG72 soy and rotational corn, undermining the benefit of crop rotation in forestalling resistance.

APHIS also mistakenly says that FG72 soybeans "will permit pre-emergent use of ... glyphosate," when in fact it enables post-emergence use of glyphosate (and either PRE or POST application of IFT). Glyphosate would be ineffective on the biotype with dual-resistance to glyphosate and IFT noted above. More importantly, we discuss further below the millions of acres of cropland infested with glyphosate-resistant waterhemp, where use of glyphosate and IFT would be tantamount to one effective mode of action (IFT), thus likely foster rapid evolution of dual resistance to both herbicides.

Finally, "pre-emergent use of an herbicide" was NOT sufficient to control the HPPD-resistant waterhemp population, as APHIS claims, citing a Syngenta press release (Syngenta 2010). In fact, Syngenta claims that THREE herbicides combined (mesotrione, S-metolachlor and atrazine) provided effective control when applied pre-emergence, not just one. Even this claim is suspect, however, given the resistance of this waterhemp population to applications, individually, of mesotrione and atrazine, and its tolerance to S-metolachlor, as reported by Hausman (2012); and also because Syngenta reported this in a press release rather than a peer-reviewed study,

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[8] See http://www.weedscience.org/Details/Case.aspx?ResistID=5491 and http://www.weedscience.org/Details/Case.aspx?ResistID=5490, last visited 8/31/13.

[9] USDA NASS (2011). Agricultural Chemical Usage for 2010, USDA National Agricutlural Statistics Service, May 25, 2011. See spreadsheet for corn pesticides at: http://www.nass.usda.gov/Data_and_Statistics/Pre-Defined_Queries/2010_Corn_Upland_Cotton_Fall_Potatoes/index.asp. HPPD inhibitors reported for corn are mesotrione (17%), isoxaflutole (7%) and topramezone (2%).

> ***manufactures all three herbicides, and has an interest in downplaying weed resistance to its products. Even if effective, this example illustrates well how resistance leads to intensive use of multiple toxic herbicides, which is of course undesireable from a human health and environmental perspective.***

Two Palmer amaranth biotypes resistant to HPPD inhibitors were reported in December 2012, after APHIS's completion of the draft EA.[10] Both were reported in field corn situations. Both are resistant to three triketone HPPD inhibitors: mesotrione, tembotrione and topramezone. One is also resistant to a fourth HPPD inhibitor – pyrasulfotole – in the same HPPD inhibitor subclass (isoxazole) as isoxaflutole, and so may well also be resistant to the latter. This same population is additionally resistant to atrazine and ALS inhibitors. As discussed further below, Palmer amaranth is an extremely serious weed, widely resistant to glyphosate and other herbicides. The fact that it is of the same *Amaranthus* genus as waterhemp suggests that this family of extremely problematic weeds has a proclivity to evolve resisance to HPPD inhibitors as well as other herbicides.

The above discussion makes clear that, contrary to APHIS, the introduction of FG72 soybeans is quite likely to lead to substantial weed resistance to isoxaflutole, often in weeds already resistant to two, three or four other modes of action. Below, we provide a more general discussion of weed resistance, including an analysis of how post-emergence use of herbicides enabled by herbicide-resistant crop systems fosters more rapid evolution of resistant weeds than other uses of the same herbicides; information on particularly problematic herbicide-resistant weeds whose impacts would be exacerbated by additional resistance to isoxaflutole; the costs of herbicide-resistance; and the need for truly integrated weed management that prioritizes non-chemical modes of weed management.

c. Weed management vs. weed eradication

Weeds can compete with crop plants for nutrients, water and sunlight, and thereby inhibit crop growth and potentially reduce yield. While less dramatic than the ravages of insect pests and disease agents, weeds nevertheless present farmers with a more consistent challenge from year to year. However, properly managed weeds need not interfere with crop growth. For instance, organically managed corn has been shown to yield as well as conventionally grown varieties despite several-fold higher weed densities (Ryan et al. 2010). Long-term cropping trials at the Rodale Institute reveal that average yields of organically grown soybean were equivalent to those of conventionally grown soybean, despite six times greater weed biomass in the organic system (Ryan et al. 2009). Weeds can even benefit crops – by providing ground cover

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[10] See http://www.weedscience.org/Details/Case.aspx?ResistID=5705 and http://www.weedscience.org/Details/Case.aspx?ResistID=5700, last visited 9/1/13.

that inhibits soil erosion and attendant loss of soil nutrients, habitat for beneficial organisms such as ground beetles that consume weed seeds, and organic matter that when returned to the soil increases fertility and soil tilth (Liebman 1993). These complex interrelationships between crops and weeds would seem to call for an approach characterized by careful management rather than indiscriminate eradication of weeds.

Farmers have developed many non-chemical weed management techniques, techniques that often provide multiple benefits, and which might not be utilized specifically or primarily for weed control (see generally Liebman and Davis 2009). For instance, crop rotation has been shown to significantly reduce weed densities versus monoculture situations where the same crop is grown each year (Liebman 1993). Cover crops – plants other than the main cash crop that are usually seeded in the fall and killed off in the spring – provide weed suppression benefits through exudation of allelopathic compounds into the soil that inhibit weed germination, and when terminated in the spring provide a weed-suppressive mat for the follow-on main crop. Common cover crops include cereals (rye, oats, wheat, barley), grasses (ryegrass, sudangrass), and legumes (hairy vetch and various clovers). Intercropping – seeding an additional crop amidst the main crop – suppresses weeds by acting as a living mulch that competes with and crowds out weeds, and can provide additional income as well (Liebman 1993). One common example is intercropping oats with alfalfa. Higher planting densities can result in more rapid closure of the crop "canopy," which shades out and so inhibits the growth of weeds. Fertilization practices that favor crop over weeds include injection of manure below the soil surface rather than broadcast application over the surface. Techniques that conserve weed seed predators, such as ground beetles, can reduce the "weed seed bank" and so lower weed pressure. In addition, judicious use of tillage need not cause significant soil erosion, and is also a useful means to control weeds.

Unfortunately, with the exception of crop rotation and tillage, such techniques are little used in mainstream agriculture. This is in no way inevitable. Education and outreach by extension officers, financial incentives to adopt improved practices, and regulatory requirements are just a few of the mechanisms that could be utilized to encourage adoption of more integrated weed management systems (IWM) that prioritize non-chemical tactics (Mortensen et al. 2012). Meanwhile, the problems generated by the prevailing chemical-intensive approach to weed control are becoming ever more serious. APHIS provides no assessment of IWM systems or non-chemical tactics as an alternative to deregulation of FG72 soybean for the stated purpose of Bayer's product, to provide a means to control glyphosate-resistant weeds (DEA at 3).

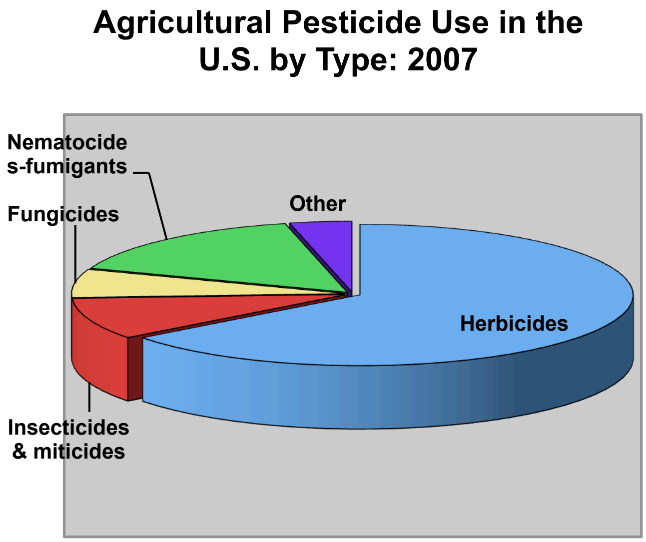
d. The high costs of herbicide-only weed control

In 2007, U.S. farmers spent $4.2 billion dollars to apply 442 million lbs of herbicide, and uncounted billions more on technology fees for herbicide-resistance traits in major crops. Overall, the U.S. accounts for one-quarter of world herbicide use (EPA

Pesticide Use 2011, Tables 3.1, 5.2, 5.6). Surely this intensive herbicidal onslaught should make American fields among the most weed-free in the world. But such is not the case. As farmers gradually came to rely more on herbicides as the preferred and then often the sole means to control weeds, herbicide-resistant weeds have become increasingly severe and costly.

The first major wave of herbicide-resistance came in the 1970s and 1980s as weeds evolved resistance to the heavily used triazines, such as atrazine (see Benbrook 2009 for this discussion). The next major wave of resistance comprised weeds resistant to ALS inhibiting herbicides in the 1980s and 1990s. Just five years intervened between introduction of the first ALS inhibitor herbicide in 1982 and the first resistant weed population (1987). One of the major factors persuading farmers to adopt Roundup Ready, glyphosate-resistant crops was the prevalence of weeds resistant to ALS inhibitors. Weeds have evolved resistance at least 21 "modes of action," or herbicide classes, in the world (ISHRW HR Weed Ranking 4/22/11).

According to the USDA's Agricultural Research Service, up to 25% of pest (including weed) control expenditures are spent to manage pesticide (including herbicide) resistance in the target pest (USDA ARS Action Plan 2008-13-App. II). With an estimated $7 billion spent each year on chemical-intensive weed control (USDA ARS IWMU-1), herbicide-resistant weeds thus cost U.S. growers roughly $1.7 billion (0.25 x $7 billion) annually. These expenditures to manage resistance equate to tens and perhaps over 100 million lbs of the over 400 million lbs of agricultural herbicide active ingredient applied to American crops each year (see figure below), as growers increase rates and make additional applications to kill expanding populations of resistant weeds



Herbicides comprise by far the largest category of pesticides, defined as any chemical used to kill plant, insect or disease-causing pests. In 2007, the last year for which the Environmental

Protection Agency has published comprehensive data, weedkillers (herbicides) accounted for 442 million lbs of the 684 million lbs of chemical pesticides used in U.S. agriculture, nearly seven-fold more than the insecticides that many associate with the term "pesticide." Source: "Pesticides Industry Sales and Usage: 2006 and 2007 Market Estimates," U.S. Environmental Protection Agency, 2011, Table 3.4 (EPA Pesticide Use 2011 in supporting materials).

Increasing the rate and number of applications, however, rapidly leads to further resistance, followed by adding additional herbicides into the mix, beginning the resistance cycle all over again, just as overused antibiotics breed resistant bacteria. This process, dubbed the pesticide treadmill, has afflicted most major families of herbicides, and will only accelerate as U.S. agriculture becomes increasingly dependent on crops engineered for resistance to one or more members of this by far largest class of pesticides (Kilman 2010). APHIS provides no assessment of the impacts or costs to farmers of past herbicide use and the resistant weeds it has triggered, an assessment that it critical to inform a similar analysis of FG72 soybean's impacts.

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 (USDA ERS AREI 2000). Little is known about the chronic, long-term effects of exposure to low doses of many pesticides, especially in combinations. Pesticides deemed relatively safe and widely used for decades (e.g. cyanazine) have had to be banned in light of scientific studies demonstrating harm to human health or the environment. Pesticides also pollute surface and ground water, harming amphibians, fish and other wildlife.

Herbicide-resistant weeds thus lead directly to adverse impacts on farmers, the environment and public health. Adverse impacts include the increased costs incurred by growers for additional herbicides to control them, greater farmer exposure to herbicides and consumer exposure to herbicide residues in food and water, soil erosion and greater fuel use and emissions from increased use of mechanical tillage to control resistant weeds, environmental impacts from herbicide runoff, and in some cases substantial labor costs for manual weed control. These are some of the costs of unsustainable weed control practices, the clearest manifestation of which is evolution of herbicide-resistant weeds. APHIS provides no meaningful assessment of the costs to farmers or U.S. agriculture from the reasonably foreseeable evolution of weeds resistant to isoxaflutole or glufosinate.

e. Why herbicide-resistant crop systems promote rapid evolution of resistant weeds

Herbicide-resistant (HR) crop systems such as FG72 soybean involve pre- and postemergence application of one or more herbicides to a crop that has been bred or genetically engineered to survive application of the herbicide(s). These HR crop systems promote more rapid evolution of herbicide-resistant weeds than non-HR crop uses of the associated herbicides. This is explained by several characteristic features of these crop systems.

HR crops foster more ***frequent*** use of and ***overreliance*** on the herbicide(s) they are engineered to resist. When widely adopted, they also lead to more ***extensive*** use of HR crop-associated herbicide(s). Herbicide use on HR crops also tends to occur ***later in the season***, when weeds are larger. Each of these factors contributes to rapid evolution of resistant weeds by favoring the survival and propagation of initially rare individuals that have genetic mutations lending them resistance. Over time, as their susceptible brethren are killed off, these rare individuals become more numerous, and eventually dominate the weed population.

High frequency of use means frequent suppression of susceptible weeds, offering (at frequent intervals) a competition-free environment for any resistant individuals to thrive. Overreliance on the HR crop-associated herbicide(s) means little opportunity for resistant individuals to be killed off by alternative weed control methods, thus increasing the likelihood they will survive to propagate and dominate the local weed population. Widespread use of the HR crop system increases the number of individual weeds exposed to the associated herbicide(s), thus increasing the likelihood that there exists among them those individuals with the rare genetic predisposition that confers resistance. The delay in application fostered by HR crop systems means more weeds become larger and more difficult to kill; thus, a greater proportion of weeds survive to sexual maturity, and any resistant individuals among them are more likely to propagate resistance via cross-pollination of susceptible individuals or through deposition of resistant seeds in the seed bank; in short, a higher likelihood of resistance evolution.

Below, we discuss these resistant weed-promoting features of HR crop systems in more detail, with particular reference to systems involving glyphosate-resistance (Roundup Ready crops).

GE seeds in general, including HR seeds, are substantially more expensive than conventional seeds (Benbrook 2009b). Their higher cost is attributable to a substantial premium (often called a technology fee) for the herbicide-resistance trait. This premium constitutes a financial incentive for the grower to fully exploit the trait through frequent and often exclusive use of the associated herbicide(s), and a disincentive to incur additional costs by purchasing other, often more expensive herbicides.

> The cost of RR [Roundup Ready] alfalfa seed, including the technology fee, is generally twice or more than that of conventional alfalfa seed. Naturally, growers will want to recoup their investment as quickly as possible. Therefore, considerable economic incentive exists for the

> producer to rely solely on repeated glyphosate applications alone as a weed control program. (Orloff et al. 2009, p. 9).

Overreliance is especially favored when the associated herbicide(s) are effective at killing a broad range of weeds, which tends to make other weed control practices less needed, at least until weed resistance emerges. Glyphosate is such a broad-spectrum herbicide; and so is isoxaflutole, although it is not as effective on grasses. Applied together or sequentially, glyphosate and isoxaflutole would initially provide broad-spectrum control of soybean weeds, making use of other weed control measures unnecessary until the inevitable evolution of isoxaflutole resistance, often in populations already resistant to glyphosate and/or other herbicides. Greater use of non-chemical weed control tactics is the only way to avoid the evolution of increasingly intractable, multiple HR weeds.

One of the key changes wrought by herbicide-resistant crop systems is a strong shift to "post-emergence"[11] herbicide application, which generally occurs later in the season on larger weeds, versus early-season use on smaller weeds or prior to weed emergence that is more characteristic of conventional crops. It is important to understand that facilitation of post-emergence herbicide use as the sole or primary means of weed control is the *sine qua non* of HR crop systems, not an incidental feature. Early-season uses include soil-applied herbicides put down around time of planting; these herbicides have residual activity to kill emerging weeds for weeks after application. The Roundup Ready soybean system has practically eliminated use of soil-applied, or indeed of any herbicide other than glyphosate. FG72 soybean would enable both pre-emergence and post-emergence use of isoxaflutole, though given the popularity of total POST weed control fostered by Roundup Ready crops, it is likely that farmers would more frequently apply isoxaflutole post-emergence.

As discussed further below, this tendency for weeds to mimic the herbicide resistances in the crop is a general feature of HR crop systems, and sets up a futile and costly chemical arms race between HR crops and weeds. APHIS fails to provide any assessment of the special proclivity of HR crop systems, or FG72 soybean in particular, to trigger evolution of resistant weeds. In order to assess the impacts of FG72 soybean, APHIS needs more specific information on projected use of these herbicides. This is a serious deficiency, as APHIS concedes frequently that it is the emergence of glyphosate-resistant weeds that forms the rationale for FG72 soybean.

f. Overview of glyphosate-resistant crops and weeds

A discussion of glyphosate-resistant crops and weeds is important for two reasons. First, the rapid emergence of GR weeds in RR crop systems is evidence of the resistant

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[11] That is, application after the seed has sprouted or "emerged," through much of the crop's life. Post-emergence use is often not possible, or only at lower rates, with conventional crops, which would thereby be killed or injured.

weed-promoting effect of HR crop systems in general, as discussed above, and provides insight into the risks of resistant weed evolution in the context of the FG72 soybean system. Second, the prevalence of glyphosate-resistant weeds is the motivating factor in Bayer CropScience's introduction and farmers' potential adoption of FG72 soybean.

Glyphosate-resistant crops represent by far the major HR crop system in American and world agriculture, and provide an exemplary lesson in how HR crop systems trigger HR weeds (see Benbrook 2009a for following discussion). Glyphosate was first introduced in 1974. Despite considerable use of the herbicide, for the next 22 years there were no confirmed reports of glyphosate-resistant weeds. A few small and isolated populations of resistant weeds – mainly rigid and Italian ryegrass and goosegrass – emerged in the late 1990s, attributable to intensive glyphosate use in orchards (e.g. Malaysia, Chile, California) or in wheat production (Australia).

Significant populations of glyphosate-resistant weeds have only emerged since the year 2000, four years after the first Roundup Ready (RR) crop system (RR soybeans) was introduced in 1996, followed by RR cotton & canola in 1997 and RR soybean in 1998 (Monsanto History undated). According to the International Survey of Herbicide-Resistant Weeds (ISHRW), multiple populations of 24 weed species are resistant to glyphosate in one or more countries today; of these, 30 populations of 11 species are also resistant to herbicides in one to three other families of chemistry in addition to glyphosate.[12] Based on acreage infested, GR weeds have emerged overwhelmingly in soybeans, cotton and soybean in countries, primarily the U.S., where RR crop systems predominate (see CFS RRSB 2010, which has further analysis of GR weeds).

The first glyphosate-resistant (GR) weed population confirmed in the U.S., reported in 1998, was rigid ryegrass, infesting several thousand acres in California almond orchards (ISHRW GR Weeds 4/22/12). Beginning in the year 2000 in Delaware, glyphosate-resistant horseweed rapidly emerged in Roundup Ready soybeans and cotton in the East and South. Just twelve years later, glyphosate-resistant biotypes of 14 species are now found in the U.S., and they infest millions of acres of cropland in at least 31 states.[13]

Based on Center for Food Safety's periodic compilation of data from the ISHRW website over the past four years, glyphosate-resistant weeds in the U.S. have evolved at an accelerated rate in recent years.[14] As of November 2007, ISHRW recorded eight weed species resistant to glyphosate, covering up to 3,200 sites on up to 2.4 million acres. By early 2012, as many as 239,851 sites on up to 16,683,100 acres were documented to be infested by glyphosate-resistant weeds (CFS GR Weed List 2012). This astonishing proliferation of resistant weeds – an over 70-fold increase in number

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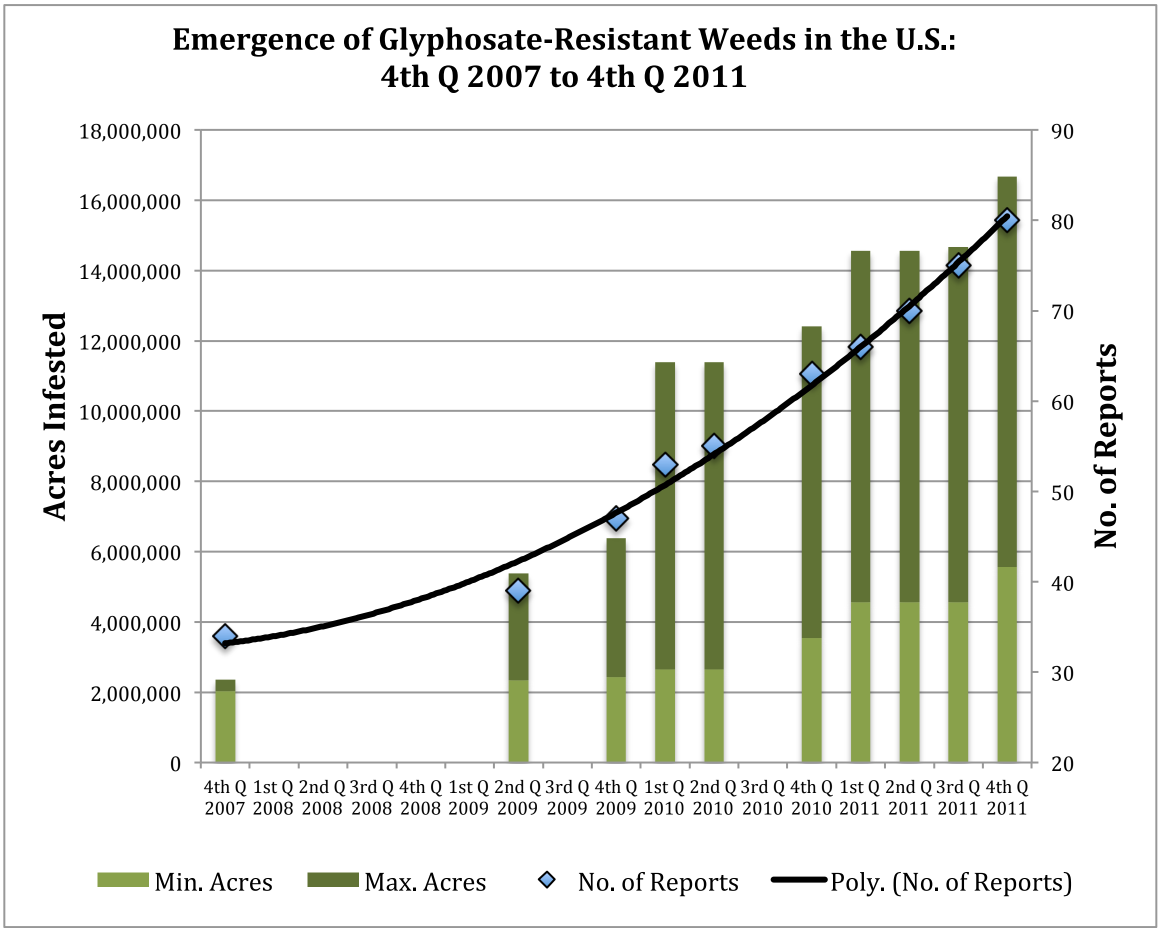
[12] See www.weedscience.com, select weeds resistant to glycines (i.e. glyphosate), last visited 9/1/13.

[13] See www.weedscience.com.

[14] ISHRW redesigned its database at www.weedscience.com several months ago, and no longer reports the acreage-infested data formerly available, and upon which the following discussion is based.

of sites and 7-fold increase in acreage – is portrayed in the figure at the end of this section. This chart and two additional charts portraying GR weeds by crop setting and farm production region are found in the file entitled at CFS GR Weed Charts (2012). The true extent of GR weeds is greater than even the maximum figures shown in the graph, because "...the voluntary basis of the contributions likely results in underestimation of the extent of resistance to herbicides, including glyphosate" (NRC 2010, p. 2-12). Many examples could be cited to illustrate to what extent ISHRW underestimates the extent of GR weed populations, but one will suffice. Illinois weed scientist Bryan Young recently reported 5-6 million acres of Illinois cropland infested with glyphosate-resistant waterhemp (as quoted in Lawton 2012, confirmed with Dr. Young, personal communication). Yet ISHRW lists GR waterhemp as infesting just 100 acres in Illinois (ISHRW Illinois Waterhemp). Inclusion of this single updated report in the ISHRW system would raise the GR weed infested acreage by one-third. It appears that much or all of this waterhemp is resistant to ALS inhibitors as well, with a significant portion also resistant to PPO inhibitors and/or triazine herbicides (Tranel 2010).



Legend: This chart plots data on glyphosate-resistant weeds in the U.S. compiled from the International Survey of Herbicide-Resistant Weeds (ISHRW) as of December 31, 2011. See CFS GR Weed List (2012) for the data upon which this chart is based. The ISHRW lists reports of confirmed herbicide-resistant weeds submitted by weed scientists.[15] Each report normally contains the year of discovery, the number of sites and acreage infested by the resistant weed population, the crop or non-crop setting where the weed was found, whether or not the population is expanding, and date the report was last updated. Note that months to several years can elapse before a putative resistant weed population is confirmed as resistant and listed on the website. ISHRW reports sites and acreage infested in ranges due to the difficulty of making precise point estimates. CFS aggregated ISHRW data for all glyphosate-resistant weed reports on ten dates – 11/21/07, 2/2/09, 11/19/09, 2/25/10, 5/18/10, 11/30/10, 1/6/11, 7/5/11, 9/28/11 and 12/31/11 – corresponding to the ten bars in the graph above. The bars were assigned to the appropriate quarterly period on the x-axis. The minimum and maximum acreage values represent the aggregate lower- and upper-bound acreage infested by all glyphosate-resistant weeds listed by ISHRW on the given date. The number of reports is plotted on the secondary y-axis. ISHRW organizer Dr. Ian Heap made a point estimate of 10.4 million acres infested with GR weeds in May of 2010,[16] when the maximum acreage infested was 11.4 million acres. This suggests that the upper-bound estimates more closely approximate real world conditions. However, many reports of glyphosate-resistant weeds in the farm press and scientific literature are never recorded by ISHRW because it is a voluntary reporting system; in other cases, old reports are not updated to reflect expanded populations. Thus, the actual acreage infested by GR weeds is likely even higher than the maximum acreage shown here.

Dr. Ian Heap, who manages the ISHRW website cited above, confirms that: "The survey is definitely too low because researchers report the first cases and enter in the area infested. Often they don't return in subsequent years to keep updating the survey." Dr. Heap estimates that "there are about 40 million acres affected by glyphosate-resistant weeds," but notes that if one accounts for "overlapping acres" infested with more than one GR weed, "the estimate probably comes down to about 30 million actual acres" (Heap 2012). Thus, actual acreage infested with glyphosate-resistant weeds is roughly double the 16.7 million acres reported by ISHRW and shown in the figure below. However, the figure can be assumed to accurately capture the rate of GR weed emergence. Agricultural consulting firm Stratus Agri-Marketing, Inc. estimates over 60 million acres infested with GR weeds on half of U.S. farms (Fraser 2013).

Early on, most resistant weed populations were driven by intensive glyphosate use associated with RR soybeans and RR cotton. However, adoption of corn with the Roundup Ready trait has increased sharply in recent years, from 20% to 72% of national corn acres from just 2004 to 2011. The increasing reliance on glyphosate associated with the growing use of RR corn/RR soybean rotations is likely responsible for the rapid emergence of resistant weeds in the Midwest and Northern Plain states. In general, more GR weeds are emerging on agricultural land planted to several crops that are predominantly Roundup Ready in the U.S., which since 2008 includes sugar beets. The most recent example is the emergence of GR common waterhemp on land

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[15] Each report may be accessed by (and corresponds to) a link at: http://www.weedscience.org/Summary/UspeciesMOA.asp?lstMOAID=12&FmHRACGroup=Go.

[16] "WSSA supports NRC Findings on Weed Control," Weed Science Society of America, 5/27/10. Dr. Heap is cited for the statement that 6% of total area planted to soybean, soybean and cotton in the U.S. [which is 173 million acres] is infested with GR weeds. http://www.wssa.net/WSSA/Information/WSSA%20position%20paper%20on%20herbicide%20resistance%205-27-2010.pdf.

planted to corn, soybeans and sugar beets in North Dakota (ISHRW GR Weeds 4/22/12).

Populations of some glyphosate-resistant weeds, such as GR Palmer amaranth, GR horseweed, GR giant ragweed, and GR common waterhemp, are properly regarded as noxious weeds. The increased use of herbicides and increased use of soil-eroding tillage operations to control them cause harm to the environment and natural resources (e.g. loss of soil and increased runoff of agricultural chemicals). When not properly managed due to the difficulty of controlling them, these noxious weeds can sharply reduce yields, while successful control efforts often involve a several-fold increase in weed control costs, in either case harms to the interests of agriculture. A brief, documented overview of these harms is provided in Benbrook (2009a, Chapter 4).

As noted above, APHIS vastly underestimates acreage infested with GR weeds (2 million rather than 30-60 million acres) by citing a six-year old figure, and otherwise provides essentially no analysis (DEA at 42 -43, 57–59), a significant flaw in the DEA for several reasons. First, the rapid emergence of GR weeds in RR crop systems is evidence of the resistant weed-promoting effect of HR crop systems in general, as discussed above, and a proper analysis would have provided APHIS with important insights into the risks of resistant weed evolution in the context of the FG72 soybean system. Second, APHIS repeatedly acknowledges that the prevalence of glyphosate-resistant weeds is the motivating factor in Bayer CropScience's introduction and farmers' potential adoption of FG72 soybean (e.g. DEA at 42). Without a proper understanding of the prevalence of GR weeds, it is impossible to gauge even roughly how widely FG72 soybean would be adopted, and the magnitude of increase in the use of herbicides, such as isoxaflutole and glufosinate, entailed by the proposed deregulation, both crucial factors in assessing the herbicide-resistant weed threat posed by the FG72 soybean system.

APHIS provides no empirical assessment of farmer use of resistant weed mitigation measures at all, but rather flaccidly relies on Bayer CropSciences's voluntary stewardship program (DEA at 58 - 59), which is quite similar to Monsanto's stewardship program for RR crops. APHIS knows that such stewardship has failed, otherwise GR weeds would not be such a serious problem; yet there is no assessment of the flaws of past stewardship plans or how they might be improved, which might have informed APHIS' assessment of the efficacy, if any, of Bayer CropScience's stewardship recommendations. APHIS should have assessed an alternative that included mandatory weed resistance management plans for FG72 soybean, as recently recommended by weed scientists from Nebraska and Illinois (Bernards et al. 2012), discussed below. These are all, to say the least, grave deficiencies in the DEA that demand redress in the context of an Environmental Impact Statement.

It is unlikely that use of both isoxaflutole and glyphosate on FG72 soybean, or glufosinate on FG72 stacked with glufosinate resistance, will hinder evolution of weeds resistant to any one of them. The argument that using the herbicides together will forestall resistance to any single one ignores the fact that the huge extent of existing GR weed populations – with many billions of individual weeds on roughly 30 million infested acres – make it near certain that some among them will have the rare genetic mutations conferring resistance to isoxaflutole or glufosinate ***as well***. Penn State weed scientists Mortensen et al. (2012) provide the mathematical exposition (emphasis added):

> First, when a herbicide with a new mode of action is introduced into a region or cropping system in which weeds resistant to an older mode of action are already widespread and problematic, the probability of selecting for multiple target-site resistance is not the product of two independent, low-probability mutations. In fact, the value is closer to the simple probability of finding a resistance mutation to the new mode of action within a population already extensively resistant to the old mode of action. For instance, in Tennessee, an estimated 0.8–2 million ha of soybean crops are infested with glyphosate-resistant horseweed (C. canadensis) (Heap 2011). Assuming seedling densities of 100 per m^2 or 10^6 per ha (Dauer et al. 2007) and a mutation frequency for synthetic auxin resistance of 10^{-9}, ***this implies that next spring, there will be 800–2000 horseweed seedlings in the infested area that possess combined resistance to glyphosate and a synthetic auxin herbicide*** ((2×10^6 ha infested with glyphosate resistance) x (10^6 seedlings per ha) x (1 synthetic auxin–resistant seedling per 10^9 seedlings) = 2000 multiple-resistant seedlings). In this example, these seedlings would be located in the very fields where farmers would most likely want to plant the new stacked glyphosate- and synthetic auxin–resistant soybean varieties (the fields where glyphosate-resistant horseweed problems are already acute). Once glyphosate and synthetic auxin herbicides have been applied to these fields and have killed the large number of susceptible genotypes, these few resistant individuals would have a strong competitive advantage and would be able to spread and multiply rapidly in the presence of the herbicide combination.

The upshot is that FG72 soybeans will very likely foster rapid evolution of weeds with additional resistance to isoxaflutole and/or glufosinate. In those cases where the GR weed populations already have resistance to one or more additional modes of action, the result will be evolution of still more intractable weeds with multiple-herbicide resistance, including to isoxaflutole and/or glufosinate.

APHIS must give a fair, balanced, and critical treatment of resistant weeds and other issues raised by FG72 soybean in the context of an EIS.

g. Multiple herbicide-resistant crops and weeds

Mortensen et al. (2012) note that there are currently 108 biotypes of 38 weed species possessing simultaneous resistance to two more classes of herbicide, and that 44% of them have appeared since 2005. Since herbicide-resistant weeds began to emerge in a significant way around 1970 (triazine-resistant weeds),[17] this means that nearly half of multiple HR weed biotypes have emerged in just the past seven years of our 40-year history of significant weed resistance. This global trend is also occurring in the U.S., where acreage infested with multiple HR weeds has increased by 400% over just the three years from November 2007 to November 2010 (Freese 2010, p. 15). There are at least 12 biotypes of weeds resistant to glyphosate and one or more other herbicide families in the U.S. (11) and Canada (1) that are attributable to RR crop systems, all but one having emerged since 2005 (ISHRW GR Weeds 4/22/12).

The progressive acquisition of resistances to different herbicide classes has the insidious effect of accelerating evolution of resistance to those ever fewer herbicides that remain effective, such as isoxaflutole. This is well-expressed by Bernards et al. (2012) with reference to multiple-herbicide-resistant waterhemp, though it applies more generally:

> The accumulation of multiple-resistance genes within populations and even within individual plants is of particular concern. This resistance stacking limits chemical options for managing waterhemp and, where weed management depends primarily on chemical weed control, results in additional selection pressure for the evolution of resistance to the few herbicides that are still effective.

There is already evidence of isoxaflutole resistance evolving in common waterhemp and Palmer amaranth already resistant to ALS inhibitors and either atrazine or glyphosate, as discussed above, raising the spector that this will also occur with three other especially problematic species of weeds: horseweed, Palmer amaranth and kochia, and in more populations of common waterhemp.

i. Horseweed

Horseweed, or marestail, is the most prevalent GR weed. First discovered in 2000 in Delaware, GR horseweed has emerged in just over a decade to infest up to 8.4 million acres in 20 states (CFS GR Weed List 2012[18]), up from 3.3 million acres in 16 states in February 2009 (Benbrook 2009a, p. 35). It is particularly prevalent in Tennessee, Kansas and Illinois, with populations infesting up to 5 million, 2 million and 1 million

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[17] A few auxin-resistant biotypes emerged in the 1950s and 1960s.

[18] Consult this chart for data in the following discussion. It should also be noted that these acreage-infested estimates are highly conservative, in view of the underreporting in the ISHRW system, as discussed above.

acres, respectively. GR horseweed in Mississippi is also resistant to paraquat, the first time multiple resistance to these two herbicides has been documented, while Ohio has glyphosate/ALS inhibitor-resistant[19] horseweed.

Weed scientists regard GR horseweed as a "worst-case scenario" in RR cropping systems because this weed is well adapted to no-tillage planting systems popular among GR crop growers. It also produces up to 200,000 seeds per plant, and its seeds can disperse extremely long distances in the wind (Owen 2008), which may partly explain the prevalence of GR horseweed.

GR horseweed can reduce cotton yields by 40 to 70% (Laws 2006), and is also problematic in soybeans. As long ago as 2003, Arkansas weed scientist Ken Smith estimated that Arkansas growers would have to spend as much as $9 million to combat glyphosate-resistant horseweed in 2004 (AP 2003). An uncontrolled outbreak of GR horseweed in Arkansas could reduce the income of cotton and soybean farmers by nearly $500 million, based on projected loss in yield of 50% in 900,000 acres of cotton and a 25% yield loss in the over three million acres of soybeans (James 2005). Tennessee is especially hard hit, with up to 5 million acres of both cotton and soybeans infested with GR horseweed.

Because GR horseweed is often controlled with tillage, it has led to abandonment of conservation tillage practices on substantial cotton acreage in Tennessee and Arkansas, with similar trends reported in Mississippi and Missouri (Laws 2006) and perhaps other states. This in turn increases soil erosion. An NRC committee reported that increased tillage and increased herbicide use are common responses to glyphosate-resistant weeds (NRC 2010). Evolution of multiple herbicide-resistance reduces options for chemical control and so increases the chances for still more soil-eroding tillage.

The many farmers with GR and multiple-HR horseweed would be prime candidates for FG72 soybean (DEA at 42). Yet Purdue University weed scientists have flagged horseweed as a weed with the genetic "plasticity" to readily evolve resistance to multiple herbicides:

> Multiple-resistant and cross-resistant horseweed populations have evolved to various combinations of the previous herbicide modes of action in Israel, Michigan, and Ohio (Heap 2009), providing evidence for the plasticity of this weed. (Kruger et al. 2010a).[20]

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[19] CFS suspects that GR weeds that are also resistant to ALS inhibitor herbicides are greatly underreported by ISHRW; this is certainly the case with common waterhemp (see discussion below).

[20] As noted above, horseweed has also evolved dual resistance to glyphosate and paraquat in Mississippi.

ii. Waterhemp

Waterhemp is regarded as one of the worst weeds in the Corn Belt. It grows to a height of 2-3 meters, and emerges late into the growing season. Controlled trials in Illinois demonstrated that late-season waterhemp reduced corn yields in Illinois by 13-59%, while waterhemp emerging throughout the season cut yields by up to 74% (Steckel and Sprague 2004).

ISHRW lists 14 biotypes of GR waterhemp, all of which have emerged since 2005 in corn, soybeans, cotton and/or sugar beets, almost certainly all in RR crop systems (CFS GR Weed List). While ISHRW records up to 1.1 million acres infested with GR waterhemp, this is a vast underestimate. As noted above, Illinois weed scientist Bryan Young estimates a substantial 5-6 million acres infested with GR waterhemp in his state.

Waterhemp has an astounding ability to evolve resistance to herbicides. Biotypes resistant to one to four herbicide families have been identified in several Midwest and Southern states, from North Dakota to Tennessee (see CFS GR Weed List 2012 and ISHRW GR Weeds for those resistant to glyphosate). Triple herbicide-resistant waterhemp infests up to one million acres in Missouri, while populations resistant to four herbicide classes, sardonically called "QuadStack Waterhemp" (Tranel 2010), have arisen in Illinois. Tranel's investigations suggest that the 5-6 million acres of GR waterhemp in Illinois noted above are all resistant to ALS inhibitors, with some additionally resistant to PPO inhibitors and/or triazines.

Tranel states that multiple herbicide-resistant waterhemp "appears to be on the threshold of becoming an unmanageable problem in soybean," and is quite concerned that if already multiple herbicide-resistant waterhemp evolves resistance to additional herbicides, "soybean production may not be practical in many Midwest fields" (Tranel et al. 2010).

We have already discussed the rapid emergence of HPPD-inhibitor-resistant common waterhemp, the fifth mode of action to which waterhemp has evolved resistance (Science Daily 2011), prompting weed scientist Aaron Hagar to comment that "we are running out of options" to control this weed. As discussed further below, Tranel et al. (2010) expect waterhemp to evolve resistance to glufosinate as well, which would undermine weed control tactics involving POST application of glufosinate in FG72 soybeans stacked with additional resistance to this herbicide.

Just months later, waterhemp resistant to its sixth mode of action, 2,4-D, was discovered, and it is potentially resistant to the popular corn herbicides atrazine and metolachlor as well, which would make it particularly difficult to manage (UNL 2011). The weed scientists who discovered this resistant weed population clearly understand the likelihood that 2,4-D resistant crop systems – "if used as the primary tool to manage weeds already resistant to other herbicides," the hallmark of these systems – will lead to still more intractable, multiple herbicide-resistant weeds:

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

In a peer-reviewed publication about this same waterhemp population, these scientists call for mandatory weed resistance prevention measures for 2,4-D-resistant soybean and similar HR crops:

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

This same caution applies to evolution of HPPD-inhibitor resistant weeds with introduction of FG72 soybeans.

Use of multiple herbicides is supposed to forestall evolution of resistance to any single herbicide, and is one of Bayer CropScience's stewardship suggestions (DEA at 58). This demonstrates the potential, discussed above with reference to glyphosate-resistant horseweed, for "resistance-stacking." More broadly, it casts doubt on the ability of multiple herbicide use on multiple herbicide-resistant crops such as FG72 soybean to forestall the emergence of herbicide-resistant weeds. On the contrary, Bernards and colleagues' call for mandatory stewardship practices suggests that HR crops, as explained above, are particularly prone to foster rapid evolution of weed resistance, and that voluntary stewardship programs are not working.

iii. Palmer amaranth

Perhaps the most destructive and feared weed in all of U.S. agriculture is glyphosate-resistant Palmer amaranth (see Benbrook 2009a, Chapter 4). Second only to GR horseweed in prevalence, GR Palmer amaranth is estimated to infest 112,000 to over 220,000 fields covering up to 7.0 million acres in 17 states. Best known for plaguing cotton and soybean growers in Southern states, this weed is rapidly emerging in Corn Belt states like Illinois and Missouri; a small population was even reported recently in Michigan (ISHRW GR Weed List 4/22/12) and also in Ohio (Ohio Farmer 2012). Still more recently, GR Palmer amaranth has emergend in Viriginia, Arizona, California and Delaware. Palmer amaranth is feared especially because of its extremely rapid growth – several inches per day – which means it can literally outgrow a busy farmer's best attempts to control it while still small enough to be killed. It also produces a huge number of seeds, so just one mature weed can ensure continuing problems in future years by pouring hundreds of thousands of resistant weed seeds into the "weed seed bank." Left unchecked, its stem can become baseball bat breadth, and is tough enough to damage cotton pickers. Glyphosate-resistant Palmer amaranth can dramatically cut yields by a third or more, and occasionally causes abandonment of cropland too weedy to salvage. In Georgia, Arkansas and other states, farmers have resorted to hiring weeding crews to manually hoe this weed on hundreds of thousands of acres, tripling weed control costs (Haire 2010). Herbicide regimes of six to eight different chemicals, including toxic organic arsenical herbicides such as MSMA otherwise being phased out (EPA 2009, p. 3), are recommended to control it (Culpepper and Kichler 2009).

At least three states (Mississippi, Georgia and Tennessee) have Palmer amaranth resistant to both glyphosate and ALS inhibitors; the most recent one, reported in 2011, infests over 100,000 sites covering up to 2 million acres in Tennessee (CFS GR Weed List 2012).

As discussed above, Palmer amaranth has also evolved resistance to HPPD inhibitors in Kansas and Nebraska, the former population exhibiting resistance to four HPPD inhibitor herbicides including pyrasulfotole (of the same subclass as isoxaflutole), as well as ALS inhibitors and atrazine. Thus, growers with GR and multiple HR Palmer amaranth would be prime candidates to adopt the FG72 soybean system. Isoxaflutole use with FG72 soybeans would likely foster rapid evolution of isoxaflutole resistance in Palmer amaranth, including in those populations already resistant to glyphosate, ALS inhibitors and/or atrazine, exacerbating the threat posed by this extremely problematic weed.

iv. Kochia

Kochia is a fourth serious weed, described further at CFS RRSB (2010). It has evolved widespread resistance to many different herbicides, and is on the ISHRW's list of the top ten most important herbicide-resistant weed species (ISHRW Worst HR Weeds). Limited populations of glyphosate-resistant kochia first emerged in Kansas in 2007, but recent reports suggest that it is now likely prevalent in the entire western third of Kansas (Stahlman et al. 2011). Subsequent GR kochia populations have been identified in South Dakota (2009), Nebraska (2011), and in Colorado, Montana, North Dakota and Alberta, Canada (all in 2012). Most of these populations have emerged in corn, soybeans and/or cotton (almost certainly RR versions), while several list cereals and "cropland" that may also include RR crops.

Stahlman et al. (2011) state that the original four populations in Kansas likely evolved glyphosate-resistance independently, but the rapid emergence across such a broad swath of the state suggests the potential for spread of the original populations, perhaps by resistant seed dispersal, as kochia "tumbleweed" can disperse seeds at considerable distances (see CFS RRSB 2010). CFS (2010) also documents that kochia is a serious weed of both alfalfa and sugarbeets, Roundup Ready versions of which have been recently introduced and are widely grown. GR kochia infesting these RR crops would seriously impair the efficacy of the RR trait; likewise, selection pressure from glyphosate use with these crop systems (especially in rotation with other RR crops, as seen particularly with RR sugar beets, which are frequently rotated with RR corn and/or RR soybeans) could rapidly lead to still more extensive emergence of GR kochia.

The FG72 soybean system has the potential to exacerbate the weed threat posed by kochia by fostering additional resistance to isoxaflutole.

h. Potential for glufosinate resistant weeds

FG72 soybeans are engineered with resistance traits for use with isoxaflutole and/or glyphosate, but glufosinate could also be applied if the trait is stacked with FG72 soybean. As discussed above, glufosinate use on soybeans has been growing rapidly since the 2009 introduction of LibertyLink soybeans, but is still used on just 1.3% of soybean acres. Overall use of glufosinate in U.S. agriculture is minuscule – estimated above at just 1.92 million lbs./year – in comparison to glyphosate, hence there has been much less selection pressure for weeds to evolve resistance to glufosinate. The entirely foreseeable emergence of weeds resistant to both isoxaflutole and glyphosate with the introduction of FG72 soybean would drive greater use of glufosinate in the future. However, there is already reason to question the efficacy of glufosinate in forestalling or managing resistance to isoxaflutole and/or glyphosate in the event that it were to be used.

Avila-Garcia and Mallory-Smith (2011) have recently discovered Italian ryegrass resistant to both glyphosate and glufosinate in an orchard with a history of glyphosate use, but where little or no glufosinate had been used, and suspect a common, non-target site mechanism – reduced translocation – for resistance to both herbicides. They regard the potential for evolution of resistance to both herbicides where both glyphosate- and glufosinate-resistant crops are grown as an "alarming weed management issue." Growers of FG72 soybean who have GR Italian ryegrass infestations would likely rely heavily on both isoxaflutole and glufosinate, since isoxaflutole is not as effective on grasses as on broadleaf weeds.

Tranel et al. (2010) find that glufosinate may soon be the only effective post-emergence herbicide option for control of already multiple-HR waterhemp in soybeans; that glufosinate is not well-suited to control this weed; and that "there is no reason to expect [waterhemp] will not evolve resistance to glufosinate if this herbicide is widely used." As noted above, waterhemp has already evolved massive resistance to glyphosate and has shown the ability to develop resistance to isoxaflutole as well.

Bayer CropScience's FG72 soybean is regarded as the "solution" to weeds resistant to glyphosate, ALS inhibitors, atrazine and other modes of action, just as RR crop systems were regarded as the solution to prior resistance, particularly epidemic ALS inhibitor-resistant weed populations in soybeans. As documented above, dual resistance to glyphosate and ALS inhibitors is quite common in weeds, particularly common waterhemp and Palmer amaranth. If HR crop systems really did "solve" resistant weed problems, one would certainly not expect multiple HR weeds to expand dramatically with their use – yet that is precisely what has happened with the Roundup Ready system. As also discussed above, there are already very good scientific reasons to suspect that the major near-term consequences of widespread use of FG72 soybean would be to foster resistance to isoxaflutole and glufosinate, with extremely serious consequences for farmers, the agricultural economy, the environment and public health.

i. Stewardship

It is highly doubtful whether Bayer CropScience's stewardship plan for FG72 soybean (DEA at 58) will be effective in forestalling weed resistance to isoxaflutole. For at least 15 years, companies and weed scientists have touted voluntary stewardship guidelines and best management practices as the chief bulwark against evolution of resistant weeds in the context of HR crop systems. These programs and exhortations have demonstrably failed with Roundup Ready crops, or there would not be an epidemic of glyphosate-resistant weeds. A critical assessment of Monsanto's failed stewardship messages, practices and actions may be useful to inform an assessment of Bayer CropScience's similar approach (DEA at 58).

Monsanto insisted that weeds would not evolve glyphosate resistance to any serious extent when RR crops were first being introduced, based mostly on assumptions concerning the presumed rarity of glyphosate-resistance mutations, the lack of glyphosate-resistant weed evolution up to that time, and nuances of the herbicide's mode of action (Bradshaw et al. 1997). Many weed scientists were not convinced, and called for serious measures to forestall evolution of GR weeds (Freese 2010, question 1). Monsanto introduced its RR crops as "RR crop systems" designed for sole reliance on glyphosate for weed control. Even several years after GR weeds had emerged, Monsanto promoted "glyphosate-only" weed control programs in farm press advertisements that leading weed scientists castigated as irresponsible for promoting weed resistance (Hartzler et al. 2004). Monsanto continues to advocate voluntary stewardship programs as an effective means to forestall or manage GR weeds, despite their obvious failure.

If Bayer CropScience was serious about stewardship, the company would include a requirement that farmers not use isoxaflutole with FG72 soybean and corn in sequential years, or on FG72 soybean in sequential years, providing some relief from selection pressure. This is because continual use of isoxaflutole and/or glyphosate on both corn and soybeans, year-in and year-out, is the surest way to foster rapid evolution of isoxaflutole-resistance in already glyphosate-resistant weeds.[21] Yet Bayer CropScience's stewardship plan for FG72 soybean has no such requirement. Instead, it suggests that growers "…apply no more than two applications of a single herbicide MoA to the same field in a two-year period" (DEA at 58). However, only one application of isoxaflutole is allowed per year, so even if isoxaflutole was applied year after year to the same acreage, this schedule would not violate the stewardship suggestion of "no more than two applications….in a two-year period".

Bernards et al. (2012) called for "mandatory stewardship practices" to accompany introduction of "soybean, cotton and corn resistant to 2,4-D and dicamba." Furthermore, the demand for "mandatory" practices is an implicit acknowledgement of the failure of voluntary programs such as Bayer CropScience's. In addition, APHIS has initiated environmental impact statements on 2,4-D and dicamba-resistant crop systems, specifically to assess the weed resistance threats they pose.[22] By precisely the same rationale, APHIS should further assess FG72 soybeans in the context of an EIS, and explicitly consider an alternative involving mandatory measures to forestall resistance to HPPD inhibitors. This is all the more needed in light of the serious errors and faulty analysis in APHIS's treatment of weed resistance as discussed above, and its failure to provide any critical assessment of Bayer CropScience's voluntary stewardship plan.

j. Spread of weed resistance and tragedy of the commons

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

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[21] As noted above, the increasing use of RR corn by farmers already growing RR soybeans led to continual, year-in, year-out glyphosate selection pressure that is the major factor driving GR weed evolution in the Midwest.

[22] See http://www.aphis.usda.gov/newsroom/2013/05/brs_24d_and_dicamba.shtml, last visited 9/1/13.

waterhemp pollen can remain viable for up to 120 hours, increasing the potential for spread of resistance traits.

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

Whether out-crossing or inbreeding, those resistant individuals with lightweight seeds can disperse at great distances. Dauer et al. (2009) found that the lightweight, airborne seeds of horseweed, the most prevalent GR weed (CFS GR Weed List 2012), can travel for tens to hundreds of kilometers in the wind, which is likely an important factor its prevalence. Hybridization among related weeds is another potential means by which resistance could be spread, for instance by weeds in the problematic *Amaranthus* genus (Gaines et al. 2012).

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

The weed science community as a whole has only begun to grapple with the implications of the ***spread*** of resistance, particularly as it relates to the efficacy of weed resistance management recommendations based solely on individual farmers reducing selection pressure. It may not be effective or rational for farmers to commit resources to resistance management in the absence some assurance that other farmers in their area will do likewise. This suggests the need for a wholly different approach that is capable of ensuring a high degree of area-wide adoption of sound weed resistance management practices. This represents still another reason to implement mandatory stewardship practices to forestall emergence of isoxaflutole-resistant weeds in the context of FG72 soybean and similar crops. APHIS did not assess the dispersal of herbicide resistance traits via pollen or seed dispersal or its implications for stewardship practices in the draft Environmental Assessment, another deficiency demanding redress in an EIS.

k. Volunteer FG72 soybean

Volunteer soybeans are not normally considered problematic weeds, but with the advent of RR soybeans there are some reports that glyphosate-resistance makes them more difficult to control. For instance, York et al. (2005) report that volunteer glyphosate-resistant soybean can be a problematic weed in glyphosate-resistant cotton planted the next season. They note in general that: "Volunteer crop plants are considered to be weeds because they can reduce crop yield and quality and reduce harvesting efficiency." York and colleagues tested several herbicidal options to control GR soybean volunteers, including pyrithiobac, trifloxysulfuron, and each herbicide mixed with MSMA, an arsenic-based herbicide that EPA is in the process of phasing out due to its toxicity, though an exemption has been made for continued use in cotton to control GR Palmer amaranth (EPA 2009). They also note that paraquat can be used to control GR soybean volunteers prior to emergence of cotton.

Some farmers have also reported problematic volunteer RR soybean in the following year's corn, and sought advice from extension agents on how to deal with it (Gunsolus 2010). Recommendations include use of 2,4-D, dicamba, atrazine and/or other herbicides. In both cases, it is glyphosate-resistance that has made volunteer soybean a control problem for farmers, and necessitated the use of more toxic herbicides for control.

FG72 soybean volunteers would possess resistance to isoxaflutole and glyphosate, and glufosinate (if stacked), making them a more difficult challenge for farmers, reducing herbicidal control options versus volunteers that have resistance only to glyphosate, and necessitating use of more toxic herbicides or tillage to control.

There is potential for FG72 soybean to cross with soybeans possessing other herbicide resistance traits to produce soybean volunteers with resistance to additional herbicides. Indeed, three different GE soybean events with resistance to dicamba (Monsanto), 2,4-D (Dow AgroSciences) and imidazolinone herbicides (BASF) are presently pending deregulation decisions by USDA (APHIS Pending Dereg 2012).[23] Such crossing could result in volunteer soybeans resistant to four or more classes of herbicide.

As a general matter, such "resistance stacking" speeds evolution to those herbicides that remain effective. It limits chemical options for managing weeds, and "where weed management depends primarily on chemical weed control, results in additional selection pressure for the evolution of resistance to the few herbicides that are still effective" (Bernards et al. 2012). While this statement was made with reference to HR waterhemp, it applies more generally to multiple HR weeds, including volunteer FG72 soybeans.

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

Soybean is primarily a self-pollinating crop, but the potential for perhaps considerable cross-pollination is suggested by the frequency with which pollinators – bees (honeybees and wild bees), wasps and flies – visit soybean fields (Anonymous 2012, O'Neal & Gill 2012). Insect pollinators are known to effect pollination at considerable distances from the source plants, including from primarily self-pollinating crops (e.g. Pasquet et al. 2008). Even if soybean cross-pollination is relatively uncommon, it could give rise to problematic volunteer HR soybean control problems where it does occur, with the adverse consequences noted above.

This potentially serious plant pest issue of resistance stacking in volunteers, presented by FG72 soybean, went completely unexamined in both the DEA and Plant Pest Risk Assessment (DEA at 41, DPPRA at 10).

7. Conservation tillage and environmental concerns

a. Overview of environmental impacts related to tillage

APHIS concludes that approving of FG72 soybean will have no greater impact on the environment and endangered species than the "no action" alternative (DEA at 23 – 24). In fact, APHIS finds that using the FG72 soybean crop system is likely to benefit the environment to the extent that it facilitates conservation tillage compared to the "No Action" alternative (e.g. DEA at 7, 26 – 27, 12, 36 – 37, 60).

These conclusions finding no difference in environmental impacts between approving and not approving of FG72 soybean have weak underpinnings in science. APHIS overestimates the contribution of herbicide resistant crops to adoption of no-till, and inflates the environmental benefits of herbicide dependent no-till methods. Also, APHIS does not factor in the unsustainable future of conservation tillage systems that are completely dependent on substituting herbicides for tillage and other non-chemical weed management tactics. Weeds develop resistance to herbicides more quickly inc the context of herbicide-resistant crop systems, thus herbicide-dependent conservation tillage will require more herbicides and a return to tillage as time goes by, as already discussed, negating any short-term benefits of soil retention.

Arguing that HR crops are environmentally beneficial because of their supposed role in fostering conservation tillage is a common way to promote development of new HR traits. Below, we critically assess the claim that herbicide-resistant crops have promoted or would promote or preserve conservation tillage. Second, we assess some of the claimed benefits of conservation tillage, finding that some are justified while others are greatly exaggerated, and that conservation tillage also has some negative impacts that APHIS did not assess.

b. Herbicide resistant crops not responsible for increased conservation tillage

APHIS links farmers' use of herbicide-resistant crops and cultivation practices that minimize soil erosion, known as conservation tillage; and then attributes to HR crops all manner of purported benefits commonly associated with conservation tillage: reduced soil erosion, declining CO2 emissions from soil, reduced fuel use on farm, as well as improved air and water quality (e.g. DEA at 16, 39, 43, 54). The great majority of herbicide-resistant crops have thus far been glyphosate-resistant, Roundup Ready varieties of soybeans, corn and cotton. APHIS presumes that FG72 soybean will have the same benefits as those claimed for Roundup Ready crops.

APHIS' argument is simple, following that of Bayer CropScience (Petition at 77 – 81). Glyphosate-resistant crop systems have promoted adoption of conservation tillage. At the same time, they have triggered massive emergence of glyphosate-resistant (GR) weeds. Increasingly intractable GR weeds have prompted some farmers to use tillage (mechanical weed control) to remove them, which is tantamount to abandonment of conservation tillage. Introduction of the FG72 soybean system would allow farmers to apply isoxaflutole in addition to glyphosate to kill weeds instead of using tillage, thereby "preserving" the conservation tillage benefits purportedly conferred by its predecessor HR system, glyphosate-resistant crops.

Even if one accepts this story at face value, it begs a very important question: If glyphosate-resistant crops promoted conservation tillage (in the short term), but are undermining it just a decade later, what is to stop FG72 soybean from triggering a repeat of this boom-bust cycle? On this point, neither APHIS nor Bayer CropScience has any satisfactory answers, and as discussed in the resistant weeds section of these comments above, it is quite clear that isoxaflutole-resistant crops will foster rapid evolution of isoxaflutole-resistant weeds and increased tillage to control them.

However, the argument presented by APHIS and Bayer CropScience fails on its face, as we demonstrate below. The following discussion may be summarized as follows.

First, there is considerable doubt concerning whether HR soybean cultivation is even correlated with conservation tillage practices.

Second, to the extent there is such a correlation, the causation is from prior adoption of conservation tillage to subsequent adoption of HR soybeans. In contrast, the adoption of HR crops does not predispose to greater use of conservation tillage.

Third, steeply declining soil erosion rates in the 1980s and the first half of the 1990s leveled out in the following decade of Roundup Ready crop adoption. These data are irreconcilable with the proposition that HR crops drive greater use of soil-saving cultivation regimes.

Fourth, soil-saving federal farm policies, not HR crops, were primarily responsible for increased use of conservation tillage and reduced soil erosion in American agriculture.

Fifth, HR crops in fact promote ***greater*** use of soil-eroding tillage to remove herbicide-resistant weeds, which the use of these crop systems fosters.

Finally, we show that some purported benefits APHIS attributes to conservation tillage are disputed in the scientific community, while in other cases this form of tillage appears to have adverse impacts.

i. Correlation in question

APHIS posits a ***correlation*** between adoption of RR soybeans and greater use of conservation tillage practices (DEA at 7). However, much of the data upon which this purported correlation is based come from suspect sources, such as the American Soybean Association, a lobby group that represents Monsanto and other large agrichemical-seed firms. In a widely cited assessment of the environmental impacts of glyphosate-resistant crops, Cerdeira and Duke (2006) note that:

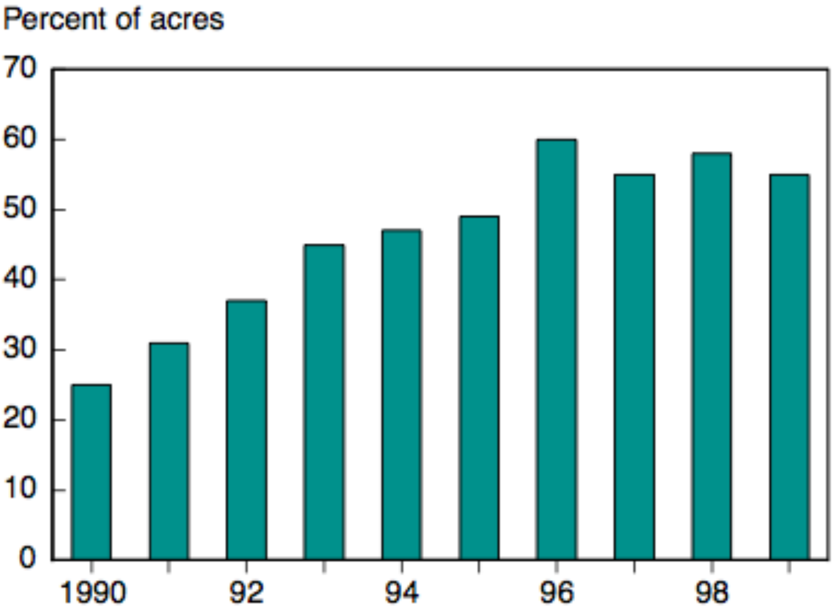
> Considering the relatively high level of potential environmental improvement that can be gained by reducing tillage, there is a remarkable paucity of refereed publications on the influence of GRCs [glyphosate-resistant crops] on tillage practices and associated environmental effects. (p. 1638).

Despite this caution, the authors proceed to base their discussion of purported reductions in soil loss and compaction from GR crop systems almost entirely on a survey conducted by the American Soybean Association (ASA) in 2001, a survey that was not subject to peer review or published in any "refereed publication." These ASA survey results are extremely difficult to reconcile with an assessment conducted the following year by USDA agricultural economists Jorge Fernandez-Cornejo and William McBride. These authors have shown that adoption of conservation tillage in soybean production rose sharply in the years ***prior to*** introduction of RR soybeans, then stagnated in at least the first four years of their cultivation (1996-1999).

> Adoption of conservation tillage for soybeans grew (at a decreasing rate) from about 25 percent of the soybean acreage in 1990 to 48 percent in 1995 (Fig. 11), the 5-year period previous to the introduction of herbicide-tolerant soybeans. Growth of conservation tillage increased further in 1996, but then appears to have stagnated between 50 and 60 percent in the following years (Fernandez-Cornejo & McBride 2002, p. 29).

Figure 11

Use of conservation tillage - soybeans



Source: Fernandez-Cornejo (2000) based on USDA data (USDA, 1997a updated from ARMS).

From: Fernandez-Cornejo & McBride (2002), p. 29.

Roundup Ready soybeans were introduced in 1996, and were adopted extremely rapidly. They comprised 7.4%, 17%, 44.2% and 55.8% of total soybean acreage in the years from 1996 to 1999, respectively. This represents 4.75, 11.90, 31.84 and 41.14 million acres of Roundup Ready soybeans in the corresponding years (see table below). Yet Figure 11 above shows clearly that soybean growers overall practiced conservation tillage to a considerably greater extent in 1996, when under 5 million acres were Roundup Ready, than in 1999, when RR soybean acreage had increased over eight-fold, to 41.14 million acres, to comprise over half of all soybeans grown. These data, at the very least, cast great doubt on a purported correlation between RR soybeans and use of conservation tillage.

Yet in the same publication, Fernandez-Cornejo & McBride (2002) present an “estimate,” based on the same USDA Agricultural Resources Management Survey (ARMS) that served as the source of Figure 11 above, to the effect that 60% of Roundup Ready soybean acres were under conservation tillage, versus just 40% of conventional soybean acres.

> A larger portion of the acreage planted with herbicide-tolerant soybeans was under conservation tillage than was acreage growing conventional soybeans. According to estimates based on USDA’s ARMS data, about 60

> percent of the area planted with herbicide-tolerant soybeans was under conservation tillage in 1997 (fig. 12). In comparison, only about 40 percent of the acres planted with conventional soybeans were under conservation tillage the same year (Fernandez-Cornejo and McBride 2002, p. 29).

These estimates are irreconcilable with the data portrayed in Figure 11, as shown in the table below.

	1996	**1997**	**1998**	**1999**
Total soybean acres (thousands)	64195	70005	72025	73730
Percent HR soybeans	7.4%	17.0%	44.2%	55.8%
HR soybean acres	4750	11901	31835	41141
Conventional soybean acres	59445	58104	40190	32589
Percent of total soybeans under conservation tillage (from Fernandez-Cornejo & McBride 2002, Figure 11)		54%		
Acres of soybeans under conservation tillage		37803		
Scenario assuming that HR soy cultivation correlates with conservation tillage (1997)				
60% HR soy under con-till		7141		
40% conv'l soy under con-till		23242		
Predicted soy acres under con-till		30382		
Scenario's deviation from reality				
Deficit in con-till acres		7421		
Amount by which actual con-till soy acres exceeds prediction (in percent)		24%		
Scenario assuming equal (54%) adoption of con-till on HR and conventional soybean acres		37803		

The estimate (scenario) according to which 60% of RR and just 40% of conventional soybeans were under conservation tillage in 1997 yields just 30.4 million acres of conservation-tilled (con-till) soybeans, when the true figure is 37.8 million acres, or 24% more. Clearly, the estimate linking RR soybeans to con-till soybeans is in error. Since the great majority (83%) of soybeans in 1997 were conventionally tilled, the most likely explanation for the deficit is that conventional soybean growers used conservation tillage (con-till) to a greater extent than presumed in the estimate. The scenario assuming equal adoption of con-till by the two groups gives the expected, and correct, result. The latter scenario of equal adoption of con-till is supported by the following finding.

ii. Conservation tillage leads to HR seeds, not vice versa

After noting the "correlation" between RR soybeans and conservation tillage that is critiqued above, Ferndandez-Cornejo and McBride conducted an econometric analysis to determine causation, which reached the following conclusion with respect to no-till, one form of conservation tillage:

> According to the econometric model results, using 1997 ARMS survey data, farmers using no-till for soybeans were found to have a higher probability of adopting herbicide-tolerant seed, but using herbicide-tolerant seed did not significantly affect no-till adoption. This result seems to suggest that farmers already using no-till found herbicide-tolerant seeds to be an effective weed control mechanism that could be easily incorporated into their weed management program. On the other hand, the commercialization of herbicide-tolerant soybeans did not seem to have encouraged adoption of no-till, at least [in] the year of the survey, 1997. (p. 29)

Thus, even if one were to posit a correlation, the causation flows from prior adoption of conservation tillage to subsequent adoption of HR soybeans, not the reverse. In short, HR soybeans do not increase adoption of conservation tillage.

It is unclear why these trained agricultural economists did not detect this serious and obvious discrepancy in the data they presented, but it is indisputable that they did. And it has had considerable influence (together with the 2001 ASA survey noted above) in fostering the erroneous notion that RR soybeans are responsible for increased use of conservation tillage, despite the proviso regarding causation.

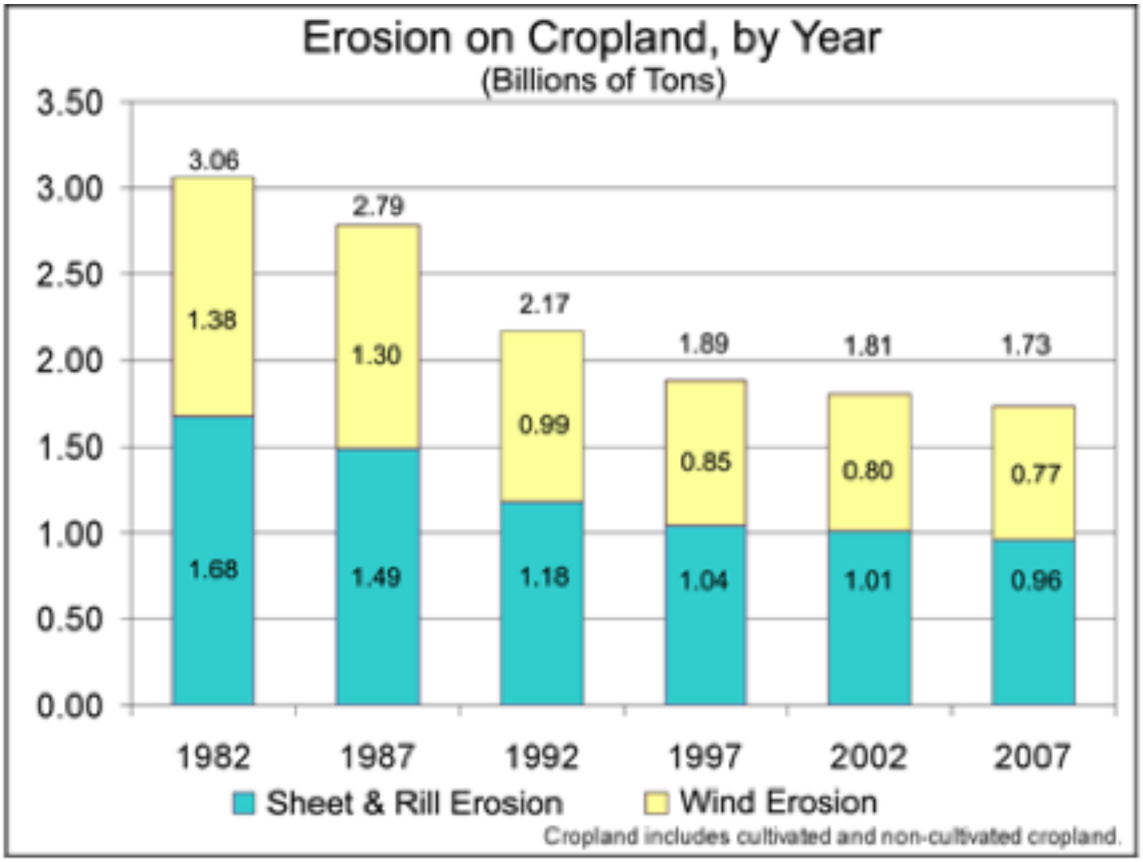
It is also quite striking that Fernandez-Cornejo and McBride (2002) offer absolutely no explanation for the rapid rise in conservation-tilled soybeans in the 5 years leading up to introduction of RR soybeans (1990-1995, see Figure 11). We offer an explanation of this below.

iii. Reductions in soil erosion come to an end during the decade of herbicide-resistant crop adoption

Conservation tillage is widely credited with bringing about large reductions in soil erosion rates. Thus, if HR soybeans, corn and cotton did in fact promote greater use of conservation tillage, one would clearly expect to see sharply falling soil erosion rates over the period of their widespread adoption, in the areas where these crops are widely grown. However, gold-standard data from USDA's soil conservation experts, the Natural Resources Conservation Service (NRCS), show that this is not the case.

Below, we reproduce a chart from page 2 of NRCS's 2010 report: "2007 National Resources Inventory: Soil Erosion on Cropland" (USDA NRCS 2010, in supporting materials). The chart represents NRCS' best estimate of cropland erosion from 1987 to 2007. According to NRCS:

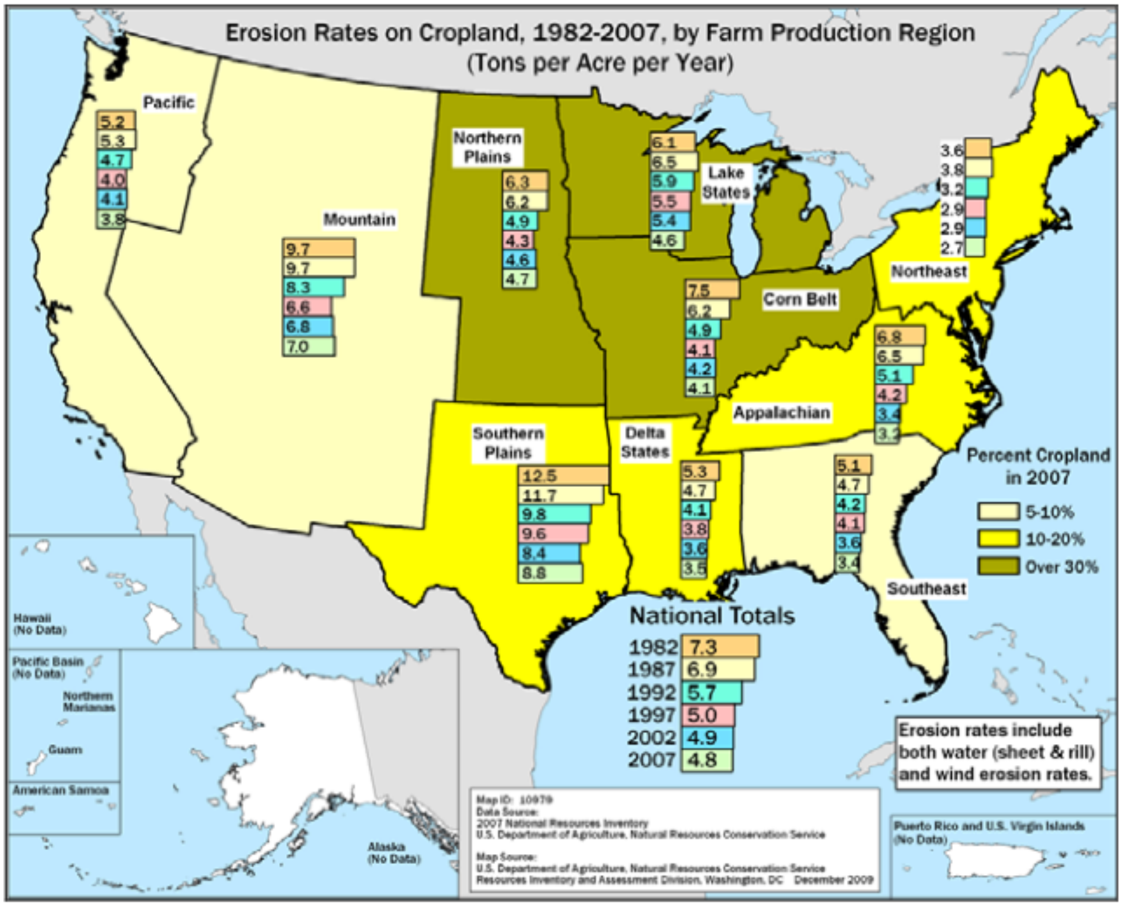
"[E]rosion rates computed from NRI data are estimates of average annual (or expected) rates based upon long-term climate data, inherent soil and site characteristics, and cropping and management practices." Tillage regimes are the primary component of "cropping and management practices," and thus play a large role in determining soil erosion rates. It is well established that soil erosion increases with the intensity of tillage, and decreases as farmers adopt regimes that leave more plant residue on the soil (USDA ERS AREI 2002). Thus, the chart below reflects in large degree the tillage regimes used by farmers.



From: NRCS (2010), p. 2

On a national basis, water and wind erosion on cropland declined sharply by 38% from 1982 to 1997, from 3.06 to 1.89 billion tons. In the following decade, however, soil erosion almost leveled out, declining by just 8%, from 1.89 to 1.73 billion tons. Herbicide-resistant crops were first introduced in 1996, and the area planted to them (HR soybeans, corn and cotton) increased steadily from 16.0 million acres in 1997 to 117.2 million acres in 2007 (Benbrook Supplemental 2009, Table 5). If HR crops promoted adoption of conservation tillage in any significant way, one would surely expect a much stronger decline in soil erosion over a period when their adoption increased by 100 million acres.

However, NRCS' survey offers still more compelling evidence at the regional level. The following map (from p. 3) breaks down average annual soil erosion rates, in tons per acre per year, by farm production region. For each region, rates for the six survey periods (1982, 1987, 1992, 1997, 2002 and 2007) are shown stacked from top (1982) to bottom (2007). The rates in this map are also listed in Table 36 of the report (pp. 12-16).



The Corn Belt states (Iowa, Illinois, Indiana, Missouri and Ohio) and the Northern Plains states (Kansas, Nebraska, North and South Dakota) comprise two-thirds of the nation's corn and soybean acreage, and all of these states have high adoption rates of GE herbicide-resistant soybeans and corn (see USDA-ERS 2011a, cited in DEA). If APHIS' and Bayer CropScience's supposition that HR crops and HR soybeans in particular promote conservation tillage were correct, one would certainly expect to see an appreciable decline in soil erosion in these two regions over the 1997 to 2007 period when HR versions of these crops were widely adopted; and that decline should be far more pronounced than the national average. However, this is not the case at all.

In the Corn Belt states, the annual erosion rate remained constant at 4.1 tons per acre from 1997 to 2007, while ***erosion actually increased in the Northern Plains states*** over this same period, from 4.3 to 4.7 tons per acre, in both cases bucking the national trend of modest decline. Of the eight other farm production regions, all but two (Mountain and Lake States) had declining erosion rates. Clearly, the massive adoption of HR corn and soybeans from 1997 to 2007 did not foster increased adoption of soil-conserving practices; if it had, it would have been reflected in declining rather than stable or increasing erosion rates.

iv. Federal farm policy triggered sharp declines in soil erosion prior to HR crop adoption

The other question raised by NRCS' report is this: what explains the sharp declines in soil erosion in ALL farm production regions, including Corn Belt and Northern Plains states, in the 1982 to 1997 period before any appreciable adoption of HR crops? The decline in soil erosion over this period is also consistent with increased use of conservation tillage in soybeans from 1990 to 1995, as displayed in Figure 11 above. The answer is clear. Strong financial incentives to adopt soil-saving farming practices contained in the 1985 and 1990 Farm Bills were chiefly responsible for increased use of conservation tillage. According to Coughenour and Chamala (2000), authors of a book examining the history of conservation tillage in the U.S. and Australia:

> There is little mystery about what brought ***a sea change in farmers' tillage*** decisions as the 1990s unfolded. The compliance provisions of the 1985 Farm Bill and the 1990 amendments dramatically altered the effective policy and institutional environment. ***Farmers who wanted governmental support payments had to begin implementing their farm conservation plans (FCPs) by 1995, and their plans often included provision for conservation tillage.*** The balance of factors favoring use of no-tillage systems has also been strengthened by the progressive change in the cultural climate favoring farmers' acceptance of program requirements and changes in farming practice. (p. 286, emphases added)

v. Weakening enforcement of farm conservation plans brings soil erosion reductions to an end

Soon after the 1995 deadline for implementation of farm conservation plans had passed, however, enforcement of these plans dramatically weakened, and further progress in preventing soil erosion was stymied. As explained by the Environmental Working Group:

> In 1997, after a decade of historic progress cutting soil erosion and polluted runoff from farmers' fields, America's soil, streams, lakes and rivers were improving.
>
> That historic achievement was driven by a 1985 federal law that required farmers to put conservation practices in place on their most vulnerable cropland in return for the billions of dollars of income and insurance subsidies they were getting from taxpayers. The "Highly Erodible Land Conservation" provisions of the 1985 Food Security Act required farmers to fully implement an approved soil conservation plan by 1995 on cropland that was determined to be "highly erodible." USDA's Economic Research Service (ERS) completed a comprehensive evaluation of those so-called conservation compliance provisions in 2004. ERS concluded that conservation compliance reduced soil

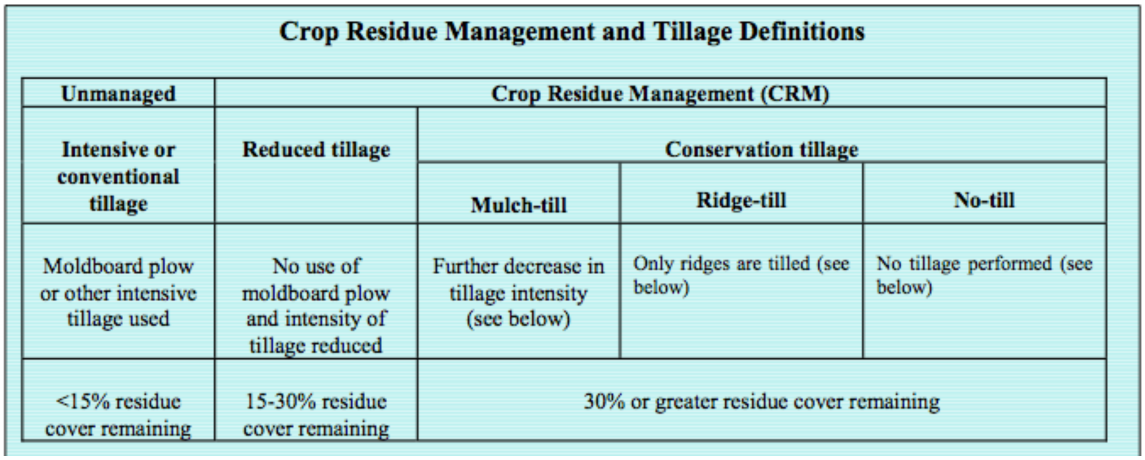
> erosion on highly erodible cropland by 331 million tons a year — a 40 percent reduction between 1982 and 1997 (USDA ERS 2004).
>
> ***Unfortunately, those gains were short-lived. Enforcement of conservation requirements weakened and in 1996 went off the rails altogether when Congress made an abortive push to phase out farm subsidies — and with them the conservation requirements.*** The phase-out of farm subsidies turned out to be a mirage, and Congress immediately returned to its old habits — plowing billions into farmers' hands through ad hoc disaster payments and bringing all the farm subsidies back with a vengeance in the 2002 farm bill.
>
> ***The only thing that turned out to be real was the phase-out of enforcement of conservation requirements. The result has been a decade of lost progress and mounting problems.*** (EWG 2011, p. 28, emphases added).

In short, sharp reductions in soil erosion from the mid-1980s to the mid-1990s were driven by federal farm policy that made subsidies to farmers contingent on implementation of soil conservation plans. Dramatic weakening of USDA enforcement of those plans in the mid-1990s explains the leveling off of soil erosion rates from 1997 to 2007. HR crops, adopted during this same decade, had essentially no influence on farmers' use of conservation tillage practices.

USDA's Natural Resources Conservation Service also credits federal farm policy as being "largely responsible" for increased use of soil-conserving cultivation practices. In a short work referenced by APHIS (DEA at 35), NRCS experts state:

> Total acres of conservation tillage systems rose steadily in the late 1980s to 37.2% of all planted acres in 1998 (Figure 2b). The implementation of Farm Bill Compliance standards containing residue management practices was largely responsible for much of this increased adoption (USDA-NRCS 2006, p. 3).

"Residue management practices" refer to conservation tillage practices.



Crop Residue Management and Tillage Definitions

Unmanaged	Crop Residue Management (CRM)			
Intensive or conventional tillage	Reduced tillage	Conservation tillage		
		Mulch-till	Ridge-till	No-till
Moldboard plow or other intensive tillage used	No use of moldboard plow and intensity of tillage reduced	Further decrease in tillage intensity (see below)	Only ridges are tilled (see below)	No tillage performed (see below)
<15% residue cover remaining	15-30% residue cover remaining	30% or greater residue cover remaining		

From: USDA ERS AREI (2002), p. 23

Conservation tillage is officially defined as cultivation practices that leave 30% or more of the soil surface covered with crop residues (USDA ERS AREI 2002, p. 23). Since reduced tillage leaves only 15-30% of the soil surface covered by crop residues, it is not a form of conservation tillage.

Industry-funded studies that purport to show an association between Roundup Ready crops and conservation tillage are often cited in support of a causal link.

For example, Givens et al. (2009, as cited in the DEA) is a phone survey of farmers that purports to show a correlation between increased conservation tillage and Roundup Ready crop cultivation (DEA at 26 - 27). However, several aspects of this survey raise questions as to its objectivity. First, the study does not give methodological details, referring readers to a previous survey (Shaw et al. 2009, as cited in Givens et al. 2009). That survey reveals that the growers who were interviewed in Givens et al. (2009) were selected from a list provided by Monsanto, raising the possibility of selection bias on the part of Monsanto. Second, the study itself was funded by Monsanto, raising similar concerns of bias.[24] Table 3 of Givens et al. (2009) shows that most of the farmers who switched tillage regimes after adopting RR crops were RR cotton growers, and even these growers switched primarily to "reduced till" rather than no-till. Furthermore, among adopters of RR soybeans who had been previously used conventional tillage, and who grew them in rotation with a non-RR crop, only 17% transitioned to no-till, versus 39% to reduced till and 44% who continued to practice conventional tillage (Table 3). Finally, this survey, which is based on numbers of growers rather than acreage, tells us nothing about acres of cropland under the various tillage regimes, either before or after adoption of Roundup Ready crops.

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[24] Monsanto and other agrichemical-seed companies provide substantial research funding to the weed science community, a problematic relationship that may bias the findings and conclusions reached in such studies.

In short, all of the unbiased, credible evidence points indisputably to federal farm policy as the chief motivating factor for massive adoption of conservation tillage, and attendant sharp reductions in soil erosion. The fact that the decline in soil erosion essentially stopped when enforcement of farm conservation plans lapsed in the mid-1990s further demonstrates the importance of federal farm policy. The further fact that farmer adoption of over 100 million acres of herbicide-resistant crops from 1997 to 2007 coincided with ***stagnant or increasing*** soil erosion where HR soybeans and corn are most grown, entirely refutes APHIS' and Bayer CropScience's false depiction of this matter.

c. Environmental impacts of conservation tillage

Even if FG72 soybean is managed with conservation tillage, the environmental benefits attributed to reduced tillage are not well substantiated, other than slowing soil loss.

i. Soil and water

Although herbicide-facilitated no-till methods may decrease soil erosion, they do not always increase soil quality or reduce water pollution, and under some conditions actually increase agrichemical runoff, degrading water quality.

No-till and other conservation-tillage systems discourage the disturbance of the soil, which can lead to over-compaction (Fabrizzi et al. 2005, Tebrugge 1999). In the absence of soil disturbance, some studies have shown that fertilizers broadcast on the soil surface are washed off the field by rain, thus polluting waterways as well as lowering nutrient-use efficiency (Malhi et al. 1996). Pesticides also can end up at higher concentrations in runoff from fields in conservation tillage. Crop residues are left on the surface in these systems, and surface residues intercept sprayed pesticides that are then washed off during rain (Baker and Shiers 1989, Martin et al. 1978). "If this washoff water becomes a part of surface runoff, herbicide concentrations can be quite high." (Mickelson et al. 2001). Research conducted on corn herbicides confirmed these conclusions. While no---till systems had the lowest volume of runoff, the concentrations of atrazine and cyanazine in runoff water were always greater (statistically significant in most cases) in no---till systems than for the other tillage regimes (Mickelson et al. 2001).

Fertilizer and pesticides can also run off more rapidly from no-till fields into drainage ditches, then into the watershed via more extensive pores, including earthworm burrows (Shipitalo et al. 2004, Comis 2005).

There is thus no guarantee that use of herbicide-dependent conservation tillage systems will result in overall benefits to soil and water quality, even if FG72 soybean were to increase use of conservation tillage in the short term.

ii. Climate change

APHIS says that the "continued use of conservation tillage associated with GE crops may reduce GHG emissions as a result of increased carbon sequestration in soils, decreased fuel consumption, and the reduction of nitrogen soil amendments…" if FG72 soybean is approved (DEA t 89). These benefits for climate change of a purported preservation of no-till sobyean acreage are generally unsubstantiated. Recent work by Blanco-Canqui and Lal (2008) and a careful review of the literature by USDA researchers Baker et al. (2007) cast doubt on the claim that no-till results in more carbon sequestration than tillage in most conditions. Other gases that contribute to global warming– such as nitrous oxide (N_2O), methane (CH_4), and ammonia (NH_3) – are reported to be generally higher in no-till fields, as well.

Scientists from the USDA's Agricultural Research Service and Department of Soil, Water & Climate at the University of Minnesota (Baker et al. 2007) reviewed the literature on the effects of tillage on carbon sequestration in agricultural soils and concluded that in order to accurately determine how much carbon is sequestered, it is necessary to sample the soil to a depth that the roots grow. This is because much of the carbon fixed in photosynthesis is translocated to the roots and some is exuded into the soil where it stimulates the growth of various microorganisms. The deeper roots and microorganisms may also store carbon for a longer period of time than the more shallow roots.

The vast majority of tillage-soil carbon sequestration studies have sampled no deeper than the top 30 cm (roughly 1 foot) of soil. When studies of carbon sequestration are limited to the top 30 cm of soil, more carbon is stored in no-till than tilled fields, on average. However, when the sampling includes more of the root zone (below 30 cm; corn roots can go down more than 200 cm), tilled fields have as much stored carbon as their no-till counterparts (Baker et al. 2007). In some cases, tillage results in more carbon storage. Thus, the claim that conservation tillage results in more carbon sequestration than conventional tillage seems to be a result of sampling bias.

Blanco-Canqui and Lal (2008) published a study questioning carbon sequestration in no-till fields, as well. This study covered a large geographic area, looking at farmers' fields rather than small research plots, and sampling throughout the root zone. Not only did the plowed plots store as much carbon as the no---till plots when sampled below 10 cm, three of the plowed areas sequestered more carbon.

They come to a similar conclusion about using no-till to sequester carbon as Baker and colleagues:

> This regional study shows that NT [no-till] farming impacts on SOC [soil organic carbon] and N [nitrogen] are highly variable and soil specific. In MLRAs [Major Land Resource Areas] where NT soils have greater SOC than tilled soils, the gains in SOC are limited solely to the surface soil layers (<10

> cm). The net effect of NT on SOC sequestration for the whole soil profile (0-60 cm) is not significantly different from that of plow tillage…
>
> Based on the data on soil profile C distribution from previous reports and this regional study, the view that NT farming would increase SOC over PT [plow tillage] is questionable... (Blanco-Canqui and Lal 2008, p. 701)

Other greenhouse gases may also be affected by tillage systems:

- Fertilizers in no-till fields are generally more vulnerable to volatilization. Fertilizers are often applied to the surface in no-till fields (Rochette et al. 2009), which can result in up to 50% of urea being volatized as ammonia (NH_3) (Sommer et al. 2004). Some studies showed that cumulative NH_3 volatilization was three times greater in no-till than in plowed fields, attributed to the reduced ability of nitrogen to infiltrate soils in the presence of crop residues on the surface of untilled soils (Al-Kanani et al. 1992).

- Ammonia can be oxidized and transformed into the greenhouse gas N_2O. Once emitted, ammonia can also be rapidly converted to the aerosol ammonium (NH_4^+) that contributes to ecosystem fertilization, acidification, and eutrophication. These processes increase methane emissions and decrease carbon sequestration through photosynthesis, thereby exacerbating climate change.

- Globally, most N_2O emissions are the result of microbial processes in soil, both aerobic nitrification and anaerobic denitrification (Smith and Conen 2004). No-till soils have demonstrated elevated levels of water-filled pore space (WFPS), determined by water content and total porosity (Mosier et al. 2006). WFPS appears to be closely related to soil microbial activity. One study demonstrated that WFPS in no-till systems to be 62% compared to 44% for plowed soils (Linn et al. 1984). Other studies have implicated no-- till in greater N_2O releases, as well (Ball et al. 1999, Rice and Smith 1982).

The point of citing these studies that show exacerbation of greenhouse gas emissions and degradation of soil and water quality with no-till methods is not to discount environmental benefits of conservation tillage in specific situations, particularly when it is used with other techniques of sustainable agriculture (Davis 2010). Using sustainable methods to decrease tillage for soil conservation is indeed important. However, APHIS relies on conservation tillage as an argument for a whole range of environmental benefits of FG72 soybean without critical analysis of the best science available.

In fact, overall environmental benefits and harms from approval of FG72 soybean are likely to have more to do with changes in herbicide use that accompany the FG72 soybean cropping system than with tillage methods that may or may not be different. Thus environmental impacts of FG72 soybean from increased use and changed patterns of use of herbicides should be APHIS' main concern in their risk assessments.

8. Transgenic contamination of conventional and organic soybean varieties by FG72 soybean

Approval of FG72 soybean is likely to result in contamination of other soybean varieties with its HR transgenes. This is likely to occur via cross-pollination and seed mixing.

Although soybean is considered to be primarily a self-pollinating crop, in fact some cross-pollination by insects does occur. Honeybees housed near soybean fields use the flowers for honey, pollinating as they go (Chiari et al. 2005, Krupke and Hunt 2012, Krupke et al. 2012). Recent studies show that an array of wild pollinators also visits soybean fields (Anonymous 2012, O'Neal and Gill 2012). Presumably these insect pollinators carry soybean pollen long distances, accomplishing a low level of cross-pollination within and between fields (e.g. Pasquet et al. 2008). The extent of cross-pollination will be site-specific, depending a lot on the types and numbers of pollinators in a given location (e.g. Taki et al. 2011), making generalizations from particular studies difficult.

Transgenic contamination resulting from seed mixing can occur in different ways (Mallory-Smith and Zapiola 2008, Mellon and Rissler 2004). Retailed seeds purchased by farmers can be contaminated with the transgene, resulting in some fraction of the harvested commodity containing the trait. After harvest, bulk seeds from different sources are routinely transported, mixed and stored together, and can result in comingling of different varieties. Human error can result in mislabeling, failure to follow best practices, and so on (Marvier and VanAcker 2005).

For example, foundation seeds for non-engineered soybeans have been contaminated with transgenes:

> In 2002, the head of North Dakota State University's Foundation Seedstocks Program acknowledged that the program's foundation seed for non-engineered natto soybeans—the basic stock from which seeds are grown to sell to farmers—contained sequences from engineered soybeans. [Pates, M. 2002. Seed contamination raises control issues, posted November 12, 2002. On the Grand Forks Herald website at http://www.grandforks.com, accessed on January 7, 2003. The article identified Monsanto's Roundup Ready soybeans as the source of contamination.] (Natto soybeans are grown for premium food-grade products.) Three other foundation soybean seed programs—in Virginia, Missouri, and Michigan—have also recently reported genetic engineering contamination problems. [The Non-GMO Source. 2003. Concerns increase over GMO contamination of foundation seed. Volume 3, Number 6, pp. 1-2, June.] (Mellon and Rissler 2004, p. 10, internal citations included.)

In 2002, Union of Concerned Scientists did a study of transgenic contamination in a sample of popular non-engineered varieties of soybean seeds from major seed companies available for planting that year in Iowa and Illinois. They found that at least half of the soybean varieties tested contained transgenes at levels of less than 0.05 % to more than 1.0 %. These low levels of contamination nevertheless translate into large numbers of transgenic seeds in the non-engineered varieties. For example, if the soybean seed supply is contaminated at the 0.1% level, over 4 billion seeds would be transgenic (Mellon and Rissler 2004, Table 2-7, p. 29).

In another report, "A Growing Concern: Protecting the Food Supply in an Era of Pharmaceutical and Industrial Crops" (Andow et al. 2004), UCS enlisted the assistance of several academic experts in agricultural sciences to determine whether genetically engineered pharmaceutical-producing crops could be kept out of food. This report demonstrates how difficult it is, even for pharmaceutical crops that would be grown on small acreage and under stringent confinement, to avoid contaminating food. The authors of this report examined confinement methods, such as field separation, cleaning of farm equipment, segregation of seed, and others, and found that it would still be difficult to ensure the absence of contamination. Only by taking heroic measures, such as completely geographically isolating pharmaceutical from food crops, would contamination be unlikely. UCS concluded that even though it may be theoretically possible to prevent contamination, it would not be economically feasible.

Another route of contamination that is unpredictable, but likely over time, is human error. Two academic ecologists address this in a peer-reviewed paper (Marvier and Van Acker 2005), and conclude that contamination by genetically engineered crops due to human error or other means has occurred numerous times, and is likely to continue to occur. This paper documents many instances where genetically engineered crops are known to have contaminated non-engineered crops or food. Thus, biological contamination through human error and human behavior, such as composting, exchanging seeds, or mislabeling seeds, must be addressed in an Environmental Impact Statement.

The likelihood of contamination of soybean varieties by transgenes shown by the USC studies and past contamination incidents has important implications for the impacts of approval of FG72 soybean:

> Both commercial and legal considerations make the presence of transgenically derived sequences in agricultural products problematic. Many transgenic varieties of crops in use in the United States have not been approved in other countries and their presence in imports is unlawful. In addition, many customers for U.S. exports —particularly those looking to purchase organic food or non-organic specialty products—are exhibiting a strong preference for non-genetically engineered grains and oilseeds free of some or all transgenic varieties (Mellon and Rissler 2004, p. 7).

These impacts are discussed more fully in CFS' legal comments.

9. Conclusion

Clearly, APHIS should prepare and Environmental Impact Statement to assess the impacts of approving Bayer CropScience's petition for non-regulated status of FG72 soybean.

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