PESTICIDE USE ON GENETICALLY ENGINEERED CROPS

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Addendum: Traditional Soil-Applied Insecticides Are Surging Alongside Systemic Neonicotinoid Insecticides on Genetically Engineered Corn

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Pesticide Use On Genetically Engineered Crops

Much has been written by scientific and mainstream media about the advantages of using genetically engineered (GE) crops because, according to popular belief, these crops require significantly less pesticide to control weed and insect pests. Or in slightly more sophisticated but equally misleading coverage, cursory acknowledgement is given to increasing herbicide use, but such increase is qualified in terms of the lower toxicity profile of glyphosate relative to more toxic herbicides that are also increasingly used. (See e.g. "Labels for GMO Foods Are a Bad Idea", *Scientific American,* 8/20/13: "Because conventional crops often require more water and pesticides than GMOs do, the former are usually more expensive."; see also Seeds of Doubt, *The New Yorker,* 8/25/14; "The Promise of GMOs", *Biology Fortified*, 2/14/14 and "Environmental Benefits of Genetically Modified Crops", Fig. 7 *CropLife*, 11/02.) These accounts are inaccurate and rely on annual pesticide application rates and volumes reported prior to 2010, when widespread resistance began to emerge in "superweeds" and "superinsects." (See "What Happens When Weed Killers Stop Killing?", *Science,* 9/20/13 and "Field-evolved resistance by western corn rootworm to multiple Bacillus thuringiensis toxins in transgenic maize", *Proceedings of the National Academy of Sciences*, 9/12/13.) These reports also ignore the now widespread practice of coating seeds in systemic pesticides, which has emerged in the past 10 years. This lack of journalistic and scientific integrity distorts the facts on the ground.

In the United States, GE corn is planted on some 90 million acres, so the overuse of undesirable pesticides on this crop can have profound effects on the natural ecosystem, including beneficial organisms. GE corn makes up over 90 percent of US corn acreage as of 2014, with 76 percent "stacked" with both insecticide producing (Bt) and herbicide tolerant (Roundup Ready) traits. The latter enables heavy use of the herbicide glyphosate on food crops. (See "Recent Trends in GE Adoption", *USDA*.)

Many of us are unaware that in addition to the ever-increasing spraying of glyphosate and the presence of genetically engineered insecticidal Bt toxin in every cell of every GE crop plant, massive amounts of other pesticides (herbicides, insecticides, fungicides) are applied to genetically engineered food crops. The continuing massive overuse of pesticides – along with the failure to use refuge set-asides, the failure of GE corn to produce desired levels of Bt toxin and financial incentives for corn-on-corn planting cycles – have collectively resulted in the

selection of pesticide-resistant weeds and insects, leading to ever more pesticide applications. (See "Bt Corn Farmer Compliance with Insect Resistance", *AgBioForum,* and "Biofuels Incentives: A Summary of Federal Programs", *Congressional Research Service*, 1/11/12) This is now termed "the chemical treadmill."

Chemical companies that historically have produced DDT, PCBs, bovine growth hormone, Agent Orange, glyphosate products and, more recently, neonicotinoids have inserted themselves squarely into the seed crop production component of the world's food supplies. These corporations have a clear conflict of interest when it comes to reducing the numbers and concentrations of chemicals on crops, because any such reduction has an immediate impact on their financial bottom line. There is also a clear conflict of interest when it comes to altering farm management to avoid insect and weed resistance if it results in using fewer chemicals. As University of Nebraska entomologist Lance Meinke says, "economics are driving everything." (See "As Biotech Seed Falters, Insecticide Use Surges In Corn Belt", *NPR Morning Edition*, 6/9/13.)

The USDA has shown that since 1996, glyphosate use has increased some 12-fold during the GE crop era, with overall herbicide usage increasing by more than 500 million pounds. Meanwhile the agency has now documented weed resistance on some 60 million American farm acres. (See "USDA Report: Genetically Engineered Crops Don't Measure Up", *Examiner*, 3/5/14; "'Superweeds' Resulting from Monsanto's Products Overrun U.S. Farm Landscape", *Union of Concerned Scientists*, 12/11/13 and "Invader Batters Rural America, Shrugging Off Herbicides", *New York Times*, 8/11/14.)

The media still points to USDA charts showing that insecticide used on Bt corn had decreased substantially prior to 2010 (See "Are GE Crops Good or Bad for the Environment?" *Vox.com* 8/14, which is the last data point USDA published, but widespread reporting in subsequent literature has documented that insecticide use has dramatically *increased* since 2010.) Insecticide companies are reporting huge increases in insecticide sales applied to Bt corn. (See "Pesticides Make a Comeback: Many Corn Farmers Go Back to Using Chemicals as Mother Nature Outwits Genetically Modified Seeds", *Wall Street Journal*, 5/21/13 and "War on Cornfield Pest Sparks Clash Over Insecticide", *Bloomberg*, 1/11/14.)

Furthermore, the use of seeds coated with systemic neonicotinoid insecticides has skyrocketed in the past 10 years, but this is generally ignored. Recently, U.S.

government scientists found that the use of clothianidin on corn in Iowa alone almost doubled between 2011 and 2013, with widespread contamination of waterways and harmful effects on non-target wildlife. (See "Insecticides Similar to Nicotine Widespread in Midwest", *U.S. Geological Survey*, 7/24/14.)

Throughout the Midwest, farmers are discovering rootworms that resist genetically modified corn. Failure of the genetically engineered Bt toxin to control insect corn pests has also been recently reported in Brazil. (See "Brazil farmers say GMO corn no longer resistant to pests", *Reuters*, 7/28/14.) In Illinois, Minnesota, Nebraska and Iowa, where the rootworm has made a comeback, farmers have increasingly used toxic systemic pesticides such as clothianidin as a seed coating product or as a pre-emergent insecticide injected directly into the soil. (See "Voracious Worm Evolves to Eat Biotech Corn Engineered to Kill It", *Wired Magazine*, 3/14/14.)

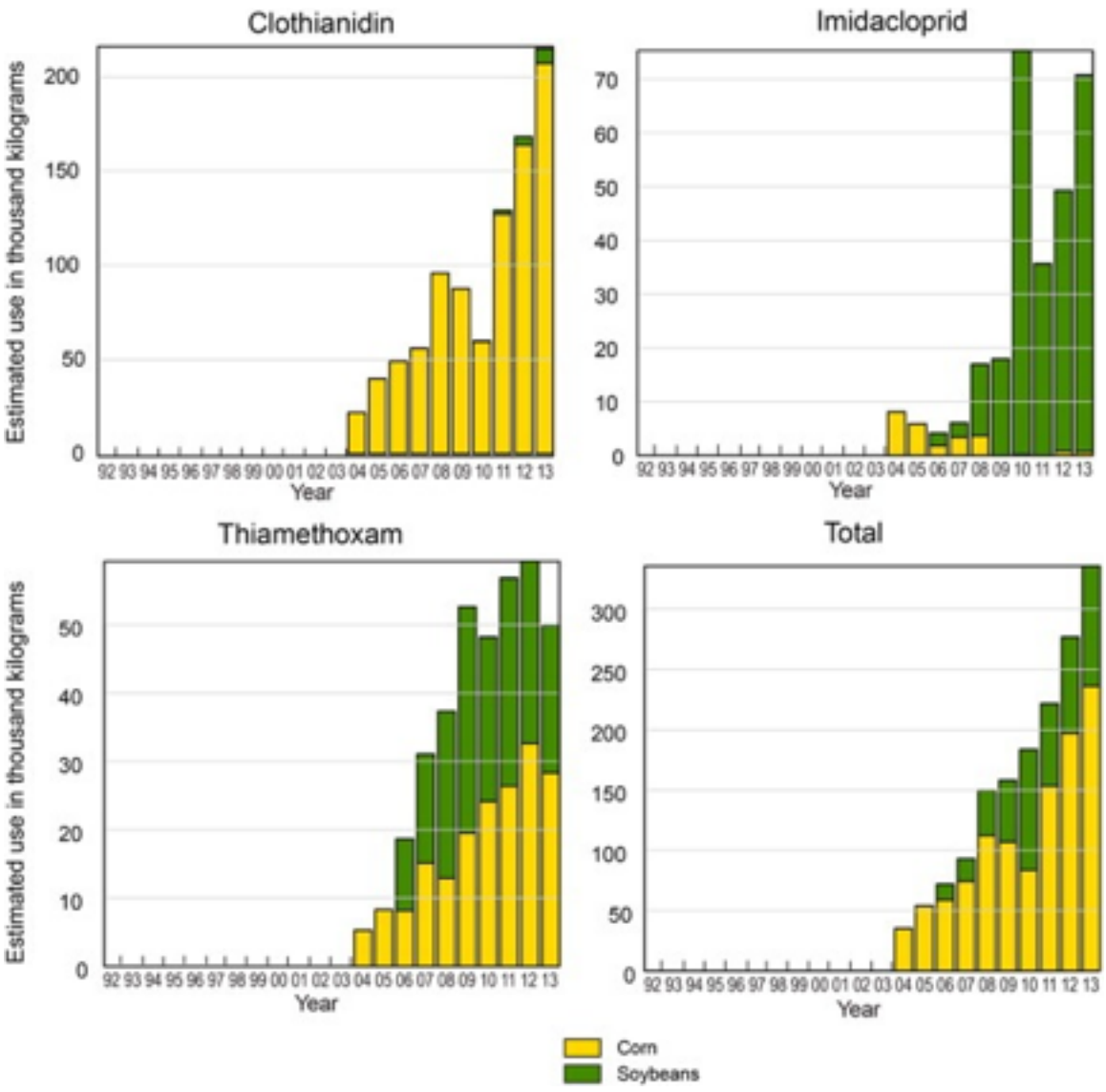
Probably for financial reasons, chemical companies have historically refused to admit that weed and insect resistance to their GE traits is an emerging – and in some locations, a serious – pest control problem. Resistance among insects and weed populations provides golden opportunities for additional corporate profits when chemical corporations offer new chemicals and engineer more genetic traits into their seed offerings. More gene traits and greater chemical use mean more profits. Through enforcement of intellectual patent rights, industry has also prohibited independent scientists from investigating emerging insect resistance problems (See "Do Seed Companies Control GM Research", *Scientific American*, 7/20/09 and "Crop Scientists Say Biotechnology Seed Companies Are Thwarting Research", *New York Times*, 2/19/09.) Without access to patent-protected genetically engineered seeds, scientists are severely limited in their attempts to identify and reduce farm crop failures. (See "Voracious Worm Evolves to Eat Biotech Corn Engineered to Kill It", *Wired Magazine*, 3/14/14.)

Company websites reflect the real story of the insect resistance problem and give farmers recommendations for controlling insect resistance outbreaks. The recommendations naturally include the use of many chemical insecticides plus multiple Bt toxin-stacked gene traits. In addition to the EPA requirement that up to 20 percent of the farmed land mass be set aside as a refuge to deter the appearance of resistant insects, farmers are strongly encouraged to develop and employ a so-called integrated resistance management scenario. This might include deployment of stacked genetically engineered Bt traits of up to eight genes (See the University of Georgia's "2012 Guide to Bt Corn"); application of pre-emergent soil-applied insecticides (insecticides injected into soil prior to crop germination); use of seeds

coated with a talcum-like powder containing up to four systemic insecticides plus a fungicide; and an annual crop rotation guide recommending the planting of other GE crops to avoid "corn after corn" cycles. There are, of course, promises of improved genetic traits in the product pipeline.

In light of the documented increased use of neonicotinoids (neonics) and insect resistance issues, one hopes the popular press will stop reporting that pesticide use in the U.S. farm belt has declined since the advent of GE crops. (See "Widespread Occurrence of Neonicotinoid Insecticides in Streams in a High Corn and Soybean Producing Region, USA", Figure 1, *Environmental Pollution*, 6/2014, which shows that 350 tons or 770,000 lbs. were used in 2014, and "Insecticides Similar to Nicotine Widespread in Midwest", *U.S. Geological Survey*, 7/24/14.) Reporting on the number of pounds of insecticide use alone does not reflect the increased toxicity and broad non-target effects that even a small amount of the now widely used neonicotinoid neurotoxins have on the ecosystem. The amounts reported in Figure 1 by the USGS are estimates only for the state of Iowa. At least seven other corn and soybean growing states in the Midwest also use neonicotinoids (See "Bee-death Insecticides Common in Midwest Rivers", *The Courier Journal*, 7/24/14). Scientists report that only 5-40 parts per billion (ppb) of these neurotoxins are lethal to pollinators. (See "Ecotoxicity of Neonicinitoid Insecticides to Bees", Table 1, and "Chronic Exposure of Imidacloprid and Clothianidin Reduce Queen Survival, Foraging, and Nectar Storing in Colonies of Bombus Impatiens", 3/18/14.) An amount of neonicotinoid powder the size of a standard pencil eraser may contain 50-100,000 lethal bee doses. The killing power of the 350 tons (770,000 pounds) of neonicotinoids used on Iowa farms last year is incalculable.

Figure 1. USGS Estimates Of Neonicotinoid Use By Year In Iowa



Source: US Geological Survey's "Widespread occurrence of neonicotinoid insecticides in streams in a high corn and soybean producing region, USA." http://www.sciencedirect.com/science/article/pii/S0269749114002802; October, 2014 (See also "Mid-western waters are full of bee-killing pesticides," Tom Philpott, Mother Jones, Jul. 29, 2014. http://www.motherjones.com/tom-philpott/2014/07/federal-agency-finds-neonic-pesticides-midwestern-water)

In the last several years, numerous scientists have shown that neonicotinoids such as clothianidin are lethal for pollinators at agricultural field concentrations and are the most likely cause of colony collapse disorder in bees. (See "Sub-lethal exposure to neonicotinoids impaired honey bees winterization before proceeding to colony

collapse disorder", Bulletin of Insectology, 2014.) Other studies show correlations between environmental neonics and the loss of birds, especially species that consume aquatic invertebrates. (See "Declines in insectivorous birds are associated with high neonicotinoid concentrations", Nature, 7/17/2014.) This study in the Netherlands was consistent with the recent study by the U.S. Geological Survey (noted above) that showed that neonics can persist from one season to the next and flush out into wetland habitats frequented by various avian species. Sadly, we have much to learn about additional non-target effects of excessive neonics use including persistence in the human food chain via contaminated food crops.

European regulators have placed a temporary halt on the use of certain neonics on agricultural crops and admitted publicly that their earlier decisions were based on faulty and incomplete data and knowledge on the fate and effects of neonicotinoids. (See "Conclusions of the Worldwide Integrated Assessment on the risks of neonicotinoids and fipronil to biodiversity and ecosystem functioning", Environmental Science and Pollution Research, 6/17/14; "EFSA identifies risks to bees from neonicotinoids"; "Conclusion on the peer review of the pesticide risk assessment for bees for the active substance clothianidin", European Food Safety Journal, 2013; and "Bees & Pesticides: Commission goes ahead with plan to better protect bees".) The European Commission has adopted a proposal [Regulation (EU) No 485/2013 PDF] to restrict the use of three pesticides belonging to the neonicotinoid family (clothianidin, imidacloprid and thiametoxam) for a period of two years.

Presumably the same information was presented to industry-friendly U.S. regulatory bodies that recently decided not to change the use status of neonics in the United States. (See "EPA Denies Emergency Petition to Suspend Clothianidin"). However, in a key development, the U.S. Fish and Wildlife Service (FWS) plans to phase out the use of genetically engineered (GE) crops to feed wildlife and will ban neonicotinoid insecticides from all wildlife refuges nationwide by January 2016. (See "Use of Agricultural Practices in Wildlife Managnement in the National Wildlife Refuge System", FWS Memorandum, 6/17/14.)

Pesticide overuse in agriculture is analogous to the overuse of antibiotics in intensive commercial livestock production systems, which has given rise to new germs that can withstand multiple antibiotics, requiring even more antibiotics at higher concentrations. These "supergerms" are like the "superweeds" and now "superinsects" that resist standard treatment options. Scientists warn that without

non-chemical management procedures, weed and insect resistances will grow and require still higher concentrations of more toxic chemicals in our food production system. The Bt insecticidal trait has not only led to resistant "superinsects," but also is directly linked to the rapid adoption and widespread use of seeds coated with systemic pesticides, which are wreaking havoc on bees and other non-target wildlife. In order to combat just glyphosate-resistant weeds, the following herbicide-resistant food crops are awaiting federal approval or are in the process of entering the commercial pipeline:

- **2,4-D tolerant crops** from Dow AgroSciences, including resistance to glyphosate, glufosinate, and ACCase-inhibitor. EPA and USDA approval expected in fall 2014; ("EPA Set to Approve Increased Use of Toxic 2,4-D on Dow's "Agent Orange" Crops")
- **ALS-tolerant crops** from Pioneer Hi-Bred, including resistance to glyphosate;
- **bromoxynil-tolerant crops** from Calgene;
- **dicamba tolerant crops** from Monsanto;
- **imidazolinone-tolerant crop**s from BASF;
- **isoxaflutole-tolerant crops** from Bayer, including resistance to glyphosate; and
- **sulfonylurea-tolerant crops** from DuPont.

A recent international report by some 60 scientists warned that current agricultural practices in developed nations cannot be maintained. (See "Wake up before it is too late: Make agriculture truly sustainable now for food security in a changing climate", Trade and Environment Review, United Nations Conference on Trade and Development.) The energy inputs, environmental destruction, habitat loss and loss of natural biodiversity are all too severe. Rapid and significant changes in the management of agricultural production systems are essential. What is recommended are agricultural practices (aka "sustainable, agroecological, or biological practices") that replace the resources consumed by intense commercial agriculture through the use of various cover-cropping strategies, ecosystem-friendly crop rotations and less use of toxic chemicals. (A good example envisioned on a large scale is described in "The Healthy Farm: A Vision for U.S. Agriculture", Union of Concerned Scientists.)

Addendum October, 2014

Traditional Soil-Applied Insecticides Are Surging Alongside Systemic Neonicotinoid Insecticides on Genetically Engineered Corn

My recent white paper (See above, "Pesticide Use on Genetically Engineered Crops," Ramon J. Seidler, Sept. 2014, EWG Ag/Mag) documented surging pesticide use on genetically engineered crops, including both insecticides and herbicides. The paper attempted to correct ongoing misreporting in mainstream and scientific media and to demonstrate, in particular, that the use of herbicides and insecticides has spiked in the past 10 years on corn genetically engineered to express up to six different Bt insecticidal proteins. These proteins primarily target the European corn rootworm and corn borer.

Due primarily to year-after-year use of genetically engineered Bt insecticides on many millions of acres, rapid and widespread resistance has emerged in target insect populations in at least five major corn-growing states, leading directly to the now-widespread practice of coating corn seeds with systemic neonicotinoid insecticides (neonics). They are now used on more than 90 percent of corn and soy acreage in the U.S. As discussed above, neonics are a relatively new class of insecticides introduced in a significant way 10 years ago and are powerful water-soluble neurotoxins that spread into and persist in the environment. They wreak havoc on non-target wildlife and pollinators, including bees, amphibians and birds, and are the lead suspect in bee die-offs, commonly called Colony Collapse Disorder.

Subsequent discussions with some readers revealed that my emphasis on the now-widespread use and negative effects of neonics may have obscured the parallel surging use of traditional soil-applied, pre-emergent insecticides on Bt corn (usually an organophosphate and/or pyrethoid). This is particularly important because USDA and EPA inexplicably do not track neonicotinoid use on genetically engineered corn and soy crops, as they do with soil insecticides. As discussed above, USDA last gathered data for soil insecticide use on corn as a percent of planted acres and overall active ingredient pounds per planted acre in 2010, before widespread resistance emerged in target insect populations. USDA gathers chemical use data for a given crop approximately every five years. (See http://www.nass.usda.gov/Surveys/Guide_to_NASS_Surveys/Chemical_Use/) Despite widespread reports in recent years in both the business and scientific literature documenting surging soil insecticide sales and widespread pest resistance, prominent journalists and scientists, as well as USDA itself, continue to rely on this clearly out-of-date 2010 USDA data.

USDA is expected to publish soil insecticide use rates on corn for 2014 in May 2015, but even cursory investigative research and literature review paint a clear picture that soil insecticide use has surged in the past five years. Relying on the out-of-date 2010 USDA data distorts current facts on the ground and amounts to an industry-friendly sleight of hand, as has been pointed out by a chorus of prominent entomologists speaking out in

scientific and business press in recent years. (See for example "Voracious Worm Evolves to Eat Biotech Corn Engineered to Kill It", *Wired Magazine*, March 14, 2014). Michael Gray, a highly respected entomologist at the University of Illinois, has extensively and rigorously documented insect resistance and surging use of soil insecticides on Bt corn, and been quoted extensively in the Wall Street Journal and Bloomberg. (See "Pesticides Make a Comeback: Many Corn Farmers Go Back to Using Chemicals as Mother Nature Outwits Genetically Modified Seeds," Wall Street Journal, 5/21/13; and "War on Cornfield Pest Sparks Clash Over Insecticide," Bloomberg, 6/11/14.)

In 2013, Dr. Gray published results of a survey of more than 500 farmers at a leading corn and soy conference in Illinois, showing that close to half of the surveyed farmers were both planting Bt corn and using soil-applied insecticides, which Bt corn was ostensibly supposed to prevent. (See Soil Insecticide Use on Bt Corn Expected to Increase This Spring Across Much of Illinois, *ProAg Consulting,* April 4, 2013) Presumably the trend has only worsened in 2014, and the percent of corn acres now treated with soil insecticide may be above 50 percent, an all-time high rather than an all-time low, as has been misleadingly reported in scientific as well as mainstream media.

USDA's historical data does indeed show a trend of decreasing corn acreage treated with (non-neonicotinoid) insecticide as of 2010, attributed to the rapid adoption of Bt corn since 2000:

1990	30.9%
1995	27%
2000	29%
2005	23%
2010	12%

(Source: http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documentID=1560)

But articles and studies published with increasing frequency in recent years show that the 2014 USDA data will likely show that soil insecticide use as a percent of all corn acres has surged to a level not seen since the 1990's, if not before. And as noted, this data will not include the arguably much more problematic surging use of neonicotinoids.

It is illustrative of the problematic industry-friendly reporting that a misleading chart was published last year by no less than the journal *Science*, in its "Special Issue on Smarter Pest Control" (See Pesticide Planet Infographic, *Science*, 8/16/13), and more recently in online environmental publications such as *Grist* and *Vox*. The *Science* chart and others like it misleadingly imply that the decreasing soil insecticide trend as of 2010 resulting from the widespread adoption of Bt corn extended into subsequent years up to and including 2013 and 2014. However, information readily available in the published literature (and linked above) shows that this is clearly incorrect. Moreover, the 2010 data point is misleadingly low in the first place since it excludes neonicotinoid data. While the fine print in the *Science* chart's caption noted that there had been an uptick in soil insecticide use due to

resistant insects, it did not indicate how much, nor was there any attempt to visually correct the downward trend line. The clear intended takeaway is that insecticide use remains at historical lows as of 2013. Further illustrating the data omission problem, the same chart was reprinted in *Vox* without the accompanying caption. (See Are genetically modified crops good or bad for the environment?, *Vox*, 8/5/14)

In the graphic below, we added a reasonable trend line for the years since 2010 to *Science's* chart, showing insecticide use per planted acre spiking dramatically. This update is based on active ingredient use rates of leading soil insecticides (conservatively 0.1 lbs/acre on average) and neonicotinoids (approximately 0.04 lbs/acre on average, extrapolating from the USGS survey discussed in my previous paper above), and recent reporting in scientific and business media suggesting that upwards of 50 percent of corn may have been using soil insecticides as of 2013, along with the well-documented 90+ percent using neonicotinoids.

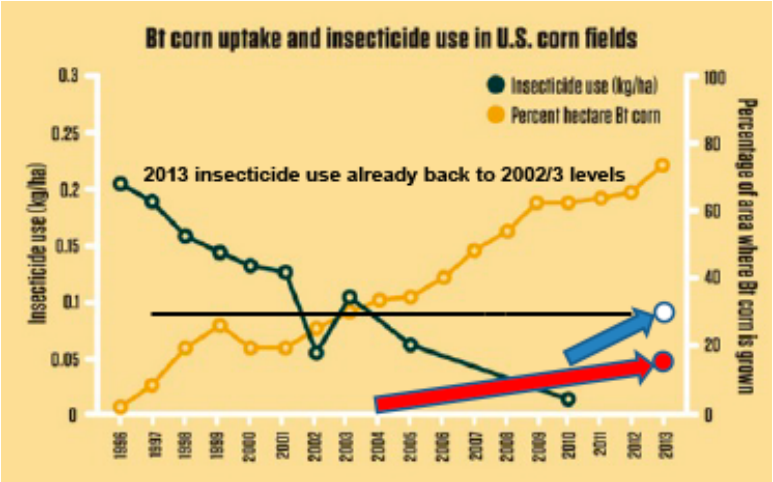


Fig 1. Extrapolated from *Science* infographic (See Pesticide Planet Infographic, *Science*, 8/16/13), with inserted red arrow indicating use of systemic neonicotinoids on seeds over time per US Geological Survey charts; blue arrow represents neonics plus conservative estimate of soil-applied pyrethroids and organophosphates.

While this paints a disturbing picture diametrically opposed to the 2010 insecticide use data, simply focusing on average pounds per acre misses the enormous killing power and negative ecological impact of water-soluble and persistent neonicotinoids even at lower use rates. It also ignores the synergistic magnification of negative effects created by combining neonicotinoids with the "pesticide cocktail" of soil-applied pyrethroids and organophosphates, as well as increasingly used herbicides and fungicides, on genetically engineered crops. As a percent of total corn acres, more corn acres (90+ percent) are now treated with (neonic) insecticides than at any other time in the history of US agriculture.

America is awash in pesticides that not only contaminate our food and water but also increase our body burden and pose significant risks to the nervous and endocrine systems of developing infants and children. (See EPA's Pesticides: Health and Safety website, Protecting Children from Pesticide Exposure). The pesticide treadmill and chemical

cocktails saturating the environment are getting worse, not better, as a result of increased planting of crops genetically engineered to produce insecticide and/or survive heavy herbicide use. Scientists emphasize that extensive application of toxins to farm soils is an unsustainable practice and must be changed to include more agro-ecological practices if we expect to feed future generations. (See "The Healthy Farm: A Vision for U.S. Agriculture", Union of Concerned Scientists.)