



From Superweeds to Cancer:

Why It's Time to Ban Monsanto's Roundup Weed Killer

Monsanto's* Roundup weed killer, and generic varieties using Roundup's active ingredient, glyphosate, are the most widely sprayed pesticides in history.¹ The weed killer was marketed as a way to help farmers control weed populations with less labor and to increase crop yields. However, in just a few decades, the escalating use of glyphosate herbicides has led to "superweeds" that are resistant to it, driving a cycle of increased use of weed killers and the heavy public health and ecological costs that come with it.

Roundup harms our health

Monsanto began selling Roundup in 1974 as a broad-spectrum herbicide, meaning that it kills most plants it comes into contact with.² Farmers using Roundup to kill weeds had to plan their applications so they would not damage crops, such as spraying between rows or after harvest, while also incorporating other weed management practices. For this reason, Roundup use on field crops remained modest for many years compared to other available herbicides.³

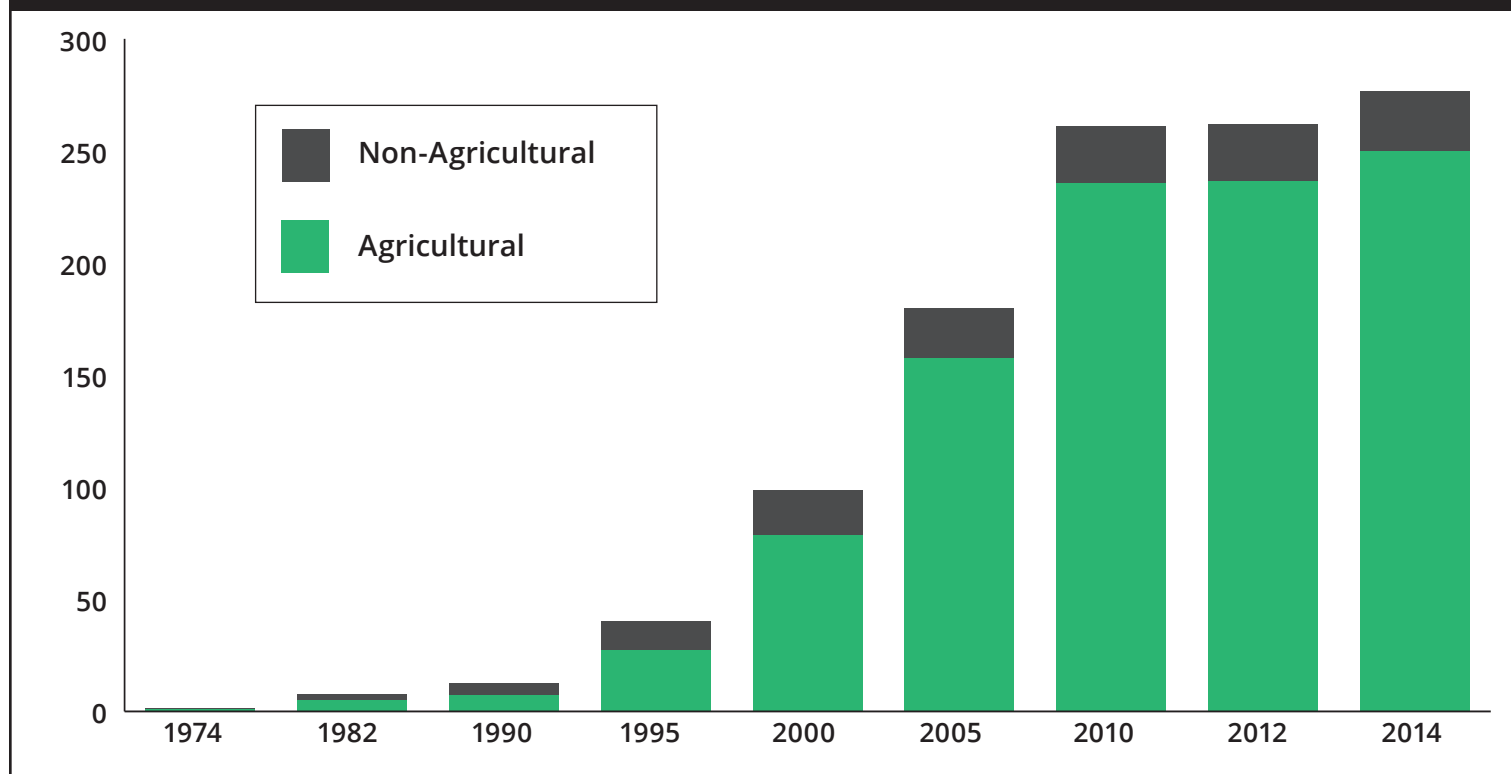
Then in 1996, Monsanto released its first genetically modified (GMO) seeds that can tolerate being sprayed

with Roundup. Roundup application surged as farmers broadly adopted these "Roundup Ready" GMO seeds and the accompanying herbicide they were designed to tolerate.⁴ Homeowners and landscapers also apply Roundup to control weeds. In 2014, 276 million pounds of Roundup's active ingredient glyphosate were sprayed in the United States, with a total of 1.8 billion pounds used globally (see Figure 1 on page 2).⁵

Monsanto markets Roundup as a low-toxicity herbicide with environmental advantages such as reducing mechanical tillage to remove weeds (which can increase soil erosion) and reduced spraying.⁶ However, study after study

* In 2018, Monsanto and Bayer (a German chemical and pharmaceutical company) finalized plans to merge into a single company. They intend to drop the Monsanto name and operate under the name Bayer, a move that would mean that all of Monsanto's products (including Roundup) would become part of the Bayer portfolio. As of this issue brief's publication, however, that transition was not complete, and so we will continue to refer to Monsanto as the developer and marketer of Roundup. See Brodwin, Erin. "After a \$66 billion merger, Monsanto is disappearing — sort of." *Business Insider*. June 7, 2018.

FIGURE 1 • Total Glyphosate Use in the United States (in millions of pounds/year)



SOURCE: Benbrook, Charles M. "Trends in glyphosate herbicide use in the United States and globally." *Environmental Sciences Europe*. Vol. 28, No. 3. February 2, 2016 at 5.

have revealed the harmful effects of Roundup and its active ingredient glyphosate:

- Glyphosate is "probably carcinogenic to humans," according to the World Health Organization's International Agency for Research on Cancer (IARC), which reviewed hundreds of publicly available studies. The IARC's cancer review has helped fuel thousands of lawsuits brought by consumers who argue that they developed non-Hodgkin's lymphoma through exposure to Monsanto's Roundup.⁷
- Roundup and its active ingredient glyphosate are possible endocrine disruptors, meaning that they can interfere with the body's hormones and lead to health problems. Such effects have been demonstrated at levels below the allowable limit for glyphosate residue on several food products in the United States.⁸
- Emerging research suggests that Roundup use may contribute to the development of antibiotic-resistant bacteria. In one study, exposing *E. coli* and *Salmonella* Typhimurium to Roundup increased the bacteria's tolerance to certain types of antibiotics. This occurred at concentrations below the application rate specified on the label.⁹
- Glyphosate herbicide use may be behind a rise in reproductive issues and birth defects in a farming

community in Argentina, as well as developmental disorders in the children of Minnesota farmers.¹⁰

Because of the widespread use of glyphosate herbicides — and the way the chemicals travel through the environment — farmers and farm workers are not the only people exposed to dangerous levels of these weed killers.

Roundup is in our food

Before the introduction of herbicide-tolerant GMO crops, farmers typically sprayed herbicides after harvest, or between crop rows and other areas where they wanted to remove all vegetation. Roundup Ready GMO varieties allow farmers to spray directly onto crops, which led to a dramatic increase in glyphosate use — and to higher residue levels of glyphosate on food. Additionally, farmers will sometimes spray glyphosate herbicides on grain crops late in the season to prepare the fields for harvest, a practice that also increases glyphosate residue on food.²⁵ Finally, cattle are often fed GMO animal feed containing glyphosate residue, which can accumulate in their organs and muscles.²⁶

In 2016, the U.S. Food and Drug Administration (FDA) began testing for glyphosate residue in food, although the results are limited as they only looked at four products (corn, soybeans, milk and eggs). Glyphosate residues did not exceed federal limits in these samples.²⁷ However, doc-

Monsanto's attacks on science

Emerging studies revealing the harmful effects of glyphosate herbicides have put Monsanto on the defensive, and the company has been using the tobacco industry's playbook to try to downplay evidence of health risks:

Monsanto repeatedly attacked the credibility of independent scientists and institutions, including the World Health Organization's IARC. Internal documents reveal that Monsanto anticipated the IARC's conclusion that glyphosate may cause cancer and prepared a public relations campaign that coordinated outside industry allies to attack the agency's credibility.¹¹ Monsanto also leveraged its ties to an academic journal to orchestrate a behind-the-scenes campaign to push for the retraction of a two-year feeding study that found harmful effects on rats that consumed Roundup residue and GMO corn.¹²

Monsanto ghostwrote "independent" scientific papers supporting the safety of glyphosate and had outside researchers sign their names as authors. This includes a paper that the U.S. Environmental Protection Agency (EPA) incorporated into its 2017 glyphosate cancer assessment.¹³ And following the IARC's cancer assessment, Monsanto funded a cancer review of glyphosate by supposedly independent panels that determined that the IARC came to an inaccurate conclusion. Internal Monsanto documents reveal that Monsanto staff heavily edited the paper and possibly hand-picked some of the panel members — contrary to what the paper states in its declaration of interest.¹⁴

Monsanto also pressured EPA officials to kill a glyphosate review that was to be undertaken by the U.S. Agency for Toxic Substances and Disease Registry, and to suspend an EPA Scientific Advisory Panel on the health risks of glyphosate.¹⁵

All of this effort to twist the science undermines Monsanto's assertion that glyphosate is safe. As Carey Gillam, veteran reporter on Monsanto and agribusiness, writes: "If what Monsanto says is true, that glyphosate is so very safe, and that there is no evidence it causes cancer or other health problems, then why all the smoke and mirrors?"¹⁶

uments obtained by *The Guardian* prior to report's release reveal that one sample showed levels of glyphosate in corn above the legal limit (although this was considered an "unofficial" sample for reasons unspecified). The documents also indicate that glyphosate was detected in other foods including honey and oatmeal.²⁸ Government testing in the United Kingdom has identified glyphosate residue in several samples of processed bread, and independent testing has detected residue in foods ranging from soybeans to beer.²⁹

Consuming food with glyphosate residue may impact human health. One study found that people who eat a conventional diet have significantly higher levels of glyphosate in their urine compared to those who eat organic. Disturbingly, chronically ill people showed significantly higher glyphosate levels than healthy people.³⁰ Another study linked glyphosate levels in urine to shorter pregnancies.³¹

There remains a dearth of comprehensive biomonitoring of residues in people's bodies that could reveal long-term impacts of glyphosate application.³² This is shocking considering that glyphosate herbicides are the most widely used herbicides in the world.³³

Roundup harms the environment

Monsanto long advertised Roundup as "environmentally friendly" and "practically non-toxic" to fish, birds and mammals — until the company was sued in 1996 by New York's Attorney General for false advertising.³⁴ In the two decades since, scientific evidence of Roundup and its active ingredient glyphosate's ecological impacts has grown.

The extensive use of glyphosate herbicides has led to widespread ecological contamination. One study analyzed water samples over a 10-year period in 38 states and the District of Columbia; it found glyphosate and related chemicals in 59 percent of surface water samples, 8.4 percent of groundwater and soil water samples, and over 50 percent of soil and sediment samples.³⁵ Another study found glyphosate-related chemicals in 86 percent of air samples and 77 percent of rain samples taken during the growing season in an agricultural region of Mississippi.³⁶

Environmental exposure to Roundup can be toxic to wildlife. One study simulated field spraying of Roundup on groups of tadpoles and juvenile frogs. One Roundup



Roundup is not just for farmers

Non-agricultural use makes up 10 percent of global glyphosate applications.¹⁷ In 2012, U.S. residents applied between 4 million and 6 million pounds of the active ingredient glyphosate to control weeds at their homes and gardens. An additional 7 million to 9 million pounds was sprayed for industrial, commercial and government use.¹⁸

Home and industrial use of Roundup and other glyphosate herbicides contribute to glyphosate levels in surface waters. For example, herbicide runoff can enter drainage systems, reaching surface water sources. One study in an area of Switzerland estimated that urban use contributes more than 60 percent of the glyphosate residue detected in surface waters.¹⁹ And, as noted above, home and garden use of Roundup may also contribute to antibiotic resistance.²⁰ These facts — along with the potential exposure to children and pets who play where Roundup is sprayed — raise concerns about the safety of non-agricultural Roundup use.

application killed 98 percent of tadpoles within three weeks and 79 percent of juvenile frogs within one day.³⁷ Another experiment found that Roundup exposure killed 100 percent of carp within an hour, at concentrations 20 to 40 times below the typical application.³⁸

Even when animals are exposed to sub-lethal levels of glyphosate, they can still experience negative impacts. For instance, glyphosate can impair the nervous systems of honeybees, potentially impacting the long-term survival of colonies.³⁹ Glyphosate herbicide use is also

linked to the decline of monarch butterfly populations, since glyphosate is effective in killing milkweed, a plant that monarch larvae feed on. Monarch egg production in the Midwest dropped 81 percent between 1999 and 2010, coinciding with the adoption of Roundup Ready crops and a significant decline in agricultural milkweed populations.⁴⁰

Roundup costs farmers

Global glyphosate use surged nearly 15-fold between 1995 and 2014, correlating with the introduction of Roundup Ready crops in 1996.⁴¹ At first, glyphosate was effective in killing a wide range of weeds and was easier to apply because farmers did not have to worry about damaging their crops.⁴² It also allowed farmers to use conservation tillage (which leaves the previous year's crop material on the field) to help prevent soil erosion.⁴³

However, these gains were short lived. Repeated applications of glyphosate on large areas of cropland helped facilitate the development of "superweeds" that are resistant to the herbicide.⁴⁴ As of August 2018, there are 42 weed species across the world that have been identified as resistant to the active ingredient glyphosate, and one-third of these first emerged in the past five-and-a-half years (2013 to August 2018).⁴⁵ The combination of herbicide-tolerant crops and Roundup that was supposed to reduce the need to spray in actuality increased overall herbicide use, as farmers now spray more often with larger doses of various herbicides to fight weeds that Roundup alone cannot kill.⁴⁶

Farmers bear the costs of superweeds. A U.S. Department of Agriculture study found that corn and soybean growers who reported a glyphosate-resistant weed problem experienced higher production costs and lower yields compared to those who did not report a weed problem.⁴⁷ A 2013 Food & Water Watch analysis estimated these costs at \$12 to \$50 per acre. The same study found that farmers pay a premium for GMO seeds — nearly \$40 per acre more for GMO corn compared to non-GMO varieties — a cost that almost tripled between 1998 and 2013.⁴⁸

Chemical companies are responding to weed resistance in baffling ways: by marketing seeds that are also tolerant to older, more dangerous herbicides. In 2016, the EPA approved the use of Monsanto's dicamba formula on soybeans that are genetically modified to be tolerant to both glyphosate and dicamba. However, dicamba is volatile and prone to drifting onto neighboring fields, and damaged an estimated 3.6 million acres of soybeans in 2017.⁴⁹ Another controversial herbicide is Dow AgroSciences' Enlist Duo,

which combines glyphosate and 2,4-D and is intended to be used on GMO crops tolerant to both herbicides.⁵⁰ However, the World Health Organization classifies 2,4-D as “possibly carcinogenic,” and the herbicide is also prone to drifting, increasing the chance of exposure to people, wildlife and neighboring fields of sensitive or organic crops.⁵¹ Environmental and family farm groups are challenging Enlist Duo’s registration in court, arguing that the EPA failed to conduct a full assessment of the weed killer’s environmental impacts.⁵²

Expanding the use of dicamba and 2,4-D may not be a long-term solution if it gives rise to superweeds resistant to the formulas. This decision to respond to the emergence of glyphosate-resistant weeds with a next generation of GMO crops that rely on even more herbicides illustrates that the beneficiaries of widespread herbicide use are not farmers, but the chemical companies that sell GMO seeds and affiliated herbicides.

Our government is failing to regulate Roundup

More and more studies are revealing glyphosate’s potential to harm the environment and our health. However, data from initial safety studies of glyphosate that concluded the chemical was “practically nontoxic” continue to make their way into reviews that are used by agencies like the EPA.⁵³

These early studies were limited in scope for several reasons. First, they assumed that glyphosate would not be toxic to humans because it is designed to disrupt an enzyme that vertebrates do not have; however, studies have since demonstrated its toxic effect on vertebrates. Second, many studies tested the toxicity of the active ingredient glyphosate in isolation; however, several studies suggest that the combination of ingredients in Roundup and other glyphosate herbicides can be more toxic than glyphosate alone.⁵⁴ Finally, these initial safety studies were funded by the companies looking to get their products approved for sale, creating inherent biases.⁵⁵ In fact, two of the laboratories contracted by Monsanto to conduct initial glyphosate studies were later exposed for having committed scientific fraud.⁵⁶

Disappointingly, the EPA’s latest glyphosate cancer assessment from December 2017 narrowly focused on the carcinogenic potential of the active ingredient glyphosate and not whole herbicide formulations (like Roundup). Additionally, the EPA relied heavily on unpublished industry studies, which were much more likely to find no evidence of

Which GMO crops are grown with Roundup?

The first three “Roundup Ready” GMO crops to be introduced were corn, cotton and soybeans in 1996.²¹ Today, crops genetically modified for herbicide-tolerance and other traits make up 92 percent of all corn and 94 percent of all soybeans and upland cotton grown in the United States.²²

Other crops with Roundup Ready varieties include animal feed crops like alfalfa and commodities like canola and sugar beets that are processed into human food products and additives.²³

The remaining corn and soy crops grown in the United States are either conventional (non-GMO) or organic. Organic crops cannot be grown from GMO seeds, nor can they be sprayed with most synthetic substances like Roundup. Additionally, organic crops are periodically tested to see if they contain chemical or GMO residue. Organic farmers take measures like planting “buffer zones” around their fields to avoid cross-contamination.²⁴



harm from glyphosate than studies taken from the open literature. For example, the incorporated tests from open literature studies on genotoxicity (the ability to damage cell DNA) were 33 times more likely to suggest evidence of glyphosate’s genotoxicity than those from industry studies. Yet the EPA effectively drowned out these findings by flooding the review with industry studies.⁵⁷

Both the EPA Office of Research and Development (ORD) and the independent Scientific Advisory Panel tasked with reviewing the assessment expressed concerns over how the assessment was conducted, with the ORD and some Advisory Panel members disagreeing with the finding of “Not likely to be carcinogenic to humans.” However, the EPA dismissed many of their concerns and maintained the

lowest possible cancer rating for glyphosate.⁵⁸ This allows Monsanto to continue to sell Roundup without any cancer warning label, putting the public at risk.

In the absence of rigorous federal oversight, states and municipalities are leading the way in protecting the public from glyphosate. California added glyphosate to its Proposition 65 list of chemicals known to cause cancer or birth defects, although Monsanto and various agricultural groups are currently trying to overturn this decision in federal court.⁵⁹ A number of U.S. cities have also restricted non-agricultural use of glyphosate, and a handful of countries have banned or restricted the use of glyphosate herbicides.⁶⁰ Even so, more than 40 years since glyphosate was first introduced, the environment and our bodies continue to serve as the main test subjects for glyphosate's impacts.

Conclusion and recommendations

Roundup has not lived up to Monsanto's promise of being a low-toxic, effective herbicide that reduces farmers' need to spray. Instead, farmers are battling new "superweeds" and seeing a rise in costs and a reduction in yields. Additionally, studies not funded by Monsanto have demonstrated that Roundup and its active ingredient glyphosate are anything but safe, linking them to cancer and kidney disease as well as to declines in wildlife populations.

The EPA must keep up with the science and stop the use of glyphosate herbicides like Roundup. Additionally, agricultural resources should focus on long-term approaches to weed management, rather than relying only on chemical solutions that come with long-term public health and environmental costs.



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