THE CENTER FOR FOOD SAFETY

Docket No. APHIS–2012–0026

Regulatory Analysis and Development, PPD, APHIS
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Comments to USDA APHIS on Draft Environmental Assessment and Draft Plant Pest Risk Assessment for Dupont-Pioneer's Petition (11-244-01p) for Determination of Nonregulated Status of Insect-Resistant and Herbicide-Resistant Pioneer 4414 Maize: Event DP-004114-3

Center for Food Safety, Science Comments

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1. Notes on science comments

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 (e.g. Benbrook 2012). Full citations are included at the end.

2. Genetically engineered corn, 4114 maize and pesticide use

a. Summary of pesticide use

Genetically engineered corn has been associated with substantial increases in the use of all three major classes of pesticide: fungicides, insecticides and herbicides. DuPont-Pioneer offers all of its corn seed with four different fungicides applied to the seed. In addition, fungicidal sprays that were once hardly ever used have become increasingly common since 2007, and are now used on over 15 million acres of cornfields. Most are sprayed aerially, leading to drift-related harm to agricultural workers and damage to fruit trees. Insecticide use in corn consists of Bt corn-incorporated insecticidal proteins, chemical insecticide seed treatments, and chemical insecticide sprays. Usage of Bt toxins and chemical insecticide seed treatments has risen dramatically over the past decade, due primarily to choices made by pesticide-seed firms rather than farmer demand. Use of chemical insecticide sprays has declined modestly, though is poised to increase in response to growing resistance to Bt toxins in corn rootworm, corn's most damaging pest. Herbicide use has increased steadily with adoption of herbicide-resistant crops, primarily glyphosate-resistant varieties though some glufosinate-resistant varieties as well. 4114 maize would be introduced in varieties stacked with resistance to glyphosate and likely other herbicides as well, for instance 2,4-D and "fops" grass herbicides. Glufosinate use will rise as growers resort to it in conjunction with 4114 corn hybrids to battle expanding populations of weeds resistant to glyphosate and other herbicides. Glufosinate usage on corn would likely increase from 1.3 million lbs. per year today to 20-30 million lbs. if resistant weeds expand greatly and/or 4114 maize is offered primarily in stacks with resistance to glyphosate but not other herbicides. A lesser increase in usage, on the order of 10 million lbs., would be expected if GR weed expansion is less aggressive, and/or 4114 maize is introduced primarily in hybrids incorporating resistance to 2,4-D and/or other herbicides in addition to glufosinate and glyphosate. APHIS's assessment of herbicide use trends with GE crops and 4114 maize in particular is deeply flawed, vitiated by factual errors, logical inconsistencies and reliance on misinformation from pesticide industry contractors, and is certainly in violation of Executive Order 13563 demanding use of the best available information for federal decision-making and the Plant Protection Act's mandate to employ sound science.

b. Introduction

Pioneer Hi-Bred International, Inc., a wholly-owned subsidiary of chemical giant DuPont (hereafter, "DuPont-Pioneer"), seeks deregulation of Event DP-004114-3 (hereafter 4114 maize), a variety of corn genetically engineered for resistance to the herbicide glufosinate and to express the insecticidal toxins Cry1F, Cry34Ab1 and Cry35Ab1 to repel various lepidopteran pests and corn rootworm.

Because APHIS's scanty assessment of the pesticide use impacts of 4114 maize is conditioned by its misconceptions about pesticide use with GE crops overall, we begin with a discussion of this topic, correcting those misconceptions in the process. Overall pesticide use has increased dramatically on corn over the past decade, the period in which herbicide-resistant corn has risen to prominence. Below we review these changes in pesticides use patterns. Major classes of pesticide used on corn are fungicides, insecticides and herbicides.

c. Sharp rise in fungicide use

Fungicides are used in two ways with corn: seed treatments and foliar sprays. Seed treatments involve coating the corn seed with one or more fungicides, which protect the seed and the young plant (which takes up the fungicide into its tissues systemically) against fungal disease. CFS is not sure when seed firms began to treat corn seed with fungicides, but the practice is nearly universal today. For instance, Pioneer's standard seed treatment package (PPST 250) includes four different fungicides: fludioxonil, mefenoxam, azoxystrobin and thiabendazole (DuPont-Pioneer 2013b), as does its premier Poncho 1250 seed treatment (DuPont-Pioneer 2013c).

In addition to four fungicides applied to the seed, there has recently been a sharp rise in the practice of spraying corn fungicides (foliar use) (EA at 15, Figure 2-1). The proportion of corn acres sprayed with fungicides rose from 10% in 2007 to an historical high of roughly 18% of corn acres, or more than 15 million acres, in 2011 (DuPont-Pioneer 2012 at 27, 80).[1] A major reason for this upsurge in foliar fungicide spraying is the heightened disease risk associated with increasing acreage planted to corn every year. Corn-on-corn growers spray preventively, to forestall pathogens that survive the winter in infested crop residue to infect the following season's corn crop (Robertson & Mueller 2007a). Other reasons for increased use are high corn prices and pesticide company marketing (Robertson et al 2007), as pesticide firms seek to increase sales by getting fungicides they originally registered for use on soybeans approved for corn as well (DuPont-Pioneer 2012 at 30).

This corn-on-corn driven rise in fungicide use has several adverse impacts. Because these applications are normally made by air, drift onto nearby fields has been known to poison agricultural workers (CDC 2008). Some foliar fungicides are extremely toxic to certain varieties of apples and grapes, which can be damaged by drift (Robertson et al 2007). Many fungicides sprayed on corn are at high risk of pathogens evolving resistance to them (Robertson & Mueller 2007b); growing use of these agents to facilitate corn-on-corn will accelerate the evolution of resistant pathogens, undermining their utility for more responsible growers. Conversely, foliar fungicides are one of several factors that induce growers who might otherwise rotate corn to plant it year after year instead.

d. Increased use of insecticides

Corn seed is "treated" with three different types of insecticide: Bt insecticidal toxins, insecticidal seed treatments and sprayed insecticides. Using the 2004-2011 time frame, Bt corn roughly doubled from 33% of total US corn acres in 2004 to 65% in 2011. Thanks to the stacking and pyramiding of various Bt toxins, the number of insecticidal proteins generated by Bt corn has more than doubled. Most Bt corn in 2004 contained just one Bt toxin, while today it is common for Bt corn hybrids to generate 3 to 8 insecticidal proteins. Growth in the use of insecticidal seed treatments has been explosive, more than quadrupling from just 20% of corn acres to 90% over the same seven-year period (EA at 15, Figure 2-1). In contrast, foliar/soil-applied insecticides have declined modestly, from 28% to 12% of corn acres (Figure 2-1).

If one totals the various types of insecticide used on corn, then it becomes evident that insecticide use has more than doubled from 2004 to 2011, based on the "percent acres treated" metric that

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[1] That routine spraying of fungicides on corn is a new practice is confirmed by USDA NASS data, which do not report fungicide use on corn in 2000 or 2002, and on less than 1% of acres in 2005. (USDA NASS AgChem 2001, 2003, 2006).

APHIS employs for herbicide use (discussed below). The average number of insecticide "treatments"[2] for an acre of corn rose from 0.81 in 2004 to 1.67 in 2011.[3] While it is true that soil-applied insecticides are generally regarded as more toxic than either Bt toxins or neonicotinoid seed treatments, Bt toxins are still being investigated as potential causes of the sharply increased incidence of food allergies in the U.S. (EPA 2009). Neonicotinioids have been found to exert toxic effects similar to those of nicotine on the development of the mammalian brain, and thus may affect human health (Kimura-Kuroda et al 2012). Neonicotinoids are also highly toxic to pollinators, and are likely one cause of the dramatic declines of pollinator populations (both native bees and honeybees) in the U.S. and elsewhere.

APHIS falsely states that "insecticide use has decreased" because of GE crops by simply ignoring the dramatic rise in use of insecticidal seed treatments discussed above, as well as the increased use of Bt insecticidal toxins in Bt corn (EA at 15). APHIS's section entitled "Pesticides – Insecticides" completely ignored insecticidal seed treatments (EA at 16), despite having promised a discussion of their increasing use on corn on the preceding page (EA at 15).

However, even the modest reduction in the use of foliar/soil-applied insecticides cited above is coming to an end thanks primarily to rapidly emerging resistance. A recent survey of Illinois corn growers indicates that nearly half intend to use ***both*** Bt corn for corn rootworm ***and*** a soil-applied chemical insecticide for larvae targeting corn rootworm (Jongeneel 2013). A desire to avoid rootworm resistance to Bt corn and concerns over secondary insect pests were the major reasons cited for this approach. Some growers use not only Bt and soil-applied insecticides; they also spray foliar insecticide in the summer to kill rootworm adults (Gray 2013). University of Illinois entomologist Michael Gray states that the environmental gains from reductions in chemical insecticide use with Bt hybrids "appear to be quickly disappearing" (Ibid). Thus, APHIS is incorrect to assume reliance on incorporated Bt proteins will continue to reduce insecticide use (EA at 113).

The first Bt corn hybrids targeting corn rootworm were released only 10 years ago, in 2003, yet already pests that have evolved resistance to them are driving a resurgence in the use of toxic soil-applied insecticides. In Iowa, Illinois, and likely in other states, resistance has evolved primarily in fields planted continuously to Bt corn over years (Gray 2013, Gassman et al 2011). Ironically, perverse and market-distorting ethanol subsidies lead to high corn prices, which encourage farmers to misuse Bt corn hybrids to facilitate the practice of corn-on-corn, which in turn fosters rapid of rootworm resistance. This erodes the efficacy of Bt corn, leading to an upsurge in the use of chemical insecticides whose partial displacement was the major reason for Bt corn in the first place.

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[2] Understood in a broad sense to encompass internal generation of a toxin and seed application as well as spraying.

[3] In 2004, 33% (Bt) + 20% (seed treatment) + 28% (insecticidal spray) = 81%, or an average 0.81 acre-treatments. In 2011, 65% (Bt) + 90% (seed treatment) + 12% (insecticidal spray) = 167% = 1.67 acre-treatments. This very rough calculation assumes that only one insecticide was used in each category. As noted above, typical Bt corn hybrids now have 3-8 insecticidal proteins. Seed treatments normally comprise a single insecticide (e.g. clothianidin, see DuPont-Pioneer Seed Treatment-3). A typical soil-applied insecticide product targeting corn rootworm larvae (Warrior) contains one active ingredient (i.e. lambda-cyhalothrin).

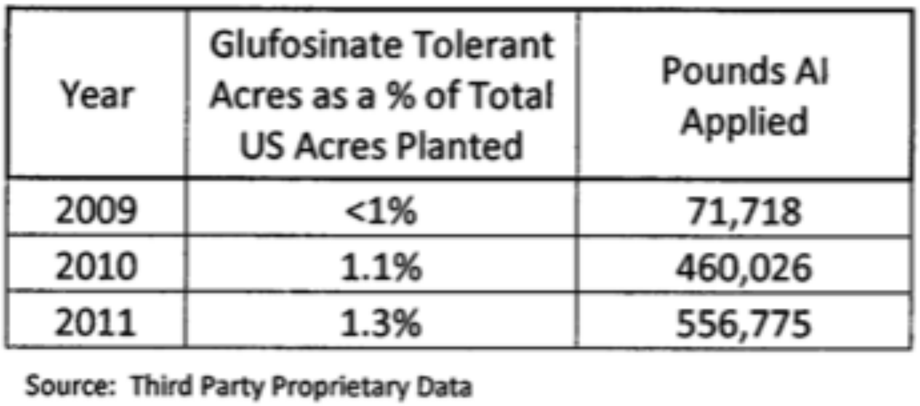
e. Estimate of glufosinate use with corn incorporating 4114 maize

DuPont-Pioneer estimates that glufosinate has been applied to 2% to 6% of corn acres since 2001 (EA at 18, 19). EPA estimates that an average of 5% and a maximum of 10% of corn acres are treated with glufosinate, at an average rate of 0.38 lbs./acre and 1.0 application per season, yielding estimated annual use on corn of 1.3 million lbs. (EPA EFED Glufosinate 2013 at 20, Table 3.2).

Glufosinate use on corn is likely to increase, perhaps sharply, in the coming years due to expanding populations of glyphosate-resistant (GR) weeds. According to a three-year survey of glyphosate-resistant weeds in 31 states by the agri-marketing firm Stratus, 49% of farmers surveyed in 2012 had glyphosate-resistant weeds on their farm, up from 34% of farmers in 2011; 61.2 million acres of cropland are now infested by GR weeds; GR weeds are rapidly expanding in the Midwest; and ever more farmers report two or more resistant species on their farms (Stratus 2013).

Post-emergence glufosinate applications with glufosinate-resistant crops are one of the major recommendations being made today to cope with GR weeds. These recommendations are impacting farmer practice. In cotton, where GR weeds have caused the most economic and agronomic damage, there has been a major shift to more glufosinate use on glufosinate-resistant cotton over the past several years. Proprietary data cited by Dow suggests that glufosinate use has been rapidly climbing in soybeans as well, in conjunction with adoption of glufosinate-resistant, LibertyLink soybeans (see table below). Soybeans have also been heavily infested with GR weeds for 13 years. Rising use of glufosinate has even triggered shortages in the U.S. market.

GR weeds began emerging in cornfields in 2005, later than in cotton and soybeans, but have expanded rapidly since that time. Thus, it is reasonable to assume that corn growers will make more use of glufosinate-resistance in corn by applying more of the herbicide as GR weeds worsen in the years to come.



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.

Glufosinate Projection With Increasing Use of 4114 Maize-Derived Corn Hybrids

Usage Assumption	**Rate** (a.i./acre/year)	**Annual Use in Different Scenarios: 10%, 25%, 50% Corn Acres Treated** (assuming 100 million acres)		
		10%	**25%**	**50%**
EPA average current use	0.38 lb.	3.8 million lbs	9.5 million lbs	19 million lbs.
Maximum label	0.80 lb.	8.0 million lbs	20.0 million lbs	40 million lbs.

There are many uncertainties in projecting future glufosinate use on corn hybrids incorporating 4114 maize. The severity of GR and multiple herbicide-resistant weeds in the coming years will help determine the need for glufosinate. The survey cited above suggests that GR weeds have expanded sharply over recent years, and continued expansion seems likely. However, 4114 maize will likely be introduced in hybrids with resistance to herbicides other than glyphosate. For instance, DuPont-Pioneer indicated the potential for 4114 maize to be stacked with Dow's 2,4-D/AOPP resistance trait (DuPont-Pioneer 2012 at 78-79). This would be completely in line with DuPont-Pioneer's aggressive strategy to develop GE crops with resistance to multiple herbicides (Green et al 2007). In fact, DuPont-Pioneer envisions crops with resistance to as many as seven (or more) classes of herbicide (DuPont-Pioneer 2009, par. 33).

Thus, there may be many post-emergence herbicide options for growers of corn hybrids incorporating 4114 maize, depending on how many HR traits DuPont-Pioneer decides to stack. The table above covers a range of potential scenarios. Glufosinate use on corn could rise from 1.3 million lbs. to on the order of 20 to 30 million lbs. if applied to 25% or 50% of corn acres. These scenarios are more likely if GR weeds continue their rapid spread, and/or most 4114 maize hybrids incorporate additional resistance only to glyphosate, since in that case glufosinsate will be the only mid- to late post-emergence option for glyphosate-resistant weeds. Usage on the order of 10 million lbs. is more likely if the pace of GR weed expansion slows, and/or most 4114 maize hybrids are stacked not only with glyphosate, but also with 2,4-D and/or other herbicides, since in this case rising use of 2,4-D et al would offset somewhat the volume of glufosinate that would otherwise be used. Glufosinate use will also be spurred by the evolution of creeping resistance to this herbicide in weeds.

f. APHIS's flawed assessment of herbicide use

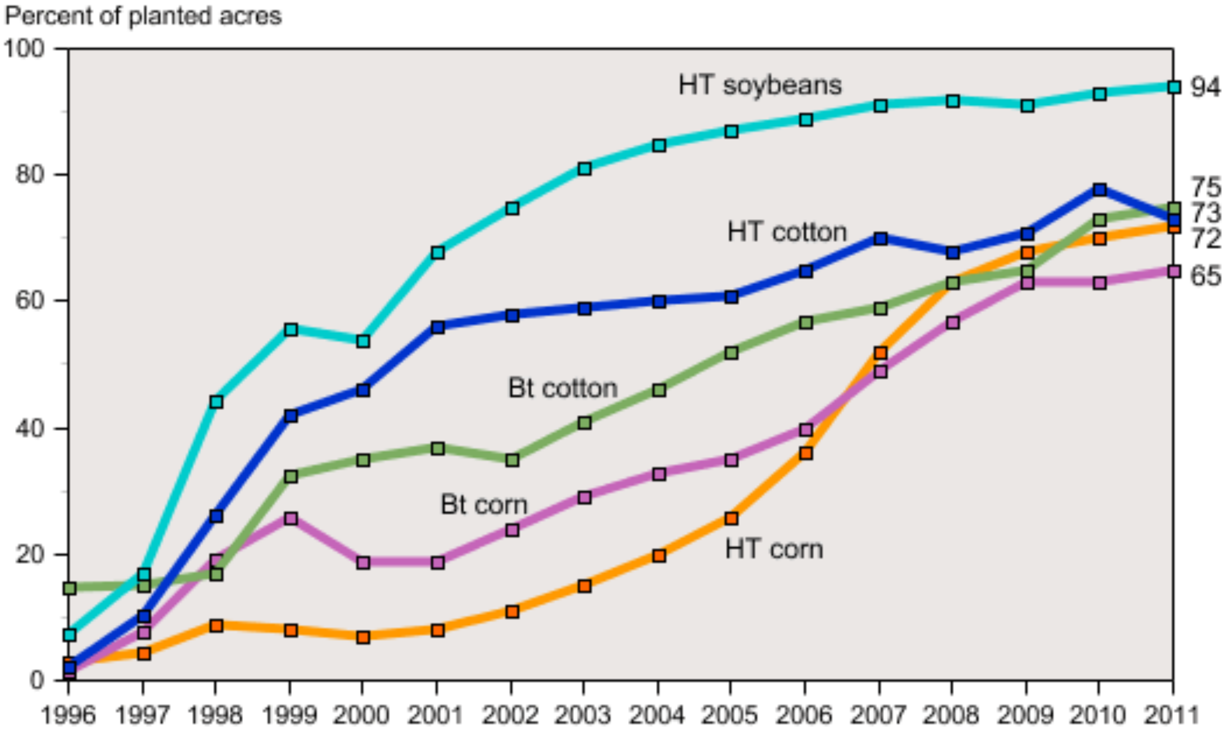
APHIS's treatment of the pesticide use impacts of GE crops, including hybrids incorporating 4114 maize, is riven with factual errors, contradictions, and obvious logical lapses. APHIS's discussion of this topic is also vitiated by reliance on pesticide industry-funded misinformation that conflicts with reliable data from credible sources, including APHIS's own sister agency, the National Agricultural Statistics Service (NASS). APHIS's treatment of pesticide use in in blatant violation of Executive Order 13563, which demands with respect to emerging technologies that:

"[D]ecisions should be based on the best reasonably obtainable scientific, technical, economic and other information, within the boundaries of the authorities and mandates of each agency." (as quoted, EA at 50).

Because the Plant Protection Act demands that decisions under its aegis "shall be based on sound science" (EA at 49), and it is impossible to make decisions based on sound science when false or unreliable or substandard data are employed, APHIS's treatment of pesticide use in the plant pest risk assessment and draft EA is also in blatant violation of the Plant Protection Act.

In the 16 years from 1996 to 2011, herbicide-resistant (HR) corn increased herbicide use in the US by 101 million lbs. over what would have been used in its absence (Benbrook 2012, Supplemental, Table 15). From 1996 through 2002, impacts were extremely small due to the small amount of HR corn planted in this period, which peaked at 11% of total corn acres in 2002 (see figure below). The great majority of this increase has come in the past few years: 21.6 million lbs. in 2010 and 27.5 million lbs. in 2011, as HR corn reached 70% and 72% of corn acres, respectively (Ibid).

Growth in adoption of genetically engineered crops continues in the U.S.



Data for each crop category include varieties with both HT and Bt (stacked) traits.
Sources: 1996-1999 data are from Fernandez-Cornejo and McBride (2002). Data for 2000-11 are available in the ERS data product, Adoption of Genetically Engineered Crops in the U.S., tables 1-3.

Benbrook's assessment is based on pesticide usage data from USDA's National Agricultural Statistics Service (NASS). NASS data are regarded as superior to and more transparent than similar data supplied, at high cost, by private firms such as Doane to paid subscribers. According to NASS's Advisory Committee on Agricultural Statistics:

> The proprietary agreements entered into by Doane subscribers extend well beyond prohibitions on data disclosure, to embargo revelation of the sampling and analytical procedures used to generate their data. Thus, it may be that a large number of the area wide estimates included in the Doane system are based on individual or statistically unrepresentative observations.[4]

In contrast, the Committee praises the NASS program for ensuring "a high level of data reliability and accuracy, which are the greatest advantage of NASS data. NASS employs rigorous methods to ensure that statistically representative samples are achieved."

Benbrook's assessment is consistent with, because based on, NASS data. Yet it does depend on assumptions about how overall corn herbicide use breaks down for HR corn versus non-HR corn. However, analysis of NASS data without such assumptions provides support for Benbrook's assessment. NASS data show that both the intensity and frequency of herbicide use on ALL corn have increased substantially during the years when the great majority of HR corn adoption took place. HR corn first exceeded 10% of corn acres in 2002 (11% adoption), rising steadily to 70% of corn acres in 2010. NASS data show that the ***intensity*** of annual corn herbicide use increased a substantial 19% over this period, from 1.865 to 2.225 lbs./acre (see Intensity of Herbicide Use figure below). NASS data also show that the ***frequency*** of herbicide use on corn increased by a similar amount over this same period, from 2.48 to 2.99 acre-treatments,[5] for a 21% increase. Thus, the average acre of corn in 2010 was treated with an herbicide three times, up from 2.5 treatments in 2002; and with 2.225 lbs. of herbicide, up from 1.865 lbs in 2002.

These USDA data are extremely difficult if not impossible to reconcile with the proposition that HR crops have decreased herbicide use, as maintained by Brookes and Barfoot (2012) (EA at 19). For their results to be true, the putative herbicide-reducing effects of HR corn would have had to be swamped by some other factor(s) that very significantly increases herbicide use. Only in this way could their analysis comport with gold standard NASS data showing substantial, 20% increases in both the intensity and frequency of herbicide use on corn. Brookes and Barfoot (2012) do not identify any such factors. Indeed, they completely ignore NASS pesticide usage data, despite its quality. Instead, they construct highly manipulable "simulations." These simulations are based not on data, but on simplistic assumptions (educated guesses) regarding how much herbicide is applied to the typical acre of an HR crop versus a conventional or non-HR crop. While NASS surveys thousands of farmers on their actual herbicide use practices, and does so in a manner that ensures the surveyed population is representative, and the survey itself statistically valid, Brookes and Barfoot do not survey a single farmer. Freed from the constraints of reality, they are free to manipulate their assumptions so as to arrive at results that serve the interests of their pesticide industry sponsors.

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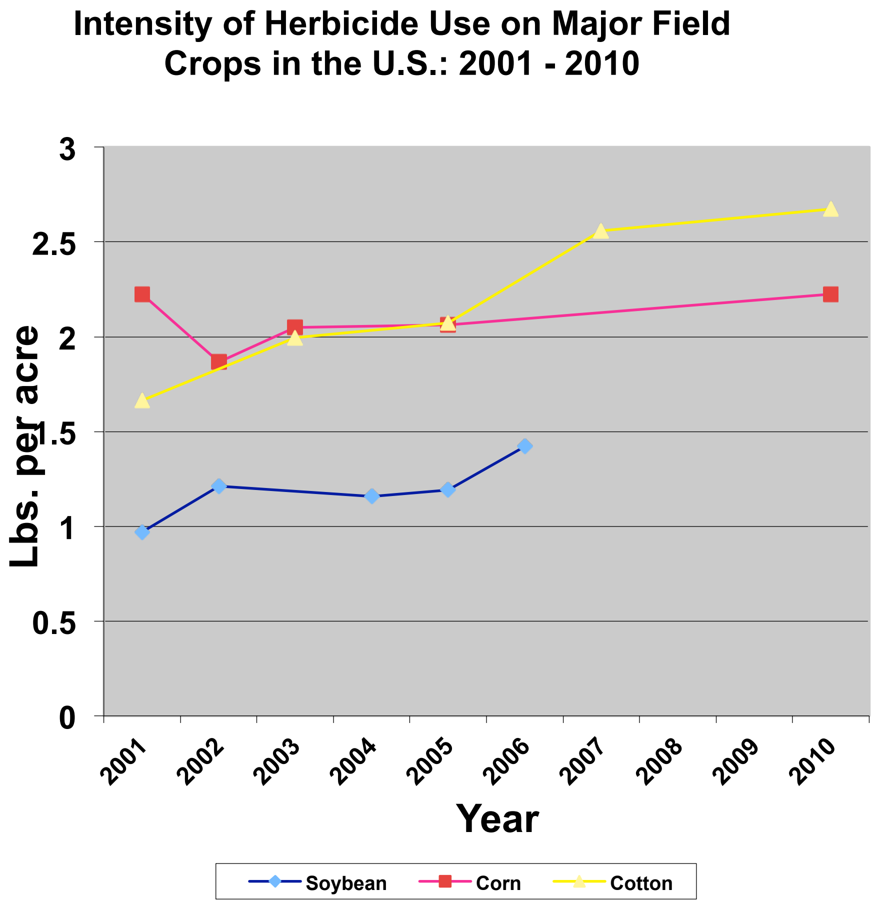
[4] "Meeting of the Advisory Committee on Agriculture Statistics (ACAS): Summary and Recommendations," February 14-15, 2006, USDA NASS, Appendix III, at: http://www.nass.usda.gov/About_NASS/Advisory_Committee_on_Agriculture_Statistics/advisory-es021406.pdf.

[5] Acre treatments represent the average number of herbicide applications a given unit area of cropland (e.g. an acre) receives in the course of the year. It should be noted that the acres treatment metric does not distinguish between two herbicides applied sequentially and two herbicides applied together as a mixture – both represent 2 "acre treatments." In addition, the two treatments can be different herbicides, or the same herbicide applied twice.


Intensity of Herbicide Use on Major Field Crops in the U.S.: 2001 - 2010

Notes: Average annual per acre herbicide use on soybean, soybeans and cotton from 2002-2010. **Source:** "Agricultural Chemical Usage: Field Crops Summary," USDA National Agricultural Statistics Service, for the respective years. USDA does not collect data every year for each crop. For instance, no soybean data has been collected since 2006, and no corn data was collected from 2006 to 2009. 2010 corn and cotton data in USDA-NASS AgChem (2010). http://usda.mannlib.soybeanell.edu/MannUsda/viewDocumentInfo.do?documentID=1560

APHIS must explain how HR crops and HR corn in particular can decrease herbicide use by the amount suggested by Brookes and Barfoot (2012) when herbicide use increased substantially over the years of its adoption. This would involve identification and quantitative assessment of the precise factors which have led to an overall 20% increase in per acre corn herbicide use since 2002, despite the large putative reduction that Brookes and Barfoot (2012) claim has been triggered by HR corn. In other words, APHIS must reconcile Brookes and Barfoot's simulation with NASS data. If unable to do so, then both EO 13465 and the PPA's mandate to practice sound science demand that APHIS drop all reference to work by these industry contractors and revise its herbicide use section to better represent the truth.

It is interesting to note that while HR corn (nearly all glyphosate-resistant) has triggered an enormous increase in glyphosate use, glyphosate has not displaced other herbicides to nearly the extent seen with either HR cotton or HR soybeans. APHIS's casual assessment of this issue (EA at 18, Figure 2-3) is rife with errors and deeply flawed in several respects. First, APHIS purports to demonstrate the putative "glyphosate displacement effect" by comparing the percent of corn acres treated with seven herbicides in 1995 and 2010. But 1995 does not represent the proper baseline for this comparison; 2002 would serve much better. Glyphosate-resistant corn was not introduced until 1998; and herbicide-resistant corn overall comprised 11% or less of total corn acres from 1996 to 2002 (see "Growth in Adoption" figure above). The impact of any changes in herbicide use wrought by HR crops planted on less than one-tenth of total corn acres can simply not be read from data on overall herbicide use, which is heavily weighted to reflect herbicide practices on the ~90% of corn acres planted to non-HR corn varieties. In other words, any HR corn impacts during this 1995 to 2002 period would have been swamped and hidden by other factors altering herbicide use that have nothing to do with HR corn, as demonstrated below.

The seven herbicides chosen for Figure 2-3 are the six most widely used corn herbicides (in terms of % acres treated) in 1995, plus glyphosate. The figure might lead one to believe that glyphosate with HR corn completely displaced cyanazine, which was not used at all in 2010; yet that is not the case. After many years of intensive use following its introduction in 1976, cyanazine was found to be a probable human carcinogen. EPA cancelled all uses in 1999, allowing stocks to be used through 2002 (EPA Cyanazine 2000), a year in which less than 1% of corn acres were treated with this herbicide (USDA NASS 2003). As explained above, 2002 is also the year in which HR corn began to be introduced in a significant way. Thus, HR corn had NOTHING to do with the elimination of cyanazine.

APHIS shows both metolachlor and S-metolachlor applied to the same proportion (29%) of corn acres in 1995. This is erroneous. S-metolachlor was not introduced until 1997, after which time it gradually replaced the quite similar metolachlor (Benbrook 2001).[6] The 1995 bar representing putative S-metolachlor use is spurious and should be eliminated. HR corn did not displace metolachlor usage, S-metolachlor did.

APHIS implies that glyphosate with HR corn has displaced more toxic herbicides like fomesafen and metolachlor (EA at 19). This is false. Fomesafen is not even registered for use on corn! Rather, it is registered for use on soybeans, snap beans, dry beans, cotton and for other non-corn uses (EPA Fomesafen 2007). Neither has usage of metolachlor/S-metolachlor[7] been affected by HR corn adoption. Combined use has remained constant from 2002 (23% of corn acres), through 2005 (25%) to 2010 (24%). Thus, glyphosate has not displaced either fomesafen or (S-)metolachlor on corn.

One reason that glyphosate has not greatly displaced other corn herbicides even as its use has risen with adoption of glyphosate-resistant corn is that it has different properties and uses than many corn herbicides. Glyphosate has essentially no residual activity. That is, it kills only those weeds actually sprayed with it, and does not persist in the soil to kill weeds that emerge weeks after its application as some herbicides do. This makes it best-suited for post-emergence use to

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[6] USDA NASS (1996) lists only metolachlor (29%), NOT S-metolachlor, among herbicides used on corn in 1995.

[7] As discussed above, the two chemicals are closely related, and S-metolachlor is gradually displacing metolachlor, thus the two must be assessed together.

kill weeds that emerge later in the season. In contrast, residual herbicides like atrazine, acetochlor and (S-)metolachlor, which remain very popular with corn growers, are applied to the soil early in the season prior to crop emergence to kill emerging weed seedlings; and their killing power persists for weeks. Thus, many growers have found glyphosate to be complementary to, rather than a replacement for, other corn herbicides. NASS pesticide data bear this out. The combined use of the three major corn residual herbicides mentioned above did not change from 2002 to 2010, even as glyphosate use skyrocketed with massive adoption of glyphosate-resistant corn.

Corn Herbicide by Type	**Percent Corn Acres Treated**	
	2002	**2010**
Atrazine	62%	61%
Acetochlor	25%	25%
Metolachlor/S-metolachlor	23%	24%
TOTAL MAJOR RESIDUAL	**110%**	**110%**
Glyphosate	9%	76%
Glufosinate	3%	2%
TOTAL HR CROP POST	**12%**	**78%**

Source: USDA NASS (2003, 2011)

Glufosinate is very similar to glyphosate in this respect. It has no residual activity (Vencill et al 2012), and its major use in field crops is post-emergence application to glufosinate-resistant varieties. Thus, it will no more displace the popular corn residuals than glyphosate has. It will instead be used precisely as glyphosate is used, as a complement to residual herbicides that farmers have used and relied on for decades.

APHIS's notion that 4114 maize hybrids stacked with glyphosate resistance "may allow growers to substitute glufosinate or glyphosate or both for other herbicides such as atrazine and metolachlor…." (EA at 114) is thus completely unsupported by historical use patterns, and exhibits ignorance of the most basic knowledge of herbicides, their properties and their uses. In fact, APHIS's notion is directly contradicted by the very source it cites for this statement! Vencill et al (2012) do NOT say that glufosinate and/or glyphosate will substitute for atrazine and metolachlor. Instead, they note that soil-applied residual herbicides like metolachlor can in some circumstances be applied post-emergence in a tank mixture WITH glyphosate or glufosinate. That is, glufosinate/glufosinate do not displace metolachlor/atrazine, the latter complement the former, leading to greater overall herbicide use.

DuPont-Pioneer likewise misleadingly implies that glufosinate with 4114 maize will displace use of more toxic herbicides, such as alachlor, 2,4-D, atrazine, butylate and EPTC (DuPont-Pioneer 2012 at 29, 79-80). This fallacy with respect to atrazine was addressed above. Glufosinate cannot displace alachlor, butylate or EPTC because none of them are even corn herbicides. These herbicides were either not used at all, or on at most 1% of total corn acres, in both 2002 and 2010 (USDA NASS 2003, 2011). 2,4-D is used to a small extent (4% of corn acres in 2002, 9% in 2010), and it is often used post-emergence on corn; thus there might be a small potential for glufosinate to displace it. However, DuPont-Pioneer is likely to stack 4114 maize with 2,4-D resistance

(DuPont-Pioneer 2012 at 78-79), so it is even more likely that glufosinate and 2,4-D will both be used post-emergence on corn hybrids incorporating 4114 maize.

APHIS also erroneously reports glyphosate use on corn (EA at 16). The figures APHIS uses there – 66% of corn acres treated, ~57 million lbs. – represent only one (the isopropylamine salt) of five forms of glyphosate reported by USDA NASS, the source APHIS cites. Counting all five forms, overall glyphosate use on corn in 2010 was 64.4 million lbs. applied to 76% of Program State corn acres (USDA NASS 2011). The Program States surveyed by NASS comprised 93% of total US corn acres in 2010. Because it is absurd to assume that the remaining 7% of corn acres go untreated with herbicides, one must adjust NASS figures to obtain a good estimate of total national use. The most reasonable assumption is that the unsurveyed 7% of corn acres received the same average amount of herbicide as those surveyed. Applying this adjustment factor (64.4/0.93) gives 69.3 million lbs. of glyphosate applied to corn in 2010. Similar adjustments to other figures cited by APHIS (EA at 16, 19) yield 55.1 million lbs. of atrazine, 30.1 million lbs. of acetochlor, and 555,000 lbs. of glufosinate applied in 2010. Total 2010 herbicide use on corn was a substantial 196.2 million lbs.

APHIS' continued reliance on misinformation from the pesticide industry and its contractors (CFS has critiqued such studies in many past comments on APHIS GE crop assessments), as well as its continued refusal to consult the gold standard data produced by its sister agency, NASS, is entirely inconsistent with the "sound science" standard demanded of it by the National Environmental Policy Act and other federal laws. This deficiency must be redressed in the context of an Environmental Impact Statement that relies on sound science and accurate data.

g. Genetically engineered corn cultivation associated with increased use of pesticides

Genetically engineered corn is associated with increased use of fungicides, insecticides and herbicides. Fungicidal seed treatments are near-universal on corn seed, but since 2007 have been supplemented by vastly increased fungicide spraying, on over 15 million acres of corn. Bt traits in corn involve production of ever more insecticidal toxins in corn grain and other tissues; chemical insecticidal seed treatments (neonicotinoids) are also used on practically all corn today, up from only 20% of corn seed in 2004; only the use of foliar/soil-applied insecticides has declined somewhat. The increase in fungicide and insecticide use is associated with two adverse trends in American agriculture. First, an "insurance pest management" or preventive approach to pest control that has rapidly displaced integrated pest management. Second, increasing use of these pesticides has ***facilitated*** a substantial rise in continuous corn cultivation, a development which is ***driven*** primarily by enormous subsidies for growing corn, particularly for production of ethanol from corn. Both developments have numerous adverse impacts, not least of which is the accelerated evolution of pesticide resistance in insect pests, which is already leading farmers to increase their use of soil-applied insecticides once again.

3. 4114 maize and herbicide-resistant weeds

a. Summary of herbicide-resistant weeds

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 no assessment of it. Multiple herbicide-resistant weeds are also 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 glufosinate. The emergence of a weed population resistant to both glufosinate and glyphosate, though only the latter herbicide was used on the field in question, raises alarming weed management issues. First, post-emergence glufosinate use with glufosinate-resistant crops such as 4114 maize is one of the major recommendations to control glyphosate-resistant weeds. The potential for widespread evolution of weeds resistant to both herbicides would greatly complicate weed control efforts and entail much increased use of toxic herbicides. Second, this weed population and others like it demonstrate that using "multiple modes of action" (many herbicides that kill weeds in different ways) is often an ineffective approach. APHIS provides no critical assessment of voluntary stewardship efforts to forestall weed resistance touted by DuPont-Pioneer, despite the failure of similar plans in the past. APHIS fails to assess the spread of herbicide-resistant weeds, or mandatory weed resistance management options. APHIS does not adequately assess the adverse impacts of 4114 maize hybrids as volunteer weeds, and provides no assessment of their potential for accelerating evolution of resistance to corn rootworm, an extremely serious pest of corn. Finally, a broader look at the history of herbicide-resistant weeds and in particular the accelerated emergence of multiple herbicide-resistant weeds over the past decade reveals that multiple-herbicide resistant GE crops are no "solution" to epidemic weed resistance, but rather will exacerbate the problem and have negative impacts on farmers, the environment, and US agriculture as a whole in the coming years.

b. Weed management vs. weed eradication

Weeds can compete with crop plants for nutrients, water and sunlight, and thereby inhibit crop growth and potentially reduce yield. While less dramatic than the ravages of insect pests or disease agents, weeds nevertheless present farmers with a more consistent challenge from year to year. However, properly managed weeds need not interfere with crop growth. For instance, organically managed has been shown to yield as well as conventionally grown varieties despite several-fold higher weed densities (Ryan et al. 2010). Long-term cropping trials at the Rodale Institute reveal that average yields of organically grown soybean were equivalent to those of conventionally grown soybean, despite six times greater weed biomass in the organic system (Ryan et al. 2009). Weeds can even benefit crops – by providing ground cover that inhibits soil erosion and attendant loss of soil nutrients, habitat for beneficial organisms such as ground beetles that consume weed seeds, and organic matter that when returned to the soil increases fertility and soil tilth (Liebman 1993). These complex interrelationships between crops and weeds would seem to call for an approach characterized by careful management rather than indiscriminate eradication of weeds.

Farmers have developed many non-chemical weed management techniques, techniques that often provide multiple benefits, and which might not be utilized specifically or primarily for weed control (see generally Liebman-Davis 2009). For instance, crop rotation has been shown to significantly reduce weed densities versus monoculture situations where the same crop is grown each year (Liebman 1993). Cover crops – plants other than the main cash crop that are usually seeded in the fall and killed off in the spring – provide weed suppression benefits through exudation of allelopathic compounds into the soil that inhibit weed germination, and when terminated in the spring provide a weed-suppressive mat for the follow-on main crop. Common cover crops include cereals (rye, oats, wheat, barley), grasses (ryegrass, sudangrass), and legumes (hairy vetch and various clovers. Intercropping – seeding an additional crop amidst the main crop – suppresses weeds by acting as a living mulch that competes with and crowds out weeds, and can provide additional income as well (Liebman 1993). One common example is intercropping oats with alfalfa. Higher planting densities 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 in a manner that does not contribute to soil erosion is also a useful means to control weeds.

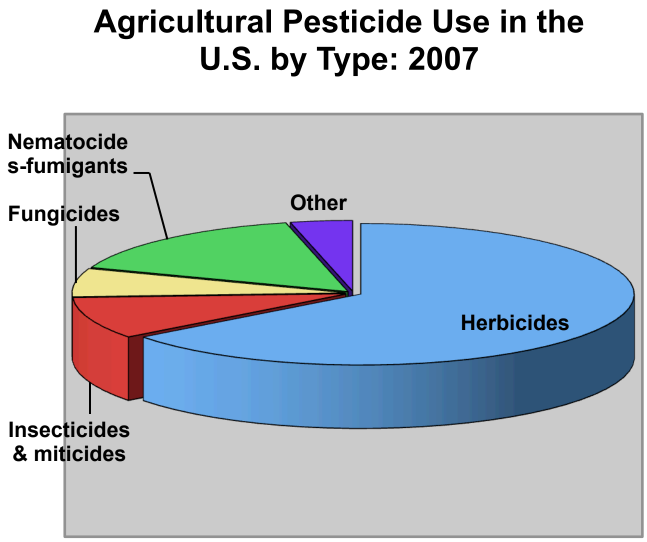
Unfortunately, with the exception of crop rotation and tillage, such techniques are little used in mainstream agriculture. This is in no way inevitable. Education and outreach by extension officers, financial incentives to adopt improved practices, and regulatory requirements are just a few of the mechanisms that could be utilized to encourage adoption of more integrated weed management systems (IWM) that prioritize non-chemical tactics (Mortensen et al. 2012). Meanwhile, the problems generated by the prevailing chemical-intensive approach to weed control are becoming ever more serious. APHIS provides no assessment of IWM systems or non-chemical tactics as an alternative to deregulation of 4114 maize for the stated purpose of DuPont-Pioneer's product, to provide a means to control glyphosate-resistant weeds.

c. The high costs of herbicide-only weed control

In 2007, U.S. farmers spent $4.2 billion dollars to apply 442 million lbs of herbicide, and uncounted billions more on technology fees for herbicide-resistance traits in major crops. Overall, the U.S. accounts for one-quarter of world herbicide use (EPA Pesticide Use 2011, Tables 3.1, 5.2, 5.6). Surely this intensive herbicidal onslaught should make American fields among the most weed-free in the world. But such is not the case. As farmers gradually came to rely more on herbicides as the preferred and then often the sole means to control weeds, herbicide-resistant weeds have become increasingly severe and costly.

The first major wave of herbicide-resistance came in the 1970s and 1980s as weeds evolved resistance to the heavily used triazines, such as atrazine (see Benbrook 2009a for this discussion). The next major wave of resistance comprised weeds resistant to ALS inhibiting herbicides in the 1980s and 1990s. Just five years intervened between introduction of the first ALS inhibitor herbicide in 1982 and the first resistant weed population (1987). One of the major factors persuading farmers to adopt Roundup Ready, glyphosate-resistant crops was the prevalence of weeds resistant to ALS inhibitors. Weeds have evolved resistance at least 21 "modes of action," or herbicide classes, in the world (ISHRW HR Weed Ranking 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 4114 maize'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 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 glufosinate if 4114 maize is deregulated.

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

Herbicide-resistant (HR) crop systems such as 4114 maize involve post-emergence application of one or more herbicides to a crop that has been bred or genetically engineered to survive application of the herbicide(s). These HR crop systems promote more rapid evolution of herbicide-resistant weeds than non-HR crop uses of the associated herbicides. This is explained by several characteristic features of these crop systems.

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

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

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

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).

DuPont-Pioneer has not revealed its pricing for 4114 maize, but it is likely to be considerably more expensive than currently available GE varieties, so a similar dynamic will be in play to foster excessive reliance on glufosinate.

One of the key changes wrought by herbicide-resistant crop systems is a strong shift to "post-emergence"[8] herbicide application, which generally occurs later in the season on larger weeds, versus early-season use on smaller weeds or prior to weed emergence that is more characteristic of conventional crops. It is important to understand that facilitation of post-emergence herbicide use as the sole or primary means of weed control is the *sine qua non* of HR crop systems, not an incidental feature. Early-season uses include soil-applied herbicides put down around the time of planting; these herbicides have residual activity to kill emerging weeds for weeks after application.

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[8] 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 scientist Paul Neve has simulated the rate at which weeds evolve resistance to glyphosate under various application regimes (Neve 2008). His results show unambiguously that the post-emergence use of glyphosate unique to glyphosate-resistant crop systems fosters resistant weeds much more readily than traditional uses ("prior to crop emergence") typical of conventional crops. This is consistent with the massive emergence of glyphosate-resistant weeds only after glyphosate-resistant crops were introduced (see below):

> Glyphosate use for weed control prior to crop emergence is associated with low risks of resistance. These low risks can be further reduced by applying glyphosate in sequence with other broad-spectrum herbicides prior to crop seeding. Post-emergence glyphosate use, associated with glyphosate-resistant crops, very significantly increases risks of resistance evolution. (Neve 2008)

One way that glyphosate-resistant crop systems promote emergence of resistant weeds is by facilitating delayed post-emergence application to larger weeds:

> Growers rapidly adopted glyphosate-resistant crops and, at least initially, did not have to rely on preventive soil-applied herbicides. Growers could wait to treat weeds until they emerged and still be certain to get control. ***Many growers waited until the weeds were large in the hope that all the weeds had emerged and only one application would be needed. Today, experts are challenging this practice from both an economic and a sustainability perspective.*** (Green et al. 2007, emphasis added)

> Following the widespread adoption of glyphosate-resistant soybean, ***there has been a subtle trend toward delaying the initial postemergence application longer than was once common***. Because glyphosate provides no residual weed control and application rates can be adjusted to match weed size, ***producers hope that delaying the initial postemergence application will allow enough additional weeds to emerge so that a second application will not be necessary.*** (Hagar 2004, emphasis added)

University of Minnesota weed scientist Jeff Gunsolus notes that: "Larger weeds are more apt to survive a postemergence application and develop resistance." (as quoted in Pocock 2012).

Glufosinate-resistant crops also foster late post-emergence applications. University of Arkansas weed scientist Ken Smith notes that application of Ignite (glufosinate) to cotton plants with dual resistance to glyphosate and glufosinate (Widestrike) in order to control large glyphosate-resistant weeds risks generating still more intractable weeds resistant to both herbicides (as quoted in Barnes 2011, emphasis added):

> Many growers who use Ignite on WideStrike varieties do so after they discover they have glyphosate-resistant weeds, according to Smith. To combat this, ***growers will make an application of Ignite on weeds that, on occasion, have grown too big to be controlled by the chemistry. This creates a dangerous scenario which could***

> ***possibly encourage weeds to develop resistance to glufosinate***, the key chemistry in Ignite. ***The end-result, according to Smith, would be disastrous***.

It should be noted that Dr. Smith's concern is that weeds will evolve resistance to the same two herbicides to which the HR crop is resistant, which both undermines the utility of the crop and creates a potentially noxious HR weed that becomes extremely difficult to control. As discussed further below, this tendency for weeds to mimic the herbicide resistances in the crop is a general feature of HR crop systems, and sets up a futile and costly chemical arms race between HR crops and weeds. APHIS fails to provide any assessment of the special proclivity of HR crop systems, or 4114 maize in particular, to trigger evolution of resistant weeds. This is a serious deficiency that must be made good in the context of an EIS.

e. 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),[9] 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. 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.

f. High potential for more glufosinate-resistant weeds

Glufosinate is much less used than most major herbicides. Most of its registered uses are in orchards, relatively low acreage nut and fruit trees. Its use in major field crops has thus far been quite limited: roughly 1% of soybean acres and 5% of corn and cotton acres. Overall agricultural use is 2.24 million lbs. annually (EPA EFED Glufosinate 2013 at 20, Table 3.2). Glufosinate does

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

not appear on EPA's list of the 25 most heavily used pesticides in U.S. agriculture, a list that includes 13 herbicides (EPA Pesticide Use 2011). Thus, it is not surprising that very few glufosinate-resistant weeds have been identified thus far (EA at 34-35). However it is instructive to recall that glyphosate-resistant weeds, now epidemic thanks to glyphosate-resistant crop systems, were virtually unknown prior to Monsanto's introduction of these crops.

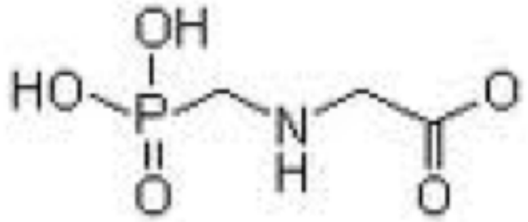
That said, glufosinate use is rising sharply in response to glyphosate-resistant weeds in cotton and soybeans, even to the point of creating shortages (Roberson 2012). Cotton growers are applying glufosinate to Phytogen Widestrike cotton varieties that are not "officially" glufosinate-resistant, but rather contain a resistance marker gene that confers partial tolerance (Golden 2010). Soybean growers are beginning to adopt LibertyLink soybeans, and according to data supplied by DuPont-Pioneer applied over 500,000 lbs. of glufosinate to 1.3% of soybean acres in 2011.

Corn with glufosinate resistance was reportedly planted on 16% of corn acreage in 2010, yet glufosinate was applied to only 2% of corn acres (EA at 113-114). Yet as glyphosate- and multiple herbicide-resistant weeds expand in corn, growers will quite likely make greater use of glufosinate to help control them, just as cotton and soybean farmers have. The highest risk for glufosinate-resistant weeds will occur on those acres where glufosinate-resistant crops are grown, and post-emergence glufosinate applications are made, every year. This would include continuous glufosinate-resistant corn, or rotation of resistant varieties of corn and soybeans and/or cotton. This would mirror the rapid emergence of glyphosate-resistant weeds in corn, which occurred only after Roundup Ready corn began to be grown on large areas in rotation with Roundup Ready soybeans and to a lesser extent RR cotton.

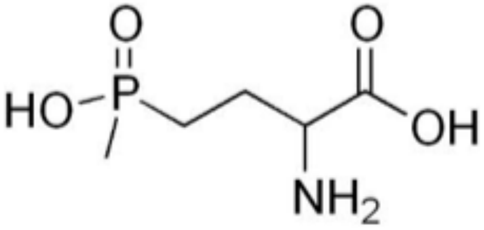
APHIS repeatedly touts the tactic of applying herbicides with multiple modes of action to manage glyphosate-resistant weeds, noting that "[g]lufosinate is one such herbicide offering another mode of action to control glyphosate-resistant weeds" (EA at 106). However, recent research casts grave doubt on this contention.

Avila-Garcia and Mallory-Smith (2011) have recently discovered an Italian ryegrass biotype that is resistant to both glyphosate and glufosinate in an Oregon orchard with a history of glyphosate use, but where little or no glufosinate had been used. They suspect a common, non-target site mechanism – limited translocation – for resistance to both herbicides. In other words, glyphosate use in this Oregon orchard exerted selection pressure that drove Italian ryegrass to evolve a biotype that limits the movement (translocation) of glyphosate in its tissues, and thus reduces the amount of glyphosate that reaches the plant's glyphosate-sensitive target site, resulting in resistance. The surprising finding here is that the same mechanism that limits the movement of glyphosate in this Italian ryegrass biotype apparently also limits the movement of glufosinate, making it resistant to both herbicides.

This finding challenges the foundational assumption of the "multiple modes of action" approach to preventing or controlling herbicide-resistant weeds. This approach assumes that use of two herbicides with different modes of action will prevent resistance from evolving to either one. Yet this finding suggests that resistance mechanisms like reduced translocation can confer resistance to several different types of herbicide even if just one is used. The corollary is that that use of both herbicides will not prevent resistance from evolving; in this case, the Italian biotype would likely have evolved resistance even if glufosinate had been used in addition to glyphosate. It is of interest to note that glyphosate and glufosinate have very similar chemical structures (see below), which may help explain why the plant's evolved ability to limit movement of glyphosate also confers the ability to limit movement of glufosinate.



Glyphosate



Glufosinate

It is interesting to note that glyphosate resistance has been confirmed in 24 weed species worldwide [cite] and that "the most frequently observed mechanism has been limited translocation," which has been confirmed in at least four GR weed biotypes (Avila-Garcia & Mallory-Smith 2011). Mechanisms of glyphosate-resistance have not been identified in most GR weeds. Thus, it is quite possible that other GR weed populations harbor yet undiscovered, additional resistance to glufosinate. Only time and increasing use of glufosinate will reveal whether this is the case. Avila-Garcia and Mallory-Smith (2011) regard the potential for evolution of resistance to both herbicides where both glyphosate- and glufosinate crops are grown as an ***"alarming weed management issue."*** This would of course include individual crops – like 4114 maize stacked with glyphosate resistance – that harbor resistance to both herbicides. APHIS appears completely oblivious to the potential implications discussed above, merely noting the existence of this dual-resistant Italian ryegrass biotype (EA at 34-35), apparently unaware that it directly contradicts the "multiple modes of action" dogma (EA at 83, 123). APHIS does at least note that weeds evolving resistance to glyphosate and glufosinate will likely be treated with more toxic herbicides, "such as gramoxone [i.e. paraquat][10] and atrazine" (EA at 84). DuPont-Pioneer also concede that glufosinate-resistant weeds will increased herbicide use (DuPont-Pioneer 2012 at 80). However, APHIS provides no discussion of the environmental, human health or socioeconomic impacts entailed by increased use of such toxic herbicides.

An important factor that will likely accelerate resistance to glufosinate is the pre-existing prevalence and spread of weeds resistant to multiple herbicides, as discussed above. This is because the progressive acquisition of resistances to different herbicide classes has the insidious effect of accelerating evolution of resistance to those ever fewer herbicides that remain effective. This is well-expressed by Bernards et al. (2012) with reference to multiple-herbicide-resistant waterhemp, though it applies more generally:

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

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

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[10] Gramoxone (Syngenta's trade name for the paraquat) should either be capitalized, or replaced by paraquat. Paraquat is a potent neurotoxin, a potential cause of Parkinson's disease, and one of the most toxic herbicdes in use today.

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.

In 2011, waterhemp populations resistant to HPPD inhibitors (Science Daily 2011) and 2,4-D (UNL 2011), were identified, the fifth and sixth modes of action to which waterhemp has evolved resistance. The scientists who discovered the latter population are extremely concerned that 2,4-D and dicamba-resistant crop systems could foster rapid evolution of resistance to these herbicides:

> 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:

> ***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)

In this regard, it is interesting to note that Tranel et al. (2010) found 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." This would be especially likely to occur on land where several glufosinate-resistant crops are grown, for instance 4114 maize and LibertyLink soybeans. According to Tranel, if waterhemp were to evolve additional resistance to glufosinate, "soybean production may not be practical in many Midwest fields" (Tranel et al 2010). Corn is often rotated with soybeans, and so could be similarly affected.

Both waterhemp (see above) and Italian ryegrass (EA at 84) are problematic weeds in corn and other crops.

APHIS's assessment of weed resistance is faulty in part because it relies much too heavily on pesticide industry sources and academics who conduct research for pesticide-seed firms. For instance, APHIS repeatedly cites Owen et al (2011) and Wilson et al (2011), two of many such "benchmark" studies funded by Monsanto to defuse concern over glyphosate-resistant weeds, and promote multiple herbicide-resistant crops and associated more intensive herbicide use in response. It is worth noting that the lead authors of both these studies have a poor track record in the area of glyphosate-resistant weeds. Owen authored a 1993 letter, which was solicited by Monsanto, in which he assured APHIS that introduction of Roundup Ready soybeans would not lead to emergence of glyphosate-resistant weeds. Wilson appeared in a Monsanto-sponsored advertisement in the farm press, advising farmers that continual planting of glyphosate-resistant crops and associated use of glyphosate every year posed no greater risk of glyphosate-resistant weed evolution than using a variety of herbicides (Hartzler 2004). The study upon which Wilson based these recommendations was also funded by Monsanto. APHIS should base its assessments on studies conducted by better-qualified scientists who are not funded by pesticide companies.

If one steps back a moment to look at the big picture, herbicide-resistant weeds are clearly an unavoidable consequence of herbicide-only weed control regimes and the weed eradication fallacy on which they are based. The massive emergence of GR weeds following the deployment of the first major herbicide-resistant crop system (Roundup Ready crops) demonstrates that this approach fosters especially rapid evolution of resistance. Multiple HR weeds will continue their dramatic emergence, accelerated by and mimicking the resistances of the multiple HR crops that APHIS will likely deregulate in the coming months and years. The consequences will be continued sharp increases in toxic herbicide use, and the human health and environmental harms that entails; a continuing increase in soil erosion as growers employ more tillage; and continued large increases in production costs for farmers spending more on both multiple HR crop seeds and the herbicides used with them. Only a renewed USDA commitment to sustainable weed management practices that minimize reliance on herbicides would provide at least a chance of avoiding this fate.

g. Stewardship

It is highly doubtful whether any DuPont-Pioneer's stewardship plan for 4114 maize will be effective in forestalling weed resistance to glufosinate and/or other herbicides. 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. APHIS provides no critical assessment of DuPont-Pioneer's stewardship plan. There is no indication that it differs from failed stewardship plans of the past, and hence no scientific or empirical basis upon which to expect it to succeed.

h. Spread of weed resistance and tragedy of the commons

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

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

Whether out-crossing or inbreeding, those resistant individuals with lightweight seeds can disperse at great distances. Dauer et al. (2009) found that the lightweight, airborne seeds of horseweed, the most prevalent GR weed (CFS GR Weed List 2012), can travel for tens to hundreds of kilometers in the wind, which is likely an important factor 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 & 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 weeds resistant to glufosinate and other herbicides in the context of 4114 maize. 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.

i. 4114 maize volunteers as weeds

Volunteers are crop plants that sprout from unharvested seed to infest the following season's crop grown on the same field. Harvesting equipment always leaves some proportion of the crop seed in the field. For instance, storms and other factors and other factors like plant disease that cause corn plants to topple, often leading to ears of corn on or near the ground that are then missed by harvesters. Some proportion of this seed will find conducive conditions to sprout, so some level of volunteer presence is an inescapable fact of farming. Corn volunteers can be a troublesome weed in the following season's crop (e.g. soybeans). Just two to four volunteer corn plants per square meter can reduce yields in soybeans by 20% (Morrison 2012). Control of volunteer corn becomes much more problematic when it is herbicide-resistant. In 2007, volunteer glyphosate-resistant corn (Roundup Ready) was rated as one of the top five weeds in Midwest soybean fields (Morrison 2012). APHIS also cites studies showing the prevalence and problematic nature of volunteer GE corn in soybeans (EA at 36).

Volunteer control options diminish with the number of herbicides the crop (volunteer) is resistant to (EA at 124). Thus, both glyphosate and glufosinate would be eliminated as effective control tools for volunteers if 4114 maize stacked with glyphosate-resistance is introduced, as DuPont-Pioneer plans to do assuming deregulation (EA at 110). Already, SmartStax corn volunteers (which incorporate both glyphosate and glufosinate resistance) have been noted as even more problematic weeds than RR corn volunteers, especially in corn-on-corn rotations (Brooks 2012, Morrison 2012). APHIS concedes that effective control of such dual, herbicide-resistant corn volunteers in corn-on-corn rotations would entail either a pre-emergence application of a paraquat-atrazine mixture, or post-emergence use of inter-row cultivation (EA at 37). However, APHIS nowhere factors in the environmental or economic cost entailed by increased use of this toxic herbicide mixture or the greater use of tillage; and in fact elsewhere falsely assumes that 4114 maize hybrids would lead to decreased use of atrazine, and sustain conservation tillage, as discussed elsewhere in these comments.

DuPont-Pioneer will very likely stack 4114 maize with still more herbicide-resistance traits, such as DuPont-Pioneer's 2,4-D and AOPP herbicide-resistance trait (DuPont-Pioneer 2012 at 78-79), yielding 4114 maize hybrids resistant to four classes of herbicide. AOPP grass herbicides like quizalofop are often used to kill volunteer corn in soybeans; that option would be eliminated with the above-cited stack. Monsanto is developing corn resistant to dicamba and AOPP herbicides, which could also be stacked with 4114 maize, yielding corn resistant to five herbicides. As noted above, DuPont-Pioneer envisions corn varieties engineered for resistance to seven or more classes of herbicide.

Volunteers of 4114 maize hybrids expressing multiple herbicide-resistance pose at least two serious risks. First, control of such volunteers will require substantial use of and overreliance one of the few remaining effective herbicides, which in turn will accelerate evolution of resistance to that herbicide in weed populations, triggering all of the adverse effects entailed by weed resistance. Alternately, growers will make greater use of tillage (EA at 37), increasing soil erosion and sediment and pesticide pollution of waterways and bays.

Second, multiple herbicide-resistant corn volunteers incorporating 4114 maize will accelerate the evolution of Bt resistance in corn's billion-dollar pest, corn rootworm. Krupke et al (2009) examined volunteers of stacked glyphosate-resistant/insect-resistant corn emerging in follow-on glyphosate-resistant soybeans. They found that 65% of the volunteers tested positive for CryBb1 (corn rootworm toxin), and that 60% tested positive for both glyphosate-resistance and CryBb1. Surprisingly, CryBb1-positive corn volunteers exhibited the same degree of root damage from larval rootworm feeding as volunteers that tested negative for the CryBb1 rootworm toxin. They hypothesized that these volunteers produce lower, non-lethal levels of CryBb1 toxin due to deficient nitrogen in soybean fields that are not amended with this nutrient. Exposure of corn rootworm to low levels of Cry3Bb1 in corn volunteers will likely accelerate evolution of resistance, increasing the risks posed by corn rootworm and undermining insect resistance management efforts.

Corn volunteers have become an increasingly problematic weed in their research area (Indiana) and throughout the Corn Belt because glyphosate-only weed control programs with Roundup Ready soybeans fail to control glyphosate-resistant/Bt corn volunteers in common soy/corn rotations. Krupke et al conclude that "weedy volunteer corn plants stacked with GR [glyphosate-resistance] and Bt traits may accelerate the development of Bt-resistant WCR [western corn rootworm] populations, circumventing the current [Bt insect-resistance] management plans." Corn volunteers with multiple resistance to glyphosate, glufosinate and/or other herbicides would clearly exacerbate this threat by eliminating more volunteer control options and enhancing volunteer survival. While Krupke's work involved Bt corn expressing a different rootworm toxin (Monsanto's Cry3Bb1), it is quite possible that 4114 maize volunteers would also express lower levels of its Cry34Ab1/Cry35Ab1 toxin, presenting similar issues.

APHIS completely failed to assess either of these risks in the Plant Pest Risk Assessment or draft EA. APHIS's "assessment" was essentially limited to listing herbicides that might control 4114 maize volunteers, with or without glyphosate resistance. APHIS provided no assessment of control options for volunteers that incorporate resistance to more than two (glyphosate and glufosinate) herbicides (EA at 124), or the cumulative adverse impacts of such control options, as discussed above.

4. Human health impacts of 4114 maize and associated glufosinate use

APHIS should assess the health impacts of glufosinate based on the increased use of glufosinate with 4114 maize. We project a substantial increase in glufosinate use with the introduction of 4114 maize hybrids, an increase that depends on the severity of GR weeds and other factors, as discussed above. From current usage of 1.3 million lbs., glufosinate use on corn could easily rise to 10 or 20 million lbs. annually. 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 its 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.

APHIS fails to mention much less assess this evidence of glufosinate's reproductive toxicity (DEA at 59).

Glufosinate use is currently being reviewed for health and safety by the US EPA. Given the dramatic increases in use that will be brought about if 4114 maize is approved, APHIS should explore these impacts utilizing information from the EFSA and EPA review in a fuller assessment before making any decision on the petition.

5. Environmental impacts and plant pest risks of 4114 maize and increased glufosinate use

a. Overview of environmental impacts

Corn acreage has been increasing dramatically in recent years, driven by high corn prices that are in turn stoked by demand for corn to make ethanol. This increase in corn cultivation includes more acres planted to corn continuously, year after year on the same field. Corn-on-corn has numerous adverse impacts, including increased use and runoff of nitrogen fertlilizer and the many adverse impacts that entails; increased use of fungicides and insecticides; and more soil-eroding tillage operations, among others. Bt corn targeting corn rootworm is an important facilitator of corn-on-corn, which is otherwise quite risky because highly prone to corn rootworm infestations. By displacing current hybrids incorporating 1507 and/or 59122, 4114 maize would likely lead to more corn-on-corn acres, exacerbating these impacts. Herbicide-resistant corn is associated with constant or slightly declining use of conservation tillage, and 4114 maize will not, as APHIS maintains, have any countervailing tendency to increase or maintain conservation tillage. Glufosinate is a potent broad-spectrum herbicide, toxic to non-target crops and wild plants at low levels via drift and runoff of water and soil (Carpenter and Boutin 2010, EPA EFED Glufosinate 2013). Therefore an increase in glufosinate use will impact non-target crops and wild plants, including threatened and endangered plants, with consequences for biodiversity. In addition, glufosinate is directly toxic to some animals at environmentally relevant concentrations. Beneficial insects may be particularly at risk from glufosinate use on 4114 maize, including predatory mites and spiders, and lepidopteran pollinators. Mammals present in the agroecosytem may experience chronic toxicity. Pest and pathogen levels may be altered. Also, threatened and endangered animals may be put at greater risk by glufosinate use on 4114 maize. These are significant adverse impacts that APHIS must assess and meaningfully consider in determining whether or not to deny or to approve the petition for deregulation or to approve it with restrictions. APHIS must also engage in ESA consultations with appropriate agencies.

b. 4114 maize would facilitate more continuous corn and its adverse impacts

Below, we assess the likelihood that introduction of corn hybrids incorporating 4114 maize will lead to increased corn acreage, and/or increased acreage planted in continuous corn. Continuous corn refers to the planting of corn in successive years in the same field rather than in alternating years in rotation with other crops such as soybeans. This is an important question because continuous corn (also known as "corn-on-corn") has considerably greater adverse environmental impacts than corn grown in rotation with other crops. If 4114 maize fosters more corn-on-corn cultivation, it will change agricultural practices in ways that increase damage to the environment and the interests of agriculture.

Corn is the most environmentally damaging crop in American agriculture even when grown in rotations. It is responsible for far more synthetic nitrogen and phosphorous fertilizer use than any other crop, and it also consumes roughly 40% of overall agricultural herbicide use, including 80% or more of endocrine-disrupting atrazine, a pesticide regularly detected in ground and drinking water supplies. Continuous corn exacerbates these impacts in many ways, for instance when compared to common corn-soybean rotations (DuPont-Pioneer 2012, 22-26). First, it is well established that corn yields drop when corn is grown continuously versus in rotation with soybeans. In compensation, farmers increase applications of synthetic nitrogen fertilizer, which is associated with runoff and eutrophication of waterways and water bodies such as the Gulf of Mexico and the Chesapeake Bay. Dead zones result that are devoid of fish and other aquatic life. Nitrogen fertilizer also volatilizes into NOx species that exacerbate climate change. Continuous corn is also associated with more plant disease, and thus increased fungicide use, which is often applied prophylactically in expectation of disease. As discussed above, disease concerns associated with continuous corn have been the main driver of increased fungicide spraying on over 15 million corn acres today. Continuous corn is almost always associated with tillage, which is necessary to avoid the buildup of large amounts of corn residue over years that would occur, and make planting operations quite difficult among other problems, if no-till or other soil-conserving tillage methods were used instead. Thus, corn-on-corn is associated with higher rates of soil erosion and associated runoff of agricultural chemicals into waterways. As discussed further below, continuous corn accelerates the evolution of Bt toxin-resistant corn rootworm when corresponding Bt hybrids are grown, as the pests have a continual source of nutrition every year.

As APHIS notes, strong demand for corn to supply the rapidly growing ethanol industry has raised corn prices in recent years (EA at 10). This demand, stoked by billions of dollars in subsidies to promote ethanol production from corn, has made corn relatively more profitable than other crops for an increasing number of farmers, who have responded by growing more corn. Corn acreage has increased a substantial 31% since 1990, to a near historical high of 96.9 million acres in 2012. (APHIS incorrectly maintains that 80 million acres of corn are grown in the U.S. (PPRA at 1), which hasn't been true since the mid 2000s.) The 19% increase in corn acreage since the year 2005 in particular is attributable largely to ethanol demand, as the portion of the U.S. corn production utilized for ethanol rose from just 14% in 2005 to a substantial 42% in 2012. This rise in overall corn acreage has meant more acres planted to corn on corn.

Farmers have traditionally been reluctant to plant corn in successive years because of the problems noted above, and above all because they did not want to risk corn rootworm infestations, which become much more likely, and more damaging when they do occur, when corn is grown every year. Bt corn that incorporates one or more insecticides targeting corn rootworm has eroded that reluctance, and become an important facilitating factor in the rise of corn-on-corn. Understanding this dynamic, seed firms have actively promoted Bt corn for this use.

According to Wyffels Seed Company:

"With the advent of seed technology that puts rootworm protection in the plant, growing corn-on-corn has become much easier. Selecting hybrids with Agrisure® 3000GT, Herculex® XTRA, Genuity® SmartStax®, Genuity® VT Triple PRO® or YieldGard VT Triple® technologies is a great way to go." (Wyffels Hybrids undated)

Several of these varieties incorporate DuPont-Pioneer's 59122 event for resistance to corn rootworm (e.g. Herculex XTRA and Genuity SmartStax).

Monsanto goes so far as to offer farmers "Corn-On-Corn Clinics," events designed to increase sales of the company's SmartStax corn seed by persuading farmers to switch from rotated corn to corn-on-corn (Monsanto undated). SmartStax is presented as the technical means to make corn-on-corn good or at least acceptable agronomic practice. Monsanto accomplishes this by branding its sales pitches with the scientific-sounding term "clinics," and by organizing panels of experts from industry and academia to in effect endorse corn-on-corn by recommending practices that, in concert with Bt corn targeting rootworm, facilitate it. Monsanto even entices farmers to attend its

"Corn-On-Corn Clinics", buy its seed and grow continuous corn by offering attendees the chance at a $500 gift card.

4114 maize is a molecular stack that incorporates resistance to lepidopteran pests (Cry1F) and corn rootworm (Cry34Ab1/Cry35Ab1), the "functional equivalent" of the breeding stack 1507 x 59122. As APHIS asserts repeatedly throughout the draft EA, 4114 will be incorporated in hybrids designed to substitute for or replace current varieties that incorporate 1507 and/or 59122 (e.g. EA at 100).[11] This means that DuPont-Pioneer will retire these "replaced" predecessor lines. In the future, farmers seeking a DuPont-Pioneer product with either resistance to lepidopteran pests or to corn rootworm will have to purchase seed with both traits (and others) in the form of 4114-containing hybrids. This follows from the fact that the traits of a molecular stack are indissolubly linked, unlike those of a breeding stack.

DuPont-Pioneer reports that farmers now grow corn with event 1507, which does not have rootworm resistance, on 9 million acres (DuPont-Pioneer 2012 at 19). With the retirement of 1507, these farmers would then likely grow a 4114-containing hybrid that combined Cry1F from 1507 and corn rootworm resistance, whether they wanted the latter trait or not. This would have two adverse effects. First, corn rootworm toxins would be expressed in 9 million acres of corn where it is not now found (that area now planted to 1507), meaning superfluous selection pressure for evolution of resistance. Second, once farmers are growing a corn variety with rootworm resistance they did not originally want, but which facilitates corn-on-corn, they are then much more likely to adopt this bad farming practice given the lure of historically high corn prices and the powerful suasions of seed firms and their indentured academics.

Thus, it is reasonably foreseeable that introduction of 4114-containing hybrids as a replacement for varieties containing 1507 and/or 59122 will exacerbate the current trend to more and more acres of continuous corn by acting as a technical facilitator and promoter of this practice, which is driven primarily by high corn prices from ethanol demand. This is a cardinal example of how agricultural technologies can have profoundly different impacts depending upon the broader agronomic and societal contexts into which they are introduced.

U.S. agricultural policy promotes corn like no other crop by means of billions of dollars in market-distorting subsidies, for instance to convert corn to ethanol. The high prices that result send price signals to farmers, who respond by planting record amounts of corn, including more corn planted continuously. A technology – Bt for corn rootworm – facilitates the extremely bad farming practice of corn-on-corn, which is also vigorously promoted by pesticide-seed firms who make the majority of their profits from sale of corn seeds (Monsanto 2010). One result is that the technology is rapidly being undermined by evolution of resistance and supplemented or replaced by soil-applied chemical insecticides, as discussed above. Other adverse impacts are those of corn-on-corn, discussed above: greater fertilizer use and attendant harms to aquatic life, air quality, climate change and human health; increased use of fungicides and chemical insecticides; greater soil erosion from abandonment of conservation tillage; among other adverse impacts.

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[11] Because 4114 maize will be used exclusively as breeding stock to develop more highly stacked GE corn hybrids – varieties that will have additional GE traits beyond those in 1507 and 59122 – its deregulation has the potential to do more than replace 1507 and 59122.

APHIS failed to assess these extremely important potential consequences of 4114 maize deregulation, and should do so in the context of an Environmental Impact Statement.

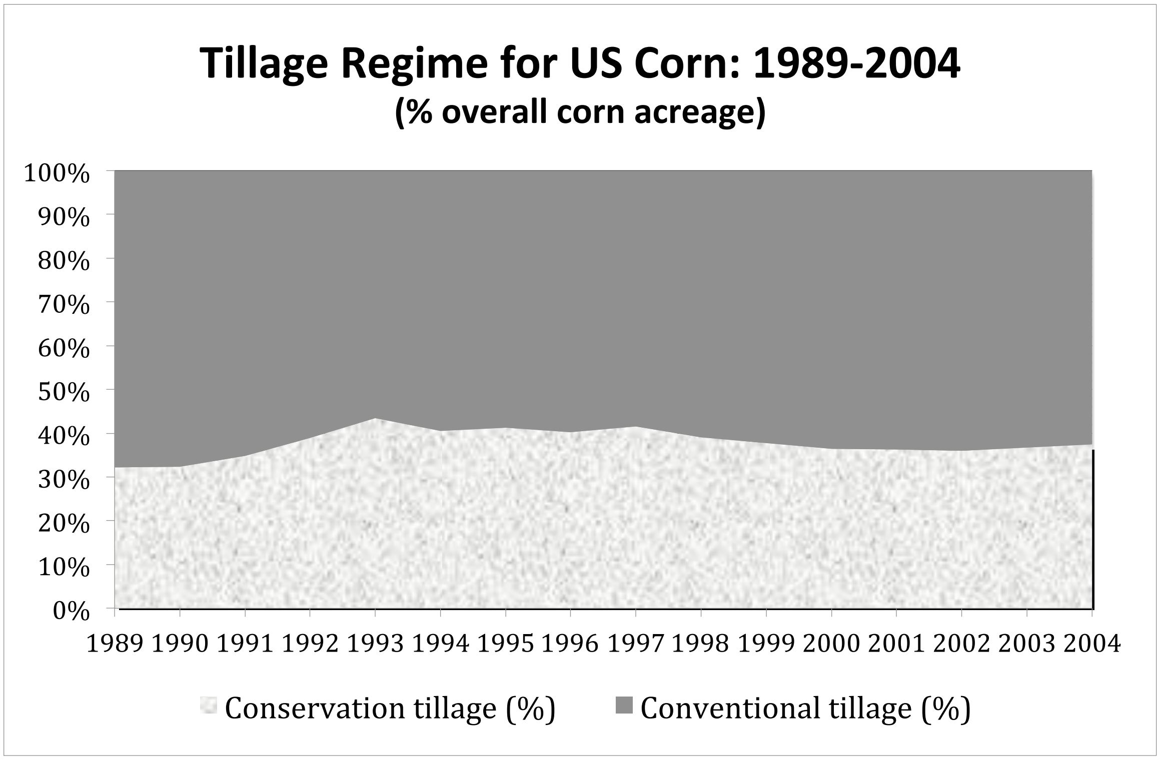
c. Herbicide-resistant corn such as 4114 maize does not promote conservation tillage

APHIS concedes that use of conservation tillage practices in corn is not attributable to the adoption of GE herbicide-resistant corn varieties (EA at 57). Indeed, conservation tillage (con-till) climbed rapidly from 32% of corn acres in 1989 to reach its historical peak of 43% of national corn acreage in 1993, before any GE HR corn variety had been deregulated. Con-till remained above 40% of corn acres through 1997, then dipped below 40% in 1998, the year glyphosate-resistant corn was introduced. There has been no trend since that time, except perhaps for a slight decline, with the proportion of corn-growing land under con-till fluctuating from 36-39% through 2004 (see figure on the next page).

Unfortunately, CFS has not been able to find reliable figures on conservation tillage in corn or any crop since 2004. The data reported in the figure below were collected by USDA's Natural Resource Conservation Service in collaboration with the Conservation Tillage Information Center (CTIC). These data are based on surveys of farmer practice in 3,092 U.S. counties, sufficient for extrapolation to national trends. Unfortunately, CTIC collected data from far too few counties in 2006 to 2008 (from just 67 to 375 of 3,092 counties) to permit legitimate extrapolation to national trends (CTIC 2006, 2007, 2008). An agronomist with NRCS agrees that since 2004, there has not been enough data collected to make any national predictions on crop residue management (personal communication to Bill Freese, 4/6/09, see Widman 2009 in supporting materials). Thus, we excluded those data from the graph below.

Data collected by a private firm, GfK Kynetec, suggest that no-tillage production acres in major crops has declined rather sharply in recent years. These data, as reported by Iowa State University weed scientist Micheal Owen, show that the percent of corn acres under no-till declined by 5.1% from 2007 to 2008, by 5.4% from 2008 to 2009, and by 3.1% from 2009 to 2010 (Owen 2011, Table 1), for a 13% decline in no-till acres from 2007 to 2010. In these years, GE herbicide-resistant corn adoption increased significantly from 52% to 70% (see Adoption graph above).

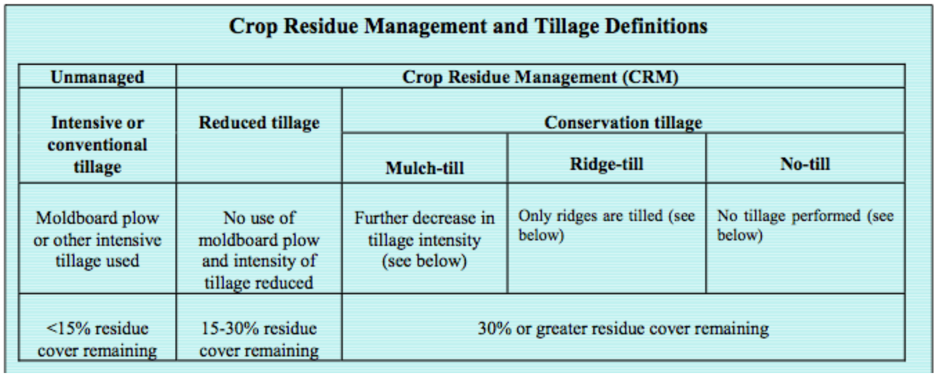
In short, USDA NRCS/CTIC data document constant to slightly declining use of conservation tillage in corn from 1998 to 2004, which includes the initial years of HR corn adoption. According to data from a private firm, no-till practices in corn have declined in the latter years of HR corn adoption (2007 to 2010). These findings, together with APHIS's admission that HR corn does not promote conservation tillage (EA at 57), suggest strongly that 4114 maize hybrids will not, as APHIS inconsistently claims, support continued use of conservation tillage systems in corn (e.g. EA at 114, 117, 118, 119, 121-122, 130). On the contrary, the more likely impact is fostering populations of glufosinate-resistant weeds that then would require more tillage to control, which is precisely what has happened with glyphosate-resistant crop systems.



Sources: For 1989-2000, see: USDA ERS AREI (2002) in supporting materials: "Agricultural Resources and Environmental Indicators: Soil Management and Conservation," US Dept. of Agriculture, Economic Research Service, Chapter 4.2, Table 4.2.9: "Tillage systems used on major crops, contiguous 48 states: 1989-2000." For 2002-2004, see CTIC (2002, 2004). CTIC = Conservation Tillage Information Center. Data not available for 1999, 2001, or 2003; those values were interpolated. CTIC data for 2006, 2007 and 2008 were based on far too few counties to permit extrapolation to national trends in conservation tillage on corn, as explained in text.

APHIS presents data suggesting that conservation tillage in corn has climbed considerably since 2001 (EA at 57, Figure 4-1). These data diverge substantially from the sources cited above, and are difficult to reconcile with the widespread acknowledgement that glyphosate-resistant weeds are legion, and have driven increased use of tillage and partial abandonment of conservation tillage practices in Roundup Ready crops planted on over 150 million acres, as acknowledged by a National Academy of Sciences committee in 2010 (cited in EA at 46).

One potential reason for the discrepancy is confusion of terms. APHIS incorrectly groups "reduced till," which refers to tillage methods that leave 15-30% of the soil covered with residue, as "conservation tillage" (EA at 11). Reduced till is not a form of conservation tillage. Conservation tillage is defined as methods that leave >30% coverage of the soil with crop residue. These are the definitions agreed upon by USDA's soil conservation experts, the Natural Resource Conservation Service (see definitions below).



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.

APHIS also cites a USDA ARMS survey, reported by NASS, to the effect that 62% of corn acres were under "no-till or minimum till systems" in 2010 (EA at 11). Yet "minimum till" is not defined by either APHIS in the EA or NASS in the reference cited by APHIS (USDA-NASS, 2011c), and it is not a term used by NRCS.

The best available data suggests strongly that HR corn either has no impact on, or leads to lesser adoption of, conservation tillage practices. APHIS is urged to correct its draft EA in this regard in the context of an EIS.

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

DuPont-Pioneer's 4114 maize is genetically engineered to be resistant to broadcast applications of glufosinate, whereas fields of corn without the glufosinate-resistance trait can only be treated with glufosinate before planting. On 4114 maize, growers may either apply one burndown application; or glufosinate may be applied one or two times, over the top of the crop, after seedlings emerge but before plants are 24" tall or the V-7 stage of development, whichever comes first. Any of these applications may be made with ground or aerial equipment (Bayer 2011). The post-emergence applications can also be made when corn is 24" to 36" tall if ground equipment with drop nozzles is used.

During ground or aerial applications, a certain amount of glufosinate will move away from the target field as spray particles (drift). Drift is likely over a larger area from aerial applications, with greater impacts (EPA EFED Glufosinate 2013), but APHIS does not discuss the likelihood or impacts of aerial applications in the DEA. In fact, the sample glufosinate label in the DEA is missing sections related to aerial applications that are included in recent specimen labels (compare Liberty 280 SL label from 2011, Bayer 2011; with the Liberty label in Appendix B of the DEA at 189 – 197). APHIS must assess environmental impacts of both ground and aerial glufosinate applications.

During and after applications, glufosinate can also leave the target field dissolved in runoff or attached to soil particles, exposing non-target organisms in aquatic and semi-aquatic environments (EPA EFED 2013).

e. Field reports of injury from glufosinate applications

Injury to organisms from glufosinate applications has been recorded in EPA's Ecological Incident Information System (EIIS), searched in November 2012 (EPA EFED Glufosinate2013 at 57). Forty-four of the 51 incidents in the EIIS between 1999 and 2011 involved registered uses of glufosinate on crops resulting in injury to corn and canola. In one case, 160 acres of pistachio trees were impacted. With wider use if 4114 maize is approved, applications that injure adjacent non-resistant crops and wild plants will no doubt occur more frequently.

There were also two aquatic incidents reported, where fish in ponds in or near agricultural areas were killed. It was probable that one of the fish kills was associated with an application of glufosinate, although the reason for toxicity is unknown. According to EPA, "[g]iven the low toxicity of the glufosinate technical grade active ingredient (TGAI) to fish, it is plausible that these fish kill events may be the result of indirect effects such as water column oxygen depletion due to decreased photosynthesis and increased biochemical oxygen demand from decaying plant material [killed by the glufosinate], or perhaps from ammonium toxicity if the watershed contained other significant sources of ammonium (e.g., fertilizer runoff, decaying organic matter) (EPA EFED Glufosinate2013 at 5).

These incidents show that most of the reported injury to non-target organisms is from use consistent with label directions rather than misuse of glufosinate, contrary to the assertion by APHIS that following the label will protect non-target organisms (e.g. DEA at 82, 142). Also, the absolute number of incidents reported is no doubt low compared to actual incidents, and EPA cautions, "[b]ecause of limitations in the incident reporting system, the lack of additional incident reports cannot be construed as the absence of incidents from the registered use of glufosinate." (EPA EFED Glufosinate 2013 at 58).

In fact, it is likely that crop injury from pesticide drift is routinely 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 and animals are harmed, injury may not be noticed or reported at all. Therefore, most information about risks of herbicide exposure for wild plants, animals and ecosystems comes from experimental studies and comparative surveys rather than from incident reports.

f. Experimental studies, comparative surveys, and risk assessments of glufosinate impacts to non-target organisms

i. Non-target plants

Non-target crops that are not engineered to be resistant to glufosinate and wild plants are very sensitive to glufosinate (Carpenter and Boutin 2010, Davis et al. 2009). Drift levels can cause sub-lethal vegetative effects such as necrotic leaves, chlorosis and stunting, and reproductive effects such as flowering delay, deformed flowers, sterility and fewer or smaller seeds (e.g. Davis et al. 2009, Carpenter and Boutin 2010). Species vary in their responses and sensitivity. Also, some species can recover from early injuries caused by drift rates of glufosinate, and other species appear to recover but exhibit reproductive abnormalities later (Carpenter and Boutin 2010). In fact, in their study of the responses of several crop and wild species to sub-lethal glufosinate applications, Carpenter and Boutin (2010) found that "reproductive outputs" were a more sensitive measure than vegetative injury for more than half of the plants tested. They conclude that plants in their natural habitats might be even more sensitive:

> The low hazardous doses determined in this experiment fall within this critical range, thus indicating that glufosinate ammonium spray drift could potentially be highly toxic to non-target plants. Though these results were obtained through controlled greenhouse experiments, it is possible that the same effects could be mimicked, if not exacerbated, in natural areas where environmental conditions, species composition (Kegode and Fronning 2005) and competition could further hamper the survivability of susceptible species. (Carpenter and Boutin 2010).

They then describe in more detail how these kinds of sub-lethal injuries from glufosinate drift can affect natural ecosystems:

> From a biological standpoint, both early reductions in biomass and overall decreases in reproductive outputs can have substantial impacts on plant community dynamics with cascading effects on wildlife behaviour. Though biomass recovery was noted in this experiment, all plants were grown individually in pots under uniform, controlled conditions, and without direct competition from other plant species. In natural environments subtle decreases in growth of a susceptible species could lead to it being outcompeted for light and nutrients by more resistant, healthier and larger species (Weiner 1990), while decreases in health may make susceptible species more vulnerable to pathogen attacks (Brammall and Higgins 1988; Wang and Freemark 1995). Such events can lead to dominance shifts and simplifications within the community (Hume 1987; Pfleeger and Zobel 1995). Riemens et al. (2004) noted a shift towards increases in monocot biomass relative to dicot biomass for increasing doses of glufosinate ammonium following a 4 week mesocosm study. In a study on forest regeneration following a one-time exposure of

> hexazinone, it was shown that effects were still present after 17 years (Strong and Sidhu 2005). Though a majority of species had a decrease in canopy cover, some species (possibly due to resistance) did show an increase over control levels. Similarly, a long-term study by Crone et al. (2009) observed that a one-time application of picloram to a natural area for the control of spotted knapweed (*Centaurea maculosa*), had negative long-term effects on the flower production (and hence seed production) in the native perennial, arrowleaf balsamroot (*Balsamorhiza sagittata*) for approximately 4 years, though leaf production (as a nondestructive measure of biomass) was unaffected (Crone et al. 2009).
>
> In addition, seed and fruit loss would directly relate to declines in seedbank numbers, and subsequently affect future seedling recruitment. Delays in flowering can also be problematic from the seasonal perspective. Though both *Hypericum perforatum* and *Solanum dulcamara* did demonstrate biomass recovery, the loss of the primary meristem was found to be related to lack of flowering within the experimental timeframe. Under field conditions, these perennials may not have been able to contribute to their perspective seedbanks before the first frost.

Animals depend on plant biodiversity for most of their needs, so it would be surprising if these kinds of herbicide drift-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.

These are significant adverse impacts that APHIS must assess and meaningfully consider in determining whether or not to deny or to approve the petition for deregulation or to approve it with restrictions.

ii. Non-target organisms beneficial to agriculture

APHIS concluded in the draft PPRA that there are no non-target impacts of 4114 maize on “beneficial organisms in the corn agroecosystem” (PPRA at 11), but it did not take into account use of glufosinate in the 4114 maize crop system. Experimental evidence and risk assessments by EFSA and EPA point to a variety of impacts to beneficial organisms that do need to be considered by APHIS.

<u>Predatory mites and spiders</u>

Glufosinate is toxic via a metabolic pathway found in animals and microorganisms, as well as plants, and some animals are injured or killed by herbicidal doses (EPA EFED 2013). Arachnids such as mites and spiders are particularly sensitive to glufosinate.

Although some mite species are serious agricultural pests of many crops, including corn, the use of pesticides for their control is not generally an effective strategy. Pesticides fail because many pest mites have developed resistance; while predatory mites, spiders and other insects that are important for keeping pest mite populations low are susceptible. Therefore, Integrated Pest

Management systems are recommended, where healthy predator populations are encouraged (Peairs 2010).

Glufosinate can harm predatory mites. Experiments on the direct toxicity of various pesticides to a predator mite found in Virginia vineyards showed glufosinate to be particularly toxic, causing 100% mortality within a day (Metzger and Pfeiffer 2002). Although the dose used was greater than that for resistant corn, lower doses were not tested.

Further experiments on glufosinate and beneficial arthropods were carried out in conjunction with a risk assessment by the European Food Safety Authority (EFSA 2005), and included glufosinate applications as used on corn:

> The European Food Safey Authority (EFSA 2005) evaluated a series of extended laboratory and semi-field studies on beneficial insects including the parasitoid wasp (*Aphidius rhopalosiphi*), predatory mite (*Typhlodromus pyri*), wolf spider (*Pardosa* ssp.), green lacewing (*Chrysoperla carnea*), ground beetle (*Poecilus cupreus*), and rove beetle (*Aleochara bilineata*). “Severe” effects were observed with a potential for population recovery in one season when glufosinate was applied at rates consistent with use on glufosinate-resistant corn (two application at 0.8 kgai/ha) (EPA EFED Glufosinate 2013 at 95)

Although there was “potential for population recovery in one season”, the risks to beneficial insects were considered to be high enough to warrant mitigation:

> As described in the EFSA (2005) report, the EFSA Peer Review Coordination (EPCO) expert meeting (April 2004, ecotoxicology) recommended mitigation measures for risk to nontarget arthropoods, such as a 5-m buffer zone when glufosinate is applied to corn or potatoes. (EPA EFED Glufosinate 2013 at 95).

Data from EPA also indicates that large buffers may be required to protect non-target terrestrial plants from injury (EPA EFED Glufosinate 2013 at 98), and thus reduce harm to non-target predatory mites and spiders, and other beneficial arthropods.

Pollinators

Pollinators are beneficial to agriculture, and even though corn is wind-pollinated, pollinators necessary for other crops and wild plants are known to collect pollen from corn (Krupke et al. 2012), or use the other plant species found within and around cornfields for food and other habitat requirements (Pleasants and Oberhauser 2012). Thus APHIS must assess the impacts on pollinators of glufosinate use with the 4114 maize system.

Glufosinate may have direct effects on lepidopteran pollinators when larvae eat glufosinate-containing pollen or leaves, either after direct over-spray or from drift. Laboratory experiments with the skipper butterfly *Calpodes ethlias* showed that larvae fed glufosinate-coated leaves were injured or killed by inhibition of glutamine synthase, at doses “comparable to the amount that might realistically be acquired by feeding on GLA [glufosinate]-treated crops.” These studies were done with the active ingredient, not a full formulation, and so may have underestimated field toxicity (Kutlesa and Caveney 2001).

Pollen of glufosinate-treated 4114 maize may accumulate significant levels of glufosinate. Although primarily a contact herbicide, glufosinate does translocate via phloem to a limited degree, depending on the plant species (Carpenter and Boutin 2010). In experiments comparing glufosinate translocation in GE resistant canola versus a susceptible variety (Beriault et al. 1999), glufosinate translocated more readily in resistant plants. However, in both resistant and susceptible canola, glufosinate moved in the phloem to developing anthers without causing injury to tissues along the way. If glufosinate is retained in leaves of resistant corn, it may translocate to pollen later, even if the applications occur well before pollen formation.

APHIS should examine data on glufosinate levels in leaves and pollen of 4114 maize after labeled applications to assess risks to beneficial pollinators.

Pollinators may also be affected by changes in habitat from glufosinate toxicity to plants. Numbers and kinds of plants can change dramatically in response to herbicide applications, with impacts that ripple through ecosystems. In particular, glufosinate may be more toxic to dicots than monocots in a particular environment, risking replacement of nectar-producing plants with grasses that reduce the value of the agroecosystem for pollinators (Longley and Sotherton 1997). In addition, pollinators that depend on specific host plants may be affected if those plants are more sensitive to glufosinate (Pleasants and Oberhauser 2012).

Large buffers may be required to protect non-target terrestrial plants from injury (EPA EFED Glufosinate 2013 at 98), and thus reduce harm to pollinators.

Mammals

Some mammals are considered beneficial to agriculture, including corn. For example, some rodents eat weed seeds, reducing the weed seed bank (EFSA 2005), or become food for predators that control pest species. Other mammals are predators of corn pests.

Glufosinate use on 4114 maize is likely to exceed levels of concern for chronic risk to mammals that eat insects, and plant parts other than strictly fruits, seeds and grains (EPA EFED Glufosinate 2013 at 70), as summarized:

> The screening level assessment with preliminary refinements concludes that the use of glufosinate in accordance with registered labels results in chronic risk to mammals that exceeds the Agency’s chronic risk Level of Concern (LOC). Adverse effects in mammals following chronic exposure to glufosinate in laboratory studies include reductions in growth and in offspring fitness and viability; these effects are seen across generations and in multiple species (EPA EFED Glufosinate 2013 at 5).

Chronic effects of glufosinate at the expected exposure levels in laboratory studies “include reductions in parental and offspring growth and offpsring viability. These effects have been observed in multiple studies and have been shown to extend to the second generation (no subsequent generations were tested)." (EPA EFED Glufosinate 2013 at 92)

Formulated products are more acutely toxic to mammals than the active ingredient alone by an order of magnitude (EPA EFED Glufosinate 2013 at 91), and formulations may also cause chronic toxicity at lower levels.

EFSA identified a high risk to mammals from glufosinate use in resistant corn based on chronic toxicity, and considered it to be "critical area of concern" (EFSA 2005).

Microorganisms

Beneficial microorganisms include species in the rhizosphere of corn and on leaf and stem surfaces that mediate nutrient relationships, diseases, and environmental stresses. Also, soil microbes involved with decomposition, nutrient cycling, and other functions may be affected by glufosinate.

Some studies have indeed shown negative effects of glufosinate on beneficial microbes. Pampulha et al. (2007) treated soil in laboratory microcosms with the glufosinate formulation "Liberty" at different concentrations and durations, and then determined the types, numbers and functional activity of culturable microorganisms – bacteria, fungi, and actinomycetes; cellulolytic fungi, nitrite oxidizing bacteria, and dehydrogenase activity. They found a complex pattern of changes in number and activity of microbes. However, the most dramatic change in response to glufosinate was a large decrease in dehydrogenase activity over time, which they say is a good indicator of general microbial activity. They conclude that glufosinate use "may have injurious effects on soil microorganisms and their activities."

g. Diseases of plants and other organisms

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, such as "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).

Glufosinate has been shown to affect various plant pathogens, both after applications to resistant crops, and in culture (reviewed in Sanyal and Shrestha 2008). Also, in glufosinate-resistant rice, glufosinate has been shown to trigger transcription of pathogenesis-related genes and other defense systems that act in concert with direct suppression to protect the GE rice from blast and brown leaf spot diseases (Ahn 2008). Again, some effects of glufosinate on pathogens may be beneficial for agriculture, and some may be harmful. For example, glufosinate may suppress pathogens of weeds or pests, allowing those weeds and pests to cause more damage.

Therefore, APHIS must consider the changes in pests and pathogens of non-target organisms as a result of increased glufosinate use with 4114 maize. These are significant adverse impacts that APHIS must assess and meaningfully consider in determining whether or not to deny or to approve the petition for deregulation or to approve it with restrictions.

h. Composition and agronomic properties of 4114 maize

One major flaw of APHIS's assessment is its failure to determine whether 4114 maize exhibits altered composition or agronomic properties relative to non-genetically engineered corn (PPRA 4-7). Such an assessment must accomplish two objectives. First, 4114 maize must be compared to a conventional isoline control (non-transgenic corn line that is genetically near-identical to 4114 maize except for the genetically engineered traits) grown under identical conditions to control for environmental effects. This comparison is needed to detect unintended effects of the genetic engineering process used to generate 4114, including any with adverse environmental or agronomic impacts. Second, because 4114 maize is explicitly engineered to facilitate direct application of glufosinate herbicide, APHIS must assess 4114 maize sprayed directly with glufosinate. Glufosinate is extremely toxic to corn (whether conventional corn or biotech varieties that do not contain the *pat* gene), and thus is never sprayed directly on it. Because herbicides can have substantial effects on crop composition and agronomic properties, it is obviously necessary to conduct a thorough comparison of glufosinate-sprayed 4114 maize and 4114 not sprayed with glufosinate.

APHIS should conduct both assessments based on data collected with sensitive metabolic profiling, DNA microarray, or similar non-targeted techniques that measure the levels of a large number of known plant constituents, and which are also capable of detecting any novel compounds generated unintentionally by the mutagenic genetic engineering process (Kuiper et al 2001). Such methods could also detect any impacts of glufosinate application on the composition or agronomic properties of 4114 maize.

Instead, APHIS's assessment was based on inadequate testing conducted by DuPont-Pioneer (Petition, 100-142). None of the firm's tests involved glufosinate-treated 4114 maize. Thus, any adverse impacts from the direct spraying of glufosinate on 4114 maize (which is how corn varieties incorporating 4114 will often be used in reality) went undetected. DuPont-Pioneer also utilized "targeted" test protocols which involved choosing selected components to measure. Any such targeted testing protocol is to a certain extent arbitrary in light of the mutagenic nature of genetic engineering and the plethora of unpredictable, unintended effects it triggers (Wilson et al 2006).

Compositional changes can have numerous adverse effects that are relevant to APHIS's assessment. For instance, a reduction in lignin or its precursor compounds – whether as an unintended effect of genetic engineering or of direct glufosinate application – could render 4114 maize more susceptible to insect attack or disease, given lignin's well-known roles in plant defense; or more prone to lodging, since lignin is the structural component of plants that make them stiff. A second example. Corn has been found to harbor potent substances that profoundly affect the sexual hormones and behavior of rodents. These substances – tetrahydrofuran and leukotoxin diol derivatives of the abundant corn fatty acid linoleic acid – have been detected in corn cobs as well as grain and processed food products (Markeverich et al 2005, 2007). The compositional and agronomic properties testing reviewed by APHIS is not capable of detecting such potentially serious adverse effects.

The fact that APHIS has previously approved different varieties of glufosinate-resistant corn is immaterial, since those varieties were deregulated, as APHIS here proposes with 4114 maize, without tests conducted on glufosinate-sprayed 4114 maize. It is remarkable that, nearly two decades after deregulation of the first glufosinate-resistant crop, the compositional and agronomic consequences of spraying glufosinate on it remain almost entirely unknown. CFS stresses once again that direct application of glufosinate to a crop is an entirely novel practice that has only become feasible with the advent of genetically engineered glufosinsate resistance.

CFS knows of a single study that addresses this issue. Reddy et al (2011) examined a handful of compositional effects of glufosinate when sprayed on glufosinate-resistant soybeans. Interestingly, they found that application of glufosinate triggered unexplained changes in most of the very few constituents they measured. Protein content increased by 2.6%, while overall oil content declined by 4.3%. Apparently just five fatty acids were measured, and reported as a proportion of total oil. The proportions of linoleic, stearic and palmitic acid were unchanged relative to unsprayed, glufosinate-resistant soybeans. Linolenic acid declined from 8.4% to 7.0%, while oleic acid increased from 22.6% to 26.1%, of total oil.

Reddy et al speculate in very general terms that "glufosinate may alter carbon metabolism," citing similar effects exerted by glyphosate; that increased protein could be a stress response of the soybean to glufosinate treatment; and that the increase in oleic acid and decline in linolenic acid "could be due to indirect physiological disturbances that affect fatty acid desaturases" or to an alteration in carbon metabolism. These general speculations, however, are little more than restatements of the observed effects in more technical terms.

The issue is not the safety implications of the detected changes; the changes in oleic and linolenic acid levels obviously do not pose risks. The point is that these few significant changes that happened to be detected through very limited testing almost certainly point to a host of other unknown compositional effects, some of which could have serious adverse implications. In the absence of complete mechanistic explanations for how glufosinate affects crop metabolism (which would be ideal), non-targeted profiling techniques as suggested above are required to canvass the broadest possible array of plant constituents for potential impacts.

Corn resistant to and sprayed with both glufosinate and glyphosate could well have substantially altered composition, contrary to APHIS (127-28, 129).

CFS urges APHIS to collect data as outlined above to better assess the potential adverse impacts associated with the 4114 maize system before making any decision on the petition for deregulation.

i. Threatened and endangered species

All of the harms from increased use of herbicides on 4114 maize 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 4114 maize 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).

APHIS needs to update their section on threatened and endangered species to reflect EPA's Environmental Fate and Ecological Risk Assessment for Registration Review of Glufosinate (EPA EFED Glufosinate 2013), where preliminary assessments of risks to listed species are presented in detail.

For the pattern of glufosinate use on 4114 maize, the following taxa of federally listed species were determined by EPA to be potentially at risk from direct effects of glufosinate when used "on label": aquatic nonvascular plants (at 87), terrestrial plants in wetlands (at 95), terrestrial invertebrates (at 93), and some mammals (at 91).

Indirect effects from alteration of habitat are likely also: "Consistent with the intended use of glufosinate as an herbicide, potential risk to nontarget terrestrial and aquatic plants is expected. Effects on plants, which are the primary producers in most ecosystems, may result in potential indirect effects on consumers." (EPA RPA at 10). Also, for aquatic organisms, indirect effects were discussed, as quoted above regarding fish kills.

APHIS mistakenly relies upon the idea that "following directions" will protect listed species, stating that "adherence to US-EPA label use restrictions by the pesticide applicator will ensure that the use of glufosinate will not adversely affect TES or critical habitat" (DEA at 142), and elaborates:

> There are legal precautions in place to reduce the possibility of exposure and adverse impacts to TES from application of glufosinate to Pioneer 4114 Maize. These precautions include the USEPA pesticide label restrictions and best practice guidance provided by the herbicide manufacturer (see, e.g., Bayer, 2012). Adherence to these label use restrictions by the pesticide applicator will ensure that the use of the herbicide will not adversely affect TES or critical habitat. Labeled uses of glufosinate are approved pending the outcome of the US-EPA's ecological risk analysis. No changes to the US-EPA approved label applications of glufosinate are proposed for cultivation of Pioneer 4114 Maize. (DEA at 152)

Now that EPA has presented their preliminary risk assessments and found that labeled uses are indeed likely to exceed levels of concern for listed species, APHIS must initiate consultations with the appropriate federal agencies.

6. Socioeconomic impacts of 4114 maize

4114 maize is intended to replace 1507 and/or 59122 corn (e.g. EA at 56, 63, 100). 1507 incorporates resistance to certain above-ground lepidopteran pests (the Cry1F toxin), while 59122 expresses the Cry34Ab1/Cry35Ab1 toxin that targets corn rootworm. Both varieties have resistance to glufosinate herbicide. 4114 maize expresses both the insect resistance traits and the glufosinate resistance of 1507 x 59122.

4114 maize is a “molecular stack” that combines the genes conferring the three traits at the same chromosomal location. If deregulated, it will not be offered as a stand-alone commercial product, but will be combined with other events to generate GE corn varieties with four or more transgenic traits. DuPont-Pioneer anticipates that it will be easier and more efficient to conduct breeding with 4114 than with the “functionally equivalent” 1507 x 59122 (EA at 2). For instance, 1507 x 59122 is already a component of SmartStax corn (EA at 60), which expresses eight different proteins, 6 insecticidal and 2 for herbicide resistance. 4114 maize will more easily be incorporated via breeding into such highly stacked varieties.

APHIS wrongly assumes that any potential efficiency gains accruing to DuPont-Pioneer in replacing 1507 and/or 59122 with 4114 maize will somehow translate into lower seed prices for farmers (PPRA at 12). There is absolutely no evidence to support this naïve assumption, and much to suggest otherwise. In fact, introduction of 4114 maize will contribute to still higher corn seed prices.

The table below contains USDA ERS data on the cost of corn, soybean and cotton seed to plant one acre. Clearly, seed prices have skyrocketed in the biotech era, beginning in 1995, versus the preceding two decades. Biotechnology company profit motives and pricing strategies explain why this is so.

Crop Seed Cost ($/planted acre)	1975	1995	2011	1975-1995 (% increase)	1995-2011 (% increase)
Soybeans	$8.32	$13.32	$56.58	60%	325%
Corn	$9.30	$23.98	$86.16	158%	259%
Cotton	$5.88	$15.67	$96.48	166%	516%
Figures from USDA Economic Research Service: Commodity Costs and Returns: U.S. and Regional Cost and Return Data. Datasets accessible at: http://www.ers.usda.gov/Data/CostsAndReturns/testpick.htm. See Appendix 4 for graph of complete datasets.					

Biotechnology companies generally raise the price of seed with each new biotech trait they introduce. Thus, SmartStax is both the most highly stacked and the most costly corn seed on the market today (Tomich 2010). As biotech firms introduce new, more highly stacked and more expensive varieties, they retire conventional varieties and those with fewer traits, both to maximize sales of the most profitable seeds and to keep inventories manageable (Goldman-Sachs 2008). By easing the development of still more highly stacked and priced products, 4114 maize will accelerate already steeply rising seed prices. APHIS must assess the trend in steeply rising seed prices for farmers, its interrelationship with more highly stacked offerings, and apply this to an analysis of the likely impact of 4114 maize on seed prices paid by farmers.

APHIS also wrongly assumes that the introduction of 4114 maize will increase seed options for farmers (PPRA at 12). Once again, APHIS presents no evidence in support of this view. In fact, as explained above, 4114 maize may lead to ***more rapid*** development of highly stacked and priced products (though there is no reason to believe it should lead to options that would not be obtainable through breeding with 1507 x 59122 under the No Action alternative). But it will also lead to accelerated retirement of more affordable seed varieties with fewer traits.

Contrary to APHIS (EA at 109), once 4114 maize replaces 1507 x 59122, DuPont-Pioneer will have little reason to continue offering either 1507 or 59122. Maintaining a full suite of varieties based on either transgenic event platform alone will be economically unjustifiable, and DuPont-Pioneer will phase out both lines and offer 4114 maize-based hybrids in their stead. It simply does not matter that “some growers may only have a need for the 1507 product” (EA at 109). If meeting that need is not justified by the bottom line, DuPont-Pioneer will not meet it. The farmer will have to buy a more expensive 4114-based hybrid instead, or a similar product from Monsanto. This has been the course of GE seed marketing thus far, particularly in corn. Single-trait varieties were replaced by triple-stack varieties, which are now being replaced by eight-trait SmartStax. This is the natural and expected result of a highly concentrated seed industry, which ensures a dearth of competition, and few if any companies to meet the demand for less highly stacked, less profitable but more affordable seed (Hubbard 2009).

A typical example is Somerville, Tennessee farmer Harris Armour, who has deep reservations about SmartStax seed, as expressed in the following excerpt of a newspaper article (Roberts 2008):

> "I like to buy what I want," he said. "When they start stacking for things I don't need, it just makes the price of the seed go up."

He figures that once SmartStax gets a hold in the market, Monsanto will have no reason to produce the double- and triple-stacked gene technologies he likes.

"They say those decisions will be based on demand," he said. "The trouble is, Monsanto gets to decide what is enough demand."

APHIS unwittingly supports this analysis. In describing the differing insect resistance traits of 1507 and 59122, and their respective target specificities, APHIS states: "This target specificity allows a grower to select a corn variety containing a Cry protein specific to an insect pest. For example, Cry1F in 1507 Maize targets lepidopteran pests and Cry34Ab1/Cry35Ab1 in 59122 Maize to target coleopteran pests (Pioneer, 2011b, 2012)." (EA at 16)

What APHIS fails to realize is that it is precisely this grower choice for "target specificity" that will be lost once 4114 maize displaces its predecessor lines in the marketplace.

APHIS also makes completely insupportable statements to the effect that glufosinate use with 4114 maize hybrids will replace other corn herbicides, leading to reduced input costs (EA at 107). CFS has refuted this fantasy in the pesticide use section. The recent history of herbicide-resistant crops and resistant weed evolution demonstrates conclusively that input costs will rise along with seed prices in vain attempts to control increasingly resistant weeds.

By accelerating the introduction of highly stacked varieties and displacing its predecessor 1507 and 59122 lines, 4114 maize will accelerate the already steeply rising price of corn seed for farmers; and it will reduce the choice of more affordable seed options.

7. Conclusion

As these comments make clear, APHIS's deregulation of 4114 maize would have numerous adverse impacts that require much more serious and competent analysis than has been given them in the deeply flawed Plant Pest Risk Assessment and Environmental Assessment. APHIS must reconsider the significant adverse impacts described in these comments and assess and meaningfully consider them in determining whether or not to deny or to approve the petition for deregulation, or to approve it with restrictions.

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