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Regulatory Analysis and Development
PPD, APHIS
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4700 River Road Unit 118
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Comments to USDA APHIS on Environmental Assessment for the Determination of Nonregulated Status of Herbicide-Tolerant DAS-40278-9 Corn, *Zea mays*, Event DAS-40278-9

Center for Food Safety, Science Comments I – By Bill Freese, Science Policy Analyst

These comments submitted by Center for Food Safety are one of three sets of comments from our organization. Legal comments and a second set of science comments are also being submitted. 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 of each section.

THE IMPACT OF DAS-40278-9 ON CORN HERBICIDE USE

Summary of herbicide use

Dow's DAS-402787-9 corn is genetically engineered for resistance to 2,4-D and quizalofop, and if deregulated would be marketed with additional resistance to glyphosate and likely glufosinate – fostering greater use of three to four herbicide classes. APHIS must assess DAS-42078-9 as Dow intends it to be used, as a weed control system. DAS-40278-9 eliminates the risk of crop injury that currently limits 2,4-D use on corn, and is thus reasonably projected to trigger an up to 30-fold increase in the use of this toxic herbicide on corn, equivalent to a four-fold increase in overall agricultural use of 2,4-D, by the end of the decade. It would also spur entirely new use of quizalofop on corn, and increase overall corn herbicide usage. DAS-40278-9 would also substantially alter herbicide use patterns. The consequences of these substantial changes in farming practice are addressed elsewhere in these and a second set of comments (CFS Science Comments – II). APHIS's assessment of herbicide use in the DEA is seriously deficient, and does not meet the "sound science" standard demanded by NEPA for environmental assessments. The draft EA (DEA) is undermined by numerous, fundamental errors of fact and interpretation; lacks virtually any quantitative assessment of herbicide use; relies unduly on Dow and other industry sources; and neglects to consider quality data from APHIS's USDA sister agencies; and excludes important considerations.

Introduction

Dow AgroSciences seeks deregulation of DAS-40278-9 corn, a variety of corn genetically engineered to withstand direct application of high rates of phenoxy auxin and AOPP ("fops") herbicides, specifically 2,4-dichlorophenoxyacetic acid (2,4-D) and quizalofop. Dow will stack DAS-40278-9 with glyphosate-resistance and perhaps glufosinate-resistance as well, for resistance to three and perhaps four herbicide classes.

Herbicide-resistant (HR) crops are weed control systems involving one or more post-emergence applications of the HR crop-associated herbicide(s). Dow describes DAS-40278-9 corn in precisely these terms, as the "Enlist Weed Control System" (DAS 2011a), with the brand name "Enlist" referring to both the HR trait and Dow's 2,4-D herbicide. Monsanto describes its HR crops in similar terms: "The utilization of Roundup agricultural herbicides plus Roundup Ready soybean, collectively referred to as the Roundup Ready soybean system..."[1] APHIS must assess both DAS-40278-9 in its own right and as a component of an HR corn system, in which 2,4-D and quizalofop would be used in different amounts and in altered patterns by virtue of the genetically engineered resistance to these herbicides in DAS-40278-9 corn seed. The certain use of glyphosate and potential use of glufosinate must also be assessed. As shown below, APHIS has failed to provide an adequate assessment of the DAS-40278-9 corn system.

According to APHIS and Dow, the purpose of the DAS-40278-9 system is give farmers herbicidal options to manage difficult weeds, in particular weeds that have evolved resistance to glyphosate. This purposed use of DAS-40278-9 cannot be assessed without careful consideration of the herbicidal components of the system, any more than an automobile can properly assessed without putting gasoline in the tank and subjecting it to a road test. APHIS's failure to assess Monsanto's glyphosate-resistant, Roundup Ready (RR) crop varieties as HR crop systems led to unregulated cultivation, which as discussed elsewhere generated the glyphosate-resistant weed epidemic that is now the rationale for Dow's corn. APHIS's preferred alternative in the draft Environmental Assessment (DEA)– full deregulation – would repeat this same mistake with the DAS-40278-9 corn system, and trigger impacts still more severe than did its RR crop predecessors.

APHIS's assessment of herbicide use in the DEA is seriously deficient, and does not meet the "sound science" standard demanded by NEPA for environmental assessments (EAs). The draft EA (DEA) is undermined by numerous, fundamental errors of fact; lacks virtually any quantitative assessment of herbicide use; relies excessively and cursorily upon Dow's conclusions with no critical analysis of the same; and excludes important considerations.

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

DAS-40278-9 will sharply increase use of 2,4-D in American agriculture

APHIS concedes that its proposed full deregulation of DAS-40278-9 "is expected to result in an increase in the use of the herbicide 2,4-D in corn, as well as the new use of quizalofop on corn" (DEA at 42, see also 56, 58, 75, 87), yet provides no estimate, however rough, of the magnitude of the expected increase in use of either herbicide.

Dr. Charles Benbrook, an eminent agricultural scientist and former executive director of the Board on Agriculture of the National Academy of Sciences, has projected that introduction and widespread adoption of DAS-40278-9 would increase overall use of 2,4-D on corn by roughly 30-fold by the end of the decade: from 3.3 million lbs. in 2010 to 104.3 million lbs. (Benbrook 2012). Below, we discuss the reasons for this huge projected rise in 2,4-D use, with reference to Dr. Benbrook's projection and APHIS's treatment of the subject.

2,4-D use on DAS-40278-9 would be the product of the rate applied per application, the number of applications per season, and the number of acres planted. USDA last reported these data for current 2,4-D use on conventional corn in 2010 (USDA-NASS AgChem 2010, USDA-NASS AgChem 2010-1).

In 2010, farmers applied 2,4-D to 10% of U.S. corn acreage. An average of 1.12 applications were made on treated acreage, at an average rate of 0.35 lb./acre/application. Overall, 3.3 million lbs. were applied (Benbrook 2012). APHIS makes no reference to any of these data in the DEA,[2] while they form the basis for Benbrook's 2010 baseline for current 2,4-D use. Benbrook estimates that both the average number and rate of 2,4-D applications on corn will gradually increase, slightly more than doubling by 2019, and assumes that 55% of corn acreage will be treated by that date, for total usage of 104.3 million lbs. in 2019. As discussed below, these are reasonable assumptions for Dr. Benbrook's "upper end" estimate of 2,4-D use with introduction of DAS-40278-9.

The rate at which 2,4-D is applied to conventional vs. DAS-40278-9 corn, and the number of applications per year, are dependent on several factors, including the amount that can be applied without injuring the crop, the EPA's current and proposed label restrictions, and the severity of farmers' weed problems, particularly glyphosate-resistant weeds. Frames of reference for the number of acres planted to DAS-40278-9 include overall US corn acreage, herbicide-resistant corn acreage, and prevalence of glyphosate-resistant weeds. Each of these factors is discussed below.

2,4-D rates and crop injury

DAS-40278-9 is engineered to withstand extremely high rates of 2,4-D applied post-emergence (to the growing plant). Dow reports negligible plant injury of 5% or less from application of 4480 grams per hectare, equivalent to 4 lbs./acre, the highest rate tested (Dow Petition, henceforth "DAS 2010," p. 103). In contrast, the same rate caused unacceptable 35% injury to a conventional corn hybrid (Id.). APHIS also reports that the

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[2] APHIS is apparently not even aware that these 2010 data exist, stating incorrectly that USDA-NASS last collected agricultural chemical usage data on corn (which includes herbicide use) in 2005 (DEA at 13). It is unclear why APHIS did not consult its sister USDA agency, the National Agricultural Statistics Service.

rate at which 2,4-D can be used on conventional corn is limited by crop damage (DEA at 79). While such high rates are not expected to be applied very often to DAS-40278-9 (they exceed the proposed label rate), it is important to understand that they could. Under certain circumstances, farmers growing DAS-40278-9 might be tempted to exploit the crop's considerable resistance by applying high 2,4-D rates to deal with particularly intractable weeds (e.g. weeds that are large or have evolved 2,4-D-resistance), an option not available to conventional corn growers. DAS-40278-9 corn removes the biological constraint of crop injury that currently limits (as much or more than EPA's label) use of high 2,4-D rates on conventional corn.[3] In our treatment of resistant weeds and herbicide drift below, we discuss how DAS-40278-9's high-level resistance may change farmers' weed management practices, with adverse consequences.

<u>2,4-D rates and EPA label restrictions</u>

DAS-40278-9 is designed primarily to allow post-emergence (POST) applications of 2,4-D, that is, applications to the growing corn plant. The proposed label for DAS-40278-9 would permit up to four-fold more 2,4-D to be applied POST than is currently allowed on conventional corn, 2.0 versus 0.5 lbs./acre/year (DEA at 56, Table 4-1, reproduced below).[4] A substantial increase in such POST applications of 2,4-D is one of the major factors that would drive overall increasing use of 2,4-D in corn with introduction of DAS-40278-9. An additional application of 1.0 lb./acre can be applied "pre-plant" or "pre-emergence" to either conventional or DAS-40278-9 corn (Id.). Finally, the current label for 2,4-D (but not the proposed label for DAS-40278-9) allows for a 1.5 lb./acre "preharvest" treatment.

APHIS makes much of the fact that the overall ***permitted*** use of 2,4-D is the same for conventional and DAS-40278-9 corn – 3 lbs./acre/year – and on this basis even suggests that "…per acre applications of 2,4-D are not expected to change" with introduction of Dow's corn (DEA at 80; see also DEA at 58-59, 80, 100). This argument has no merit, as it conflates maximum ***permitted*** use with ***actual*** use. Conventional corn growers actually use on average just ***one-eighth*** to ***one-sixth*** of the maximum permitted annual use of 2,4-D: 0.38 to 0.50 lbs/acre/year (USDA-NASS AgChem 2010).[5] One reason for this is that fully half of the current label for 2,4-D on conventional corn (1.5 of 3 lbs/acre/year) is reserved for "preharvest" application, which farmers rarely use.[6] Consequently, the removal of this

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[3] 2,4-D can injure conventional corn at rates lower than 4 lbs/acre; Dow reports 10%, 14% and 29% plant injury at 560, 1120 and 2240 grams/hectare, equivalent to 0.5, 1.0 and 2.0 lbs./acre, respectively (Dow Patent 2009, Table 25, paragraph 0354)

[4] One POST application of 0.5 lb./acre to conventional corn vs. two POST applications of 1.0 lb./acre each for a total of 2.0 lbs./acre on DAS-40278-9.

[5] As noted above, APHIS was not aware that these USDA-NASS data even existed, and otherwise provides no data on rates of 2,4-D actually used on conventional corn.

[6] Also called "rescue treatments," herbicides are applied pre-harvest only in those infrequent instances when late-season weed infestations have become so severe as to make harvest difficult or impossible. Farmers seldom let weeds proliferate like this, since it reduces yields considerably (Knake undated, p. 3). If pre-harvest 2,4-D applications (which must be made at higher rates to kill larger weeds, explaining the high label rate of 1.5 lb/acre rate) were used to any significant extent, average 2,4-D use would be much higher than 0.38-0.50 lbs/acre/year.

use from the proposed 2,4-D label will not have any significant impact on projected 2,4-D use on DAS-40278-9 corn.

Table 4-1: Comparison of Current and Proposed Application Rates for 2,4-D on Corn

	Conventional Field Corn and Popcorn		Proposed New Use on DAS-40278-9 Corn	
Crop Stage	Maximum Application Rate (lb/acre)[1,2]	Directions and Timing	Maximum Application Rate (lb/acre)[1,2]	Directions and Timing
Pre-plant or Pre-emergence	1.0	Apply before corn emerges to control emerged broadleaf weed seedlings or existing cover crops	1.0	Apply before corn emerges to control emerged broadleaf weed seedlings or existing cover crops
Post-emergence	0.5	Apply when weeds are small and corn is less than 8 inches tall (to top of canopy). When corn is over 8 inches tall, use drop nozzles and keep spray off foliage.	0.5 to 1.0	Apply after crop and weed emergence but before corn exceeds growth stage V8 or 48" in height, whichever occurs first. Make 1 to 2 applications with a minimum of 12 days between applications.
Pre-harvest	1.5	Apply after hard dough (or at denting) stage.	---	---
Total Annual Maximum Application	3.0	---	3.0	---

Source: DAS, 2011e

Notes:

1. All values expressed as acid equivalents.
2. 1 lb/acre is the equivalent of 1,120 g/hectare.

As discussed above, the major impact of DAS-40278-9 would be to dramatically increase post-emergence use of 2,4-D, consistent with the Dow-proposed label permitting four-fold more 2,4-D to be applied during this period.

<u>2,4-D applications and 2,4-D-resistant weeds</u>

DAS-40278-9 is targeted for use especially by farmers with glyphosate-resistant weeds (DEA at 3). Several of the most problematic glyphosate-resistant weed species have already shown the capacity to evolve resistance to 2,4-D, including common waterhemp, horseweed and kochia, as discussed further below. The evolution of 2,4-D-resistant weeds with introduction of the DAS-40278-9 corn system will trigger more frequent applications at higher rates in response. In addition, problematic GR weeds like waterhemp and its pigweed cousin, Palmer amaranth, emerge not just in one "flush," but rather through much of the season. Farmers will often make two post-emergence applications of 2,4-D to control such weeds at different times of year.

<u>U.S. corn acreage</u>

Overall corn acreage represents the upper limit of potential DAS-40278-9 adoption. APHIS notes that corn acreage has increased since the mid-2000s, and reached 92.3 million acres in 2011, up 5% from 2010, due primarily to increased demand for corn to make ethanol and the associated rise in corn prices (DEA at 11). APHIS projects corn cultivation will increase by two to four million acres over the next decade (DEA at 44), for 94.3 to 96.3 million acres by 2019, yet provides no assessment of how adoption of DAS-40278-9 might be influenced by this expanding corn acreage. Dr. Benbrook's projection similarly assumes that overall corn acreage will increase gradually to 96.4 million acres by 2015, then remain steady to the end of the decade.

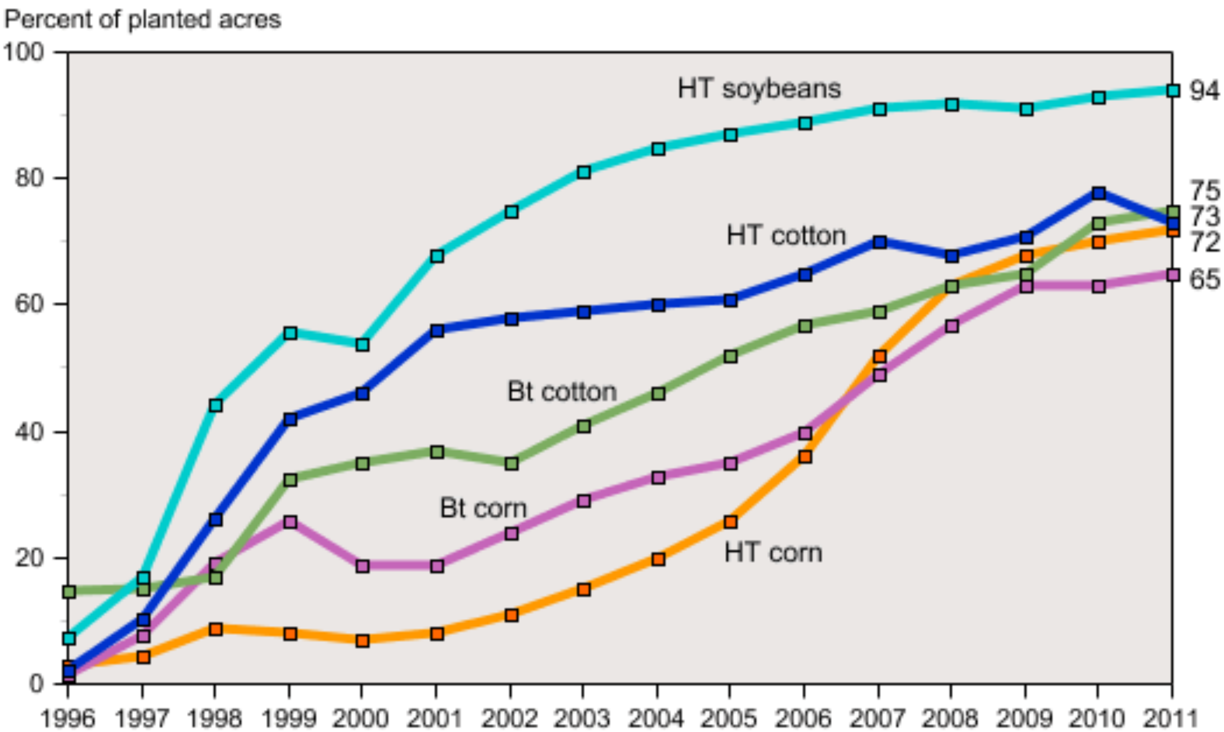
Acreage of GE herbicide-resistant corn

Current growers of herbicide-resistant corn varieties (nearly all glyphosate-resistant) might be likely adopters of DAS-40278-9 corn, since these farmers are much more likely to have resistant weeds. APHIS asserts that: "In 2011, approximately 23% of corn planted in the U.S. possessed tolerance to an herbicide that was conferred by GE [genetic engineering]…," citing USDA-ERS 2011a (DEA at 3).[7]

This is blatantly incorrect, contradicted by APHIS's source, USDA's Economic Research Service. ***In fact, herbicide-resistant corn was planted on 72% of U.S. corn acres, more than triple APHIS's incorrect figure***, as can be seen in the USDA ERS graph reproduced below, and in USDA ERS GE Adoption 2011 in the supporting materials.

Reference to the table APHIS cites (USDA-ERS 2011a, cited in the DEA) reveals that its 23% figure refers to "Herbicide tolerant only" corn, and excludes the 49% of "stacked gene varieties" corn that has ***both*** herbicide-tolerance and insect resistance. Adding the two figures (23+49) gives the total percentage of U.S. corn (72%) that "possesse[s] tolerance to an herbicide conferred by GE..." (DEA at 3). APHIS apparently does not understand that its sister agencies, the Economic Research Service (ERS) and National Agricultural Statistics Service (NASS), define stacked varieties as follows: "Stacked gene varieties are those containing GE traits for both herbicide tolerance (HT) and insect resistance" (USDA ERS GE Adoption 2011).

[7] Repeated with similar language at e.g. DEA 14, 27, 53, 65.



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.

From: http://www.ers.usda.gov/Data/BiotechCrops/, last visited 4/23/12. See "HT corn" line = 72%. The same webpage states: ""Stacked" gene varieties are those containing GE traits for both herbicide tolerance (HT) and insect resistance."

APHIS is supposed to be USDA's expert on biotechnology. It is shocking that it does not have even a basic grasp of key data such as this. According to APHIS's false assumption, there would have been only 21.2 million acres of HT corn in 2011 (23% of 92.3 million acres), when the true figure is 66.5 million (72% of 92.3 million acres), ***over 45 million acres more.*** This error is still more incomprehensible in that APHIS made it once before in another environmental assessment, and was corrected by CFS in public comments (CFS HT Corn Comments 2009, pp. 6-8).

APHIS's vast underestimate of the nation's herbicide-resistant corn acreage leads it to assume a much lower HR corn universe than actually exists, and hence much lower potential adoption of DAS-40278-9 and use of 2,4-D by existing HR corn growers, the most likely market for Dow's corn. This is just one of numerous errors that undermine the DEA and call for a competently drafted Environmental Impact Statement.

Prevalence of glyphosate-resistant weeds

A third frame of reference for estimating the near-term potential adoption of DAS-40278-9 is suggested by the purpose of the Dow's corn: to permit control of glyphosate-resistant weeds through use of 2,4-D and quizalofop (DEA at 3). Yet APHIS fails to provide any assessment of the prevalence of glyphosate-resistant weeds. CFS provides such an assessment later in these comments. In brief, there are 16.8 million acres of cropland infested with glyphosate-resistant weeds at present, up from just 2.4 million acres less than four years ago, and the area infested continues to expand rapidly. Recent introduction of glyphosate-resistant alfalfa and sugar beets will spur GR weed emergence still more. Much of this infested acreage is planted to corn and/or crops rotated with it, particularly soybeans. GR weeds are rapidly expanding in major corn-growing states like Illinois, Missouri, Iowa, Kansas and Minnesota. Several years ago, Syngenta projected that GR weeds will infest 38 million acres by 2013 (Syngenta 2009). In light of the rapid spread of GR weeds, current GR weed-infested acreage represents only the near-term potential market for DAS-402787-9.

Projection of 30-fold increase in 2,4-D use on corn

The number and rate of applications used by Benbrook (2012) in his projection are quite reasonable in light of the considerations discussed above. He assumes average 2,4-D rates increasing from 0.60 lbs/acre in 2013 to 0.84 lbs/acre in 2019, well under the proposed maximum single application of 1.0 lb./acre. He assumes the average number of applications rising from 1.5 in 2013 to 2.3 in 2013, well within the maximum of 3 applications permitted in the proposed label (one preemergence and 2 post-emergence). The very likely emergence of 2,4-D-resistant weeds will drive rising numbers and rates of application.

Benbrook (2012) projects that the percent of overall corn acres treated with 2,4-D will gradually increase with increasing adoption of DAS-40278-9 corn. Starting from a baseline of 10% of corn acres treated with 2,4-D in 2010, 2,4-D use expands to 19% of corn in 2015, 34% in 2017, and to 55% of corn acres in 2019. Benbrook's projection assumes no planting of a potential competitor product in Monsanto's pipeline, GE corn resistant to dicamba, an herbicide very similar to 2,4-D (Mortensen et al 2012). If this product is successfully developed, deregulated and marketed, it could reduce acreage planted to DAS-40278-9 and treated with 2,4-D, replacing them acres planted to dicamba-resistant corn and treated with dicamba (Benbrook 2012). However, it is unknown whether this crop will be introduced.

Benbrook (2012) also projects a much lesser increase in 2,4-D use on corn if DAS-40278-9 is not deregulated: from 3.3 million lbs. at present to 6.8 million lbs. by 2019. This increase is consistent with a trend of generally increasing use on corn since the year 2002, likely a response to glyphosate-resistant weed evolution.

DAS-42078-9 will lead to novel use of quizalofop on corn

DAS-42078-9 is genetically engineered with the *aad-1* gene that confers dual resistance to both phenoxy auxin herbicides such as 2,4-D and aryloxyphenoxypropionate (AOPP) herbicides such as quizalofop and cyhalofop. Quizalofop is a grass herbicide not currently used on corn, a grass family plant, because it would cause severe crop injury (DEA at 6). 2,4-D is a broadleaf herbicide that is relatively inactive on grassy weeds, except at high doses. Quizalofop could be applied separately or together with 2,4-D to kill grass weeds in DAS-40278-9.

Herbicides of the AOPP class are extremely potent, and thus are used at lower rates than many other herbicides. The proposed label for quizalofop on DAS-40278-9 would permit its application at a maximal single and annual rate of 0.082 lb. ai/acre (DEA at 57, Table 4-2). However, Dow scientists report that corn genetically engineered with the *aad-1* gene found in DAS-40278-9 is "resistant to applications of the grass-active AOPP herbicides (cyhalofop or quizalofop) at rates of 0.28–0.56 kg ae/ha under greenhouse and field conditions" (Wright et al 2010, cited in DEA), equivalent to 0.25-0.5 lb. ae/acre. Thus, there would apparently be no biological constraints (i.e. risk of crop injury) from applications of quizalofop or cyhalofop at rates up to six times higher than the label rate.

The label rate of quizalofop is roughly double the average rate of this herbicide applied to soybeans (0.038 lb. ai/acre), a crop naturally tolerant to quizalofop (USDA NASS 2006, p. 28). Dow is heavily marketing DAS-40278-9 for use with 2,4-D and glyphosate, so it is uncertain to what extent farmers would apply quizalofop. Benbrook (2012) projects that DAS-40278-9 could be grown on 52.9 million acres by 2019. If one assumes 20% of this acreage were treated at the proposed annual label rate of 0.082 lb. ai/acre, the result would be 868,000 lbs. of new quizalofop use. In 2006, 14,000 lbs. of quizalofop were applied to soybeans (USDA NASS 2006, p. 28).

<u>Use of other herbicides from "stacking" DAS-42078-9 with additional resistance traits</u>

Dow plans to market DAS-42078-9 "stacked" with glyphosate resistance together with a premix formulation of 2,4-D+glyphosate (DEA at 60). Farmers could also apply other versions of 2,4-D and/or glyphosate, either together or sequentially, without risk of crop injury. Thus, use of glyphosate on corn at roughly current levels of 0.93 -1.20 lbs. ai/acre/year (USDA NASS AgChem 2010) is expected to continue, though slight reductions in glyphosate rates are possible. In 2010, 64.4 million lbs. ai glyphosate were applied to corn in 19 Program States surveyed by USDA NASS, states that grew 93% of the nation's corn acreage (USDA NASS 2010 AgChem-1). Glyphosate is the most heavily used herbicide in the U.S. and the world, with overall agricultural use in the U.S. last estimated in 2007 by the EPA at 180-185 million lbs. (EPA Pesticide Use 2011, Table 3.6).

Dow has also stacked the *aad-1* gene conferring phenoxy auxin and AOPP resistance into SmartStax corn, which exhibits resistance to both glyphosate and glufosinate herbicides (Scherder et al 2012). APHIS acknowledges that DAS-40278-9 may be stacked with glufosinate resistance (DEA at 52). It is unclear to what extent farmers would utilize glufosinate on such a "quad-stack" HR corn variety. In 2010, glufosinate was applied to 2% of corn acres at an average rate of 0.30 lbs/acre/year, for overall use of 515,000 lbs. of glufosinate on corn in Program States surveyed by USDA NASS, which grew 93% of the nation's corn acreage (USDA NASS AgChem 2010).

Overall herbicide use on DAS-42078-9

Corn farmers could apply many other herbicides to DAS-40278-9. USDA lists 72 herbicides used on corn in 2010 comprising roughly 60 active ingredient) (USDA NASS AgChem 2010). While adoption of DAS-40278-9 may result in 2,4-D and/or quizalofop reducing use of certain other corn herbicides to some extent, there are several reasons to expect such potential reductions to be minimal.

Experience with glyphosate-resistant crops

The proportion of corn acres treated with four of the six leading corn herbicides (atrazine, acetochlor, nicosulfuron and S-metolachlor) remained relatively constant, while a fifth (mesotrione) increased sharply, during the early years of glyphosate-resistant corn's introduction, a period which saw substantially increased use of glyphosate as well (DEA at 15, Figure 2-1). More recent data (USDA NASS AgChem 2010) show a continuation of this trend over the period (2005-2010) when adoption of glyphosate-resistant crops rose from one-quarter to roughly 70% of corn acres: namely, continuing use of leading corn herbicides on roughly the same proportion of corn acres even as use of glyphosate rose to three-fourths of all corn acreage.

This minimal displacement of other herbicides by glyphosate with adoption of glyphosate-resistant corn is supported by the substantial increase in herbicide intensity on corn from 2002 to 2010. Corn herbicide use increased from 1.865 lbs./acre (2002) to 2.225 lbs./acre (2010), a substantial 19% increase (see "Intensity of Herbicide Use" figure below). These same data show that frequency of herbicide use increased by roughly the same amount over this same period, from 2.48 to 2.99 acre-treatments,[8] for a 21% increase. Thus, the average acre of corn in 2010 was treated with an herbicide three times.

2,4-D to be used post-emergence like glyphosate

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 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. This makes it best-suited for use later in the season, "post-emergence," to the growing glyphosate-resistant crop, to kill weeds that emerge later in the season. In contrast, pre-emergence, residual herbicides like atrazine, which remain very popular with corn growers, have very different properties and uses. Residual herbicides are applied mainly early 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.

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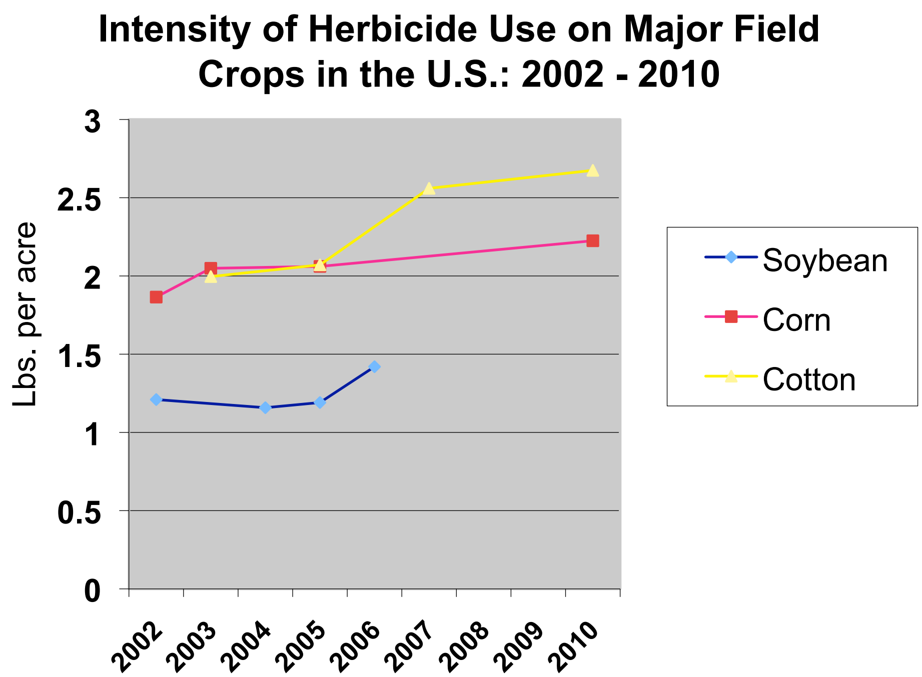
[8] Acre treatments represent the average number of herbicide applications a given unit area of cropland (e.g. an acre) receives in the course of the year. It should be noted that the acres treatment metric does not distinguish between two herbicides applied sequentially and two herbicides applied together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



Notes: Average annual per acre herbicide use on corn, 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. No corn data was collected between 2005 and 2010. 2010 corn data in USDA-NASS AgChem (2010). http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1560..

As discussed above, the primary use of 2,4-D with DAS-40278-9 would be for post-emergence weed control, very similar to glyphosate, which explains why Dow is combining it with glyphosate as a premix formulation for this use. While 2,4-D persists somewhat longer than glyphosate, it is not a residual herbicide like atrazine and other corn herbicides, and would not be expected to displace it, any more than glyphosate used with glyphosate-resistant crops has.

<u>2,4-D and multiple herbicide-resistant weeds</u>
As discussed further in the herbicide-resistant weed section, the DAS-40278-9 system is almost certain to trigger rapid evolution of weeds with growing tolerance and resistance to the herbicide, often in weeds already resistant to one or several other "modes of action." The most common response to resistant weeds is to increase rates and apply additional herbicides. This also argues for increasing overall herbicide use with introduction of DAS-40278-9. Until APHIS begins to seriously tackle the growing epidemic of resistant weeds with major outreach and regulatory programs to increase use of integrated weed management techniques that emphasize non-chemical tactics, HR crops like DAS-40278-9 will drive American agriculture into ever deeper dependence on multiple toxic herbicides.

<u>Assessments of past herbicide use with glyphosate-resistant crops</u>

As indicated above, assessment of past trends in herbicide use on glyphosate-resistant corn could be useful as a means to inform projections of the same with DAS-40278-9. APHIS's scanty assessment here is corrupted by several serious errors of fact, reliance on data one to two decades old, neglect of more relevant recent data from its sister agency (USDA-NASS), reliance on biased industry sources, and errors of interpretation. APHIS's treatment will be compared to that of Dr. Charles Benbrook in a 2009 report on this subject as well as various USDA sources.

APHIS states that: "Overall herbicide use on corn decreased … from ~213 million pounds in in 1992 to ~159 million pounds in 2002, as farmers increasingly favored the use of GE crops which allowed for fewer types and a smaller overall amount of herbicide to be used (Gianessi and Reigner 2006)" (DEA at 19). This statement is blatantly incorrect. Herbicide-resistant corn has actually led to a substantial ***increase*** in the "overall amount of herbicide" used.

First, inspection of APHIS's source for this statement (Gianessi & Reigner 2006) reveals that ***it does not say a single word about GE crops***, much less support APHIS's notion that they are responsible for any decrease in herbicide use. The work merely tabulates use of herbicides and fungicide by crop, state, etc. Second, herbicide-resistant GE corn was not grown at all (1992-1995) or only to a very limited extent (no more than 11% of total corn acres from 1996-2002) over this time period (see USDA ERS graph above). Even if herbicide use were completely eliminated on the 11% of corn that was herbicide-resistant in 2002, this could decrease herbicide use by at most 11%, not the 25% decline cited by

APHIS (213 to 159 million lbs.)[9]. Third, APHIS neglects data for the 2002 to 2010 time period when HR corn ***was*** significantly adopted, from just 11% to 70% of all U.S. corn. As detailed above, these USDA data show that corn herbicide use increased from 1.865 lbs./acre (2002) to 2.225 lbs./acre (2010). One reason for APHIS's error here may be its false assumption that glyphosate-resistant corn was introduced in 1996 (DEA at 59, 66, 70, 72) rather than in 1998, as reported by Monsanto, the developer of the crop (Monsanto History).[10]

In contrast, Benbrook (2009a) found that adoption of GE herbicide-resistant soybeans, cotton and corn over the thirteen years from 1996 to 2008 increased overall herbicide use by 383 million lbs. over what it would have been had they not been introduced. This assessment is based on careful analysis of USDA pesticide usage data. The three primary factors responsible for this result are: 1) A gradual shift to lower-dose herbicides on conventional acres; 2) A large shift to glyphosate, a higher-dose herbicide, on HR crop acres; and 3) Increased use of both glyphosate and other herbicides in response to the growing epidemic of glyphosate-resistant weeds. Dr. Benbrook's assessment is supported by the National Research Council (NRC) of the National Academy of Sciences, which in 2010 released a book-length report on GE crops. In a section entitled "Farmers' response to glyphosate resistance in weeds," the NRC states unambiguously that farmers are "...increasing the magnitude and frequency of glyphosate applications, using other herbicides in addition to glyphosate, or increasing their use of tillage" to kill increasingly resistant weeds (NRC 2010, p. 2-15).

While APHIS conducts no meaningful assessment of its own, it does rely uncritically on Dow and other biased industry or industry-funded sources for passing comments on supposed herbicide use reductions with past HR crops (e.g. DEA at 44), and for projections of the same with introduction of DAS-40278-9 (e.g. DEA at 110).

In light of the evidence presented above, based on gold standard USDA data, APHIS's reliance on biased industry-funded sources for false conclusions to the contrary (e.g. DEA at 44) is unacceptable. Works by the same authors and industry sources, have been conclusively rebutted in Benbrook (2009, Chapter 6) and CFS (2005) in the supporting materials.

<u>Dow's flawed herbicide use assessment has no merit and must not be relied upon by APHIS</u>
APHIS's reliance on these industry sources clearly prejudiced it in favor of uncritical acceptance of Dow's similar claims with respect to DAS-40278-9 (DEA at 109-110). Dow compares various projected herbicide regimes to control glyphosate-resistant weeds, with and without introduction of DAS-40278-9, to estimate the impact of its product on herbicide use. To this end, case studies of corn herbicide use were carried out in five states,

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[9] This 25% decline in herbicide use reflects a gradual shift to lower-dose herbicides on conventional corn, as well as regulatory limits on the rate of atrazine that can be applied (Benbrook 2009, p. 33).

[10] Minor use of herbicide-resistant corn in 1996 and 1997 was LibertyLink, resistant to the herbicide glufosinate. APHIS is even further off on the date that Roundup Ready cotton was introduced, stating that it was in 1993 rather than 1997 (compare DEA 59, 66, 70, 72 to Monsanto History).

each geared to a particular glyphosate-resistant weed species (DAS 2011d, p. 123). However, it is extremely difficult to assess Dow's herbicide use projections because they are completely non-transparent.

First, Dow utilizes "market research data" provided by a "third party proprietary data source" (DAS 2011d at 124). Dow does not provide even the name of the firm providing the data, but does state that it "…. has purchased licenses to access the proprietary databases for marketing and business analysis purposes" (Id). Dow is a paying customer of this "third-party propriety data source." The "source" has a clear financial disincentive (a conflict of interest) to provide data that might not support Dow's preferred conclusion of reduced herbicide use. The apparent unwillingness of the source to be named as the provider of the data can only decrease our confidence in the assessment based upon them.

Second, the provenance of the various corn herbicide regimes that Dow utilizes to calculate baseline herbicide use ***without DAS-40278-9*** for its case studies (DAS 2011d at 135-139) is entirely unclear. Dow speaks vaguely of gathering current recommendations for herbicide regimes to control glyphosate-resistant weeds from university weed scientists (Id at 127). Yet for corn, these recommendations were gathered from weed scientists in only two states, Kansas and Minnesota (Id at 189-194), only one of which (Minnesota) was the subject of a case study (Id at 123).[11] Thus, Dow calculated baseline corn herbicide use in four of five states without any input from university weed scientists. Because resistant weed threats differ greatly by state, this lapse, in itself, is sufficient to disqualify Dow's herbicide use calculations.

Third, Dow consistently bases its corn herbicide use calculations ***with DAS-40278-9*** on a 2,4-D rate of just 0.71 lb. ac/acre (DAS 2011d at 135-139), which as even APHIS cautions "is less than that currently proposed for use in the Enlist Weed Control System…" (DEA at 110). The proposed label rate for 2,4-D is 1 lb./acre, 41% higher (DEA at 56, Table 4-1).

These are just a few of the flaws and obscurities in Dow's herbicide use assessment that could be pointed out. Collectively, they render it unsuitable for any conclusions whatsoever about the quantity of herbicides that would be used, either with or without DAS-40278-9. APHIS's reliance on these data, despite its acknowledgement that a key assumption was flawed (0.71 rather than 1.0 lbs./acre of 2,4-D, DEA at 110)), is also unacceptable.

The DEA bears the clear marks of a recalcitrant agency going through the motions of NEPA compliance to create meaningless paperwork, rather than to meaningfully inform its decision-making process as required by NEPA. A serious and competent assessment is needed in the context of an EIS.

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[11] The other states for corn herbicide use case studies were Georgia, Illinois, Iowa and Ohio (Id at 123). Dow did not even consult a university weed scientist from Illinois, the second-leading corn-growing state (Id at 144).

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DAS-40278-9, Herbicide-Resistant Weeds and Crop Injury from Spray Drift

Summary
U.S. agriculture's undue reliance on single-tactic, chemical-intensive weed control generates huge costs in the form of herbicide-resistant weeds – costs that could be avoided or greatly lessened with sustainable integrated weed management techniques that emphasize non-herbicidal tactics. Herbicide-resistant crop systems promote still more rapid evolution of resistant weeds. The history of glyphosate-resistant weed emergence must be carefully heeded, yet APHIS has provided no assessment of it. Weeds resistant to synthetic auxin herbicides, the class to which 2,4-D belongs, are already numerous. Multiple herbicide-resistant weeds are a rapidly growing threat. Some existing populations of resistant weeds already rate the designation "noxious," and they will be made still more intractable and costly if they evolve additional resistance to 2,4-D. Recent scientific studies reveal that 2,4-D-resistant crop systems will likely accomplish just this. Volunteer DAS-40278-9 corn will become a problematic "resistant weed" in its own right by virtue of its resistance to two to four herbicides. Stewardship strategies proposed by Dow are quite similar to those of Monsanto with Roundup Ready crops, which have utterly failed to prevent resistant weed emergence. APHIS provides no assessment of weed resistance stewardship, nor consider an alternative involving mandatory weed resistance management, in the DEA. Under the preferred alternative, the massive increase in use of 2,4-D accompanying DAS-40278-9 and subsequent 2,4-D crops will very likely trigger rapid emergence of increasingly intractable, multiple herbicide-resistant weeds that will harm farmers, the environment, and the interests of American agriculture.

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 soybean and corn have 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 corn were equivalent to those of conventionally grown corn, 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.

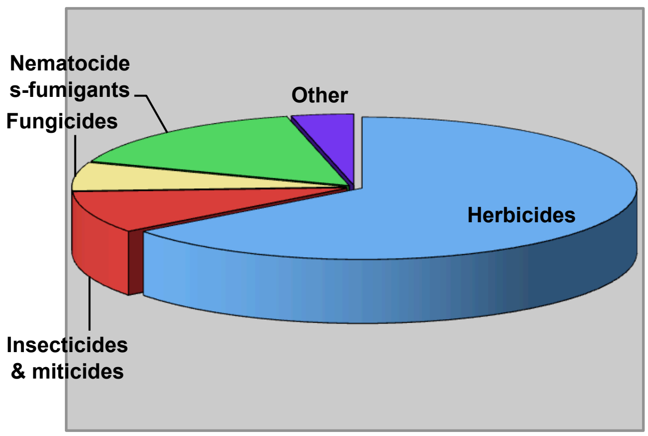
Unfortunately, with the exception of crop rotation and tillage, such techniques are little used in mainstream agriculture. This is in no way inevitable. Education and outreach by extension officers, financial incentives to adopt improved practices, and regulatory requirements are just a few of the mechanisms 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 DAS-40278-9 for the stated purpose of Dow's product, to provide a means to control glyphosate-resistant weeds (DEA at 3).

<u>The high costs of herbicide-only weed control</u>
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 more on herbicides as the preferred and then often the sole means to control weeds, herbicide-resistant weeds have become increasingly severe and costly.

The first major wave of herbicide-resistance came in the 1970s and 1980s as weeds evolved resistance to the heavily used triazines, such as atrazine (see Benbrook 2009 for this discussion). The next major wave of resistance comprised weeds resistant to ALS inhibiting herbicides in the 1980s and 1990s. Just five years intervened between introduction of the first ALS inhibitor herbicide in 1982 and the first resistance 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

Agricultural Pesticide Use in the U.S. by Type: 2007



Herbicides comprise by far the largest category of pesticides, defined as any chemical used to kill plant, insect or disease-causing pests. In 2007, the last year for which the Environmental Protection Agency has published comprehensive data, weedkillers (herbicides) accounted for 442 million lbs. of the 684 million lbs. of chemical pesticides used in U.S. agriculture, nearly seven-fold more than the insecticides that many associate with the term "pesticide." Source: "Pesticides Industry Sales and Usage: 2006 and 2007 Market Estimates," U.S. Environmental Protection Agency, 2011, Table 3.4 (EPA Pesticide Use 2011 in supporting materials).

Increasing the rate and number of applications, however, rapidly leads to further resistance, followed by adding additional herbicides into the mix, beginning the resistance cycle all over again, just as overused antibiotics breed resistant 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 DAS-42078-9'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 2,4-D or quizalofop.

Why Herbicide-Resistant Crop Systems Promote Rapid Evolution of Resistant Weeds

Herbicide-resistant (HR) crop systems such as DAS-40278-9 involve post-emergence application of one or more herbicides to a crop that has been bred or genetically engineered to survive application of the herbicide(s). These HR crop systems promote more rapid evolution of herbicide-resistant weeds than non-HR crop uses of the associated herbicides. This is explained by several characteristic features of these crop systems.

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

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

Below, we discuss these resistant weed-promoting features of HR crop systems in more detail, with particular reference to systems involving glyphosate-resistance (Roundup Ready) and 2,4-D-resistance.

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

> "The cost of RR [Roundup Ready] alfalfa seed, including the technology fee, is generally twice or more than that of conventional alfalfa seed. Naturally, growers will want to recoup their investment as quickly as possible. Therefore, considerable economic incentive exists for the producer to rely solely on repeated glyphosate applications alone as a weed control program." (Orloff et al 2009, p. 9).

Dow has not revealed its pricing for 2,4-D corn seed, but it is likely to be considerably more expensive than currently available GE varieties, based on Dow's profit projections. Dow CEO Andrew Liveris estimates that its 2,4-D resistance trait "is worth two to three times more than Smartstax corn seed, developed with Monsanto, which has a net present value of $500 million…" (Kaskey 2010). GE SmartStax corn is the most expensive corn seed on the market (Tomich 2010). In order to capture this $1 to $1.5 billion in revenue, Dow would likely have to charge a substantial premium for 2,4-D-resistant seeds beyond that charged for current GE seeds.

Overreliance is especially favored when the associated herbicide(s) are effective at killing a broad range of weeds, which tends to make other weed control practices less needed, at least until weed resistance emerges. Glyphosate and to a lesser extent 2,4-D are both such "broad-spectrum" herbicides. However, it should be noted that this holds more true of HR soybean and cotton than HR corn systems. For instance, although glyphosate use has increased dramatically on corn with adoption of Roundup Ready corn (DEA at 19), utilization of other major corn herbicides like atrazine and acetochlor has remained relatively steady (DEA at 14-15). Corn growers who have adopted Roundup Ready corn have greatly increased their use of glyphosate, but have also continued to use substantial amounts of other herbicides. Interestingly, this has not prevented rapid emergence of glyphosate-resistant weeds in corn, suggesting that use of multiple herbicides is not as effective as commonly believed at forestalling emergence of resistant weeds, and that greater use of non-chemical weed control tactics is required, as suggested above.

Frequent use and overreliance are also fostered when the HR crop-associated herbicide(s) are inexpensive relative to other herbicides. Monsanto lowered the price of Roundup herbicide (active ingredient: glyphosate) in the late 1990s to encourage farmers to adopt Roundup Ready crop systems and rely exclusively on glyphosate for weed control (Barboza 2001),[12] and the price has fallen further since then (DAS 2011c, Figure 1.2).[13] 2,4-D is even cheaper than glyphosate, and in fact is one of the least inexpensive herbicides on the market (U of Tenn 2011, p. 94). As suggested by Orloff et al (2009), quoted above, overreliance on HR crop-associated herbicide(s) is particularly favored when the HR trait premium is high and the herbicide's price is low, the likely scenario with DAS -40278-9 corn.

One of the key changes wrought by herbicide-resistant crop systems is a strong shift to "post-emergence"[14] herbicide application, which generally occurs later in the season on larger weeds, versus early-season use on smaller weeds or prior to weed emergence that is more characteristic of conventional crops. It is important to understand that facilitation of post-emergence herbicide use as the sole or primary means of weed control is the *sine qua non* of HR crop systems, not an incidental feature. Early-season uses include soil-applied herbicides put down around time of planting; these herbicides have residual activity to kill emerging weeds for weeks after application.

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 GR 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***

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[12] Monsanto has greatly increased the price of RR seed to compensate for reduced income from sale of Roundup.

[13] This and other "DAS" references refer to submissions to APHIS by Dow AgroSciences, which may be found in the bibliography of APHIS's DEA.

[14] 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.

> ***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)

University of Minnesota weed scientist Jeff Gunsolus notes that: "Larger weeds are more apt to survive a postemergence application and develop resistance." (as quoted in Pocock 2012). University of Arkansas weed scientist Ken Smith notes that application of Ignite (glufosinate) to cotton plants with dual resistance to glyphosate and glufosinate (Widestrike) 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 DAS-42078-9, to trigger evolution of resistant weeds. This is a serious deficiency, as APHIS concedes frequently that it is the emergence of glyphosate-resistant weeds that forms the rationale for DAS-40278-9.

Overview of Glyphosate-Resistant Crops and Weeds

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

Significant populations of glyphosate-resistant weeds have only emerged since the year 2000, four years after the first Roundup Ready (RR) crop system (RR soybeans) was introduced in 1996, followed by RR cotton & canola in 1997 and RR corn in 1998 (Monsanto History undated).[15] According to the International Survey of Herbicide-Resistant Weeds (ISHRW), multiple populations of 23 weed species are resistant to glyphosate in one or more countries today; of these, 26 populations of ten species are also resistant to herbicides in one to three other families of chemistry in addition to glyphosate (ISHRW GR Weeds 4/22/12). Based on acreage infested, GR weeds have emerged overwhelmingly in soybeans, cotton and corn in countries, primarily the U.S., where RR crop systems predominate (see CFS RRSB 2010, which has further analysis of GR weeds).

The first glyphosate-resistant (GR) weed population confirmed in the U.S., reported in 1998, was rigid ryegrass, infesting several thousand acres in California almond orchards (ISHRW GR Weeds 4/22/12). Beginning in the year 2000 in Delaware, glyphosate-resistant horseweed rapidly emerged in Roundup Ready soybeans and cotton in the East and South. Just twelve years later, glyphosate-resistant biotypes of 13 species are now found in the U.S., and they infest millions of acres of cropland in at least 27 states (ISHRW GR Weeds 4/22/12).

Based on Center for Food Safety's periodic compilation of data from the ISHRW website over the past four years, glyphosate-resistant weeds in the U.S. have evolved at an accelerated rate in recent years. As of November 2007, ISHRW recorded eight weed species resistant to glyphosate, covering up to 3,200 sites on up to 2.4 million acres. By early 2012, as many as 239,851 sites on up to 16,683,100 acres were documented to be infested by glyphosate-resistant weeds (CFS GR Weed List 2012). This astonishing proliferation of resistant weeds – an over 70-fold increase in number of sites and 7-fold increase in acreage – is portrayed in the figure at the end of this section. This chart and two additional charts portraying GR weeds by crop setting and farm production region are found in the file entitled at CFS GR Weed Charts (2012). The true extent of GR weeds is almost certainly greater than even the maximum figures shown in the graph, because "...the voluntary basis of the contributions likely results in underestimation of the extent of resistance to herbicides, including glyphosate" (NRC 2010, p. 2-12).[16] Many examples could be cited to illustrate to what extent ISHRW underestimates the extent of GR weed populations, but one will suffice. Illinois weed scientist Bryan Young recently reported 5-6 million acres of Illinois cropland infested with glyphosate-resistant waterhemp (as quoted in Lawton 2012, confirmed with Dr. Young, personal communication). Yet ISHRW lists GR waterhemp as infesting just 100 acres in Illinois (ISHRW Illinois Waterhemp). Inclusion of this single updated report in the ISHRW system would raise the GR weed infested acreage by one-third.

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[15] APHIS mistakenly states that RR cotton was introduced in 1993 and RR corn in 1996 (DEA at 59, 66, 70, 72), in the latter case conflating the year APHIS received Monsanto's petition for deregulation and the year Monsanto commercially introduced RR corn. APHIS did not deregulate RR corn until 1997. See http://www.aphis.usda.gov/brs/aphisdocs2/96_31701p_com.pdf and APHIS (1997). It is not clear why APHIS is four years off on the year of RR cotton introduction.

[16] APHIS mistakenly asserts that the ISHRW "provides regularly updated lists of herbicide-resistant weeds" (DEA at 90).

Early on, most resistant weed populations were driven by intensive glyphosate use associated with RR soybeans and RR cotton. However, adoption of corn with the Roundup Ready trait has increased sharply in recent years, from 20% to 72% of national corn acres from just 2004 to 2011.[17] The increasing reliance on glyphosate associated with the growing use of RR soybean/RR corn rotations is likely responsible for the rapid emergence of resistant weeds in the Midwest and Northern Plain states. In general, more GR weeds are emerging on agricultural land planted to several crops that are predominantly Roundup Ready in the U.S., which since 2008 includes sugar beets. The most recent example is the emergence of GR common waterhemp on land planted to corn, soybeans and sugar beets in North Dakota (ISHRW GR Weeds 4/22/12).

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

APHIS provides essentially no analysis of the emergence of glyphosate-resistant weeds, a significant flaw in the DEA for several reasons. First, the rapid emergence of GR weeds in RR crop systems is evidence of the resistant weed-promoting effect of HR crop systems in general, as discussed above, and a proper analysis would have provided APHIS with important insights into the risks of resistant weed evolution in the context of the DAS-40278-9 system. Second, APHIS repeatedly acknowledges that the prevalence of glyphosate-resistant weeds is the motivating factor in Dow's introduction and farmers' potential adoption of DAS-40278-9 (e.g. DEA at 3). Without a proper understanding of the prevalence of GR weeds, it is impossible to gauge even roughly how widely Dow's corn would be adopted, and the magnitude of increase in the use of herbicides, such as 2,4-D and quizalofop, entailed by the proposed deregulation, both crucial factors in assessing the herbicide-resistant weed threat posed by the DAS-40278-9 system. In addition, APHIS relies heavily on farmer use of crop rotations to mitigate evolution of resistant weeds (DEA at 12, 18), yet paradoxically concedes that more corn is being grown continuously (year after year) (DEA at 13), without attempting to reconcile the contradiction. Overall, APHIS provides no empirical assessment of farmer use of resistant weed mitigation measures at all, but rather flaccidly relies on truisms about what could or ought to be done, most drawn straight from entirely voluntary "stewardship" plans of Monsanto and Dow (DEA at 18, 90). APHIS knows that such stewardship has failed with RR crops, otherwise GR weeds would not be such a serious problem; yet there is no assessment of the flaws of past stewardship plans or how they might be improved, which might have informed APHIS's assessment of the efficacy, if any, of Dow's stewardship recommendations. APHIS should have assessed

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[17] APHIS's erroneous assertion that just 23% of U.S. corn is herbicide-resistant (e.g. DEA at 3, 53) is addressed elsewhere.

an alternative that included mandatory weed resistance management plans for DAS-40278-9. These are all, to say the least, grave deficiencies in the DEA that demand redress in the context of an Environmental Impact Statement.

Synthetic Auxin-Resistant Crops and Weeds

2,4-D is the most important and widely used member of the synthetic auxin class of herbicides, which act by mimicking plant growth hormones such as indole acetic acid. (DEA at 18). Dow scientists maintain that deployment of 2,4-D-resistant crop systems such as DAS-40278-9 would be unlikely to foster evolution of weeds resistant to 2,4-D for several reasons: 1) Very few weeds have thus far evolved resistance to the herbicide; 2) 2,4-D's mode of action is complex, suggesting that multiple mutations would be needed to confer resistance; and 3) 2,4-D will be used in combination or rotation with glyphosate, which would require weeds to evolve resistance to both at once, which is regarded as unlikely (Wright et al 2010, cited in DEA).

There are several serious flaws in these arguments, which were persuasively rebutted by Mortensen et al (2012). First, the ISHRW website lists 43 biotypes of 29 different weed species with resistance to synthetic auxin herbicides (ISHRW SynAux Weeds 4/22/12). Of the 21 herbicide classes to which weeds have evolved resistance, synthetic auxin-resistant weeds rank fourth in terms of number of resistant biotypes (ISHRW HR Weed Ranking 4/22/12). The majority of the 29 auxin-resistant species (17) are resistant to 2,4-D (Mortensen et al (2012) report 16 species, but an additional one has arisen since publication of that paper, discussed further below). This is hardly "very few 2,4-D–resistant weed species" (Wright et al 2010).

The second argument is equally specious. In most cases, scientists have not elucidated the precise mechanisms by which weeds evolve resistance, making predictions about the likelihood of weed resistance on this basis extremely hazardous. Monsanto scientists likewise predicted very little chance of glyphosate-resistant weed evolution in the 1990s (Bradshaw et al 1997), and for much the same reasons as put forward by Dow's scientists. These predictions were of course disastrously wrong, but they did help quell concerns about GR weed evolution as Monsanto was introducing its Roundup Ready crops. Interestingly, only one GR weed had been identified by the time the first RR crop was introduced in 1996 (ISHRW GR Weeds 4/22/12), in contrast to the 17 weed species with biotypes resistant to 2,4-D today.

The experience with glyphosate-resistant weeds demonstrates that neither a narrow focus on the biochemical nuances of resistance mechanisms, nor the frequency of resistance evolution in the past, provide an accurate basis for forecasting what will happen when the herbicide in question is used in the context of an herbicide-resistant crop system. What it does demonstrate is that the characteristic ways in which HR crop systems are used in the field, as discussed above, make them far more likely to trigger evolution of resistance weeds than non-HR crop uses of those same herbicides. To what little extent APHIS offers any assessment of this matter at all, it adopts the "looking backwards" approach (DEA at 90, PPRA at 4) that failed so spectacularly to predict GR weed emergence. This is not sound science, and APHIS must provide a serious assessment of weed resistance risks in an EIS.

Dow's third argument, that use of both 2,4-D and glyphosate on DAS-40278-9 stacked with glyphosate resistance will hinder evolution of weeds resistant to either one, also lacks merit. This argument ignores the fact that the huge extent of existing GR weed populations – with many billions of individual weeds on millions of infested acres – make it near certain that some among them will have the rare genetic mutations conferring resistance to 2,4-D ***as well***. Penn State weed scientists Mortensen et al (2012) provide the mathematical exposition (emphasis added):

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

The upshot is that 2,4-D-resistant crop systems like DAS-40278-9 will very likely foster rapid evolution of weeds resistant to 2,4-D and glyphosate. In those cases where the GR weed populations in 2,4-D crop fields already have resistance to one or more additional modes of action, the result will be evolution of still more intractable weeds with multiple-herbicide resistance, including to 2,4-D.

APHIS shows clear bias in its treatment of this matter, citing a paper by Dow scientists (Wright et al 2010), but not a letter to the editor critiquing that paper along the lines described above (Egan et al 2010), even though APHIS could not have missed it, since it appeared in the same issue of PNAS as Dow's response to Egan et al 2010 (Wright et al 2011), on the page preceding it. This is but one of numerous examples of bias that one finds throughout the DEA. APHIS must redress this bias and give a fair, balanced, and critical treatment of resistant weeds and other issues raised by DAS-40278-9 in the context of an EIS.

Multiple Herbicide-Resistant Crops and Weeds

Mortensen et al (2010) 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. 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). Dow touts DAS-40278-9 corn as the solution to glyphosate-resistant weeds. If HR crop systems really did "solve" resistant weed problems, as Dow maintains, one would certainly not expect multiple HR weeds to expand dramatically with their use – yet that is precisely what is happening.

The truth of the matter is that multiple herbicide-resistant weeds are the new engine of the pesticide-biotechnology industry, which is spending hundreds of millions of dollars to develop a host of new multiple HR crops in anticipation of the weeds' emergence. As Dow scientist John Jachetta told the business readers of the Wall Street Journal, glyphosate-resistant weeds and the multiple HR crops developed to counter them have inaugurated "a new era" and created "a very significant opportunity" for chemical companies (as quoted in Kilman 2010). The near-term pipeline is represented by petitions for deregulated status pending at APHIS, which shows that fully 13 of 20 GE crops awaiting approval are resistant to one or more classes of herbicides, including Dow soybeans resistant to 2,4-D, glyphosate and glufosinate, and Monsanto's dicamba-resistant soybeans, which will be stacked with glyphosate-resistance (APHIS Pending Dereg 4/22/12).

Monsanto long insisted that GR weeds would not emerge with its Roundup Ready crops (Freese 2010), and on this false basis promoted "glyphosate-only" weed control programs in farm press advertisements that leading weed scientists castigated as irresponsible for promoting weed resistance (Hartzler et al 2004). At the time, and today, Monsanto touted voluntary stewardship quite similar to Dow's recommendations with DAS-40278-9 (DEA at 90). Dow's "stewardship strategy" is as unlikely to work as Monsanto's before it.

There is already evidence that the scenario of 2,4-D resistance evolving in weeds already resistant to one or more herbicide classes, as depicted by Mortensen et al (2012), will occur with three species of weeds whose herbicide-resistant forms, at least in some populations, reach the status of "noxious" due to their many adverse impacts: horseweed, Palmer amaranth, waterhemp and kochia.

GR horseweed is often controlled with tillage, and so has led to abandonment of conservation tillage practices in some cotton-growing areas of Tennesse, Arkansas, Mississippi, Missouri (Laws 2006) and perhaps other states. This in turn increases soil erosion. An NRC committee reported that increased tillage as well as increased herbicide use are common responses to glyphosate-resistant weeds (NRC 2010). Evolution of multiple herbicide-resistance reduces options for chemical control and so increases the chances for still more soil-eroding tillage. While APHIS concedes that GR weeds triggered by RR crop systems can lead to increased tillage, it nowhere assesses the reasonably foreseeable impact of increased tillage to control weeds that become resistant to 2,4-D and/or quizalofop in the context of DAS-40278-9 cultivation. This is a serious deficiency in the DEA that must be remedied in the context of an EIS.

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

Three states have Palmer amaranth resistant to both glyphosate and ALS inhibitors; the most recent one, reported in 2011, infests over 100,000 sites covering up to 2 million acres in Tennessee (CFS GR Weed List 4/22/12). Additional resistance – for instance to 2,4-D as a result of 2,4-D use with DAS-40278-9 – would make this already intractable weed still more unamenable to control.

Nearly as bad as Palmer amaranth is its pigweed cousin, common waterhemp. Waterhemp is regarded as one of the worst weeds in the Corn Belt. It grows to a height of 2-3 meters, and emerges late into the growing season. Controlled trials in Illinois demonstrated that late-season waterhemp reduced corn yields in Illinois by 13-59%, while waterhemp emerging throughout the season cut yields by up to 74% (Steckel-Sprague 2004). 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. Dr. Patrick Tranel states that multiple herbicide-resistant waterhemp "appears to be on the threshold of becoming an unmanageable problem in soybean," and is quite concerned that if already multiple herbicide-resistant waterhemp evolves resistance to additional herbicides, "soybean production may not be practical in many Midwest fields" (Tranel et al 2010). Corn is often rotated with soybeans, and so could be similarly affected.

In early 2011, waterhemp was identified as the first weed to have evolved resistance to a relatively new class of herbicides, HPPD inhibitors, the fifth "mode of action" tow which waterhemp has evolved resistance (Science Daily 2011), prompting weed scientist Aaron Hagar to comment that "we are running out of options" to control this weed. Populations of waterhemp in Iowa and Illinois are resistant to HPPD inhibitors and two other modes of action (ISHRW Waterhemp 2012).

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

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

Other weed scientists have similar concerns. As noted by APHIS, 2,4-D is already often used in combination with other herbicides, including glyphosate (DEA at 20), and Dow envisions use of 2,4-D and glyphosate together, either in premix or tank mix formulations, on DAS-40278-9 stacked with glyphosate resistance (DEA at 60). Of course, growers will also use their own mixes. Glyphosate will not kill glyphosate-resistant weeds, so only 2,4-D will be active against them. Purdue University weed scientists have already identified increased tolerance to 2,4-D in some horseweed plants. They also note that 2,4-D is often used at reduced rates when combined with glyphosate, increasing the risks of 2,4-D-resistance rapidly evolving in already GR horseweed (Kruger et al 2008, emphasis added):

> "With the announcement that Dow AgroSciences intends to insert genes which convey 2,4-D resistance into corn (Zea mays L.), soybean [Glycine max (L.) Merr.], and cotton (Gossypium hirsutum L.) (Dow AgroSciences 2007), ***the use of 2,4-D postemergence on agronomic crop areas could dramatically increase***. This increased 2,4-D use will increase selection pressure for more tolerant weed populations such as horseweed population 34, potentially leading to the evolution of creeping resistance similar to that described by Gressel (1995). ***The use of 2,4-D in conjunction with glyphosate is often accompanied by a reduction in the rate of 2,4-D, further increasing the likelihood that horseweed plants will survive the application***."

Unfortunately, some of the worst weeds in U.S agriculture have also shown the genetic "plasticity" to evolve resistance to multiple herbicides, horseweed among them (Kruger et al 2010a):

> "Multiple-resistant and cross-resistant horseweed populations have evolved to various combinations of the previous herbicide modes of action in Israel, Michigan, and Ohio (Heap 2009), providing evidence for the plasticity of this weed."

In the analysis above, it was demonstrated that late post-emergence (i.e. POST) glyphosate application facilitated by RR crop systems is a resistant weed-promoting factor. We can expect the same dynamic of delayed application to larger weeds with 2,4-D-resistant crops. According to the same Purdue University team (Kruger et al 2010a, emphasis added):

> "With the announcement of 2,4-D resistance traits being transformed into corn and soybean (Wright et al. 2005), it is likely that POST selection pressure with 2,4-D will increase. Additionally, if 2,4-D is used POST, ***the herbicide applications will be applied to larger plants***, creating a need for understanding the impact of horseweed size on the efficacy of 2,4-D."

Follow-up research addressed this very question – "the impact of horseweed size on the efficacy of 2,4-D" – and found that larger weeds became much more difficult to control (Kruger et al 2010b, emphasis added):

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

As demonstrated above, increased survival of more difficult-to-control weeds means a greater likelihood of resistant individuals surviving to propagate resistance via cross-pollination or seed production. And as the authors acknowledge, it is "realistic" to expect late application of 2,4-D with 2,4-D crops, because that is precisely the point of these crop systems, as also demonstrated with the history of RR crops. Illinois agronomist E.L. Knake confirms that even now, with conventional corn: "some later postemergence applications are made because 2,4-D is ***more effective on larger weeds*** than are most other herbicides" (Knake undated, emphasis added). This tendency to spray later to kill larger weeds will be greatly facilitated by the ability to apply many-fold higher rates to DAS-40278-9 without risk of crop injury, higher rates which are needed for larger weeds. Thus, advising growers to spray weeds when they are small will likely not be any more effective with 2,4-D crops than it were similar recommendations made for glyphosate with Roundup Ready crops.

Kochia is a fourth serious weed, described further at CFS (2010). It has evolved widespread resistance to many different herbicides, including synthetic auxin herbicides, the class to which 2,4-D belongs (ISHRW Kochia 2012). Glyphosate resistant kochia is likely prevalent in the entire western third of Kansas, and parts of Colorado as well (Stahlman et al 2011). It, too, is a likely candidate for 2,4-D resistance with the introduction of DAS-40278-9.

Spread of weed resistance and tragedy of the commons

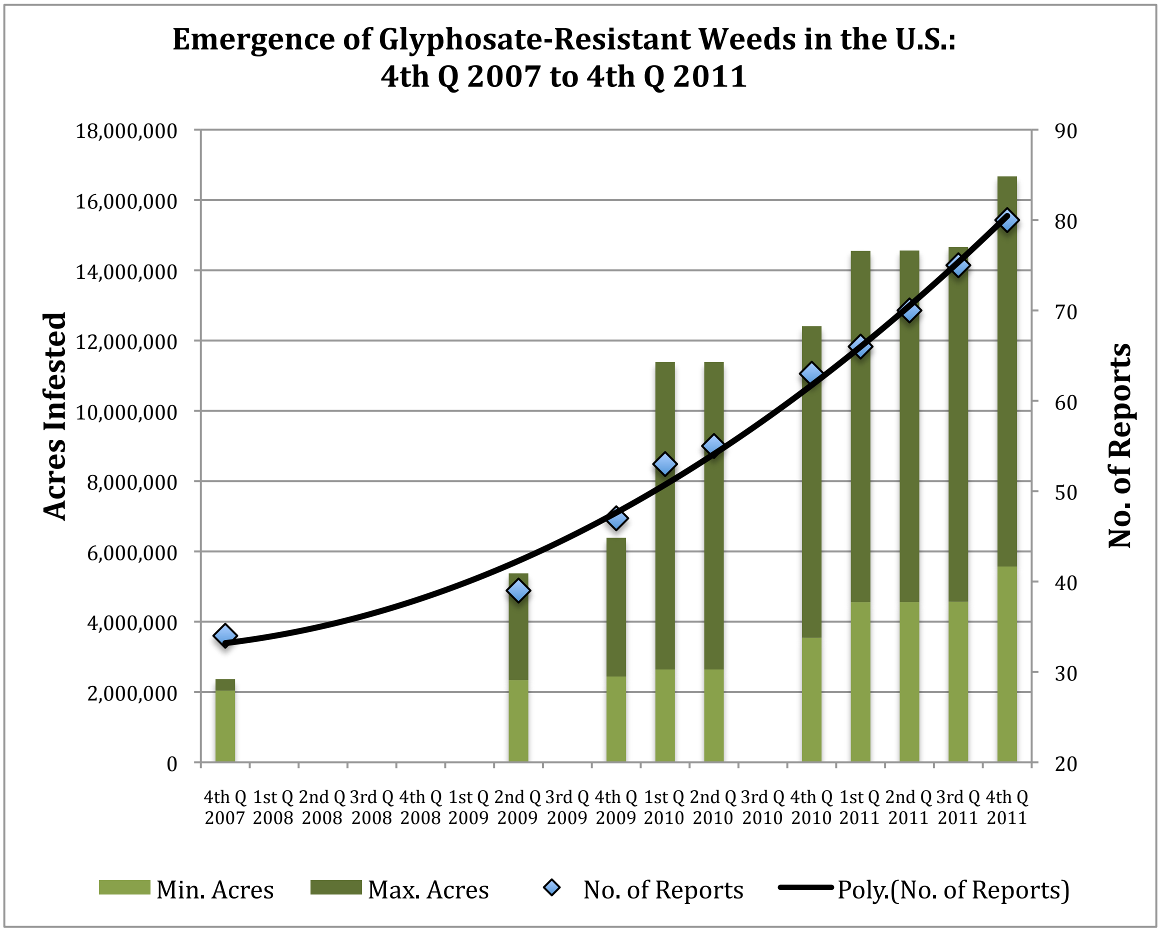
Weeds evolve resistance through strong selection pressure from frequent use and overreliance on particular herbicides, especially when applied late in the context of HR crop systems. However, once resistant populations of outcrossing weeds emerge, even small ones, they can propagate resistance via cross-pollinating their susceptible counterparts (Webster 2010). And 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 might partially explain its prevalence. 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 less careful neighbors who foster resistant weeds by relying too heavily on HR crop system weed control. With reference to GR weeds, Webster (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. Mandatory weed resistance management programs put in place by USDA would be one means to tackle this situation. However, APHIS does not consider such an option in any way re: DAS-40278-9 in the DEA, another deficiency demanding an EIS.

Volunteer DAS-40278-9 Corn

DAS-42078-9 will likely become a troublesome and costly herbicide-resistant weed in its own right. This is because corn harvest always leaves corn grain in the field. Corn that sprouts in the following season's crop can be very competitive, and reduce yields. 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. Things have become worse with adoption of SmartStax corn, which like DAS-42078-9 is resistant to two herbicides – in this case glyphosate and glufosinate (Brooks 2012, Morrison 2012). When volunteer corn emerges in soybeans, one tactic is to apply "grass" herbicides like quizalofop to kill it (effective on corn since corn is a grass family crop). This tactic would no longer be effective on DAS-40278-9 volunteers, since it is resistant to quizalofop and other "fops" herbicides like cyhalofop. In addition, Dow has already "stacked" 2,4-D and quizalofop resistance into SmartStax corn (Scherder et al 2012), which as noted above is resistant to glyphosate and glufosinate. Such volunteer corn plants would be resistant to four major modes of action, and would present still more serious control problems. APHIS touches on this issue in the Plant Pest Risk Assessment, but nowhere gives it a serious assessment. As herbicidal options available to control increasingly multiple herbicide-resistant corn volunteers narrow to one or just a few, farmer reliance on them will increase, exerting more selection pressure for resistance evolution on the more traditional weeds that will also be exposed to that one or those few herbicides. This is a serious factor that could well promote more herbicide-resistant weeds, and it relates only to DAS-40278-9 itself, not the associated use of 2,4-D and quizalofop on it. APHIS neglects this issue entirely.

DAS-40278-9 corn, in its own right, could also pose a plant pest threat. Most herbicide-resistant corn is "stacked" with insect-resistance (known as "Bt") traits: 49% is both herbicide and insect-resistant, while just 23% is herbicide-resistant only (USDA ERS 2011a, cited in DEA). One prevalent Bt trait kills corn rootworm, an extremely damaging corn pest that feeds on corn roots. Bt-resistant corn rootworm is already an emerging problem in Illinois and other states, in part because the corn produces lower levels of Bt toxin that tends to foster evolution of resistance (Gray 2011, Porter et al 2012). Volunteer corn produces ***still less*** of the insect-resistance toxin, in many cases insufficient levels to kill rootworm. The lower-level Bt toxin expression of volunteer corn allows many corn rootworm to persist into the next season, and also fosters evolution of resistance in them, regarded by agronomists as a serious emerging problem (Morrison 2012).

This plant pest risk presented by stacked volunteer corn increases with the number of herbicide resistance traits in the corn, because control options diminish as their number increases, and volunteer corn is more likely to survive to foster resistant corn rootworm. This serious plant pest issue presented by DAS-40278-9, whether unstacked or stacked with glyphosate and/or glufosinate, went completely unexamined in the DEA.



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

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

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

Crop Injury from 2,4-D Drift

2,4-D is a volatile herbicide that is prone to drift beyond the field of application to damage neighboring crops and wild plants. 2,4-D vapor injures most broadleaf (i.e. non-grass) plants at extremely low levels, as low as three-billionths of a gram per liter of air (Breeze & West 1987). Particularly sensitive crops include grapes (Walker 2011), tomatoes, cotton, soybeans, sunflower, and lettuce. Two surveys of state pesticide regulators establish that 2,4-D drift is already responsible for more episodes of crop injury than any other pesticide (AAPÇO 1999, 2005). Introduction of 2,4-D crops will greatly increase drift injury to crops over already high levels by enabling higher rates, on much greater acreage, sprayed later in the season when neighboring crops and plants have leafed out and are thus more susceptible to drift injury (Mortensen et al 2012). As discussed above, the magnitude of the increase in 2,4-D use with DAS-40278-9 could be substantial, with an up to 30-fold increase projected by Benbrook (2012). With the proposed label for 2,4-D permitting four times more post-emergence applications (2 vs. 0.5 lbs./acre/year), and the area sprayed expanding dramatically with widespread adoption of DAS-40278-9, the impacts on growers of many broadleaf crops could be severe.

Although Dow claims to have a less drift-prone formulation of 2,4-D, its efficacy has not been independently validated; and in any case, neither EPA nor Dow will be able to prevent the use of cheaper, highly-drift prone formulations.

Conventional farmers are likely to lose crops while organic farmers could lose both crops and certification. In response, family farmers and processors have formed the Save Our Crops Coalition to oppose 2,4-D crops, which pose a threat to their very survival.[i20] Vineyard operators are especially at-risk (Hebert 2004). Growers of vegetables, fruits and other smaller-acreage crops are already sparse in corn-soybean country. The introduction of 2,4-D corn and successor HR crop systems could thin their ranks still further, decreasing what little crop diversity remains in the heartland. Growers of conventional and glyphosate-resistant soybeans would also be threatened by drift. There is already substantial litigation over drift-related crop injury, pitting farmer against farmer, and it would escalate dramatically with 2,4-D crops (Huff 2011).

It is unclear whether such harms can be prevented or even mitigated should APHIS fully deregulate DAS-40278-9, yet we see no evidence that either USDA has even begun to grapple with the issue. At the very least, no decision should be made on DAS-40278-9 without serious assessment of drift-related crop injury and potential mitigation measures in the context of an Environmental Impact Statement.

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[20] Save Our Crops Coalition, at http://saveourcrops.org/2012/04/02/announcing-the-save-our-crops-coalition/.

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ISHRW Kochia (2012). List of herbicide-resistant biotypes of kochia, downloaded 4/27/12 from: http://www.weedscience.org/Case/Case.asp?ResistID=5594.

ISHRW SynAux Weeds 4/22/12. List of weeds resistant to synthetic auxins, downloaded 4/22/12 from:

http://www.weedscience.org/Summary/UspeciesMOA.asp?lstMOAID=24&FmHRACGroup=Go.

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DAS-40278-9 and Human Health

Impacts on Farmers

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

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

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

2,4-D and the closely related 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) formed the Agent Orange defoliant used in the Vietnam War. 2,4-D is one of at least 10 compounds in the chlorophenoxy class of herbicides, which include MCPA, dichlorprop, and mecoprop.[21]

Overall use of 2,4-D in the U.S. has ranged from 53 to 63 million lbs. per year since 1995, with the agricultural share declining from roughly 2/3 of overall use in 1995 to somewhat less than one-half by 2007, the latest year for which we have EPA data. 2,4-D has been the most heavily used pesticide in both the home/garden and the commercial-industrial-government sectors since 1995. Home/garden use of 2,4-D has increased slightly from 1995 to 2007 (from 8 to 9.5 million lbs./year), while industrial/commercial/ government use has nearly doubled over this period (11.5 to 20.5 million lbs./year). 2,4-D usage in 2007 is shown in Table 1.

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[21] http://www.weedscience.org/summary/ChemFamilySum.asp?lstActive=&lstHRAC=24&btnSub2=Go

Use of 2,4-D in the United States (2007)		
Sector	**Amount used (min.) (lbs. a.i.)**	**Amount used (max.) (lbs. a.i)**
Home	8,000,000	11,000,000
Industry, commercial, government	19,000,000	22,000,000
Agriculture	25,000,000	29,000,000
TOTAL	**52,000,000**	**62,000,000**

Source: EPA Pesticide Use (2011). Note: EPA reports usage in ranges. a.i. = active ingredient.

As discussed above, 2,4-D use is projected to increase dramatically with introduction and adoption of DAS-40278-9.

<u>2,4-D and Non-Hodgkin's Lymphoma</u>
Numerous epidemiological studies have reported an association between exposure to 2,4-D and non-Hodgkin's lymphoma,[22] a cancer of the white blood cells that kills 30% of those afflicted. The first studies linking 2,4-D with non-Hodgkin's lymphoma were published in Sweden thirty years ago.[23] Some of these studies also found an association with soft-tissue sarcoma, a rare and frequently fatal cancer.[24] More recently, studies published in Canada and Italy have supported these results, as have studies performed by researchers at the National Cancer Institute.[25,26,27]

Evidence from other occupational groups exposed to 2,4-D support the association found in studies of farmers. A recent study by The Dow Chemical Company of their pesticide production workers reported a 36% increase in non-Hodgkin's lymphoma in workers

[22] *See, e.g.*, Hardell L, Eriksson M. A case-control study of non-Hodgkin lymphoma and exposure to pesticides. Cancer 85:1353-1360, 1999. Hoar SK, Blair A, Holmes FF, Boysen CD, Robel RJ, Hoover R, Fraumeni JF. Agricultural herbicide use and risk of lymphoma and soft-tissue sarcoma. JAMA 256:1141-1147, 1986. McDuffic HH, Pahwa P, McLaughlin JR, Spinelli JJ, Fincham S, Dosman JA, Robson D, Skinnider LF, Choi NW. Non-Hodgkin's lymphoma and specific pesticide exposures in men: Cross-Canada study of pesticides and health. Cancer Epidemiol Biomarkers Prev. 10(11):1155-63, 2001.

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classified as exposed to 2,4-D, but the authors concluded the result was not statistically significant.[28]

A retrospective study of golf course superintendants (based on death certificates) revealed a proportionate mortality ratio for NHL of 237, meaning that death from NHL was 2.37 times more likely in this group than in the general population (Kross et al 1996). Many golf course superintendants have a history of pesticide application. 2,4-D is heavily used on golf courses. For instance, the authors note that 2.4-D is the most common herbicide applied to Iowa golf courses, representing about 42% of the total amount of herbicide applied. As noted above, EPA figures show that 2,4-D is the most heavily used herbicide in the industrial/commercial/government sector, with usage nearly doubling from 1995 to 2007.

Additional evidence of a link between 2,4-D and NHL comes from studies of canine malignant lymphoma conducted by National Cancer Institute scientists, which showed increased incidence of the canine equivalent of NHL in dogs exposed to 2,4-D-treated lawns (Hayes et al 1991, 1995).

In light of this abundant evidence, it is not surprising that scientists at the National Cancer Institute regard the link between 2,4-D and NHL as "the strongest association" yet found in "epidemiological investigations focusing on pesticides" (Zahm & Blair 1995).

NHL is a disease of the lymphocytes, or white blood cells. Cancer involves uncontrolled cell growth, or proliferation. Exposure to 2,4-D increases lymphocyte replication in humans. One study of pesticide applicators found increasing lymphocyte proliferation of 11 to 14 percent greater than normal in the applicators in a manner that was directly related to 2,4-D absorbed dose.[29] This finding was confirmed in a follow-up study, showing a 12-15% rise in lymphocyte proliferation, with a further indication that higher-dose exposures may cause direct damage to white blood cells, thereby increasing the risk of lymphoid cancer in humans.[30] These findings are consistent with, and provide mechanistic support for, the frequently-reported epidemiologic evidence linking 2,4-D exposure to non-Hodgkin's lymphoma in humans discussed above.

In 2010, approximately 65,540 people in the United States were diagnosed with non-Hodgkin's lymphoma. The incidence of this disease in the United States has increased to about double the rate seen in the 1970s, even when adjusted for population size and age.[31]

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[28] Burns C, Bodner K, Swaen G, Collins J, Beard K, Lee M. Cancer Incidence of 2,4-D Production Workers. Int J Environ Res Public Health 8:3579-3590, 2011.

[29] Figgs LW, Holland NT, Rothmann N, Zahm SH, et al. Increased lymphocyte replicative index following 2,4-dichlorophenoxyacetic acid herbicide exposure. Cancer Causes Control 11(4):373-80, 2000.

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As noted above, studies from around the world have shown that farmers are more likely to contract NHL than the general population. Based on these multiple, mutually supporting lines of evidence, it is reasonable to conclude that 2,4-D is likely responsible for some portion of non-Hodgkin's lymphoma cases each year.

Tanner et al (2009) found a much increased risk of Parkinson's disease in those exposed to 2,4-D.

Liver Toxicity

Leonard et al (1997) documented a case of acute hepatitis in a golfer who played on a golf course treated with 2,4-D, and who engaged in the common golfer practice of licking his golf balls. After exhaustive analysis of medical tests (e.g. liver enzyme assays) and ruling out other potential causes, the researchers concluded that there was "little doubt that our patient's hepatitis was due to ingestion of 2,4-D from his golf ball." A case of chronic hepatitis tending to cirrhosis was diagnosed in an avid golfer who had for many years frequently licked his golf balls (Johnston et al 1998). Though not confirmed to be due to 2,4-D exposure, the authors found no other cause that might explain the patient's condition.

The evidence recounted above represents just a fraction of the medical research literature implicating 2,4-D as the cause of numerous adverse health impacts. The World Health Organization's International Agency for Research on Cancer classifies chlorophenoxy herbicides, the predominant member of which is 2,4-D, as "possibly carcinogenic to humans" (IARC 1987) for multiple types of cancer (IARC by site).

One possible cause of 2,4-D's toxicity is the continuing presence of dioxins, a difficult and perhaps impossible to eliminate contaminant of the production process. The latest available industry tests on 2,4-D continue to find its presence (EPA Dioxins in 2,4-D)

The Institute of Medicine (IOM) of the National Academy of Sciences has conducted biennial reviews of the toxicity of Agent Orange compounds (2,4-D, 2,4,5-T and dioxins) for the Veteran's Administration for many years. Recognizing the difficulty in separating out effects due to each, the IOM's approach is to assesses the toxicological evidence for what it terms "chemicals of concern," which encompass all three components of Agent Orange – 2,4-D, 2,4,5-T and the class of dioxin compounds – implicitly recognizing the difficulties involved in attempting to cleanly separating the effects of any one (class). The IOM Committee seriously considers and gives substantial weight to epidemiological evidence, in stark contrast to EPA's dismissal of even strong epidemiological associations.

In consequence, the IOM Committee's most recent review (IOM 2012) concludes as follows:

There is sufficient evidence of an association between exposure to the chemicals of interest and the following health outcomes:

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http://seer.cancer.gov/csr/1975_2008/, based on November 2010 SEER data submission, posted to the SEER web site, 2011.

* Soft-tissue sarcoma (including heart)
* Non-Hodgkin's lymphoma
* Chronic lymphocytic leukemia (CLL) (including hairy cell leukemia and other chronic B-cell leukemias)
* Hodgkin's disease
* Chloracne

Sweden, Norway and Denmark have banned 2,4-D on the basis of its strong epidemiological link to NHL (Boyd 2006).

APHIS has not provided any assessment of 2,4-D's potential health impacts on farmers, farmworkers or the general public, despite its NEPA obligation to assess its regulatory decision on the DAS-40278-9 corn system in light of its effects on the "human environment." This deficiency is all the more serious in light of the projection of a many-fold increase in use of 2,4-D with DAS-40278-9 corn, and the ample evidence of health harms briefly discussed above.

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