Collateral Damage:

How Factory Farming Drives Up the Use of Toxic Agricultural Pesticides

CENTER for BIOLOGICAL DIVERSITY

WORLD ANIMAL PROTECTION

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Introduction

Wildlife and farmed animals are both suffering on a massive scale, and in many cases the culprit is the same: toxic agricultural pesticide use. When most people grab a burger, the last thing they're thinking about is pesticides. But meat production is a driving force behind the use of massive amounts of deadly pesticides in agriculture. In 2018, the most recent year with full data available, an estimated 235,976,274 – nearly 1/4 billion – pounds of herbicides and insecticides were applied in the US just to the corn and soybeans grown for farmed animal feed.

The growth and expansion of factory farming is not only perpetuating enormous cruelty and suffering for the billions of animals farmed annually, but also pushing wild animals and plants to the brink by destroying their native habitat and then drenching what is left in massive quantities of toxic pesticides. Yes, that's right, meat production is a major driver of pesticide use.

An enormous portion of our agricultural lands, roughly one-third[1], are used for mass-producing corn and soy, the vast majority of which is not for human consumption. Globally, roughly 67[2] – 77%[3] of soy produced is used as feed for livestock[4], and 36 - 45% of the corn produced in the US is used as feed.[5]

Not only are our existing agricultural lands heavily used to produce just these two crops, but worse, wildlands are continuing to be converted to cropland in order to grow more.

From 2018-2019 alone an estimated 2.6 million acres of grasslands in the US were plowed up and converted to row crop agriculture, with 70% of this conversion occurring for just three crops: corn (25%), soy (22%) and wheat (21%).[6] For soy in particular, the "conversion of important grasslands and conservation lands to soybean production is one of the biggest issues"[7] facing high conservation value native vegetation in the US.

The massive scale of soy or corn cropping systems leads to loss of biodiversity and threatens thousands of endangered and threatened species. Foxes and bats, migratory birds, bumblebees, and prairie butterflies, are all imperiled by grassland conversion and industrial agriculture.

High levels of meat consumption are driving the decline in wild animal populations via the ever-increasing intensification of monoculture feed crop cultivation to feed the farmed animals raised in the factory farming systems that produce the majority of meat consumed in the US today.

This is best evidenced by the hundreds of millions of pounds of hazardous chemicals applied to corn and soy crops as pesticides in the US. These toxic chemicals are impeding the ability of insects, birds, fish, and other taxa to survive and thrive as well as destroying the diversity of native plants on which they rely for shelter and food.

Even further, use of pesticides on corn and soy has steadily greatly increased alongside the growth of factory farmed animal production in the US as the industries are completely intertwined and dependent on one another.

To protect wildlife, biodiversity, and native ecosystems, we must reevaluate our consumption of animal products and choose a more sustainable future that emphasizes the production and consumption of diverse, mostly whole and plant-based foods.

And we must hold the large corporations that are perpetuating these harms – those producing feed crops, meat and dairy, and the pesticide agents – accountable.

Through reducing the role of meat and dairy in our diets we can curb the growth of factory farming and reduce our collective and individual pesticide footprint.

Executive Summary

The expansion of factory farming in the US to produce meat and dairy on an industrial scale has correlated with increasing production of corn and soybeans in large, industrial monocultures to provide high-calorie feed ingredients for the billions of farmed animals being raised for food.

Monoculture row crop production not only destroys native biodiversity by shifting ecosystems to a single dominant crop, but further threatens wild plants and animals via the heavy usage of herbicides and insecticides in attempt to prevent weeds and insects from impeding maximum crop yields.

In 2018, the most recent year with full data available, an estimated 235,976,274 – nearly ¼ billion – pounds of herbicides and insecticides were applied in the US just to the corn and soybeans grown for farmed animal feed (see Appendices A and B for full methodologies and calculations).

These are not crops grown primarily to feed people, but part of an inefficient system that misdirects significant calories and the resources consumed to create them to farmed animals.

In the factory farming model, corn and soybeans have become the predominant ingredient in farmed animal diets. The high-energy diets forced upon modern farmed animals prop up a system that treats sentient animals as mere commodities, fattening them as quickly as possible while crowding them into barren buildings, barns, or lots and demanding the animals conform to the system rather than the other way around.

It is a system that prioritizes maximization of profits at the expense of animal welfare, public health, and the planet.

The production of corn and soybeans globally account for roughly 49% of all sales of highly hazardous pesticides.[8] These chemicals are manufactured and sold by just a handful multinational corporations, many of which are headquartered in countries that have banned their use due to concerns for the environment and human health.

The global pesticide market is controlled by the EU–primarily France and Germany–China, and the US, which together account for 83% of pesticide sales as of 2018.[9] North America is the third largest revenue-generating market for agrochemicals[10], and in the US sales of herbicides and seed treatments have increased year after year since 2012, and continued growth is projected through 2024.[11]

Outside of the US, developing and emerging countries are the primary buyers of these chemicals, and the companies "take advantage of the weakness of regulations in those countries to continue selling their products" despite consequences for local populations and the environment.[12]

Use of pesticides often results in reduction of non-target, beneficial insects, and "changes in biodiversity and the natural biological balance. It is estimated that less than 0.1% of applied pesticide reaches the targeted pests directly."[13] A review of nearly 400 studies showed that pesticides harmed beneficial, soil-dwelling invertebrates, including earthworms, ants, beetles, and ground-nesting bees, in 71% of cases reviewed.[14]

Pesticide use also causes surface and groundwater contamination, affecting the human populations dependent on these water sources as well as toxicity to farmers and farmworkers.[15] Research by the US Geological Survey testing water samples from 72 sites across the country found that 88% of the roughly 1,000 samples taken had five or more pesticides present, with at least one sample positive for 60 different pesticides.[16]

These pesticides are taking a toll on our environment and biodiversity. Endangered species like the highly imperiled whooping crane, monarch butterflies, all species of salmon, the rusty-patched bumble bee, the San Joaquin kit fox, and the northern long-eared bat, as examples, all face significant threats from industrial agricultural operations and the chemicals applied.

This report highlights a shortlist of just six individual chemicals and one class of chemicals that are commonly used on corn and soybeans in the US and have increased in use over recent years. With projections showing a likely continued

increase in the production and consumption of meat and dairy in the US if nothing changes, it can be assumed that these pesticide use levels will also continue to increase alongside demand for industrially-produced feed, unless something changes.

The symbiotic relationship between pesticide use on corn and soy and the factory farm industry is decimating our health, causing suffering for farmed animals, and threatening thousands if not millions of wild species.

The chemicals highlighted in this report are:

- **Glyphosate**: In 2018, a total of 171.5 million pounds of glyphosate were applied to corn and soy in the US, roughly 100 million pounds of which are attributable to farmed animal feed production.[17] Glyphosate is likely to harm, injure or kill 93% of the plants and animals protected under the Endangered Species Act[18] and adversely modifies critical habitat for 759 endangered species.[19] More than 13,000 lawsuits have been filed in the US alleging that the pesticide causes non-Hodgkin's lymphoma[20] and The World Health Organization's International Agency for Research on Cancer has said that glyphosate is "probably carcinogenic to humans."[21]

- **Atrazine:** In 2018, 60.8 million pounds[22] of atrazine, a potent endocrine disruptor, was used on corn and soybeans in the US, representing a 17% increase from 2012 levels. Approximately 25 million pounds of atrazine used was attributable to farmed animal feed.[23] Despite its popularity in the US, atrazine has been banned in 35 countries[24] including a ban in the EU due to persistent groundwater contamination.[25] Atrazine is regularly detected in streams in the US[26] and research demonstrates its ability to alter reproductive health in amphibians.[27] Atrazine use is likely to harm over 1,000 protected species – 56% of all endangered plants and animals in the US – including the highly endangered whooping crane, the San Joaquin kit fox, and the California red-legged frog.[28]

- **Paraquat:** In 2018, 4.2 million pounds of paraquat were applied to corn and soybeans in the US[29], roughly 2.9 million pounds of which are attributable to farmed animal feed production.[30] Paraquat was banned in the European Union in 2007[31] and as of 2020 is banned in 53 total countries, including recent bans in China, Cambodia, Laos and Vietnam.[32] Paraquat is one of "the most embryotoxic contaminants for bird eggs" and negative impacts to eggs or nestlings from approved application rates have been reported in Japanese quail, mallards, bobwhite quail, and ring-necked pheasant.[33] Paraquat's efficacy as a poison has contributed to numerous accidental and intentional human poisoning incidents.[34]

- **Dicamba:** In 2018, 17 million pounds of dicamba were used on corn and soybeans in the US, a 1200% increase from 2012 levels. Just over 11 million pounds of this use attributable to farmed animal feed production.[35] Data indicates that since 2018 use of dicamba has continued to increase due to approvals for dicamba-tolerant genetically engineered soybeans in the US in 2016. Approval for dicamba-tolerant corn on the horizon as well.[36] Many species are imperiled by dicamba. Monarch butterflies, especially, are under threat as their migration seasons often correlate with times when dicamba is particularly likely to be sprayed.[37] Researchers at the National Institutes of Health recently found that use of dicamba by workers to be linked to increased risk of developing numerous cancers, including liver and intrahepatic bile duct cancers, acute and chronic lymphocytic leukemia, and mantle cell lymphoma.[38]

- **2,4-D:** In 2018, 14.6 million pounds of 2,4-D was applied to corn and soybeans in the US, a 45% increase from levels used in 2012. Nearly 9 million pounds of which is attributable to farmed animal feed production.[39] 2,4-D has been shown to harm beneficial insects and arthropods that are important for healthy ecosystems, including ladybugs[40] and earthworms.[41] In humans, studies suggest that 2,4-D is a potential endocrine disruptor and may interfere with thyroid hormones. 2,4-D has also been linked to immune and neurological system problems, including Parkinson's disease.[42]

- **Neonicotinoids ("Neonics"):** At least 2.6 million pounds of just three neonics are used on corn and soy in the US each year, approximately 1.5 million pounds of which were used for the purpose of farmed animal feed production. These three commonly used chemicals - Clothianidin, Thiamethoxam, Imidacloprid - were recently determined by the US Environmental Protection Agency (EPA) to be likely to harm all of the US's 38 protected amphibian species and three-fourths of all endangered plants and animals.[43] Neonics pose particular risks to bees, birds, butterflies, and bats. A single corn kernel treated with any of the commonly used neonicotinoids can kill a songbird, and 1/10 of a treated corn kernel is enough to reduce reproduction in a songbird.[44]

- **Bifenthrin:** In 2018, more than 700,000 pounds of bifenthrin was used on corn and soybeans in the US, a 130% increase from 2012 levels.[45] Approximately 370,000 pounds of this usage was attributable to farmed animal feed production.[46] A neurotoxin, bifenthrin is toxic to bees and highly toxic to aquatic species. In zebra fish, exposure of embryos to bifenthrin accelerated the hatching process and caused morphological impairments.[47] Female honeybees exposed to bifenthrin produced fewer eggs and the next generation had observable developmental impairments, including higher egg weight, lower success rate of egg development, and delayed hatch time.[48]

Further, the insecticide chlorpyrifos offers a prime example of the challenges advocates and communities face in the fight to end the use of toxic chemicals in our food system. It took over two decades of advocacy, led by farmworkers who for decades had experienced some of the worst impacts of chlorpyrifos firsthand, to get this one dangerous pesticide banned from food uses in the US. Exposure to chlorpyrifos results in neurological effects, autoimmune disorders, and persistent developmental disorders. Exposure during pregnancy results in impaired mental development of the child.[49] Its use was estimated to jeopardize 1,399 plants and animals on the endangered species list.[50]

With such overwhelming evidence of harms from chlorpyrifos and the other chemicals outlined in this report, their continued use in US agriculture is unacceptable. It must not take several decades of advocacy and lawsuits for the US government to take action against these chemicals.

Government agencies and programs should instead support a shift to a more humane and sustainable food system that prioritizes the production of crops for human consumption and farming practices that foster rather than deplete biodiversity. This requires a reconceptualization of how we produce and consume protein.

Our appetite and demand for animal proteins is fueling the further expansion of factory farming systems that are propped up by millions of pounds of herbicides and insecticides. This model is not only causing the suffering of billions of cows, pigs, turkeys, and chickens, but countless wild species exposed to these toxic chemicals.

By significantly reducing the amount of meat and dairy we produce and ensuring that the farmed animals that remain in production systems are living in higher welfare conditions we can create a more planet- and animal-friendly food system.

Factory Farming, High-Energy Feed and Animal Suffering

Each year, an estimated 10 billion farmed animals in the US endure the pain, stress, and appalling suffering experienced in factory farms in order to outpace the projected growth in demand for cheap meat. This model of animal protein production is driving the destructive production and trade of massive quantities of feed crops – primarily corn and soy – associated with habitat loss for wild animals, declining biodiversity, water pollution, pesticide pollution, soil degradation, and greenhouse gas emissions.

Farmed animals suffer in the factory farming model in a number of ways: painful mutilations (such as tail docking, teeth clipping, and beak trimming), overcrowding, weaning from their mothers at too young an age, poor air quality, cage confinement, rough handling, and long-distance transport. It is a life characterized by stress, boredom, injuries, physical ailment, hunger, and social deprivation. Genetic selection adds another layer of cruelty, forcing animals to grow fast, have large litters, lay high numbers of eggs, or produce maximum volumes of milk, causing emotional distress and physical harm.

The massive quantities of high-energy feed inputs are further compounding this distress as they contribute to unnatural animal growth rates and are far from the diverse, foraging diets the animals would naturally eat, leading to digestive problems and other health issues.

What's more, they are also taking an enormous toll on the planet.

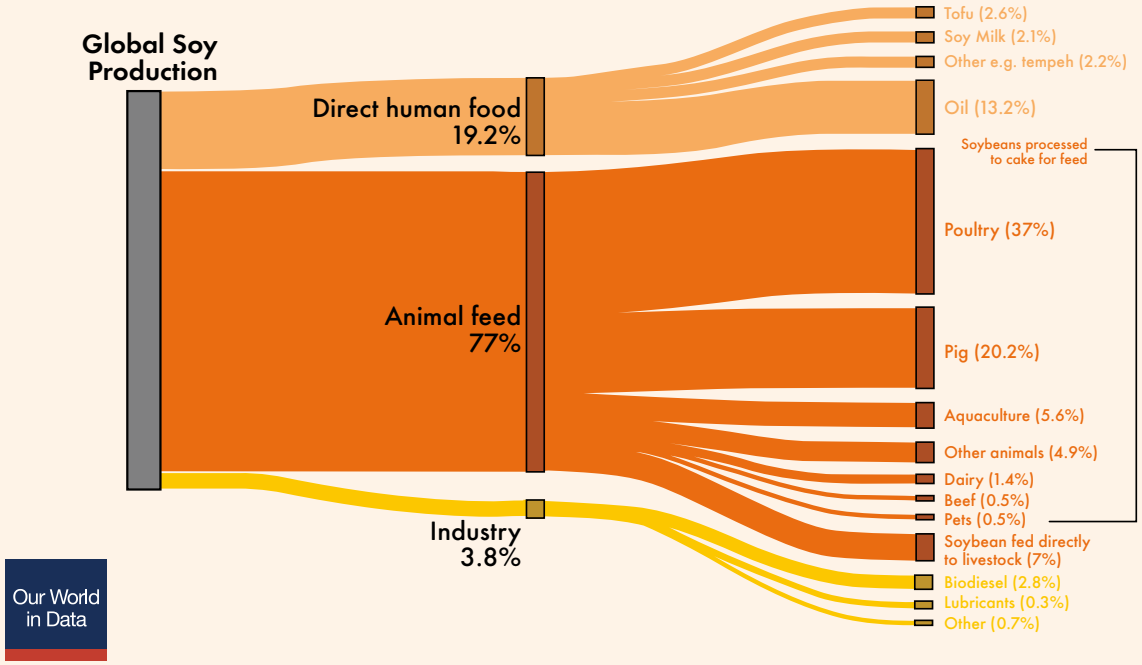
Looking solely to maximize animal weight and production volume at the lowest cost, the industry formulates feeds that are high in ingredients derived from corn and soy. To meet demand, row-crop agribusiness has intensified its reliance on industrial-scale monocultures and, in so doing, expanded its use of pesticides that threaten vulnerable species, ecosystems, and people.

Highly Hazardous Pesticides are Propping up Factory Farming

More than 70 billion land animals – primarily chickens, pigs, cows, turkeys, and ducks – are raised for food in factory farms around the world today, approximately 10 billion of which are raised annually in the US alone.[51] These intensively farmed animals, who are kept in extreme confinement facilities, are fed high-energy diets of corn, soy, and pharmaceuticals to maximize weight gain. Factory farmed animal feed is not only inhumane for the animals, contributing to unnatural growth rates that strain their joints, hearts, and bones, but it relies on a complex global web of large agribusinesses producing and transporting billions of pounds of corn and soy all over the world, all just to churn out meat as quickly as possible.

The World's Soy: is it used for Food, Fuel, or Animal Feed?

Shown is the allocation of global soy production to its end use by weight. This is based on data from 2017-2019

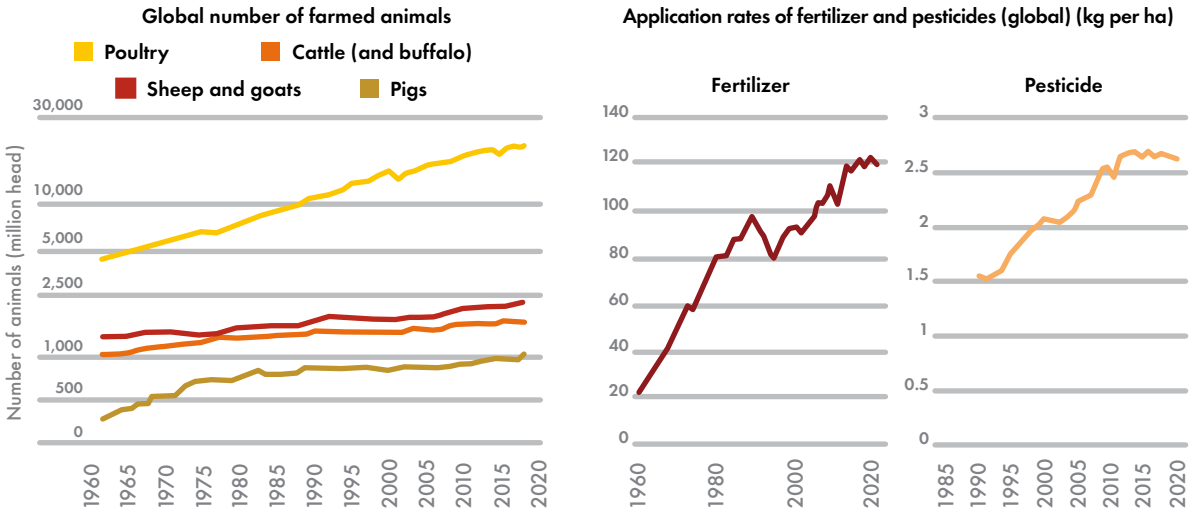


Data source: Food Climate Resource Network (FCRN), University of Oxford; and USDA PSD Database.
OurWorldinData.org - Research and data to make progress against the worlds largest problems.

Globally, industrial monoculture corn and soy plantations have taken over entire landscapes, propped up by the massive demand for feed for factory farmed animals. But these intensive grain and oilseed production facilities would not exist without the billions of pounds of hazardous chemical pesticides that are applied each year to their seeds and cropland.

Herbicides such as paraquat, glyphosate, and atrazine, and insecticides such as chlorpyrifos and bifenthrin are being manufactured by companies in the EU, China, and the US and sprayed in massive quantities throughout the US, Latin America, and Asia on these two crops.

As a result, the global pesticide market continues to grow in tandem with the industrial factory farming industry, despite the known consequences to human health and wildlife from their use.



Source: Food and Agriculture Organization of the United Nations (2018), FASTAT, www.fao.org/faostat/en/#data/OA

Hazardous Pesticides are Big Business

The global pesticide market was valued at $65.3 and $68.6 billion in 2018 and 2019, respectively, and estimated to grow to $87.5 billion by 2024.[52] Roughly 55% of the 4.5 million tons of pesticides applied globally each year are applied in agriculture[53] – a significant amount of which are used to grow soy and corn for use by factory farms.

North America is the third largest revenue-generating market for agrochemicals, led by the US.[54]

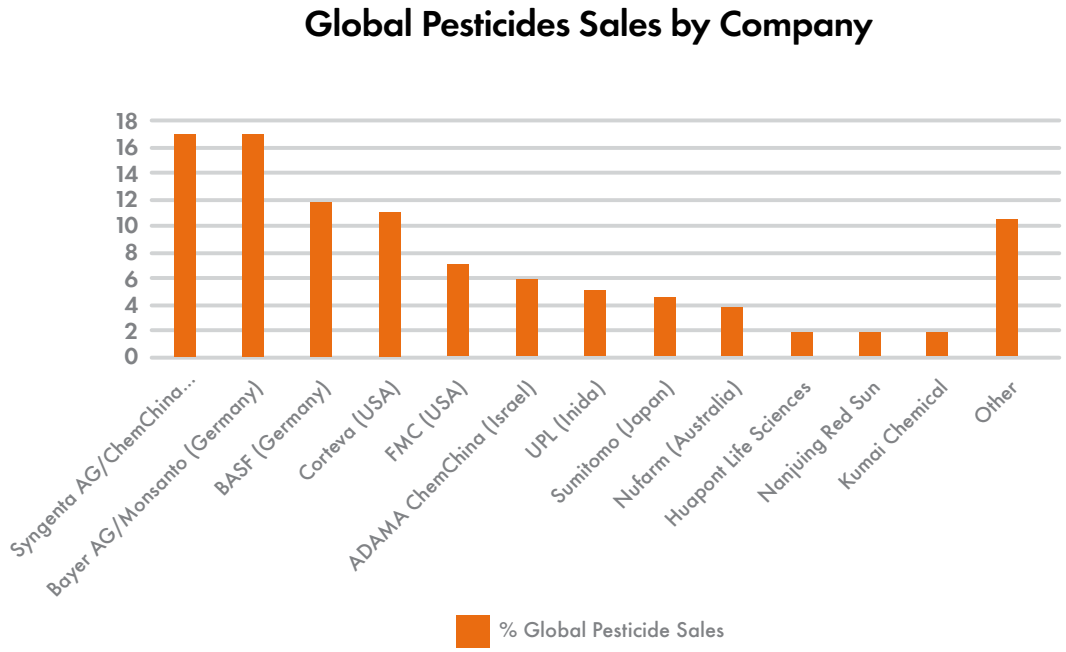
In the US, sales of herbicides and seed treatments have increased year over year since 2012, and continued growth is projected through 2024.[55]

North American Volumes of Synthetic Pesticides, by Type, Through 2024
(Kilotons)

Type	2018	2019	2024	CAGR % 2019 - 2024
Herbicides	134	136	148	1.7
Insecticides	59	60	69	2.8
Fungicides	40	43	50	3.1
Others	70	69	71	0.6
Totals	303	308	338	1.9

Source: BCC Research

The global pesticide market is controlled by the EU–primarily France and Germany–China, and the US, which together account for 83% of pesticide sales as of 2018.[56] The largest companies by pesticide sales are:



More than 1/3 of the pesticides sold by the top 5 companies–Syngenta, Bayer, BASF, Corteva, and FMC – were substances that are classified as "highly hazardous" to human health, wildlife, or ecosystems.[57] Just four chemicals – glyphosate, atrazine, paraquat, and thiamethoxam – account for the largest portion of these sales, all of which are used heavily in US corn and soy production and several of which have been increasing in recent years. In fact, corn and soy alone use 49% of the highly hazardous pesticide sales, globally.[58]

Outside of the US, developing and emerging countries are the primary markets for these chemicals, and the companies "take advantage of the weakness of regulations in those countries to continue selling their products" regardless consequences for local populations and the environment.[59] This is often also despite that many of these pesticides are banned in the countries in which many of the top agribusiness companies are headquartered.[60]

However, due to the pesticide industry's strong influence over pesticide regulators and policymakers in the US, the EPA allows the use of 85 pesticides that have been banned or are being phased out in the EU, China or Brazil.[61] In 2016, the US used 322 million pounds of pesticides that are banned in the EU, accounting for more than one-quarter of all agricultural pesticide use in the US. US applicators also used 40 million pounds of pesticides that are banned or being phased out in China and 26 million pounds of pesticides that are banned or being phased out in Brazil.

Pesticides Pose a Threat to Humans, Wildlife, and Ecosystems

Use of pesticides often results in reduction of non-target, beneficial insects, and "changes in biodiversity and the natural biological balance. It is estimated that less than 0.1% of applied pesticide reaches the targeted pests directly."[62] Pesticide use also causes surface and groundwater contamination, affecting the human populations dependent on these water sources as well as toxicity to farmers and farmworkers.[63] "Continual use of pesticides reduces the general biodiversity of the soil, whereas a reduction in the use of pesticides results in increased soil quality, fertility and water retention capacity."[64] A review of nearly 400 studies showed that pesticides harmed beneficial, soil-dwelling invertebrates, including earthworms, ants, beetles, and ground-nesting bees, in 71% of cases reviewed.[65]

There is no taxa that is spared from the effects of pesticide use. "Around 5 million to 10 million non-target species in the environment are affected by toxic effects from the repetitive use of pesticides."[66] Birds are especially hard hit. "The U.S. Fish and Wildlife Service estimates that approximately 72 million birds are killed every year due to the use of pesticides in the U.S." [67]

Global Volumes of Synthetic Insecticides, by Type, Through 2024
(Kilotons)

Type	2018	2019	2024	CAGR % 2019 - 2024
Organophosphates	150	157	190	3.9
Pyrethroids	102	104	118	2.5
Neonicotinoids	67	70	87	4.4
Methyl carbamate	68	70	83	3.5
Others	190	201	268	5.9
Totals	577	602	746	4.4

Source: BCC Research

Global Market for Synthetic Insecticides, by Type, Through 2024
($ Millions)

Type	2018	2019	2024	CAGR % 2019 - 2024
Organophosphates	3,764	3,928	4,821	4.2
Pyrethroids	2,482	2,553	2,945	2.9
Methyl carbamate	1,407	1,460	1,759	3.8
Neonicotinoids	1,180	1,236	1,562	4.8
Others	3,623	3,851	5,226	6.3
Totals	12,456	13,028	1,613	4.6

Source: BCC Research

The expected growth and expansion of factory farming worldwide will only exacerbate the problem by demanding more pesticide-intensive feed crop production that further threatens wild animals and humans, particularly children, farmworkers and their families.

These harms should not be tolerated. By exposing the impacts of agrochemicals in global soy and corn production for animal feed, World Animal Protection and Center for Biological Diversity aim to highlight the unsustainability of the factory farming model due to its reliance on resource-intensive and polluting chemical inputs.

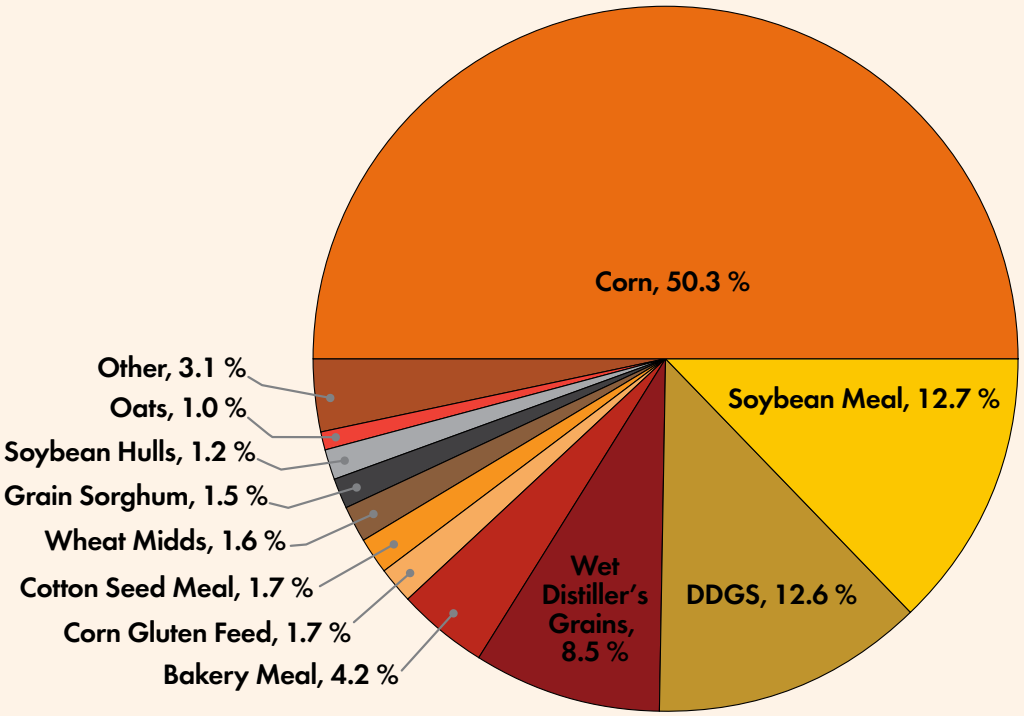
Factory Farming and our Pesticide Footprint

In 2018, the most recent year with full data available, an estimated **235,976,274** pounds of herbicides and insecticides were applied to corn and soybeans grown for farmed animal feed in the US (see Appendices A and B for full methodologies and calculations).

This is directly linked to reliance by the factory farming industry on enormous volumes of corn and soy feed inputs for high-energy, high-growth diet formulations instead of the animals natural growth and diets. The expansion of factory farming in the US has not only increased use of corn and soy due to the larger number of animals being raised, but also because the industry has actively shifted farmed animal diets to consist almost exclusively of corn, soybeans, and their byproducts.

Between 1984 – 2016, while production of corn and soybeans doubled, production of other traditional animal feed inputs including sorghum, barley, wheat, oats, and alfalfa simultaneously decreased.[68] This illustrates a clear and intentional shift in farmed animal diets toward greater proportions and overall predominance of corn and soy.

Estimated 2016 US Total Diet Composition for All Species



Source: Decision Innovation Solutions (2017). 2016 U.S. Animal Food Consumption Report. Prepared for Institute for Feed Education and Research, December 2017.

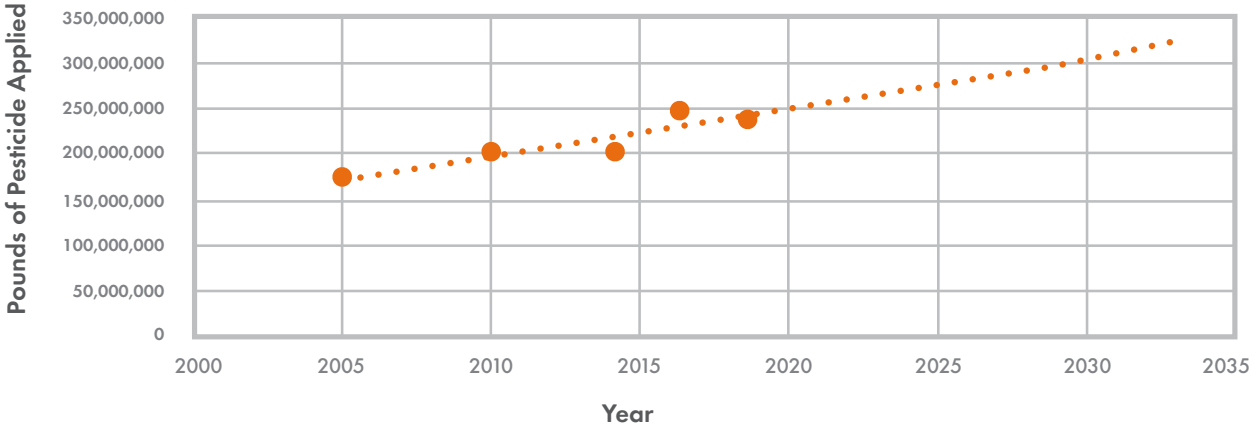
Roughly 50% of highly hazardous pesticide use, globally, is on corn and soy alone.[69] This report explores six individual chemicals and one class of chemicals (neonicotinoids) that are used heavily in US corn and soy production, focusing on their connections to factory farmed animal feed production and their known impacts to human health, wildlife, and the environment. This analysis is not comprehensive. There are dozens of pesticides that can be used on corn and soy, but these seven examples provide a valuable snapshot of the types of pesticides used, and a sampling of their effects.

Endangered species like the highly imperiled whooping crane, monarch butterflies, all species of salmon, the rusty-patched bumble bee, the San Joaquin kit fox, and the northern long-eared bat all face significant threats from industrial agricultural operations.

Our country's appetite for meat and dairy is driving this toxic burden and perpetuating the imperilment of thousands of species. And it's only projected to get worse.

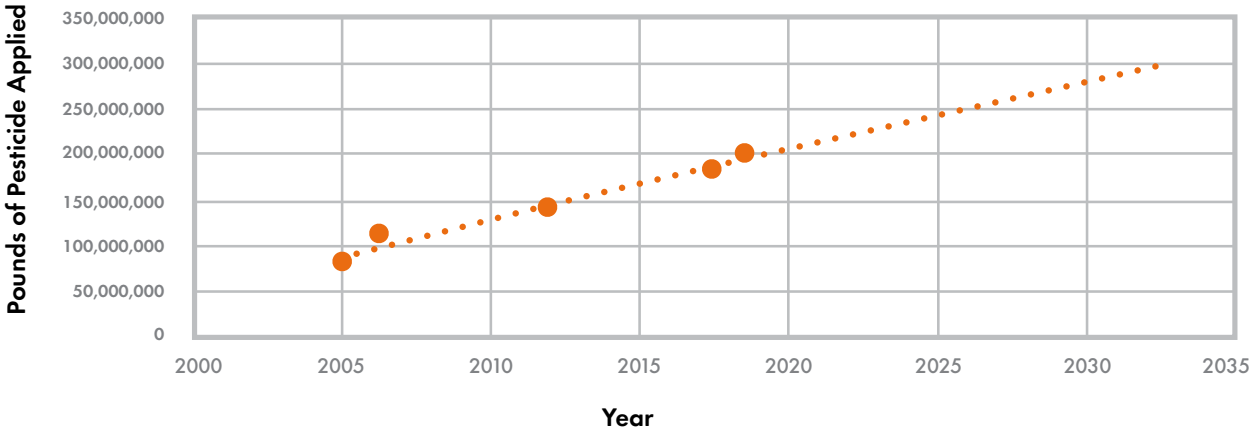
In the past fifteen years, use of pesticides on corn and soy has increased 5% and 7% each year, respectively. This increase has significant implication for future years given how much pesticide is already used on just corn and soy and how much meat production in the US is expected to grow as well. Further, the industry continues to claim without proof that newer chemicals are better and safer, and will replace older, more harmful compounds, yet we continue to see increases in both old and new agricultural chemicals. Some newer chemicals, such as dicamba, may actually be more harmful as well.

Corn



Source: The Pesticide Use Data System, https://hygeia-analytics.com/pesticides/usage/puds-the-pesticide-use-data-system/.

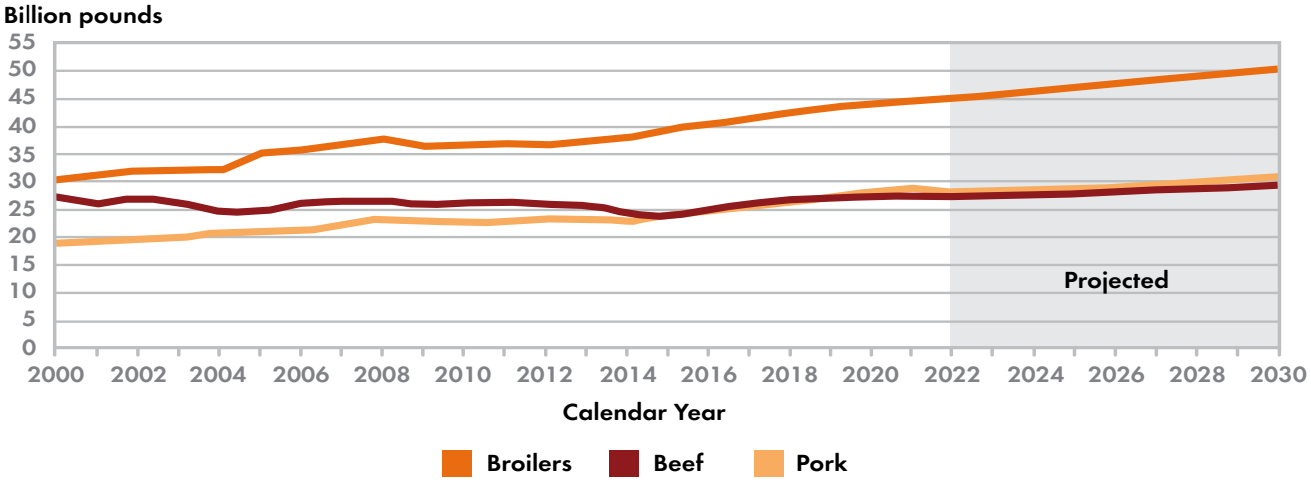
Soy



Source: The Pesticide Use Data System, https://hygeia-analytics.com/pesticides/usage/puds-the-pesticide-use-data-system/.

Over this same period, meat (beef, pork, and chicken) production increased approximately 2% each year, 2005-2020, with continued increases projected through 2023, especially for chicken production.

US Animal Product Production, 2000 - 2030



Source: USDA Office of the Chief Economist, February 2021, https://www.usda.gov/sites/default/files/documents/USDA-Agricultural-Projections-to-2030.pdf

Meat production in the US is expected to continue to increase. Thus, we can expect to see use of these hazardous chemicals increase correspondingly as well. To prevent this increase in our chemical footprint and harms to thousands of already imperiled species we necessarily must reduce the amount of meat and dairy we are producing and consuming.

As we work toward a more humane and sustainable food system, increasing consumption of plant-based foods and stopping the growth of factory farming systems will help to reduce the industry's reliance on hazardous chemicals, helping to protect people, animals, and the planet.

Herbicides

Glyphosate

In 2018, a total of 171.5 million pounds of glyphosate were applied to corn and soy in the US, roughly 100,856,205 pounds of which are attributable to farmed animal feed production.[70]

Overall, roughly 0.879 pounds of glyphosate were applied per acre of corn harvested, and 1.122 pounds per acre of soy harvested.[71,72]

Glyphosate is one of the most widely used herbicides worldwide, primarily on corn, soybeans, hay, and pastures, all of which relate directly to the feeding of livestock.[73] While use in corn and soy in the US has decreased slightly in recent years – due to a shift to other, more toxic chemical cocktails following the emergence of glyphosate-resistant super weeds that can withstand what used to be a normally deadly dose of the chemical – glyphosate remains one of the most used pesticides on the two crops in terms of pounds applied each year. This is tied to the deregulation and marketing of genetically-engineered "RoundUp Ready" corn and soy, genetically designed to withstand applications of the chemical that would otherwise be fatal.

Globally, the market for glyphosate is projected to grow significantly, and reach a value of $9.9 billion by 2022[74] and $13.3 billion by 2027.[75] This is perhaps unsurprising as the global demand for meat and other animal products is expected to continue to increase.[76]

Glyphosate has a half-life of 47 days, meaning that the residues degrade by half roughly every 47 days or 1.5 months, allowing it to persist in the environment for months after it is applied.[77]

Case Study 1: Species Imperiled by the 100 million pounds of glyphosate propping up factory farming

Our appetite for meat has contributed to high volumes of glyphosate applied to fields of corn and soybeans raised for animal feed in the US to keep the factory farming model in place. Glyphosate use is increasing threats to already threatened and engangered species, such as those outlined below.

Monarch butterfly[78]

The monarch butterfly is one of the most recognizable butterflies in North America.[79] Their orange wings are laced with black lines that are bordered with white dots.[80] The wingspan of the adult butterfly can reach nearly five inches and their epic migrations fuel our imaginations.

Monarch butterflies are now heading towards extinction, and largely as a result of glyphosate use. Because glyphosate is used in such massive quantifies throughout the US, it has killed many of the plants monarchs need to survive. In particular, glyphosate is a potent killer of milkweed, the sole host plant for monarch caterpillars.

In the winter of 2020-2021, only 1,914 monarchs were recorded overwintering on the California coast – the lowest number ever recorded, down from 30,000 the year before and 1.2 million just two decades ago. During that season, there were more Starbucks' in California than monarch butterflies. This years' returns are already better, indicating that all the emergency efforts of planting milkweed are helping. But the population is still perilously close to collapse.[81]

Similarly, the eastern population of monarch butterflies, who every year embark on an epic 3,000-mile migration from Canada and the northern United States to overwinter in the central mountains of Mexico, declined by 80% over the last two decades.[82] The US Fish and Wildlife Service estimates there to be an 80% chance the eastern population will collapse within 50 years.[83]

Hine's emerald dragonfly[84]

The Hine's Emerald Dragonfly is recognizable for their vibrant emerald-green eyes and metallic green body.[85] They depend on stream and wetland environments, requiring good water quality for growth and development[86], and are significantly threatened by glyphosate and other pesticide uses that can kill them outright or destroy their habitat. Found, primarily in the Great Lakes region and into the Midwest, the Hine's Emerald is on the brink of extinction today.[87]

Black-footed ferret[88]

Black-footed ferrets are North America's only native ferret species.[89] They are slender, with wiry fur, black feet, a black coloring around their eyes, and a black-tipped tail.[90] They are very playful. During play, they arch their backs and hop backward with their mouths wide open, a display affectionately known as the "ferret dance."[91] They are very vocal, using a variety of calls and sounds to communicate.[92] Once thought extinct, conservation and repopulation initiatives have increased their numbers, but they remain critically endangered; the EPA has found that they are harmed by glyphosate and other pesticides.

Utah prairie dog[93]

Prairie dogs live only in North America.[94] In the squirrel family, the Utah prairie dog is recognized for their dark eyebrow-like markings above their eyes and white-tipped tail. Their diet consists primarily of flowers, seeds, grasses, leaves, and insects.[95] Prairie dogs are among the most social of animals, living together in large groups called colonies or towns and make their homes in intricate networks of burrows. Lookouts take turns in a constant watch for predators, issuing sharp barks to warn the colony of danger.[96] Utah prairie dog's are a keystone species, meaning a species on which many others in the ecosystem depend such that, if removed, the ecosystem would be drastically altered.[97]

Ozark hellbender[98]

Although the name sounds scary, the Ozark hellbender is a shy amphibian who poses no harms to people.[99] They are aquatic salamanders with flattened bodies that can reach lengths of nearly two feet. They can live up to 30 years. Hellbenders have very specific habitat requirements, making them extremely vulnerable to disturbances and changes in water quality.[100] Glyphosate is known to reduce biodiversity in aquatic communities and has been shown to have significant negative impacts on amphibians.

Applications of glyphosate have also been shown to reduce species abundance in aquatic communities, reducing overall biodiversity by 22%, with negative effects most pronounced for amphibian reproduction.[101] According to a 2020 biological evaluation of glyphosate prepared by the EPA, the pesticide is likely to harm, injure or kill 93% of the plants and animals protected under the Endangered Species Act, or 1,676 species.[102] Additionally, EPA also found that glyphosate adversely modifies critical habitat for 759 endangered species.[103]

Beyond harm to wildlife, the most commonly recognized negative impacts of glyphosate use relate to the effect of exposure on human health. More than 13,000 lawsuits have been filed in the US alleging that the pesticide causes non-Hodgkin's lymphoma.[104] The World Health Organization's International Agency for Research on Cancer has said that glyphosate is "probably carcinogenic to humans."[105] Scientific studies show a strong correlation between glyphosate and serious health hazards including disruption of the hormonal system and beneficial gut bacteria, damage to DNA, developmental and reproductive toxicity, birth defects, other cancers, and neurotoxicity.[106]

"Glyphosate is likely to harm, injure or kill 93% of the plants and animals protected under the Endangered Species Act."

Atrazine

In 2018, 60.8 million pounds[107] of atrazine, a potent endocrine disruptor, were used on corn and soybeans in the US, representing a 17% increase from 2012 levels. Of this, approximately 24,819,444 pounds were used for the purpose of producing feed for farmed animals.[108]

Overall, atrazine was applied at a rate of 0.738 pounds per acre of corn harvested[109] and 0.0057 pounds per acre of soy harvested.[110,111]

Atrazine is one of the most widely used, and toxic, agricultural pesticides in the US – primarily used on corn, sorghum, and sugarcane. The vast majority applied in the US, some 87%, is applied solely to corn and an estimated 60-70% of all corn is treated with atrazine.[112]

Even as one of the most widely used pesticides, use in the US increased 17% in just six years from 2012 to 2018.[113] While data beyond 2018 is limited, available data shows that use of atrazine on soy increased drastically from 2018 to 2020, more than doubling from 490,000 pounds to over 1 million pounds in just two years.[114] This is likely a result of glyphosate-tolerant superweed proliferation.

The global atrazine market is expected to grow by 6% from 2019 to 2024 and to reach a value of $2.58 billion, with much of the growth projected for the Asia-Pacific region. Farmers in China and India, especially, are increasingly focusing on cultivating grains, including for animal feed, on a commercial scale.[115]

Despite its popularity in the US and the Asian-Pacific region, atrazine has been banned in 35 countries.[116] It was banned in the EU due to persistent groundwater contamination.[117] It is relatively mobile, regularly entering water bodies via runoff and rainfall, and has been detected in rain or air in Europe and the US more than any other currently used pesticide.[118] According to United States Geological Survey (USGS) assessments, atrazine has been detected in streams at levels of 200 micrograms per Liter (µg/L) and repeatedly detected at above 100 µg/L.[119] In waters adjacent to treated fields atrazine was found in concentration as high as 1000 µg/L.[120]

Case Study 2: Species imperiled by the 25 million pounds of atrazine propping up factory farming

Our appetite for meat is fueling growth in the use of atrazine on corn and soybeans in the US to keep the factory farming model in place, escalating threats to already threatened and endangered species. The below species are just a small set of the many endangered species who the EPA has identified as likely harmed by atrazine, a known endocrine disrupter with high toxicity.

Northern long-eared bat[121]

As the name suggests, the northern long-eared bat is known for their characteristic long ears even compared to other bats.[122] Their body length is just over 3 inches, with a wingspan of less 10 inches. They hibernate in caves during the winter, and in the summer roost underneath the bark of trees.[123] Their lifespan is estimated to be 18 years, though a disease known as "White-nose Syndrome" is a major cause of their population decline.[124] Agricultural applications of atrazine and other chemicals is unnecessarily compounding threats to this species.

"To prevent this increase in our chemical footprint and harms to thousands of already imperiled species we necessarily must reduce the amount of meat and dairy we are producing and consuming."

San Joaquin kit fox[125]

Despite their oversized ears, the San Joaquin kit fox is the smallest member of the dog family in North America.[126] The average adult male stands 12 inches high at the shoulder and weighs about 5 pounds.[127] Their large ears help them dissipate body heat in their hot, dry environment, as well as target tiny noises in the night when they hunt for prey.[128] They were once widely distributed throughout grassland of the San Joaquin Valley, but agricultural and other human development has led to substantial losses in habitat and range.[129] They are significantly threatened by pesticides in intensive agriculture, which can bioaccumulate in the kit foxes when they eat contaminated prey.[130]

Columbia Basin pygmy rabbit[131]

Pygmy rabbits are typically found in areas that include tall, dense sagebrush, which they rely on for food and shelter.[132] They are the smallest members of the family that includes rabbits and hares, with adults averaging about 10 inches in length and weighing less than a pound.[133] Large-scale loss and fragmentation of their native habitats to cropland is a leading cause of their population declines.[134],[135]

Photo Credit: R. Dixon and H. Ulmschneider

Streaked horned lark[136]

The streaked horned lark is endemic to the Pacific Northwest region. Horned larks are small, ground-dwelling birds roughly only 6-8 inches in length. Their yellow coloration distinguishes them from similar subspecies.[137] They are found in wide open spaces with no trees and few shrubs, preferring to build their ground nests in dense grassy areas and prairies, or even sandy beaches along rivers. The most significant threat is conversion of their range to agriculture and industry.[138]

Whooping crane[139]

The whooping crane is an iconic bird of North America, hence their Latin name being Grus americana. They are the tallest bird in North America, with snowy white plumage, red coloring on their heads, and black wing tips. They can be as tall as 5 feet with wingspans longer than 7 feet.[140] They get their name from their loud, rattling calls.[141] They migrate more than 2,400 miles a year from breeding areas in northern Canada to the southeastern US.[142] Their wetland habitats are vulnerable to agricultural contamination of waterways from atrazine and other chemicals.

California tiger salamander[143]

With their wide mouths lined in yellow, California tiger salamanders always look like they're smiling.[144] The yellow "grin" matches the bright yellow spotting along their bodies that stand out against the black background of the rest of their bodies. They thrive in specific habitats like grasslands and oak woodlands, that are imperiled by agricultural expansion and pollution. They primarily live underground using burrows created by other animals.[145]

Oregon spotted frog[146]

The Oregon spotted frog has disappeared from over 90% of their former range.[147] They are named for the black spots covering their head, back, sides, and legs, which become larger and darker as they age.[148] The red coloration of their abdomen also increases with age, as well as distinguishing them from other native frogs.[149] They range from California into British Columbia, Canada, and were the first species every to be emergency-listed as endangered in Canada.[150] Atrazine is a potent endocrine disrupter frequently found contaminating aquatic environments, posing significant threat to the spotted frog and other amphibians.[151]

Valley elderberry longhorn beetle[152]

Listed as threatened, the valley elderberry longhorn beetle is "likely to become endangered in the foreseeable future."[153] They have long antennae more than 2/3 of their body length, which is typically just 0.5 -1 inches long.[154] Males have vibrant red-orange wing covers with four elongated black spots. They are reliant on their host plants – elderberry – for their entire lifecycle. Agricultural expansion and pollution that threatens native elderberry vegetation puts these important pollinators at risk.

There is substantial evidence that aquatic species are negatively affected by atrazine at levels at or below those detected in waters near to application sites.

Dramatic changes in sexual differentiation of amphibians have been reported from atrazine exposure at concentrations as low as 0.1 µg/L (0.0001 mg/L), while consistent effects have been observed on growth, morphology, and functionality of both fish and amphibians at concentrations of 500 µg/L (0.5 mg/L) or lower.[155] Reproductive effects in birds have been reported for atrazine concentrations of 75 mg per kilogram in the diet, including reduced egg viability, reduced male weight gain, and decreased hatchling weight.[156]

Studies have shown potential risk concern to amphibians due to atrazine exposure when used in accordance with the label and atrazine is considered to have medium-high risk for altering development and growth for amphibians at concentrations that have been detected in surface waters.[157] Further, "in addition to its high use, ubiquitous contamination in aquatic environments, persistence, and mobility, atrazine is a concern because it is a potent endocrine disrupter in wildlife."[158]

There is also evidence that atrazine disrupts the function of aquatic plants, such as reducing the production of chlorophyl in freshwater algae by 50% at concentrations of just 4.5 µg/L, a concentration 20 times lower than that routinely detected in US waters. [159] Negative impacts to aquatic plants, such as algae, can have cascading effects on ecosystems such as marshes, ponds, lakes, and streams, impacting the aquatic species that rely on these plants for food and habitat.[160]

A 2020 assessment by the EPA found that atrazine use is likely to harm over 1,000 protected species – 56% of all endangered plants and animals in the US – including the highly endangered whooping crane, the San Joaquin kit fox, and the California red-legged frog (see breakout box).[161]

Atrazine is a potent endocrine disruptor and is linked to a variety of human health issues, including different types of cancer, Parkinson's disease, and harm to the reproductive system.[162] After just six hours of exposure an increase in cell death and DNA damage were observed.[163] The same level of damage from exposure to Gamma radiation would take a full 15 minutes.[164] Atrazine also alters the levels of dopamine and norepinephrine in the brain and decreases the electrical activity of certain cells in the cerebellum (the region of the brain that controls motor function).[165] As an endocrine disruptor it can interfere with the balance of hormones in the body, significantly impacting overall physiology and development.[166]

Dicamba

In 2018, 17 million pounds of dicamba were used on corn and soybeans in the US, a 1200% increase from 2012 levels; just over 11 million pounds of this use attributable to farmed animal feed production. [167]

Overall, dicamba was applied at a rate of 0.04 pounds per acre of corn harvested[168] and 0.16 pounds per acre of soy harvested. [169,170]

Dicamba is primarily used on corn and soy, as well as rye, asparagus, barley, oats, sugarcane, and wheat.[171] Use of dicamba in corn and soy has skyrocketed since 2012 from 1.3 million pounds applied across both crop types that year to 17 million pounds in 2018.[172] This increase is largely the result of the increase in weeds resistant to glyphosate, the chemical of choice for intensive corn and soy for years prior.[173] Data indicates that since 2018 use of dicamba has continued to increase due to approvals in 2016 of dicamba-tolerant genetically engineered soybeans in the US; these numbers are likely to further increase approval for dicamba-tolerant corn on the horizon as well.[174] As part of the approval process, the company that created dicamba-tolerant soy, Monsanto, estimated that dicamba use would increase to over 20 million pounds per year on soy alone by the time of full market penetration.[175]

The global market for dicamba is expected to reach $626.5 million by 2027, led primarily by expected growth in use in China, the US, Japan, and Canada.[176] Major companies manufacturing dicamba include Nufarm, BASF, DuPont, UPL, and Syngenta. [177]

Dicamba is highly volatile, "increasing the potential for damage to non-target organisms due to spray drift" and negatively affecting plant and arthropod communities in field edges, semi-natural habitats, and other areas.[178] Application levels substantially lower than suggested application rates resulted in observable declines in plant cover at the farm edge, as well as declines in three herbivorous insect species that rely on the vegetation.[179] This has implications for biodiversity within and adjacent to agroecosystems, as declines in plant life due to drift of dicamba and similar pesticides destroys critical food sources, habitat, and protection for many species. Dicamba levels that are too low to kill terrestrial plant life can still negatively impact wild communities as exposed plants "may produce fewer floral resources and be less frequently visited by pollinators," thus disturbing plant and beneficial insect communities.[180]

Many species are imperiled by dicamba. Monarch butterflies, especially, are under threat from increased dicamba use and drift, as their migration seasons can unfortunately correlate with times when dicamba is particularly likely to be sprayed on dicamba-tolerant soy crops. Off-target movement of dicamba has the potential to degrade monarch habitat on a massive scale, destroying what little plant diversity currently exists in the margins between monoculture grain and soy fields.[181] These pockets of biodiversity are essential for sustaining animal populations that rely on the plants for nectar, pollen, and food. Reduction in flowering plants along monarch migration routes could impair adult butterflies' ability to make the migration, survive the winter, and breed.[182]

"Off-target movement of dicamba has the potential to degrade monarch habitats on a massive scale."

Researchers at the National Institutes of Health recently found uses of dicamba by workers to be linked to an increased risk of developing numerous cancers, including liver and intrahepatic bile duct cancers, acute and chronic lymphocytic leukemia, and mantle cell lymphoma.[183] An earlier study by the National Cancer Institute found that exposure to dicamba doubled a farmer's or farmworker's risk of contracting non-Hodgkin's lymphoma as long as two decades after exposure.[184]

2,4-D

In 2018, 14.6 million pounds of 2,4-D were applied to corn and soybeans in the US, a 45% increase from levels used in 2012, nearly 9 of those million pounds are attributable to farmed animal feed production.[185]

Overall, roughly 0.07 pounds were applied per acre of corn harvested[186] and 0.1 pounds per acre of soy harvested.[187],[188]

2,4-D is one of the top five most used herbicides in the US overall[189], with the bulk of use applied to pastureland, wheat, corn, and soy.[190] Famous for being one of the ingredients in Agent Orange – a chemical cocktail used as a defoliant by the US military during the Vietnam war – from 2012 to 2018 there was a massive 45% increase in use of 2,4-D on corn and soy, jumping from 10 million pounds to 14.6 million pounds applied per year.[191] Since then, the government's approval of genetically modified herbicide-tolerant soy and corn is expected to triple the amount of 2,4-D applied to these crops by 2020, with use on corn potentially increasing 30-fold from 2010 levels[192], though data sources utilized for this report only provide application levels through 2018 at this time.

Leading market players include Dow AgroSciences, Bayer AG, Syngenta, and FMC. [193]

2,4-D is an herbicide – its mode of action targets plants considered pests – but studies have shown it can significantly impact beneficial insects from approved applications. Studies on lady beetles (AKA ladybugs) show that exposure to 2,4-D caused shorter larval development, reduced survival rates up to 80%, and decreased male populations when applied at commercial rates.[194] Field-relevant concentrations caused observable reductions in fitness of earthworms[195], which are vital to healthy, productive soils. Exposure to 2,4-D at concentrations far below recommended use rates resulted in 100% mortality for a species of beneficial termite, leading researchers to conclude that beneficial insects may experience high mortality "if they are sprayed upon or come into contact with plant materials that have been freshly sprayed" with the recommended concentrations.[196]

Further, a number of studies have shown that organisms can bioaccumulate – concentrate increasing levels inside their bodies – 2,4-D in a very short period of time. Aquatic species, in particular, can bioaccumulate lethal concentrations in the case of direct agricultural applications.[197] 2,4-D is very mobile in aquatic systems and contamination can disrupt aquatic predator-prey interactions.[198] A recent study documented that 2,4-D is the major frequently detected herbicide in surface waters in Massachusetts.[199] In the 1980s, applications of 2,4-D in Greece resulted in lower survival of tortoises compared to areas not impacted by the chemical, and tortoise populations in sprayed areas declined to near zero in just four years.[200]

In humans, studies suggest 2,4-D is a potential endocrine disruptor and may interfere with thyroid hormones. It has also been linked to immune and neurological system problems, including Parkinson's disease.[201] In 2015, the International Agency for Research on Cancer declared 2,4-D a possible human carcinogen based on evidence that it damages human cells and a number of studies in which it caused cancers in laboratory animals.[202]

Paraquat

In 2018, 4.2 million pounds of paraquat were applied to corn and soybeans in the US[203], roughly 2.9 million pounds of which is attributable to farmed animal feed production.[204]

Overall, paraquat was applied at a rate of 0.009 pounds per acre of corn harvested[205] and 0.04 pounds per acre of soy harvested in 2018.[206],[207]

Paraquat is widely used in many parts of the world, despite the fact that it is exceedingly toxic to humans.[208] Its use is increasing in the US for corn and soy. In 2012, 1.2 million pounds of paraquat were applied to corn and soy in the US compared to 4.2 million pounds in 2018, a 250% increase.[209] Leading global manufacturers of paraquat are Titan AG and Syngenta. [210] It was banned in the European Union in 2007[211] and as of 2020 is banned in 53 total countries, including recent bans in China, Cambodia, Laos, and Vietnam.[212]

Paraquat can negatively impact insects, birds, and fish. Deer mice living near farms that applied paraquat had residues of the chemical in their tissues and signs of liver damage.[213] Paraquat is one of "the most embryotoxic contaminants for bird eggs" and negative impacts to eggs or nestlings from approved application rates have been reported in Japanese quail, mallards, bobwhite quail, and ring-necked pheasant.[214] Paraquat caused 23% mortality for mallard eggs at just half of the field-level application rate.[215] There is also general agreement on the embryotoxic effects of paraquat on amphibians[216], and evidence that sub-lethal concentrations can lead to reduced reproductive success in fish.[217]

Paraquat is classified as highly hazardous for human health by Lancet Planet Health.[218] The EU banned the chemical because even when workers wear personal protective equipment their safety cannot be guaranteed. Chronic exposure can adversely impact the respiratory system, including by reducing lung function, and workers exposed over a long period were found to be at increased risk for Parkinson's disease. In epidemiological studies, paraquat has been associated with increased incidence of leukemia, lymphoma, skin cancer, and brain cancer.[219] Paraquat was associated with long-term respiratory defects among fruit growers in South Africa.[220] It is listed as a potential endocrine disruptor, meaning it is likely to block the effects of hormones in the body, adversely impacting developmental and reproductive health.[221]

In 2021, a class action lawsuit was filed against Syngenta, a major manufacturer of paraquat, alleging that exposure to the chemical led to them developing Parkinson's disease.[222]

Paraquat's efficacy as a poison has contributed to numerous accidental and intentional poisoning incidents.[223]

The significant health concerns from paraquat have led medical experts to call for a global ban or significant restrictions on its availability and use. In the US, paraquat caused the majority of all herbicide-related deaths from 1998-2001.[224]

Insecticides

Neonicotinoids - Clothianidin/Thiamethoxam/Imidacloprid

Neonicotinoids are the most popular class of insecticides in the world. Despite abundant data showing that they play an outsized role in driving pollinator declines, they are still used widely in sensitive habitats. Neonicotinoids are sprayed, injected, and used as seed coatings. One of their main uses in the US is as a prophylactic seed coating, meaning these ultra-toxic insecticides are used to make every part of a plant deadly toxic to insects like bees, just in case of a bug

problem. Due to a widely exploited loophole known as the treated article exemption, the total quantity of neonicotinoids used for seed coatings remains unknown. However, neonicotinoid treated seeds are believed to be used on hundreds of millions of acres in the US, including on nearly all non-organic corn and the majority of soy. Thus, comprehensive data providing precise application rates for neonicotinoid insecticides are not readily available, particularly data providing volumes of use as seed coatings for corn and soybean seeds, the predominant use of neonicotinoids in the US. However, with these seeds used on such vast acreage, the effects to wildlife are extreme.

There are several neonicotinoid insecticides used in US agriculture, the top three being clothianidin, thiamethoxam and imidacloprid. For the purposes of this report and due to limited data, these three compounds are combined and used as a proxy for neonics generally.

Based on available data, at least **2.6 million pounds of just these three neonics are used on corn and soy in the US each year, roughly 1,480,781.25 pounds of which were attributable to farmed animal feed** (see Appendix B for calculation methodology).

Case Study 3: Species Imperiled by the 1.5 million pounds of neonics propping up factory farming

Neonics pose significant risks to thousands of already threatened or endangered species, particularly already imperiled pollinators such as birds, bees, bats, and butterflies. The following are just a few examples of species that the EPA found to be at risk from use of neonics.

Ozark big-eared bat[225]

The Ozark big-eared bat is found only in a small number of caves in the southern central US. Also known as the lump-nosed bat, they have two distinctive facial glands on either side of their face resembling mittens in addition to the more notable over-sized ears.[226] They feed on moths and other insects along forest edges, which are imperiled by systemic use of neonics.

New Mexico meadow jumping mouse[227]

The New Mexico meadow jumping mouse is endemic to the southwestern US. They rely on dry soils for nesting but mostly use dense, vegetative stream sides for their habitat. They are notable for their elongated feet and extremely long, bi-colored tails. They hibernate during winters, and during the growing season are active among the grasses and forbs to eat the seeds that make up their main source of food.[228] They consume a wide variety of grass seeds, in addition to flowers and some small fruits.

Whooping crane[229]

The Whooping Crane is an iconic bird of North America, hence their Latin name being Grus americana. They are the tallest bird in North America, with snowy white plumage, red coloring on their heads, and black wing tips. They can be as tall as 5 feet with wingspans longer than 7 feet.[230] They get their name from their loud, rattling calls.[231] They migrate more than 2,400 miles a year from breeding areas in northern Canada to the southeastern US.[232] Their wetland habitats are vulnerable to agricultural contamination of waterways from neonics and other chemicals, such as atrazine noted earlier in this report. It is common practice to apply several pesticides to the same crops or cropland, compounding the threats to vulnerable species from intensive animal feed production.

Red-cockaded woodpecker[233]

Sometimes called the "Yankee Doodle Bird," the Red-cockaded woodpecker gets their name from the small red streak on each side of the male bird's head. They make their homes in mature, open pine forests in trees averaging 60 – 100 years old, and are the only species of woodpecker who exclusively makes their homes in pine trees. They have complex social systems, living in groups with a mated pair, their current year's offspring, and helpers that are usually adult offspring from previous seasons. They are not far-ranging birds and if suitable habitat is not close by the newest generation of birds is unlikely to succeed.[234]

Rusty patched bumble bee[235]

Rusty-patched bumble bee are so named for the rusty reddish patch centrally located on their backs. They once occupied grasslands and prairies throughout the upper Midwest and northeastern US, but most of this native habitat has been degraded or fragmented due to agricultural conversion and urbanization. Their range once included 28 states and 2 Canadian provinces, but since 2000 they have been reported only in 13 states and 1 province, and their populations have precipitously declined. Use of pesticides, and neonicotinoids specifically, and loss of floral resources due to intensive monocultures are recognized as significant causes of their declines.[236] They absorb neonicotinoids directly through their exoskeleton as well as through contaminated nectar and pollen. As ground-nesting bees, rusty-patched bumble bees are particularly susceptible to pesticides like neonicotinoids that are highly persistent in the soil. [237]

Poweshiek skipperling[238]

The Poweshiek skipperling is a small orange and brown butterfly native to several states in the Midwest. Once abundant in tallgrass prairies, they have a faced a population collapse in the last two decades.[239] They are important pollinators and "a valuable indicator of prairie ecosystem health."[240] They are unable to survive outside of tallgrass prairie as the caterpillars eat only grasses and adults feed on the nectar of yellow flowers.[241] Neonicotinoids are recognized as significant factor in their decline.

California tiger salamander[242]

With their wide mouths lined in yellow, California tiger salamanders always look like they're smiling.[243] The yellow "grin" matches the bright yellow spotting along their bodies that stand out against the black background of the rest of their bodies. They thrive in specific habitats like grasslands and oak woodlands, that are imperiled by agricultural expansion and pollution. They primarily live underground using burrows created by other animals.[244] As with whooping cranes, these salamanders serve as an example of how species may be vulnerable to multiple pesticides commonly sprayed on the same lands to prop up intensive animal feed production.

Chiricahua leopard frog[245]

When a Chiricahua leopard frog wants attention, they snore. Or rather, their distinctive call sounds like snoring. Once found in more than 400 sites in the Southwestern US, they are now found at fewer than 80, declining more than any other leopard frog in Arizona.[246] The EPA found that all endangered amphibian species, including the Chiricahua leopard frog, are imperiled by neonics.

Unarmored threespine stickleback[247]

Only two inches long as adults, the Unarmored threespine stickleback are nevertheless fierce defenders of their nets, dashing forward with mouth agape and "hackles" raised.[248] A freshwater fish, they inhabit streams and rivers, preferably shaded by dense and abundant vegetation.[249]

Neonics are highly water soluble, systemic, persistent, and broadly toxic to a wide range of terrestrial and aquatic invertebrates.[250] Despite their increasing use in the US, "neonic seed treatments are, for the most part, untracked and ignored." [251]

A recent assessment by the EPA found that these three insecticides likely harm all of the US's 38 protected amphibian species and three-fourths of all other endangered plants and animals.[252] Overall:

- 1,445 different endangered plants and animals – nearly 80% of all endangered species –are likely to be adversely affected by imidacloprid.[253]
- 1,396 different endangered plants and animals – 77% of all endangered species –are likely to be adversely affected by thiamethoxam. [254]
- 1,225 different endangered plants and animals – about 67% of all endangered species –are likely to be adversely affected by clothianidin. [255]

Neonics pose significant risks to bees and birds. One study showed that exposure of bumble bees to imidacloprid at rates as low as 1 µg/L reduced brood production by one-third.[256] The vast majority of native bees in the US are solitary and ground-nesting, which has serious implications for their level of exposure to neonicotinoids.[257] Neonics are long-lasting and may contaminate soils in and around fields for years after application. Farmland in the US has seen a 121-fold increase in the overall environmental load of chemicals toxic to bees, "largely because of neonicotinoid treated corn and soybean seeds."[258] Twenty-four percent of native bees in Colorado were found to have detectable levels of clothianidin in their tissues, with an average concentration of 50 nanograms/gram (ng/g).[259]

Beyond bees, populations of common farmland butterflies have declined in conjunction with increasing neonic usage in California.[260] In field studies, clothianidin reduced the survival and biomass of earthworms by 32% and 39%, respectively.[261] Neonics have been documented via field studies to reduce populations of beetles, who often serve a beneficial role in soil ecosystems.[262]

Neonics have been linked to declines in bird populations through effects on food chains with reviews documenting a loss of bird populations of 30% in North America – 75% losses for grassland bird species, specifically – with neonics noted as a contributing factor.[263]

There is also mounting evidence that neonics are harmful to bats. For example, researchers demonstrated that chronic exposure to imidacloprid may significantly impair the spatial memory and flight patterns of Formosan bats.[264]

Plants can take up neonics via their roots and transfer the chemical to insects living on the plants, and higher mortality has been demonstrated for ladybeetles and butterfly larva raised on infected plants compared to uninfected plants.[265,266] Small and medium sized birds are all also risk via consuming contaminated insects, identified as a potential acute risk for all crop exposure scenarios.[267]

When used as a seed treatment, in particular, neonics harm seed-eating birds. A single corn kernel treated with any of the commonly used neonicotinoids can kill a songbird, and 1/10 of a treated corn kernel is enough to reduce reproduction in a songbird.[268] A scan of 71 fields sown with treated seeds found a high percentage, 35%, of seeds were uncovered by soil and present at the surface and thus available to non-target birds.[269]

Neonic contamination of water in the US has been well documented, with water quality monitoring surveys finding clothianidin in 24% of sampled streams across the country[270] and 85% of wetlands in Nebraska.[271]

Neonics are largely banned in the EU due to their environmental effects but the EPA has resisted taking meaningful action to restrict their use in the US.

Bifenthrin

In 2018, more than 700,000 pounds of bifenthrin was used on corn and soybeans in the US, a 130% increase from 2012 levels.[272] Approximately 370,000 pounds of this usage was attributable to farmed animal feed. [273]

The greatest use of bifenthrin, globally, is on corn, and the Asia-Pacific region is the fastest-growing bifenthrin market due to increasing demand from emerging economies such as India and China. [274]

Use of bifenthrin in corn and soy in the US has more than doubled in the past several years from 300,000 pounds to just over 700,00 pounds applied in 2012 compared to 2018, with the bulk of the increase occurring in corn.[275]

Bifenthrin is a pyrethroid. It is a neurotoxin that affects the peripheral and central nervous system of insects.[276] "Bifenthrin affects the electrical impulses generated by the nerves, which overstimulates the nerve cells, resulting in tremors and eventually paralysis. The chemical is absorbed by the skin. It is quickly broken down and excreted."[277] It is moderately toxic for various birds and toxic to honeybees and highly toxic to aquatic organisms such as crustaceans and fish.[278]

Bifenthrin can be harmful at low levels as it can last a long time in the environment and may bioaccumulate in fish, posing risks to animals that rely on fish in their diet.[279] Sublethal concentrations of bifenthrin caused observable behavioral effects in fish species, particularly hyperactivity.[280] In zebra fish, exposure of embryos to bifenthrin accelerated the hatching process and caused morphological impairments. [281]

Female honeybees exposed to bifenthrin produced fewer eggs and the next generation had observable developmental impairments including higher egg weight, lower success rate of egg development, and delayed hatch time. [282]

Chlorpyrifos

It took over two decades of advocacy, led by farmworkers who for decades had experienced some of the worst impacts of chlorpyrifos firsthand, to get this one dangerous pesticide banned from food uses in the United States. Community groups teamed up with Earthjustice in 2007 to petition the EPA to ban agricultural uses of chlorpyrifos because it was harming the developing brains of children, causing serious cognitive problems. The EPA ignored the petition, but in 2015, after a lawsuit leading to and a judge calling the EPA out on their "egregious delay," it finally proposed to ban chlorpyrifos on food. But in 2017 the Trump administration reversed that proposal, and the groups went back to court in 2018.

The groups won again in 2019, with the court ordering the EPA to make a decision. Trump's EPA then declined to ban chlorpyrifos, despite the mountains of evidence that it must. The groups then went back to court, and won again in April of 2021. The court ordered the EPA to determine that chlorpyrifos was safe or ban it, noting that "the EPA's egregious delay exposed a generation of American children to unsafe levels of chlorpyrifos." Finally, just before its court imposed deadline, the EPA issued a narrowly crafted ban on all food uses of this terrible chemical on August 18, 2021, although it still may be used in plant nurseries, on tree farms and golf courses, on fenceposts, and other non-food uses.

Chlorpyrifos is a broad-spectrum chlorinated organophosphate insecticide, it was introduced by Dow Chemical in 1965. It kills insects by attacking their nervous system. According to the EPA, it is one of the most widely used organophosphate insecticides.[283]

Use of chlorpyrifos on corn and soy in the US decreased slightly in the past decade, from roughly 2.6 million pounds applied in 2012 to 1.6 million pounds in 2018, leading up to the recent ban.[284] This is primarily due to decreasing use in soy, as applications to corn doubled in that same time period.[285]

Chlorpyrifos is considered very highly toxic to freshwater and marine organisms[286], and even a minimal concentration of chlorpyrifos can accumulate in the tissues of several aquatic organisms.[287]

Chlorpyrifos is moderate to highly toxic to birds and also affects other animals, including honeybees and wildlife. It should not be used where bees are collecting nectar or pollen and should not be used for grazing. It has been observed that regular and continuous exposure to chlorpyrifos leads to its accumulation in animals, reaching toxic levels after some time.[288] Its half-life in the environment is 60-120 days, but could be as long as one year depending on factors such as climate and soil type.[289]

Chlorpyrifos is moderately toxic to humans with exposure resulting in neurological effects, autoimmune disorders, and persistent developmental disorders. Exposure during pregnancy results in impaired mental development of the child.[290]

Recommendations

For governments and intergovernmental organizations:

Short term:

- Stop funding promotion campaigns for meat and dairy.
- End bailouts for meat and dairy and prioritize plant-based agriculture in emergency funding allocations and surplus pricing.
- Require companies and financial institutions to measure and disclose biodiversity risks and impacts in the meat and dairy supply chain.
- Include food and agriculture in emissions-reductions targets and climate action plans.

Medium term:

- Adopt sustainable dietary guidelines that encourage diets higher in plant-based foods and lower in animal-based foods.
- Reduce meat and dairy and increase plant-based options in procurement policies and government-supported nutrition programs.
- Create food policy councils to support dialogue across governmental departments – including agriculture, environment, climate, forests, and health and nutrition – and with community stakeholders to ensure policies and regulations are aligned with reducing or eliminating chemical pest management practices, promoting and increasing access to plant-based foods, and protecting biodiversity.

Long term:

- Redirect industry subsidies and financial incentives towards diversified cropping systems that reduce or eliminate chemical pest management practices as well as towards increasing production and consumption of plant-based foods.
- Incentivize and support farmers to transition from animal-based to plant-based production systems.
- Increase funding and technical support for farmers' markets, community gardens, urban agriculture, and chemical-free and less intensive production and market opportunities to increase access to fresh produce.

For businesses and institutions:

Short term:

- Support a protein transition in line with global average reduction in animal protein production and consumption of 50% by 2040.
- Publicly document progress towards these targets annually.
- Prioritize and promote plant-based options on menus and in advertising.

Medium term:

- Meet the FARMS Responsible Minimum Standards' animal welfare requirements for production and procurement as a minimum, including phasing out the use of high productivity breeds and shifting to more appropriate diets to reduce reliance on commodity animal feeds.
- Increase the proportion of plant-based protein options to support an average global reduction in animal protein production and consumption by 50% by 2040, and publicly document progress.
- Shift procurement policies to reduce meat and dairy and increase plant-based options.
- Include food and agriculture in emissions-reductions targets and reporting.

Long term:

- Develop an overarching animal welfare policy informed by the Five Domains model that leads to a good life for farmed animals.
- Purchase from regional food hubs and adjust menus to support seasonal, regional, and bumper crop purchasing.
- Commit to shifting to circular agricultural systems, with a phase out of commodity crop animal feed.
- Adopt initiatives to achieve zero food waste to ease pressure on the food supply chain and track and publicly report progress.

For individuals:

Short term:

- Learn tips and tools to begin reducing the amount of meat and dairy in your diet at meatinghalfway.org.
- Share plant-based meals and information (such as this report) with friends and family.

Medium term:

- Tell the grocery chains you shop at to increase the availability and promotion of plant-based protein options on their shelves.
- Tell restaurant chains and cafeterias where you dine to increase the availability of plant-based protein options on their menus.

Long term:

- Commit to cutting the amount of meat and dairy in your diet by at least 50% and replacing these animal proteins with plant-based and other alternatives.
- Urge your elected officials to support policies that advance sustainable agricultural practices, set climate targets for food and agriculture, end subsidies for factory-farmed meat and dairy, and encourage higher consumption of plant-based foods and lower consumption of animal-based foods in dietary guidelines.

Conclusion

Protecting biodiversity and wild animal habitats requires reimagining how we are producing and consuming protein, including by ending the factory farming of animals for meat and dairy.

In the factory farming model, corn and soybeans have become the predominant ingredient in farmed animal diets. The high-energy diets forced upon modern farmed animals prop up a system that treats sentient animals as mere commodities, fattening them as quickly as possible while crowding them into barren barns or lots and demanding the animals conform to the system.

Factory farming's reliance on intensive monoculture row crop production not only destroys native biodiversity by shifting ecosystems to a single dominant crop, but further threatens wild plants and animals via the heavy usage of herbicides and insecticides in attempt to prevent weeds and insects from impeding maximum crop yields.

In 2018, an estimated 235,976,274, nearly ¼ billion, pounds of herbicides and insecticides were applied in the US just to the corn and soybeans grown for farmed animal feed.

These pesticides are taking a toll on our environment and biodiversity. Endangered species like the highly imperiled whooping crane, monarch butterflies, all species of salmon, the rusty-patched bumble bee, the San Joaquin kit fox, and the northern long-eared bat, as examples, all face significant threats from industrial agricultural operations and the chemicals applied.

In order to conserve biodiversity and better protect vulnerable species and their habitats we must reduce the production and consumption of animal protein and shift to a food system that prioritizes diverse plant foods.

Eating more plant-based diets can reduce the burden on our planet and the animals with which we share it.

Learn more at https://reports.worldanimalprotection.org/US/Pesticides#1.

Appendix A:

Total herbicides and insecticides applied and top 10 applied to corn and soy in the US, 2018[291]

Corn:

- **231,917,910** pounds of herbicide, including:
    - Glyphosate, glyphosate dimethylammonium, glyphosate isopropylamine Salt, glyphosate potassium salt: **71,918,850** pounds
    - Atrazine: **60,375,932** pounds
    - Acetochlor: **41,861,035** pounds
    - S-metalochlor, metalochlor: **32,484,776** pounds
    - 2,4-D 2-ehe, 2,4-D dimethamine salt: *5,733,115* pounds
    - Mesotrione: **4,511,534** pounds
    - Dimethenamid-P: **3,683,105**
    - Dicamba: **3,163,580**
    - Paraquat: **693,417**
    - Glufosinate ammonium: **527,083**
- **2,254,140** pounds of insecticide, including:
    - Chlorpyrifos: **672,895** pounds
    - Propargite: **634,012** pounds
    - Bifenthrin: **434,196** pounds
    - Tefluthrin: **170,654** pounds
- **234,172,050** pounds of herbicide and insecticide on US corn in 2018.
- With 36 – 45% of US corn produced for farmed animal feed, for an average of 40.5%, the volume of herbicides and insecticides attributable to feed corn in the US is: **94,839,680** (not including neonicotinoids, see Appendix B).

Soy:

- **191,568,424** pounds of herbicide, including:
    - Glyphosate, glyphosate ammonium salt, glyphosate dimethylammonium, glyphosate isopropylamine Salt, glyphosate potassium salt: **99,623,708** pounds
    - Metalachlor, s-metalochlor: **25,281,913** pounds
    - Dicamba, dicamba BAPMA salt, dicamba diglyceride salt, dicamba dimethylamine salt, dicamba isopropylamine salt, dicamba sodium salt: **13,380,062** pounds
    - Glufosinate ammonium: **10,157,103** pounds
    - 2,4-D, 2,4-D 2-ehe, 2,4-D Dimethamine salt, 2,4-D Isopropanolamine salt: **8,876,926** pounds
    - Acetochlor: **5,491,226** pounds
    - Metribuzin: **4,599,266** pounds
    - Fomesafen sodium: **3,791,610** pounds
    - Paraquat: **3,598,023** pounds
    - Sulfentrazone: **3,475,209** pounds

- **2,397,982** pounds of insecticide, including:
    - Chlorpyrifos: **904,449** pounds
    - Acephate: **668,189** pounds
    - Bifenthrin: **267,483** pounds
    - Lambda-cyhalothrin: **156,119** pounds
- **193,966,406** pounds of total herbicides and insecticides on soybeans in the US in 2018. With an estimated 67 – 77% of US soybeans produced for farmed animal feed for an average of 72%, the volume of insecticides and herbicides attributable to feed soybeans comes to: **139,655,812** (not including neonicotinoids, see Appendix B).

Total herbicides and insecticides used on corn and soybeans for farmed animal feed in the US, not including neonicotinoids: 234,495,492 pounds

Appendix B:

Neonicotinoid estimates methodology and resources

According to the EPA, over 700,000 pounds of imidacloprid–a neonicotinoid–was used annually as a seed treatment in the US between 2005-2015.[292] Similarly, according to EPA, between 2005-2014 an average of 1,400,000 pounds of clothianidin and 800,000 pounds of thiamethoxam were used annually as seed treatment for various crops.[293]

Based on this, for the purposes of this report it was estimated that 700,000 pounds of imidacloprid, 1,400,000 pounds of clothianidin, and 800,000 pounds of thiamethoxam were used as seed treatment in the US in 2018, for a total of 2,900,000 pounds combined.

Additionally, seed treatment use of neonics in the US is primarily on corn and soybeans; there is some additional use on cotton, potato, and wheat as well[294], but "[c]orn and soybean seed treatments represent the largest uses of neonicotinoids, nationally."[295] A 2015 study compiling available data on neonic usage in the US indicates that corn and soy account for roughly 87.5% of total neonic seed treatments in US agriculture.[296] A 2021 article estimates that nearly 100% of non-organic corn seed in the US is coated with one of either clothianidin or thiamethoxam, and that approximately 76% of US soybeans acres a replanted to insecticide and fungicide-coated seed.[297]

Using this figure, a fair estimate for 2018 use of neonic seed treatments just for corn and soy in the US was taken as 2,900,000 x 0.875, or 2,537,500 pounds. This is likely a conservative estimate as data from USGS indicates total neonicotinoid use on corn and soy as seed treatment in 2014 was roughly 3.7 – 3.8 million pounds[298], and there is no indication that use decreased in the following years.

Additionally, according to the EPA, approximately 5,000 pounds of clothianidin[299], 50,000 pounds of imidacloprid[300], and 40,000 pounds of thiamethoxam[301] were sprayed on soybeans each year between 2013 and 2018, in addition to that used for seed treatments. Adding this estimate of 95,000 pounds of additional use on soybeans brings the 2018 estimate for the two crops to 2,632,500 pounds.

For the purposes of this report, we are seeking the total use attributable to corn and soy grown and processed for farmed animal feed. Roughly 67 – 77% of US soybean crop and 36 – 45% of US corn crop is used for animal feed annually. As we were unable to access sufficient data demonstrating the proportion of neonicotinoids used on corn compared to soybeans and only have the combined usage estimate, we combined the above percentage ranges into a single average percentage of 56.25% of US corn and soybean crop attributable to farmed animal feed.

As such, of the estimated 2,632,500 pounds of neonics used on corn and soy in the US in 2018, 56.25% of that is assumed to be used on crops produced for animal feeds for the purposed of this report, coming to **1,480,781.25 pounds**.

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