



ROUNDUP REVEALED

Glyphosate in our Food System



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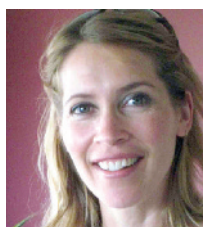
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INTRODUCTION

Glyphosate, the key ingredient in the widely used herbicide Roundup®, has sparked a battle over the future of food. Over the past decade, it has become the most widely used and heavily applied herbicide in history.

The majority of genetically engineered (GE) crops in the U.S. are designed to survive direct applications of glyphosate. As use of GE crops has increased, use of the herbicide has skyrocketed.

A lesser-known use of glyphosate is also attracting scrutiny as it becomes more widespread. Glyphosate is increasingly sprayed on crops like wheat, oats, and beans days prior to harvest to desiccate the plants so harvest operations are easier and can be started earlier. Pre-harvest use results in much higher residues of glyphosate in foods. To address this increase in residues, regulators have consistently raised the legal limits of glyphosate on food crops, despite vigorous public opposition.

Two years ago, the World Health Organization's cancer authority classified glyphosate as a probable human carcinogen. Many countries, communities, and businesses have taken or are considering action to restrict glyphosate use. However, national regulators in the U.S. and EU have historically maintained that glyphosate is safe.

The controversy over glyphosate is located at the nexus of several important trends. Recently, the handful of firms that control world markets in proprietary seeds and pesticides have further consolidated. Some of these companies are staking their futures on new GE crops that are engineered to tolerate not only glyphosate but herbicides that are even more dangerous and volatile. These manufacturers' goals are in sharp contrast to consumer movements that increasingly value fresh, healthy, and socially beneficial food.

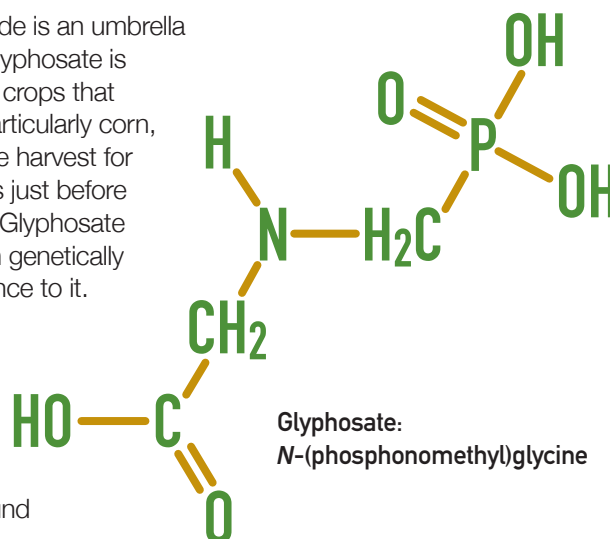
This report tells the story of glyphosate – how and why it is used, what we know about it, and what we do not. It focuses on human health concerns, such as increasing dietary exposures linked to pre-harvest use of glyphosate and the mounting criticism of current U.S. pesticide regulation. The final section outlines our recommendations.

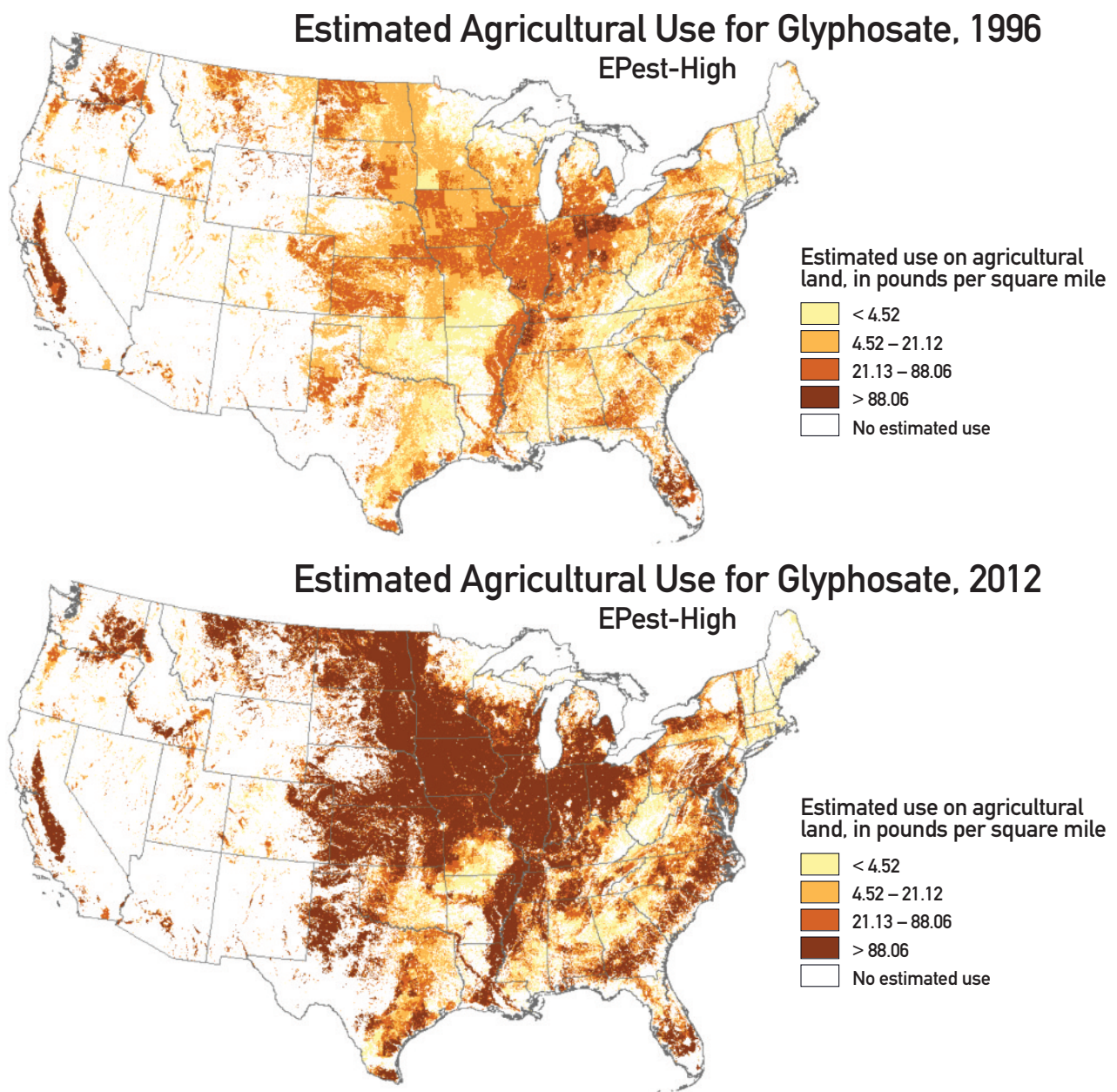
The modern industrial food system, which heavily uses herbicide-resistant GE crops, is increasingly understood to be unsustainable. Investors, companies, and communities will all benefit from a more sustainable food system, that will feed the planet today and for generations to come with reduced human and environmental impact.

WHAT IS GLYPHOSATE?

Glyphosate is the most heavily used pesticide in history (pesticide is an umbrella term that includes herbicides, insecticides, fungicides, etc.).¹ Glyphosate is an herbicide most frequently used in agriculture to kill weeds in crops that have been genetically engineered to survive glyphosate use, particularly corn, soybeans, and cotton. It is also sprayed on certain crops before harvest for burndown and desiccation (i.e., to kill weeds and dry out plants just before harvest), a controversial practice this report will cover in depth. Glyphosate kills all plants to which it is applied except those that have been genetically engineered to tolerate it, or weeds that have developed resistance to it.

Glyphosate works by disrupting the shikimate pathway (a series of chemical reactions in every plant cell), shutting down the plant's ability to combat bacterial or viral pathogens, which in turn kills plants within a few days.² Animal cells do not have the shikimate pathway, but the pathway is found in some bacteria and fungi.³ Studies have found





Glyphosate use in the U.S. rose nearly 15-fold between 1996 and 2012.¹⁰

that high concentrations of glyphosate are toxic to bacteria known to colonize the guts of livestock;⁴ these microbes play an important and often historically overlooked role in physiology.⁵

Glyphosate is sold in proprietary formulations that contain other compounds. One widely applied formulation is Monsanto's Roundup⁶. Monsanto, an American agrochemical and biotechnology firm, currently in the process of being acquired by the German chemical giant Bayer, patented the glyphosate-based herbicide Roundup in the 1970s.⁷ Monsanto once famously advertised that glyphosate was safer than table salt.⁸ Like other pesticide products, the only ingredient listed on the Roundup product label is the “active” ingredient glyphosate; the full list of ‘inert’ ingredients in the product is a trade secret. There is strong evidence that the “inert” ingredients in formulated Roundup products are often themselves toxic, especially when combined with glyphosate, the active ingredient (See “Health Impacts of Glyphosate,” page 8).

Monsanto's U.S. patent for glyphosate expired in 2000. Since then, glyphosate-based herbicide products, such as Dow's Durango DMA® and DuPont's Polaris® have been sold by hundreds of companies around the world.⁹ Monsanto has retained a significant share of the glyphosate market through the development and promotion of new uses for glyphosate, including pre-harvest use and genetically engineered crops.

Genetically Engineered Crops Are the Largest Driver of Glyphosate Sales

Genetically Modified Organisms (GMOs), also known as Genetically Engineered (GE) organisms, are plants or animals in which genetic material (DNA) has been altered in a way that does not occur naturally by breeding and/or natural recombination. The promise of GE crops was that they would decrease pesticide use, improve nutrition, and increase drought tolerance, among others benefits.

However, the majority of GE crops are not engineered to provide these beneficial characteristics. Two of the most widely planted GE crops – cotton and corn – are engineered to constantly produce Bt, a bacterial insecticide, and most GE-Bt seed varieties are also engineered to be glyphosate-resistant, which means that the crops will survive direct applications of glyphosate.¹¹ Glyphosate use has skyrocketed as a result.¹² Roughly 99% of GE crop acreage planted in the U.S. expresses a least one herbicide-resistant gene, an insecticide-producing gene, or both. Very limited acreage is devoted to GE crops that provide improved nutrition, drought tolerance, or other desirable traits.¹³

Approximately half of U.S. cropland is planted with GE corn, soybeans, and cotton.

The GMO Controversy

GMOs have become a highly polarized and controversial issue worldwide. GMOs must be labelled (partially or fully) in 64 countries, as of 2014, including the European Union, India, Russia, China, and Japan.¹⁷ According to research in 2015 by Sustainable Pulse, 38 countries have officially banned the cultivation of GE crops, and only 28 countries actually grow them (most of which grow less than 500,000 hectares).¹⁸ The U.S. federal government has embraced GE crop technology, in part because of the claim that the technology will provide U.S. farmers a competitive edge in global food commodity markets. To date, this does not appear to be the case; for example, corn and soybean productivity and profitability have evolved along similar trajectories in the U.S., where the vast majority of these crops are GE, and in Europe, where almost no GE corn and soybeans are grown.¹⁹

Companies in the agriculture and food industries have been adamant that GE crops are safe; however, criticism of GE crops and associated agricultural methods has focused on public health concerns²⁰, environmental damage from pesticides, and economic concerns (including seed sovereignty, intellectual property, contamination incidents, and competition in agricultural markets).²¹

The main GE crops in the U.S. are corn, soybeans, cotton, canola, sugar beets, and alfalfa.¹⁴ Approximately half of U.S. cropland is planted with GE corn, soybeans, and cotton.¹⁵ The adoption of herbicide-resistant GE crops in the U.S. is responsible for the massive increase in glyphosate application over the last two decades,¹⁶ as well as a host of environmental impacts associated with this increase (See “Glyphosate Residue in Food (And Everywhere Else),” page 11).

The Rise of Pre-Harvest Glyphosate

Pre-harvest glyphosate use (also known as “desiccation,” “harvest-aid,” or “crop-topping”) is a lesser-known use of glyphosate. Because some crops are traditionally harvested after plant foliage has died and seed or grain moisture has decreased, applying glyphosate to these crops just before harvest can promote drying (“desiccation”) in a quicker and more uniform manner than occurs naturally. Monsanto encourages farmers to use glyphosate pre-harvest on several crops such as wheat, feed

(Source: PFleming for iStock.)



barley, oats, canola, flax, peas, lentils, soybeans, and dry beans, even where they are not genetically engineered to resist glyphosate.²²

Pre-harvest glyphosate use began on wheat crops in the U.K. in the early 1980s, growing steadily in northern Europe through the rest of the decade.²³ Currently, between one-third and two-thirds of the wheat and other small grains in northern Europe are treated with pre-harvest glyphosate.²⁴

Pre-harvest Use on Wheat in the U.S.

Wheat ranks third among U.S. field crops in planted acreage, behind corn and soybeans.²⁵ While there is no genetically engineered variety of wheat on the market, use of glyphosate on wheat has been steadily increasing since 2005.²⁶ Pre-harvest glyphosate on wheat remains most common in the northern edge of the U.S. wheat belt.²⁷

In 2015, an estimated 14.8 million pounds of glyphosate were applied to 15.3 million acres of wheat in the United States.²⁸ These figures suggest that approximately 28% of U.S. wheat acres were treated with glyphosate that year.²⁹ Publicly available data on pesticide use generally does not specify how or when pesticides are used, making it difficult to be certain about the prevalence of pre-harvest glyphosate applications. The State of California's Department of Pesticide Regulation (DPR) added an entry for pre-harvest application of glyphosate to its survey in 2015. DPR is expected to publish its 2015 data in 2017, which will shed light on pre-harvest glyphosate use in California.³⁰

Easier, Faster Harvest – At What Cost?

Monsanto claims that pre-harvest glyphosate application can make harvest easier and faster.³¹ While manufacturers of glyphosate have promoted pre-harvest glyphosate use to farmers, its benefits are variable, according to a U.K. literature review³² and materials from a U.K. government group.³³ The benefits depend on several factors, including the crop, climate, current conditions, and use of certain farming practices.³⁴ If the conditions are not optimal, then the marginal benefits of pre-harvest glyphosate application can disappear while the risks (and financial costs) remain.

Pre-harvest glyphosate use can be problematic to surrounding crops, especially seed potatoes, as a result of drift. Glyphosate that drifts onto a seed potato field will translocate into tubers, where it sits idly until seed potatoes begin to grow the next year.³⁵ As the seed potatoes grow, the glyphosate is activated and creates deformed, stunted crops. Pre-harvest glyphosate use causes this effect on many seed plants, including soybeans and wheat. Thus, the use of glyphosate near a crop grown to produce seed can render the harvested seed unfit for planting and production of another crop.³⁶

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Another cost of pre-harvest glyphosate use may be public health impacts due to higher glyphosate residues in such crops. Pre-harvest application of glyphosate leaves higher glyphosate residues on the harvested crop,³⁷ leading to heightened human exposure via diet.

The growing prevalence of pre-harvest glyphosate use has begun to receive international attention from regulators and food companies. While many European countries have approved pre-harvest glyphosate use, many have not, including Germany, Austria, Finland, France, Greece, Italy, Portugal, Slovakia, Switzerland, and Turkey.³⁸ Austria banned the use of pre-harvest glyphosate in 2013, citing the precautionary principle,³⁹ and Germany prohibited the practice in May 2014.⁴⁰ Taiwan conducted a recall of Quaker Oats products imported from the U.S. in 2016 after detecting glyphosate residues that exceeded the country's limit.⁴¹ In the case of oats, which are not a GE crop, residues were likely caused by pre-harvest use.

Food companies are also beginning to demonstrate concern. Grain Millers Inc., an oat purchasing company in Western Canada, announced in April 2015 that it was refusing oats on which pre-harvest glyphosate had been used.⁴² In a follow-up statement in 2016, Grain Millers stood by its decision, noting that the use of pre-harvest glyphosate produces poor quality oats by preventing the plant from fully maturing.⁴³ Recently, The Detox Project launched a Glyphosate Residue Free certification program, demonstrating the growing consumer preference for avoiding glyphosate residues.⁴⁴

HEALTH IMPACTS OF GLYPHOSATE

As glyphosate has become the world's most heavily used herbicide, its health effects have been increasingly scrutinized. The world's leading cancer authority, the World Health Organization's (WHO) International Agency for Research on Cancer (IARC), classified glyphosate as "probably carcinogenic to humans," a decision that made headlines around the world.⁴⁵ Research also suggests that glyphosate may have significant endocrine-disrupting effects, among other health impacts.

A Probable Carcinogen

In March 2015, IARC published a summary of its monograph on glyphosate, classifying it as "probably carcinogenic to humans" (Group 2A)

based on sufficient data from animal studies, limited epidemiological data, and confirmatory evidence from mechanistic data demonstrating its potential to cause cell and DNA damage.⁴⁶ In IARC's classification scheme, "probably carcinogenic to humans" is a designation with less confidence than a "known" carcinogen (Group 1) and more confidence than "possibly carcinogenic to humans" (Group 2B).⁴⁷ The glyphosate classification working group was led by Dr. Aaron Blair, a distinguished epidemiologist recently retired from the U.S. National Cancer Institute.⁴⁸

IARC conducts hazard assessments, rather than risk assessments, and thus the agency did not attempt to determine the *extent* of the risk associated with glyphosate use and exposure, or what uses put people at the greatest risk.⁴⁹ Experts agree that there is no "safe" dose of a carcinogen, as cancer is a "multi-hit" model.⁵⁰

The IARC assessment prompted a massive media campaign from Monsanto and other pesticide industry groups claiming that glyphosate is safe.⁵¹

The World Health Organization's (WHO) International Agency for Research on Cancer (IARC), classified glyphosate as a "probable human carcinogen" in 2015.

The Difference Between IARC and EPA Assessments

IARC's new classification is at odds with many national agency health assessments. The U.S. Environmental Protection Agency (EPA) classified glyphosate as a possible carcinogen in 1985,⁵² but push-back from Monsanto led the EPA to reclassify glyphosate as non-carcinogenic in 1991.⁵³ In 2016, the EPA reaffirmed its position that glyphosate is “not likely carcinogenic” to humans.⁵⁴

In late 2016, the EPA convened a scientific advisory panel (SAP) to review the EPA's assessment of glyphosate. Before the proceedings, the agency was criticized as capitulating to pesticide industry demands by postponing a scheduled advisory panel meeting and removing a scientist who had been critical of the pesticide industry.⁵⁵ In March 2017, the SAP published a report concluding that the *EPA, in reclassifying glyphosate as not likely to be carcinogenic, failed to follow its own guidelines*.⁵⁶ The report also described division among panel members, with one contingent supporting a classification of “suggestive evidence of carcinogenicity.”

Just before the publication of the SAP report, litigation against Monsanto resulted in email correspondence between Monsanto and EPA employees being unsealed by a Federal judge. The email discussions revealed debate within the EPA regarding the assessment of glyphosate: the EPA's Office of Research and Development had raised concern about the robustness of an assessment carried out by EPA's Office of Pesticide Programs (OPP), recommending in December 2015 that the OPP take steps to “strengthen” its “human health assessment.”⁵⁷

The emails also indicated that a senior official at the Environmental Protection Agency had worked to quash a review of glyphosate to be conducted by the Department of Health and Human Services (DHHS). The official in question served as Deputy Director of the Office of Pesticide Programs at the time. A Monsanto executive said in an email that the Deputy Director had told him “If I can kill this, I should get a medal” in reference to DHHS' potential review, which never took place. In another email, a Monsanto executive noted to a colleague that this same EPA official was planning to retire and said he “could be useful as we move forward with ongoing glyphosate defense.” The emails also suggested that Monsanto had ghostwritten research that was later attributed to academics.⁵⁸

The most common criticisms of the EPA's assessment and conclusion fall into two categories:

1. **Failure to consider interactions with “inert” ingredients or other pesticides.** When the EPA's pesticide office evaluates the toxicity of pesticides, it focuses only on active ingredients like glyphosate.⁵⁹ However, inert ingredients⁶⁰ in pesticide formulations can increase the toxicity of active ingredients, or may be toxic in their own right. The EPA also fails to evaluate exposure to multiple toxic endpoints; people may be exposed to several pesticides that cause damage in the same way, but this does not factor into the EPA's evaluation.⁶¹
2. **The EPA's pesticide office excludes the majority of peer-reviewed, journal-published scientific literature.** The EPA relies almost entirely on experiments conducted by pesticide companies, and dismisses or minimizes studies if they do not follow the EPA-defined “Good Laboratory Practices” (GLP). GLP was not developed to improve scientific rigor, but to combat widespread fraud in the late 1970s by private research companies; this misconduct was possible because, unlike published academic research, private research data is not typically subject to rigorous peer-review.⁶² In addition, the EPA virtually ignores human epidemiological studies carried out by independent scientists.⁶³

Another problem worth noting is that the EPA's pesticide office approves hazardous pesticides based on the assumption that farmers and pesticide applicators will comply perfectly with exposure reduction measures, despite evidence that some such measures are unrealistic and often not followed.⁶⁴

Similar concerns have been raised with the European Food Safety Authority's (EFSA) methods. Nearly 100 scientists from around the world co-authored a commentary on the difference between IARC's assessment of glyphosate and that of the EFSA,⁶⁵ an agency that classifies glyphosate as “unlikely to pose a carcinogenic hazard to humans.” The commentary defended the scientific validity of IARC's analysis and criticized the EFSA determination on several points. For example, the scientists stated that the EFSA ignored established guidelines cited in the EFSA's own report, “incorrectly discarded all findings of glyphosate-induced cancer in animals as chance occurrences,” and “ignored important laboratory and human mechanistic evidence of genotoxicity.”⁶⁶

Other Health Impacts

Increased risk of cancer may not be the only health risk from glyphosate and the formulated herbicide products that contain it. Several studies on low doses of glyphosate-based herbicides – at levels considered safe by regulators – “suggests” that these compounds may contribute to liver and kidney damage.⁶⁷

A “state of the science” literature review in 2016 concluded that glyphosate-based herbicides can interfere with numerous biological processes in mammals, even at very low levels (similar to those found in food), and are often amplified by “inert” ingredients in the formula.⁶⁸ In March 2017, experts conducting a review of safety standards for glyphosate-based herbicides came to similar conclusions, noting that “the current safety standards are outdated and fail to protect public health and the environment.”⁶⁹

Multiple studies on glyphosate-based herbicides suggest that these compounds disrupt the endocrine system.⁷⁰ Generally speaking, endocrine-disrupting compounds are considered to be most dangerous for infants and children, as they can disrupt or derail developmental processes.⁷¹ It can take many years for these types of health impacts to emerge after exposure to glyphosate-based herbicides. The link between glyphosate-based herbicides and endocrine-related health impacts is made more difficult because people exposed to glyphosate may also be exposed to other agricultural chemicals, in addition to other endocrine-disrupting compounds.

Several studies have also found that glyphosate may negatively affect the balance of gut bacteria in livestock, in potential favor of pathogenic bacteria, which may tend to harm the immune system or result in other harms.⁷² One study in particular found that glyphosate killed many species of beneficial animal gut bacteria, while not affecting more harmful gut bacteria, such as *E. coli* and the bacteria that causes botulism.⁷³

Disadvantaged Communities Face Highest Risk

Frontline (workers) and fenceline communities bear a disproportionate burden of the impacts of pesticides, including glyphosate. Workers that apply glyphosate, and communities that reside nearby, face significant and regular exposure to the chemical's impacts.

A recent report by a coalition of nonprofit groups found that more than half of the glyphosate sprayed in California is applied in the state's eight most impoverished counties.⁷⁴ These findings parallel a California Environmental Protection Agency study finding that Hispanics and people in poverty disproportionately live in areas of high pesticide use.⁷⁵ A California Department of Public Health study found that Hispanic children were 46 percent more likely than white children to attend schools near hazardous pesticide use.⁷⁶

Unknown Impacts of Ingredients Used With Glyphosate

Pesticide additives (called “inert” ingredients or “adjuvants”) are considered a trade secret in the U.S.⁷⁷ Little is known about these ingredients.⁷⁸ As described in the previous section, the limited available research suggests that Roundup's inert ingredients may pose harm to human health and the environment, and that much more scientific scrutiny is warranted. In 2013, a research study detailed the composition and toxicities of several glyphosate-based

POEA in Combination with Glyphosate

One of the most common ingredients combined with glyphosate is polyethoxylated tallow amine (POEA), a surfactant used in the original Roundup formulation.⁸¹ Different versions of Roundup have included different percentages of POEA. Research has concluded that POEA is more toxic to fish and amphibians than glyphosate.⁸² Germany banned the inclusion of POEA in herbicide formulations in 2014,⁸³ and the European Union adopted a ban on combined glyphosate and POEA use in July 2016.⁸⁴ POEA is still present in formulated Roundup herbicides in the U.S.

formulations and found that each of the formulations was more toxic than glyphosate alone in tests conducted on human cell lines.⁷⁹ The author and his colleagues reported that they experienced difficulty in obtaining pure samples of the inert ingredients, and that companies generally would not sell them. After obtaining five of the ingredients, the team published another study in 2016 which showed that each of the five inert ingredients affected the function of both the mitochondria in human placental cells and aromatase, an enzyme that plays a role in reproductive development.⁸⁰

GLYPHOSATE RESIDUE IN FOOD (AND EVERYWHERE ELSE)

Like other pesticides, glyphosate creates risk of harm through exposures via food, air, and water. Glyphosate residues have become ubiquitous; residue levels are increasing in many parts of the food supply, in the soil, in bee hives, in water resources, and in humans. Biomonitoring studies have found detectable levels of glyphosate in the vast majority of people tested. The first comprehensive and validated human biomonitoring testing project in the U.S. was conducted by the University of California San Francisco. The UCSF team found detectable levels of glyphosate in urine samples in 93% of 131 individuals tested.⁸⁵ Similarly, a German biomonitoring study conducted by the Heinrich Böll Foundation found that 99.6% of 2,000 Germans tested had glyphosate residues in their urine, and 75 percent displayed levels that were five times higher than the European Union legal limit in drinking water (which is 0.1 microgram per liter).⁸⁶ German regulatory authorities responded, stating that glyphosate residue in low concentrations should be expected, but that glyphosate is quickly excreted in the urine and poses no risk.⁸⁷ Concerns remain that while glyphosate may indeed be quickly excreted, it is being replaced quickly enough that levels in humans remain high.

Residue levels are likely to rise further since new use patterns are creating new exposure pathways and the EPA has approved higher glyphosate tolerance levels. The EPA's Allowable Daily Intake (ADI) for glyphosate is 1.75 mg/kg of bodyweight/day, while the European Union ADI is just 0.3 mg/kg/day.⁸⁸ The data used to develop these thresholds are considered proprietary and are typically not available for independent review.⁸⁹ Recently, an international team of independent scientists reviewed the data used in the latest EU renewal assessment report, and concluded that the current EU ADI is probably at least three-fold too high.⁹⁰ Thus, independent scientists recommend a limit on glyphosate exposure at least 17 times lower than current U.S. regulation.

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(Source: fotokastic for iStock.)

Glyphosate in Food

Increased glyphosate residues in human urine are likely due to the increase in glyphosate-resistant GE crops and the growing pre-harvest use of glyphosate. Both of these uses of glyphosate involve applying the herbicide directly to a food crop.

Testing of bread and flour in the United Kingdom by regulatory agencies in 2010 and 2012 began to identify residues of glyphosate at a high level compared to other pesticides,⁹¹ although the residues were still below the legal maximum. Over the past two years, a broad array of food products have been independently tested by consumer organizations. Residues of glyphosate have been found in many foods, including:

- Cheerios®⁹²
- Beer from Germany⁹³
- Wine from California⁹⁴
- Oatmeal, bagels, eggs, potatoes and soy coffee creamer⁹⁵
- Vaccines⁹⁶
- Oat cereals for babies⁹⁷
- Honey⁹⁸

Glyphosate has been found in some foods in the parts per billion (ppb) range or lower, while in others, the levels are three orders of magnitude higher (i.e., in parts per million (ppm)). Most EPA crop tolerances (allowable residue levels) for glyphosate fall between 0.1 and 100 parts per million (ppm); one ppm is 1,000 times greater than one ppb.

Glyphosate in Organic Crops

Glyphosate is not allowed for use on certified organic crops in the U.S. However, an organic grain supplier called Tropical Traditions found glyphosate residues on organic wheat.⁹⁹ Tropical Traditions is working with organic grain mills to figure out how this is happening. The residues may be caused by glyphosate drift (see below).

Glyphosate in Soil, Air, and Water

While glyphosate health concerns primarily focus on ingestion, researchers have found glyphosate to be ubiquitous in the environment, which may be increasing exposure in humans. Rainwater and irrigation frequently contain glyphosate in agricultural regions; for example, two studies by the U.S. Geological Survey (USGS) reported that glyphosate is commonly found in rain and in rivers in the Mississippi River Basin.¹⁰¹ A recent literature review concluded that glyphosate persists in water and soil longer than previously recognized – between a few days to several months in soil, or even a year, depending on soil composition.¹⁰²

Farmers may unintentionally contaminate crops (or surrounding communities and environments) via pesticide drift.¹⁰³ Drift may occur from off-target spray application; contamination can also occur from soil and plant runoff. A University of Arkansas weed scientist found that “...one of the most common problems for wheat producers [in 2011] [was] not a weed or other pest, but the occurrence of glyphosate drift” onto their crops from applications on nearby fields.¹⁰⁴

Pollinator Harm

In addition to the superweed epidemic, researchers have documented other impacts from extensive glyphosate use. According to a report by the nonprofit Center for Food Safety, leading monarch scientists agree that glyphosate overuse has contributed to the dramatic decline in the monarch butterfly population by killing off common milkweed plants in farmers’ glyphosate-resistant crop fields.¹⁰⁵

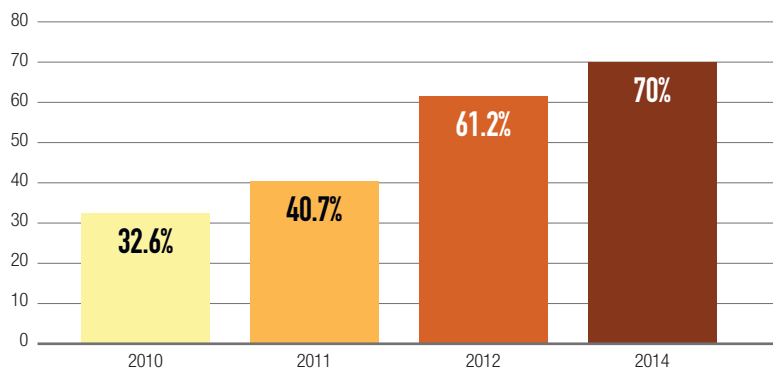
“ Though glyphosate is the mostly widely used herbicide in the world, we know very little about its long term effects to the environment. . . ”¹⁰⁰
– Paul Capel,
US Geological Survey chemist

THE NEXT GENERATION OF GLYPHOSATE

While the impacts of glyphosate use are only now beginning to get serious attention, manufacturers are already promoting a new generation of GE crops that are engineered to be used with even more toxic herbicides. Without attention, this increasingly unsustainable agricultural system will create more significant health, environmental, and economic problems.

One of the most significant environmental problems attributed to glyphosate overuse is an epidemic of glyphosate-resistant “superweeds.” As the use of glyphosate has increased over the past decade, so has the acreage infested with resistant weeds. The incidence of glyphosate-resistant weeds has led to higher use of glyphosate as well as higher costs per acre.¹⁰⁶ Nearly half of all U.S. farmers said they had “glyphosate resistant weeds” on their farms by 2012.¹⁰⁷ Farmers whose crops are infested with these weeds are using increasing amounts of glyphosate to maintain

U.S. Area Infested with Glyphosate Resistant Weeds (millions of acres)¹⁰⁹



weed control at higher costs to themselves, and to health and the environment.¹⁰⁸

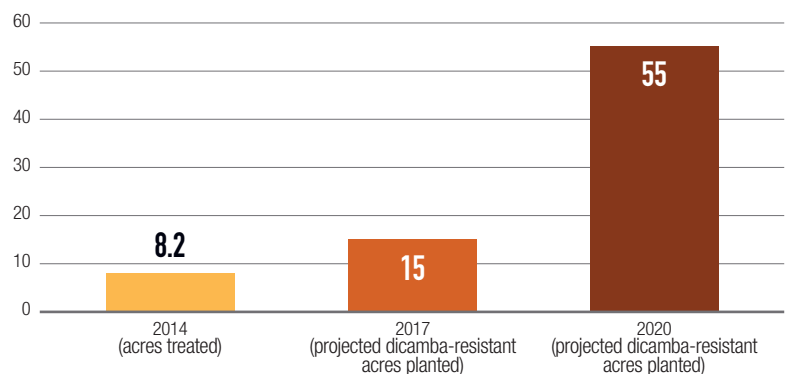
As more weeds become resistant to glyphosate, biotechnology companies are introducing new genetically engineered crops that survive direct application of older, more toxic and volatile pesticides, to be used in conjunction with glyphosate. Dow AgroSciences (a subsidiary of Dow Chemical) recently introduced new crops resistant to both glyphosate and 2,4-D, a toxic herbicide prone to drift and movement via volatilization, that is

already responsible for more incidents of crop injury than any other herbicide.¹¹⁰ Currently, 2,4-D is classified as possibly carcinogenic (Group 2B) by IARC, mainly because of association with increased rates of non-Hodgkin lymphoma in farmers.¹¹¹ Monsanto is also now introducing crops resistant to both glyphosate and dicamba (branded Xtend™).¹¹² Dicamba is responsible for the third-highest number of crop damage incidents due to pesticide drift in the U.S.,¹¹³ and has also been associated with increased risk of non-Hodgkin lymphoma in farmers.¹¹⁴

Monsanto and Dow claim that farmers will quickly and widely adopt dicamba- and 2,4-D-resistant crops. Monsanto projects that 55 million acres of Xtend™ soybeans will be planted by 2020, and that 250 of the 350 million Roundup Ready® acres planted worldwide will be converted to the Xtend™ glyphosate-and-dicamba system by 2025.¹¹⁵ The company is investing nearly \$1 billion into a dicamba manufacturing facility,¹¹⁶ and has projected that dicamba will become the world's second largest selling herbicide, behind glyphosate.¹¹⁷

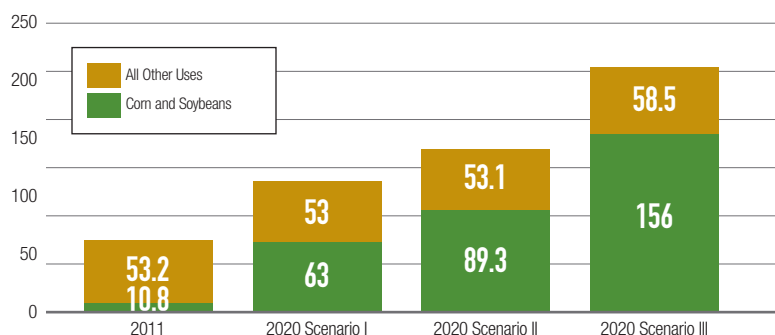
Monsanto currently produces about half of the world's glyphosate,¹¹⁸ making up nearly one-third of the company's revenue.¹¹⁹ According to earnings calls with CEO Hugh Grant, Monsanto's strategy remains focused on selling farmers pesticides to use with Monsanto's GE seeds. This gambit is risky because Monsanto is staking its future on the combined success of glyphosate in combination with more toxic herbicides.

Dicamba Applied to Soybeans in the U.S. (Monsanto projection, millions of acres treated)¹²⁰



Similarly, Dow Chemical projects that 63 to 156 million pounds of 2,4-D will be applied to U.S. soybeans and corn by 2020, compared to less than 11 million pounds in 2011. Notably, Dow predicts that glyphosate use in 2020 will remain as high as 2011 levels, despite the massive projected increase in 2,4-D use.¹²¹ Skyrocketing use of dicamba is very likely to increase adverse impacts, including damage to neighboring crops, environmental impacts, and adverse health outcomes.

2,4-D in the U.S. (Dow Chemical projection, millions of pounds applied)¹²²



Developing new herbicides is extremely difficult. As of November 2012, Purdue University researchers reported that, “no university in the country is evaluating any new herbicide active ingredient” and “the crop protection industry has not commercialized an herbicide with a new mode of action in at least 10 years.”¹²³ The difficulty of creating new, less harmful herbicides, combined with the fact that current herbicide alternatives to glyphosate are generally regarded as even more toxic, has led many researchers to believe that the chemical arms race is impossible to win, making disengagement from glyphosate-resistant crops (and pesticide-intensive agriculture generally) the only sensible policy.¹²⁴

ALLOWABLE LEVELS OF GLYPHOSATE

Farmworkers, advocates, and researchers have argued for years that U.S. pesticide regulation falls short of what is necessary to protect workers and communities. The growing controversy over glyphosate in recent years has elevated the debate about U.S. regulatory policies in this arena, including decisions regarding glyphosate residue on food crops.

The EPA holds primary responsibility for pesticide product regulation in the U.S., i.e., which pesticide products can be sold and under what conditions. Meanwhile, the U.S. Department of Agriculture (USDA) is responsible for field trials and commercial approval of GE crops, which have a large effect on pesticide use, since the vast majority of GE crops grown in the U.S. either produce insecticides or are designed to survive direct applications of herbicide.

“The entire U.S. population is exposed on a daily basis to numerous agricultural chemicals. . . . Many of these chemicals have known or suspected carcinogenic or endocrine-disrupting properties.”¹²⁵

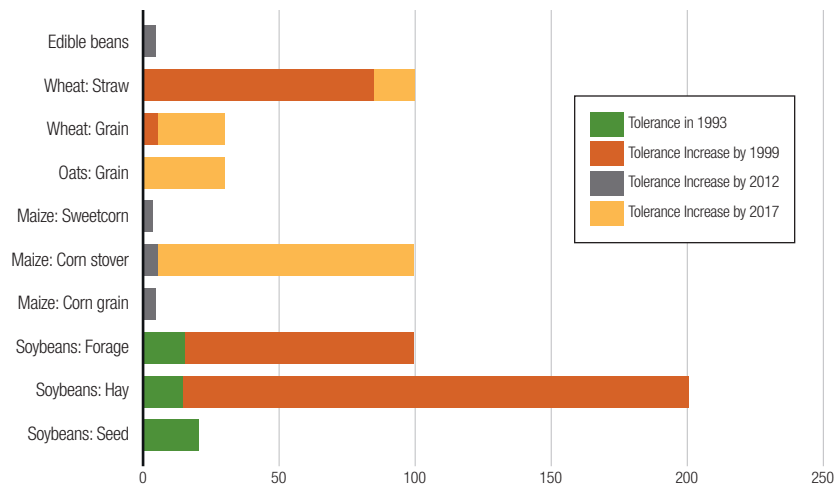
— The President’s Cancer Panel, 2010

Setting Glyphosate Tolerance

The EPA’s glyphosate tolerance levels (allowable residues) for food crops have changed drastically in the last decade. The available data strongly suggests that the EPA has continually raised the allowable limits of glyphosate residue on crops to allow for applications of glyphosate. For example, the introduction of Monsanto’s various Roundup Ready GE crops has generally coincided with EPA raising the glyphosate tolerance for these crops. Similarly, label and tolerance changes have been necessary to authorize pre-harvest glyphosate use on crops such as wheat.

For example, the glyphosate tolerance for “soybean, forage” was raised six-fold as glyphosate-resistant soybeans were adopted.¹²⁶

Changes in Selected U.S. EPA Glyphosate Tolerance Levels (ppm)¹²⁷



In July 2013, the EPA raised glyphosate tolerances for several crops, despite having received over 5,000 public comments against the proposed change in regulation.¹²⁸ Previously, oilseed crops had a variety of tolerances; this rulemaking standardized oilseed tolerances at 40 ppm (except canola), which greatly raised tolerances for most oilseeds, and lowered a few (such as sunflower). The rulemaking also increased sweet potato tolerances 15-fold (from 0.2 ppm to 3 ppm), and carrots 25-fold (0.2 ppm to 5 ppm).¹²⁹

A comment letter submitted by 21 prominent environmental

organizations in response to the 2013 rulemaking argued against increasing glyphosate tolerance levels, declaring that the decision would lead to increased glyphosate use and “poses many not yet understood risks to human and environmental health.” The letter stated that the EPA’s rulemaking was missing key pieces of information, such as a comprehensive ecological risk assessment that included an endangered species assessment, and a revised occupational human health risk assessment.¹³⁰

The amount of glyphosate residue allowed on food in the U.S. is unusual among pesticides. In 2012, none of the 77 pesticide tolerances established for “wheat, grain” were higher than six parts per million (ppm).¹³¹ However, by 2015, the glyphosate tolerance for wheat, which was 0.1 ppm in 1983, had been raised to 30 ppm.¹³² While this might be appropriate if glyphosate is orders of magnitude less toxic than other pesticides, such an assumption remains an issue of significant dispute.

Residue Testing

Following the concern and controversy in the wake of the IARC classification of glyphosate as a probable human carcinogen, the EPA announced in April 2015 that it planned on asking the USDA and FDA to begin testing food products for glyphosate residue.¹³³ Soon after this announcement, the EPA settled a suit brought by the Center for Biological Diversity and agreed to analyze the impact of glyphosate on 1,500 endangered plants and animals in the United States.¹³⁴

The FDA announced it would begin to test for glyphosate in food in early 2016; this plan was later suspended due to internal delays.¹³⁵ If implemented, the FDA program would measure glyphosate in soybeans, corn, milk, and eggs, among other potential foods.¹³⁶ The U.S. Government Accountability Office criticized the FDA for not testing for glyphosate in a 2014 audit, which listed a litany of other deficiencies in the FDA’s pesticide residue testing program.¹³⁷

The USDA’s Pesticide Data Program began to coordinate with the EPA in January 2017 and planned to begin testing corn syrup for glyphosate in April. By March, however, that plan was reported to have been scrapped.¹³⁸

POLICY DEVELOPMENTS

Glyphosate is unlikely to be fully prohibited in the United States, but pressure is mounting on food companies and the EPA to take action. Local and regional restrictions on its use may be imminent, particularly in Europe and some American cities, as consumer and environmental groups push for stricter regulatory controls.

California Classifies Glyphosate as a Carcinogen

In September 2015, the California Environmental Protection Agency's Office of Environmental Health Hazard Assessment (OEHHA) proposed listing glyphosate as a carcinogen under California's Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65). Under California law, businesses with 10 or more employees using listed chemicals in a product must label the product with a "clear and reasonable warning" of the product's potential dangers. OEHHA listed the IARC decision as the basis for its listing decision.¹³⁹ Monsanto filed a lawsuit against OEHHA seeking to reverse the decision; in March 2017, a Superior Court judge ruled against Monsanto¹⁴⁰ and California has now added glyphosate to the Proposition 65 list as a carcinogen.

The European Union Wrestles with Glyphosate

The debate over glyphosate in the European Union (EU) has been contentious. The European Food Safety Authority ("EFSA") re-reviewed glyphosate in November 2015, and concluded that the substance was unlikely to be carcinogenic. In response, 96 prominent experts published an open letter calling for the EFSA decision to be reversed or disregarded, arguing that the decision relied on six industry-funded and partly unpublished studies, and was furthermore "not credible because it is not supported by the evidence."¹⁴¹

The European Commission was set to vote on glyphosate's re-approval in March 2016, but several member countries announced their continued opposition,¹⁴² and votes were deferred.¹⁴³ Just days before glyphosate's legal status in the EU expired in June 2016, the Commission extended the herbicide's approval for 18 months.¹⁴⁴ A few months later, one of the Members of European Parliament responsible for steering glyphosate re-authorization wrote that she expected glyphosate to be banned in 2017.¹⁴⁵

In the interim, the French government has banned retail sales of pesticide products containing glyphosate, which will take effect by 2018.¹⁴⁶ Large retailers are also taking action: German retail giant REWE removed glyphosate from 350 "toom Baumarkt DIY" stores shelves in 2015,¹⁴⁷ and Swiss supermarket giants Coop and Migros announced that they no longer sell products that contain glyphosate.¹⁴⁸

GE Grass Rulings Demonstrate Potential for Eluding Existing Regulatory Controls

The development of GE grass and other biotech crops demonstrate the limitations of current regulation. In the U.S., the USDA is tasked with regulation of genetically modified organisms; the EPA is responsible for regulation of pesticides and their health and environmental impacts.

In the early 2000s, Scotts Miracle-Gro Company and Monsanto developed turf grasses engineered to be immune to glyphosate. During a 2003 field trial of GE creeping bentgrass, seeds from the grass spread beyond the 400-acre experimental plot in Oregon and into the surrounding area, including a nearby national grassland preserve. The test was shut down and Monsanto and Scotts are still attempting to control the spread of the glyphosate-resistant grass populations that resulted from the escape.¹⁴⁹ Despite this unfolding problem, the two companies successfully petitioned USDA to de-regulate GE bentgrass, claiming that they do not intend to sell the seeds until at least 2023.¹⁵⁰ The Center for Biological Diversity and the Center for Food Safety have protested this deregulation, stating that Monsanto and Scotts would no longer have any responsibility to control the GE bentgrass infestation they created, and USDA would no longer have the authority to monitor whether the companies are selling these seeds.¹⁵¹

This is just one example of the flaws in current GMO regulation. The relative trickle of genetically engineered crops in the food system may become a flood. Recently, revolutionary technologies have arrived that supercharge the ability of companies to tinker with DNA. For example, Clustered regularly interspaced short palindromic repeats (“CRISPR”) is a new technique that makes it quick, easy, and cheap to edit the genes of a living organism; it has been called a “scalpel for DNA”. Organisms engineered through CRISPR do not fall within USDA’s current regulatory authority which is limited to organisms created by splicing genes from “plant pests.” CRISPR manipulates the organism’s own DNA, rather than splicing genes from other organisms, so USDA has declined to regulate many new genetically engineered crops, such as glyphosate-resistant Kentucky bluegrass.¹⁵²

GMOs have historically been lightly regulated by USDA.¹⁵³ Now even that minimal regulation is disappearing, as the floodgates open.

Consolidation of the Pesticide Industry

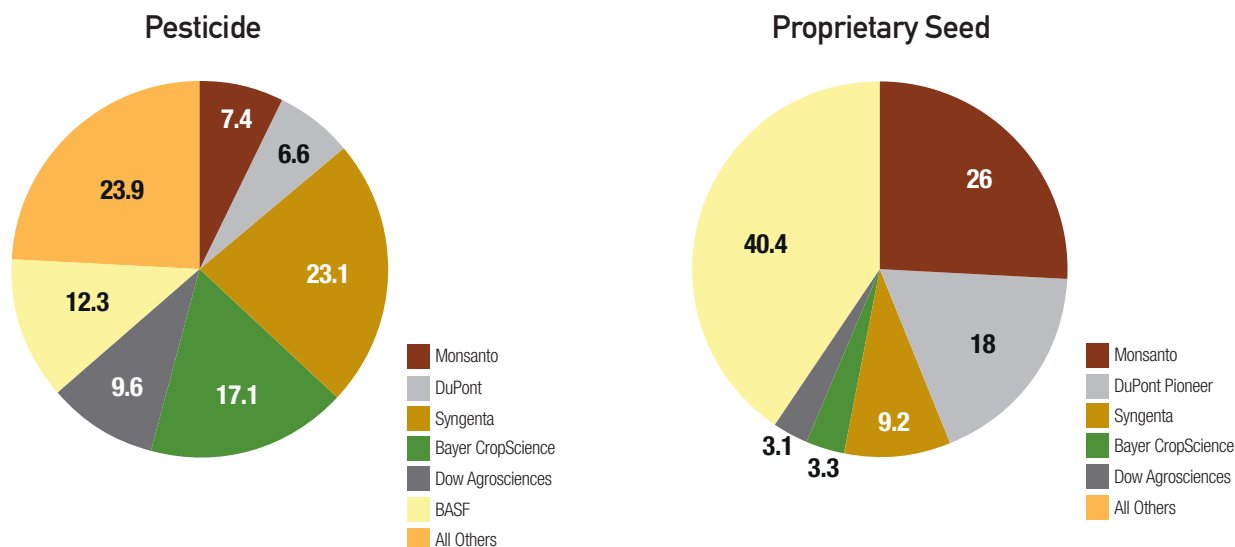
The global agrochemical industry is dominated by a handful of large companies that sell patented and genetically engineered seeds and pesticides: Monsanto, Dow Chemical, DuPont, Syngenta, Bayer, and BASF (the “Big Six”). Over the past year, these firms have further consolidated. Dow and DuPont

agreed to merge (and split their common divisions into three specialized companies), and are awaiting anti-trust clearance in the U.S.; China National Chemical Corporation has been cleared by U.S. regulators to purchase Syngenta; and in September 2016, Bayer reached an agreement to purchase Monsanto.¹⁵⁴ These deals, which have yet to win final approval, have been driven in part by falling sales¹⁵⁵ and the synergy between sales of herbicide and herbicide-resistant crops (see below).

These deals have prompted concern and outrage in some quarters. As the Big Six agrochemical companies merge, farmers suspect that even less competition will lead to higher prices and fewer choices of seeds. The pesticide industry is already highly concentrated and uncompetitive: the top four firms accounted for 58% of the global seed market in 2011. Collectively that year, the Big Six also controlled 77% of the global pesticide market.¹⁵⁶

As the Big Six agrochemical companies merge, farmers suspect that even less competition will lead to higher prices and fewer choices of seeds.

Global Market Shares (2011)¹⁵⁷



The synergy between herbicides and biotechnology is a major driving force in consolidation. For example, Monsanto owns the industry's leading seed business and Bayer has the world's second largest chemicals business.¹⁵⁸ Together, Monsanto and Bayer will be able to develop genetically engineered seeds that tolerate multiple herbicides sold by the company.

Bayer-Monsanto

It is possible that the Bayer-Monsanto deal may not happen. American and European Union regulators are reviewing this merger in the context of the industry consolidation it would bring. In addition to federal antitrust investigations, several U.S. state attorneys general reportedly joined investigations of the pending multi-billion dollar deal. The European Union not only has stricter antitrust and enterprise laws, all member states of the EU get to weigh in on the matter. Unlike their American counterparts, EU regulators have yet to approve a single merger in this industry.¹⁵⁹ Monsanto's reputation has prompted outrage from farmer groups, health advocates, and the public at large, increasing pressure on regulators to deny the merger.¹⁶⁰

THE FINANCIAL RISKS OF GLYPHOSATE

Slipping efficacy, mounting health concerns, and more frequent herbicide residues in finished food products have created new financial risks on farms and for food companies whose supply chains are dependent on GE crop technology. The "probable carcinogen" classification by IARC created a crescendo of attention from media, consumers, lawmakers, and attorneys, among others, and prompted new discussions about the impacts of glyphosate. As the pesticide industry attempts to consolidate, outside forces continue to raise concerns and take action to reduce or end glyphosate use.

The Trump Administration's pledge to cut back on regulations and reduce the EPA budget by 31%¹⁶¹ point towards more lax regulation of pesticides. The EPA's decision in early April 2017 to continue the current registrations of the highly toxic insecticide chlorpyrifos, despite the agency's previously stated plan to ban it, prompted outrage from environmental groups and scientists,¹⁶² and may deepen consumer distrust of pesticide manufacturers and the EPA.

Legal Liability from Glyphosate Harms

Monsanto faces many lawsuits regarding the health impacts of glyphosate, which cite the recent IARC decision and other recent academic research. In September 2015, a U.S. farm worker and a horticultural assistant filed lawsuits claiming Monsanto Roundup caused their cancers and that Monsanto intentionally misled the public and regulators about the dangers of the herbicide.¹⁶³ In October 2015, three more lawsuits were filed by plaintiffs claiming that Monsanto "led a prolonged campaign of misinformation to convince government agencies, farmers, and the general population that Roundup was safe."¹⁶⁴ These suits marked the beginning of what has become a flood of mass tort court filings against Monsanto, according to personal injury law firms.¹⁶⁵

Class action lawsuits and campaigns by grassroots advocacy groups threaten to erode the reputations of food companies that allow glyphosate use in their supply chains. Lawsuits have been filed with PepsiCo (producer of Quaker Oats) and Post Cereals (producers of Shredded Wheat) alleging false advertising, because the "all-natural" cereals contain residues of glyphosate (likely from pre-harvest use on oats and wheat, respectively).¹⁶⁶ Petitions and boycotts may become more prevalent. More than 120,000 people signed a recent Change.org petition calling for Costco to stop selling Roundup.¹⁶⁷

According to emails obtained by the nonprofit U.S. Right to Know and covered in the *New York Times*, the biotechnology industry enlisted academics to improve public opinion about glyphosate and other pesticides over the last several years.¹⁶⁸ Monsanto and the trade groups it belongs to, including the Biotechnology Industry Organization and Grocery Manufacturers Association, penned articles for academics to publish in media outlets and peer reviewed journals. The company also paid for travel expenses and consulting fees to encourage academic experts to speak

out about and testify on behalf of biotechnology companies in formal reviews. They have also been hired to lobby government agencies and legislatures in support of laxer pesticide regulation.

Among investors in public companies, concern about the risks of these lobbying activities is growing. Each year from 2013 to 2015, Monsanto shareholders have voted on a shareholder-filed proposal to disclose the company's lobbying oversight policies, as well as payments in support of lobbying. Support has grown for the resolution each year, reaching 28.3% of shares in 2017.¹⁶⁹

OUR RECOMMENDATIONS

This list of recommendations provides a starting point for investors, regulators, businesses, and communities to address the risks presented by glyphosate use.

Regulatory Agencies

In March 2016, a dozen prominent scientists published a Statement of Concern regarding glyphosate.¹⁷⁰ We agree with their recommendations, including the following:

- An independent examination of glyphosate-based herbicide (GBH) toxicity should be undertaken, and accompanied by systematic efforts by relevant agencies to monitor GBH levels in people and in the food supply.
- The U.S. National Toxicology Program should prioritize a thorough toxicological assessment of the multiple pathways now identified as potentially vulnerable to GBHs.
- A system should be put in place through which manufacturers of GBHs provide funds to the appropriate regulatory body as part of routine registration actions and fees. Such funds should be made available to independent scientists to conduct the appropriate long-term (minimum two years) safety studies. The assessment of GBH toxicity should encompass potential endocrine disruption, impacts on the gut microbiome, carcinogenicity, and multigenerational effects looking at reproductive capability and frequency of birth defects.

Recommendations for the EPA:

- Prohibit the pre-harvest use of glyphosate on human food crops due to resulting higher residue levels remaining in crops.
- Require the disclosure of pesticide “inert” ingredients and evaluate pesticide formulations, rather than evaluating single ingredients in isolation.
- Ensure that active ingredients are not withheld by manufacturers in agency rulemakings based on “trade secret” designations.
- Fully consider all relevant scientific literature, including epidemiological studies, when evaluating pesticides.
- Provide a clear rationale when adjusting pesticide tolerance levels.
- Assess environmental impacts of glyphosate use and incentives for more environmentally sound alternative practices.

Recommendations for the USDA:

- In conjunction with the FDA and the EPA, consider environmental and economic impacts (including indirect health impacts of herbicide use) when evaluating genetically engineered crops.
- In coordination with the FDA and the EPA, test crops for glyphosate residues as part of the Pesticide Data Program (PDP).

- Assess options to impose mandatory weed resistance management plans when herbicide-resistant crops lead to the emergence and spread of newly resistant weeds.
- Incentivize Integrated Weed Management (IWM) and Integrated Pest Management (IPM); these approaches produce competitive yields and profit margins comparable to herbicide-dependent farming, with decreased environmental impacts.¹⁷¹

Recommendations for Federal Policies Relating to Biotechnology

To address the impacts of glyphosate-resistance crops, as well as other biotech crops approved for unrestricted planting, we recommend that the federal government adopt the following policies to modernize the Coordinated Framework for the Regulation of Biotechnology:

- Adopt the definition of “modern biotechnology” set forth by the Codex Alimentarius in the *Principles for the Risk Analysis of Foods Derived from Modern Biotechnology*¹⁷² for all agencies involved in the Coordinated Framework.
- Add the U.S. Fish & Wildlife Service to the Coordinated Framework as an agency tasked with environmental assessments, particularly when another agency does not have necessary expertise.
- Assess all aspects of genetically engineered organism applications, including the novel proteins and other compounds produced by a GE plant; any other related chemicals that are used in conjunction with the GE crop technology (such as the herbicide that is used with an herbicide-resistant crop); and the interactions of “stacked traits” in GE organisms that combine multiple traits (such as a crop that is resistant to two different herbicides).

Investors

Investors who own stock in companies that make glyphosate should advocate that their companies invest in a more diversified and sustainable business model. For companies whose supply chains use glyphosate, investors should advocate that the companies consider: (1) prioritizing concerns about the continued use of glyphosate in engagements with companies, and (2) supporting shareholder proposals on companies’ proxy ballots that seek increased disclosure regarding use or steps to better understand and minimize the risks and collateral damage stemming from use of glyphosate.

Investors in agrochemical companies (Bayer/Monsanto, DuPont/Dow, BASF, Syngenta/ChemChina) should scrutinize long-term strategies, particularly the degree to which each company’s profits depend on glyphosate and its delivery systems (such as glyphosate-resistant GE crops). The externalities of glyphosate use are not currently reflected on company balance sheets and investors should demand that company management develop strategies to invest in sustainable agriculture.

More sustainable and lower impact weed management systems will depend on diversification of tactics and lessened reliance on herbicides overall, and glyphosate in particular. The best way to move toward this end is to encourage companies to adopt clear, binding weed resistance prevention plans. A key feature of such plans must be incrementally more aggressive interventions if current requirements fail to stop the emergence and further spread of resistant weeds.

Businesses

It is in the best interest of businesses, specifically those in the food and retail industries, to call for the EPA and USDA to undertake the recommendations described above to ensure the safety of GE food crops and any accompanying use of pesticides. Companies can also take immediate action by limiting or prohibiting use of chemicals of high concern in their supply chains, including glyphosate, dicamba, and 2,4-D; implementing robust integrated pest and weed management programs and reducing overall pesticide use; and updating stakeholders on the company’s progress.

When participating in the political process, businesses should encourage the construction of a rational, data-driven, prevention-based regulatory system. The elimination or weakening of environmental and health protections are not in the best interests of companies or their consumers over the long-term.

Leading the Way

Kellogg, a leading multinational cereal and snack company, reported in its 2016 Year-End Sustainability Milestone Report that it would survey suppliers on pre-harvest glyphosate use in 2017. Kellogg has committed to responsibly source¹⁷³ its key 10 ingredients by 2020,¹⁷⁴ a level of commitment matched only by General Mills,¹⁷⁵ Unilever,¹⁷⁶ and Campbell Soup¹⁷⁷ among food companies of their size.

We also recommend that businesses that produce, retail, or purchase fruit and vegetables join the Equitable Food Initiative, which brings together workers, growers, and retailers to achieve strong standards for working conditions, pesticide use, and food safety. (For more information, see www.equitablefood.org)

Communities

Individuals can affect change in several ways:

- Support responsible businesses and business practices, including use of certified organic food products (which can never be produced with the use of synthetic agricultural chemicals, including glyphosate, and, overall, harbor fewer pesticide residues¹⁷⁸).
- Avoid or reduce the use of glyphosate in homes and gardens and follow principles of Integrated Pest Management.
- Demand the labeling of products that contain glyphosate to warn consumers of possible effects.
- Undertake or increase investments in companies that seek to reduce the use and harmful impacts of glyphosate and other chemicals of high concern.
- Support strong health and environmental regulations.

CONCLUSION

There is substantial evidence that widespread glyphosate use is not sustainable. People are being exposed to this herbicide in food and water at increasingly higher levels, with more evidence suggesting that adverse health impacts are likely, even at low doses. Pre-harvest use threatens public health by increasing glyphosate residues in food. The ubiquity of glyphosate has led to superweeds on at least half of U.S. farms. Pesticide companies are planning that farmers will maintain current levels of glyphosate while also adopting more toxic herbicides to the fight growing weed tolerance, exacerbating risk to the environment and human health.

Shareholders could productively focus on reigning in the most potentially harmful and unnecessary uses of glyphosate, such as pre-harvest use. However, it remains crucial to grapple with the structural forces that keep most conventional farmers locked into a “pesticide treadmill.” As toxic pesticides like DDT were banned or phased out beginning in the 1970s, “safer” alternatives like organophosphates and glyphosate have been promoted. The flaws of those pesticides are now becoming clear. The lack of competition in the seed market and the difficulty of transitioning to different models of agriculture are barriers to farmers that want to “get off the treadmill.”

Earlier this year, United Nations food and pollution experts concluded that pesticides are not necessary to feed the world and that hunger is primarily caused by poverty, inequality, and poor food distribution. The report warns of catastrophic consequences if current pesticide-oriented farming practices continue and criticizes pesticide manufacturers for systematic denial of harms and unethical marketing tactics.¹⁷⁹ Shortly after this report was released, a study of

1,000 farms in France concluded that virtually all the farms could significantly cut their pesticide use while still producing the same quantity of food.¹⁸⁰

The path forward is clear. We are all stakeholders in the food system and the planet's ecology. The costs of our current practices are growing and the regulatory system is not responding. We must invest heavily and immediately in proven sustainable agriculture and support those who are already doing so. We will all share in the wealth and security of a safer, more just, and long-term sustainable food system.

United Nations food and pollution experts concluded that pesticides are not necessary to feed the world and that hunger is primarily caused by poverty, inequality, and poor food distribution.



(Source: valentinussanov for iStock.)

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GLOSSARY

Burndown: Use of an herbicide to destroy weeds in a field, sometimes after harvest in fall, but more often in spring prior to planting. “Green burndown” applications are applied 10 days to two weeks prior to harvest, to speed weed killing, the crop-drying process, and the beginning of harvest operations.

Carcinogen: A substance or agent capable of causing cancer.

Desiccant: A substance used to kill plants to accelerate the drying process.

Endocrine Disruptor: A chemical, or mixture of chemicals, that can interfere with the expression of hormones, or their role in governing metabolic, physiological, or developmental processes. These disruptions can increase the risk of cancerous tumors, birth defects, and other developmental disorders.

Epidemiology: The study of how often diseases occur in different groups of people, and why.

Fenceline Communities: Neighborhoods that are adjacent to industrial operations or farm fields treated with pesticides.

Frontline Communities: Those directly impacted by a harmful activity or toxic exposure.

Herbicide: A substance used to kill plants. Also commonly known as weed-killers.

Pesticide: Any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest, including weeds. Includes herbicides, insecticides, fungicides, rodenticides, etc.

Pesticide Drift: The unintentional movement of pesticides away from treated fields, which can expose nearby crops, workers, and communities to injury. Spray drift occurs when a pesticide application misses its target or is blown by wind. Volatilization drift occurs post-application, when pesticides evaporate into the air and move with the wind until transported back to the ground with precipitation.

Pesticide Residue: Refers to pesticides that remain on or in food after application of pesticides to a crop.

Pesticide Tolerance: A term used in the U.S. to refer to the maximum allowable concentrations of a pesticide allowed by the Environmental Protection Agency to remain in or on an agricultural commodity or food after application of the pesticide to a crop.

ENDNOTES

- 1 Benbrook, Charles M, "Trends in glyphosate herbicide use in the United States and globally," *Environ Sciences Europe* 28:3 (2016), doi 10.1186/s12302-016-0070-0, <http://www.enveurope.com/content/pdf/s12302-016-0070-0.pdf>.
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- 3 "The shikimate pathway is highly conserved being found in fungi, bacteria, and plant species." Tohge, Takayuki et al., "Shikimate and phenylalanine biosynthesis in the green lineage," *Plant Science* 27 (March 2013), <https://doi.org/10.3389/fpls.2013.00062>.
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172. 'Modern biotechnology' entails the application of:

- (i) In vitro nucleic acid techniques, including recombinant deoxyribonucleic acid (DNA) and direct injection of nucleic acid into cells or organelles, or (ii) Fusion of cells beyond the taxonomic family, that overcome natural physiological, reproductive, or recombinant barriers and that are not techniques used in traditional breeding and selection. *Principles for the Risk Analysis of Foods Derived from Modern Biotechnology*, Codex Alimentarius Commission, 2003, <http://www.fao.org/fao-who-codexalimentarius/standards/list-of-standards/en/>.
- 173. Kellogg defines responsible sourcing as: "supporting livelihoods and/or measuring continuous improvement on input optimization and environmental impact such as biodiversity, water use and quality, energy and fertilizer use, greenhouse gas emissions, and soil health."
- 174. Pre-harvest glyphosate: p. 30, Responsible sourcing: p. 20: "Kellogg Sustainability Milestones 2016," The Kellogg Company, December 2016, http://www.kelloggcompany.com/content/dam/kelloggcompanyus/corporate_responsibility/pdf/2017/Year%20End%20Sustainability%20Milestones2017.pdf.
- 175. General Mills has committed to sustainably sourcing 100% of its 10 priority ingredients by 2020. "Sustainable sourcing", General Mills, accessed March 29, 2017, <http://www.generalmills.com/en/Responsibility/OurPlanet/Sustainable-sourcing>.
- 176. Unilever's Sustainable Agriculture Programme requires that suppliers comply with a Sustainable Agriculture Code and make continuous improvements on 11 social, economic and environmental indicators. Unilever began the program with its top 10 ingredients (70% of total volume) and later added eight more materials (an additional 10% of volume). "Our Sustainable Agriculture Programme." Unilever, accessed April 14, 2017, <https://www.unilever.com/sustainable-living/the-sustainable-living-plan/reducing-environmental-impact/sustainable-sourcing/our-approach-to-sustainable-sourcing/our-sustainable-agriculture-programme.html>.
- 177. "Our sustainable agriculture strategy continues to focus on driving improvement in five priority areas — GHG emissions, water, fertilizer and pesticide reduction, and soil quality improvements." Campbell has committed to, by 2020, reduce GHGs per pound of ingredient by 20 percent, reduce water use per unit of ingredient by 20 percent, and reduce nitrogen applied per pound of ingredient by 10 percent. "Campbell 2016 CSR," Campbell Soup Company, accessed April 14, 2017, <http://www.campbellcsr.com/planet/agriculture.html>.
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