INSECT DECLINE | MAY 17, 2022

Study of Dramatic Flying Insect Declines Reinforces Earlier Findings

With public awareness of an ongoing 'insect apocalypse' growing, one of the first anecdotes people often note is how many fewer bugs are found splatted on their car windshield than in the past. In a recent survey, conservation groups in Britain are finding evidence of insect declines in exactly that place, providing scientific backing for these concerning suspicions. Between 2004 and 2021, 58.5% fewer flying insects were squashed onto car license plates. "The results from the Bugs Matter study should shock and concern us all," says Paul Hadaway, conservation director at Kent Wildlife Trust, which conducted the study alongside UK organization Buglife. "We are seeing declines in insects which reflect the enormous threats and loss of wildlife more broadly across the Country. These declines are happening at an alarming rate and without concerted action to address them we face a stark future. Insects and pollinators are fundamental to the health of our environment and rural economies."

The survey was conducted primarily through citizen science, utilizing the "Bugs Matter" mobile app, and a sampling grid, referred to as a 'splatometer' that is affixed to a car's license plate. Data was retrieved from trips taken by citizen scientists between June 1 and August 31 in 2004 and 2021. Locations and trip distance were written down in 2004, but automatically tracked via the app in 2021. Trip speed generally averaged under 30 miles per hour, and trip length ranged between an average of 16 to 36 miles.

Analysis of the survey results determined a splat rate of .238 insect splats per mile in 2004, but only .104 per mile in 2021. Within that period, the odds of taking a trip and seeing no insects squashed to one's license plate increased by 2.9 times. Differences were seen between different areas of the United Kingdom. Scotland witnessed the smallest decline, at 28%, which could be attributed to the region having more wild land and fewer farms and cities. England, on the other hand, saw the greatest decline, at 65%, while Wales recorded losses of 55%. (Data was not available for Northern Ireland).

These results line up with the latest data on the insect apocalypse from peer-reviewed scientific literature. Published in *Nature*, a recent study finds that in the context of climate change, low intensity agriculture and expansive natural habitats provide the best chance to reduce insect losses. The more wildland regions have surrounding their farmland, the better insects are expected to fare. The difference between the results observed in Scotland and England line up well with that modeling.

"This vital study suggests that the number of flying insects is declining by an average of 34% per decade, this is terrifying," said Matt Shardlow, CEO at Buglife. "We cannot put off action any longer, for the health and well-being of future generations this demands a political and a societal response, it is essential that we halt biodiversity decline—now!"

Research published in 2017 documented a major red flag for insect populations worldwide, finding that in German nature preserves, 75% of flying insect biomass had been lost. A systematic review of insect population decline studies subsequently published in 2019 determined that 41% of insect species worldwide are declining. Declines of butterflies, wild bumblebees, and honey bees are specifically linked to hazardous pesticide use in industrial agricultural systems.

Worldwide, roughly a quarter of the global insect population has been lost since 1990, according to research published in *Science*. This research finds worldwide trends in declines in terrestrial insect biomass to be nearly 1% each year (~9% each decade). As a 2019 review concluded, "We know enough to act now." Across the globe, data continues to line up with people's anecdotal experiences of seeing fewer and fewer insects as the years go by. Unless we act soon, ecological amnesia will set it, as subsequent generations will perceive the environment in which they were born as the norm.

Consider the decline of insects in the context of efforts to stop the deaths of eagles, falcons, condors, and other birds of prey in the 1960s from widespread DDT use. Field observations of broken eggs in Peregrine falcon nests in Britain in the late 1960s led to populations surveys. In the United States, most longstanding falcon nests were found deserted. Massive increases in pesticide use following World War II were suspected as the cause, and it was confirmed that as DDT bioconcentrated up the food chain, it would be contained in eggshells. DDT concentrations in eggshells correlated in lock step with the thinness of an eggshell, scientifically confirming the issue.

With pollinators and the wider insect world, we are at a similar moment. We know that industrial agriculture and its use of hazardous pesticides, particularly systemic insecticides like the neonicotinoid class, are harming insect life and biodiversity throughout the globe. Scientific data is now so sophisticated we can provide year-by-year and decade-by-decade models of insect declines both past and future.

It took 10 years after Rachel Carson wrote *Silent Spring* for DDT to be banned. Yet, it has taken decades for bird of prey populations to bounce back. On the east coast, local populations of Peregrine Falcons were extirpated, and needed to be reintroduced over subsequent decades. It was not until 1999 that populations recovered enough to remove the birds from the endangered species list. Bald eagles were only removed from endangered species status in 2007. It was in early May that wildlife officials and the Yurok Tribe were able to reintroduce California condors into Northern California.

How many readers have anecdotally noticed more birds of prey in their region, but fewer pollinators and other insects?

What to do: The lag time between precipitous declines and species recoveries are often decades-long affairs. As we cheer the return of birds of prey we must likewise lament the years lost without them unnecessarily and shortsightedly, and be cognizant of the ongoing harm chemical use is causing to animals that form the basis of all ecological food chains. The work to ensure future generations can experience a world where "the bees are coming back" must start now. For more information on ongoing insect declines, see Beyond Pesticides article "Tracking Biodiversity: Study Cites Insect Extinction and Ecological Collapse." See here for more resources to get engaged and collect crucial ecological information through citizen science projects.

SOURCE: Lawrence Ball , Robbie Still, Alison Riggs, Alana Skilbeck, Matt Shardlow, Andrew Whitehouse, and Paul Tinsley Marshall. BugsLife/Kent Wildlife Trust Technical Report. May 2022; BugsLife UK press release.

BIODIVERSITY COLLAPSE | DECEMBER 9, 2022

UN Again Calls for Action as Biodiversity Deterioration Worsens Worldwide

Representatives from more than 195 countries have descended on Montreal for the December 7 start of COP15—the United Nation's (UN's) Conference of the Parties to the Convention on Biological Diversity (CBD). The UN Development Programme sets out the context for this summit: "Despite ongoing efforts, biodiversity is deteriorating worldwide, and this decline is projected to worsen with business-as-usual. The loss of biodiversity comes at a great cost for human well-being and the global economy." Beyond Pesticides has documented many aspects of this decline in biodiversity, and the implications for ecosystem, human, and planetary health. In this COP15 context, the data points to the importance of broad adoption of organic regenerative/agroecological systems, which can very significantly address the interactive health, biodiversity, and climate crises.

Close on the heels of November's UN COP27 summit on climate, COP15 has commenced, with the goal of adopting a post-2020 Global Biodiversity Framework (CBF) to provide "a strategic vision and a global roadmap for the conservation, protection, restoration, and sustainable management of biodiversity and ecosystems for the next decade." The first such summit was called the Convention on Biological Diversity and was held in 1993. Out of it and subsequent meetings have come several international agreements—the 2003 Cartagena Protocol on Biosafety (focused on environmental protection from

potential risks of genetically modified organisms), and the 2014 Nagoya Protocol (aimed at sharing benefits of the use of genetic resources in equitable ways), as well as other actions related to environmental integrity, community rights, and rights of Indigenous Peoples.

Prior to that, in 2010 the conference adopted a Strategic Plan for Biodiversity—the Aichi Biodiversity Targets for the 2011–2020 period. According to the International Union for Conservation of Nature, "[a]t the global level none of the 20 Aichi Biodiversity Targets agreed by Parties to the CBD in 2010 [were] fully achieved."

Subsequently, CBD focus shifted to the development of the Post-2020 Global Biodiversity Framework via the current (through December 19) meetings in Montreal. NGOs, such as Friends of the Earth and the CBD Alliance—the latter a network of civil society organizations—are engaged in the COP15 process. The CBD Alliance has forwarded equity and transparency concerns about that process, as demonstrated in this letter, and has set out its long list of "ingredients" it wants included in a successful COP15 GBF.

Among those is a serious and ambitious focus on the role of agroecological approaches to agriculture (and forestry) operations around the world. Agroecology overlaps broadly with organic regenerative agricultural approaches—for which Beyond Pesticides advocates strongly, and which it has described and explained here, here, and here (at 46:55). Agroecological approaches are generally described as: holistic and diversified; integrating ecological principles into the design and management of food production systems; incorporating social justice and cultural concerns; and embracing of multiple kinds of outputs, as well as spatial and temporal diversification. In addition, they center the health of the soil, the organismic ecosystems beneath the soil surface, and the resultant ability to draw down and hold carbon.

Such approaches show up "on the ground" in multiple strategies, including crop rotation; no (or very limited) chemical inputs, such as synthetic pesticides and fertilizers; interplanting and succession planting; use of cover crops; no- or low-tillage (without use of herbicides); and no or few off-farm inputs (and in the former case, typically because crop production is supported by and integrated with maintaining some on-farm livestock). The UN Food and Agriculture Organization provides a primer on the elements of agroecology.

Many organic producers operate according to a majority of these principles, although U.S. organic standards (i.e., U.S. Department of Agriculture Certified Organic) do not mandate use of all the practices described above. Some consider organic farming practices to be roughly synonymous with agroecological practices, but agroecology, as it is practiced in some parts of the world, also attends to the health of forests and their management. (See an illustrative case study, of an agroecological farm in Ethiopia, in an *Organic Without Boundaries* blog entry.)

According to Beyond Pesticides Executive Director Jay Feldman, U.S. "organic" does not require and codify all of those agroecological features in its National Organic Standards (NOS). But the NOP (National Organic Program) "does have defined standards that are enforceable and subject to public review. Because issues of cost are not factored into producers' meeting OFPA [the *Organic Foods Production Act*] standards, and because scale is often based on inputs or practices that are not allowed in organic, the USDA National Organic Program has, embedded in it, standards that are generally not friendly to industrial agriculture. At the same time, with agribusiness pushing for entry into the organic market, we are vigilant in Keeping Organic Strong." (For more on what is allowed and not allowed in organic production, see the National List of Allowed and Prohibited Substances.)

The global transition to these approaches to agricultural production is imperative. In addition to Beyond Pesticides' long-standing and ardent endorsement of the transition, The Rodale Institute has studied and advocated for organic systems for decades, and in 2016, the International Panel of Experts on Sustainable Food Systems (IPES) issued a report calling for a "paradigm shift from industrial agriculture to diversified agroecological systems."

In recent years, multiple national and international entities have encouraged the transformation of food and agriculture systems, including aspects of the European Union's Farm to Fork strategy, and the United Kingdom's (UK's) Royal Society for the Encouragement of Arts, Manufactures and Commerce's Food, Farming and Countryside Commission, which issued a 2019 report—*Our Future in the Land*—calling for radical transformation of the UK food and agricultural system to sustainable, agroecological farming by 2030.

Unlike other approaches to sustainable development, agroecology helps to deliver contextualized solutions to local problems. It is based on bottom-up and territorial processes.

In his introduction to Beyond Pesticides' 2022 Forum Series seminar, Tackling the Climate Emergency, Mr. Feldman said, "We [in the U.S.] don't have to be theoretical about this. We have organic systems in place, governed by a clear definition and requirements for compliance with standards. Under OFPA in the U.S. (and similar statutes worldwide), those selling products as organic are required to adhere to a legal definition of soil management practices, a list of allowed and prohibited substances, a certification and inspection system that establishes compliance with defined organic standards, and a participatory public decision-making process for continuous improvement. This approach, whether in agriculture or in our parks and playing fields, eliminates the reliance on fossil fuel-based toxic chemicals that release greenhouse gases. It also employs the ability of healthy soil, rich in biodiversity, to draw down atmospheric carbon."

Seminar speakers emphasized the need for, and evidence of the many benefits of, the critical transition to organic regenerative/agroecological agriculture for rescuing and sustaining biodiversity, health, and climate. One of the seminar presenters was Dr. Rachel Bezner Kerr, PhD, a professor and expert on sustainable African agriculture, and on climate change adaption, who is also participating in COP15 discussions. (See Dr. Kerr's presentation at Beyond Pesticides' climate seminar, beginning at 5:48.)

Dr. Kerr recently Tweeted: "Agroecology is key to ensuring the success of the Global Biodiversity Framework," and pointed to a recent study of agroecological practices in Ethiopia as demonstrative of their potential benefits. That research paper calls agroecology "key . . . [to] meeting significant increases in our [future] food needs . . . while ensuring no one is left behind. . . . [A]groecology can promote the transition towards social-ecological sustainability. Unlike other approaches to sustainable development, agroecology helps to deliver contextualized solutions to local problems. It is based on bottom-up and territorial processes, involving the co-creation of knowledge, and combining science with the traditional, practical, and local knowledge of producers. It is characterized by its participatory approach," and enhances farmers' income, achieves food security, and protects the environment.

A report by another agroecology expert, Faris Ahmed of Carleton University, has been core to the case, pressed by advocates at COP15, to recenter the role of agriculture in recovering and supporting biodiversity, and in the GBF. His report for Friends of the Earth, *Replanting Agricultural Biodiversity in the CBD*, maintains that "agriculture needs to be dealt with both as a destructive force, and [for] its ability to nurture and restore biodiversity. Today's industrially driven, large-scale agriculture and intensive livestock production is identified as the biggest driver of land use change, ecosystem exploitation and destruction, and a significant contributor to climate change. However, agriculture is also a solution: in contrast to industrial agriculture, peasant agriculture and food provision, practiced by the majority of the world's small-scale farmers, nurtures and safeguards agricultural biodiversity."

Beyond Pesticides concurs. We have recently underscored the benefits of organic practices for biodiversity, drought resilience, climate, farm operation economics, and soil health, and amplified our call for a rapid phase-out of the use of toxic, petrochemical pesticides within a decade—a critical component in progress toward restored biodiversity and health for ecosystems and humans.

What to do: Mr. Feldman adds, "The agroecology movement is critical. We need a big tent to bring communities together worldwide and eliminate petrochemical pesticides and fertilizers in a short timeframe. At the same time, we need strong domestic and international standards, and governmental systems—with legal requirements and enforcement—that move agriculture to sustainable, agroecological/organic regenerative practices that can restore biodiversity and, simultaneously, address the climate and health crises."

Source: Friends of the Earth International

GUT MICROBIOME | CHANGES IN BEE GUT MICROBIAL ABUNDANCE | FEBRUARY 16, 2022

Review Provides New Insight into How Pesticide Exposure Disrupts Bee Gut Microbiome

Pesticide exposure disturbs the gut microbiome of social bees, leading to a range of alterations that could affect fitness in the wild, finds a major literature review recently published by researchers at the University of Ottawa, Canada. With research on bee gut microbiomes still in its infancy, the review provides a centralized overview of data collected to date, and highlights areas for further research to fill in remaining knowledge gaps. "Social bees have gut microbiotas that contribute to their health, just like we (humans) do," said Michelle Hotchkiss, a PhD candidate in the Faculty of Science at the University of Ottawa. "Further research on the interactions between pesticides, bee gut microbiotas, and bee hosts will help us better understand how pesticides affect bee health and performance."

To conduct their review, scientists collected research relating to bee gut over the last 50 years. "The earliest studies we found were published in the 1970s and the most recent ones in 2020," said Dr. Hotchkiss. "We summarized what methods were used to collect data, including which bee hosts and pesticides were examined. To summarize how the abundances of core microbes changed after pesticide exposure, we looked at studies that used molecular methods to characterize changes in microbial abundances," she added. "Importantly, we determined which microbes are most commonly affected by pesticide exposure and how they are affected. For example, does abundance increase or decrease after exposure? To what extent?" said Dr. Hotchkiss.

Studies show that pesticide use can disturb and shift the abundance of certain microbes in the bee gut microbiome, but rarely are these microbes completely eliminated. In general, researchers found declines in Bifidobacteriales and Lactobacillus bacteria to be the most common shifts observed.

Pesticide induced disturbances primarily in one of two ways—either directly harming microbes, and indirectly harming the host (bee) health and subsequently shifting the microbiome. Researchers cite glyphosate as an example of a pesticide that directly harms the growth of certain gut microbes. Indirectly, researchers cite pesticides with the ability to impact the bee immune system. Further, studies highlight how pesticides changing the physical and chemical conditions of bee guts, making their gut environment less suitable to certain microbes. These two forms of disturbances can occur at the same time, resulting in a deleterious positive feedback cycle for host bees.

The literature review also found that, regarding the impacts of exposure, the duration of pesticide exposure is more important than the amount of pesticide to which a bee is exposed. Longer exposure times result in more significant disturbances, but likely vary by pesticide mode of action.

The impacts of pesticide-induced disturbances can be extensive, and have the potential to cause adverse effects throughout a bee's entire life. While the review captures a range of impacts, the work also highlights how little data is available on these effects. Most studies are focused on the effects of insecticides, while research on herbicides and fungicides are few. And apart from one, the current data available do no delve far into how microbial shifts impact bee performance. For example, this 2016 study reveals a range of alterations to the honey bee microbiome after exposure to different pesticides, but can only speculate on the functional impact. However, researchers note this 2018 study, focused on the impacts of glyphosate on bee gut microbiota, does track and find performance declines correlated to herbicide-induced alterations to the bee microbiome.

The researchers conclude, as all scientists are wont to do, with a call for further investigation on the topic. "Social bees have gut microbiotas that contribute to their health, just like we (humans) do. Further research on the interactions between pesticides, bee gut microbiotas, and bee hosts will help us better understand how pesticides affect bee health and performance."

What to do: The emerging data make it clear that for both humans and pollinators, chemical impacts on the microbiome should be taken into account by pesticide regulators. Currently, no studies are required to be performed on the impact of pesticide exposure on the gut biome by the U.S. Environmental Protection Agency (EPA). Help us tell EPA to embrace cutting edge science in its pesticide reviews by taking action today.

SOURCE: Michelle Z Hotchkiss, Alexandre J Poulain, Jessica R K Forrest, Pesticide-induced disturbances of bee gut microbiotas, *FEMS Microbiology Reviews*, Volume 46, Issue 2, March 2022, fuab056, https://doi.org/10.1093/femsre/fuab056; uOttawa press release

GUT MICROBIOME | HONEY BEE SUSCEPTIBILITY TO PATHOGENS | NOVEMBER 1, 2022

Pesticide Mixtures Reduce Life Span of Honey Bees, Damage Gut Microbiome

Honey bees exposed to a combination of multiple pesticides suffer a reduced lifespan and experience adverse changes to their gut microbiome, increasing susceptibility to pathogens and disease. This finding comes from a study published in *Science of the Total Environment,* which examines the interactions between the insecticides flupyradifurone and sulfoxaflor and the fungicide azoxystrobin on honey bee health. Both insecticides studied are considered substitutes for notorious bee-killing neonicotinoid insecticides, which move through the vascular system of the plant and contaminates its pollen, nectar, and guttation droplets. As declines in pollinator and insect life continue throughout the world, it is critical not only to understand and restrict widely used chemicals like neonicotinoids, but also the deleterious substitutes the agrichemical industry has developed to replace them. As the present study reveals, pesticide risk assessments do not adequately capture the range of harm that can result when pesticides are combined, necessitating a shift toward safer, alternative, and regenerative organic farming systems that do not use these dangerous chemicals.

To better understand the impacts of combined pesticide exposure on honey bees, researchers employ three colonies located in Germany's Martin Luther University that were inspected and free of mites and viruses. Technical grade versions of each pesticide were used, eliminating additional confounders that could occur in consumer use products that also include "inert" (nondisclosed) ingredients.

Bees were exposed to field relevant levels of each pesticide per U.S. Environmental Protection Agency (EPA) data, as well as combinations of pesticides (specifically: flupyradifurone plus azoxystrobin and sulfoxaflor plus azoxystrobin) through sugar water for a period of 10 days. A separate experiment on the honey bee gut microbiome was constructed using newly emerged bees, which were housed and reared separately, and then exposed to a similar pesticide treatment as the initial experiment. An unexposed control group of honey bees was included in each experiment. "Our approach was based on the realistic concentrations that might be found in pollen and nectar from plants that have been treated with the pesticides," says study coauthor Yahya Al Naggar, PhD, of Martin Luther University.

For the initial experiment on individual bees, those exposed to flupyradifurone fared the worst, experiencing significantly reduced survival (50% reduction). The addition of azoxystrobin did not significantly add to this effect. However, with sulfoxaflor, it did. Bees subjected to sulfoxaflor and azoxystrobin in combination experience significantly reduced survival when compared to a sole sulfoxaflor exposure.

While direct mortality is disturbing, the pesticide-induced alterations inflicted on the bees' guts are a more insidious problem. Impacts to the gut are not seen within the first five days after pesticide exposure, but significant shifts do occur between days five and 10. At this time, treatments of flupyradifurone alone and in combination with azoxystrobin, as well as treatments of sulfoxaflor alone and in combination with azoxystobin, show significantly increased abundance of *Serratia spp.* This rod-shaped bacteria can seriously harm honey bee fitness. "These bacteria are pathogenic and harmful to bees' health," said Dr. Al Naggar. "They can make it harder for the insects to fight off infection, leading to premature death."

The ability of insecticides alone and in combination to cause delayed gut dysbiosis in honey bees is not an effect that an EPA pesticide risk assessment would ever capture under current data requirements.

The ability of insecticides alone and in combination to cause delayed gut dysbiosis in honey bees is not an effect that an EPA pesticide risk assessment would ever capture under current data requirements. EPA requires very basic screening level tests initially, and more detailed tests only if these tests indicate a need. Yet in context, while any testing is better than none, many advocates question the value of EPA protocols when initial screening is so lackluster. Case in point, both flupyradifurone and sulfoxaflor have been marketed by the agrichemical industry as "safer for bees," despite having effectively the same mode of action as bee-killing neonicotinoids. Data since their EPA registration has backed up the concerns of pollinator advocates. In fact, EPA was sued over its approval of sulfloxaflor, and rather than accept the court's decision to vacate the chemical's registration, EPA went ahead and registered the chemical again. As a result, beekeepers and conservations groups are back in court yet again to stop this bee-killing decision. With flupyradifurone, this is now the second study showing that the chemical causes signficantly more harm to bees when used in combination with a fungicide. Per a 2019 study, combinations of flupyradifurone and the fungicide propiconazole resulted in 73% mortality and increased abnormal behavior among exposed bees. Despite these concerns EPA has facilitated the expanded use of the chemical.

What to do: The combined impacts of different pesticides and how they may adversely affect the gut microbiomes of the animals we rely on to pollinate our food is something EPA should be at the cutting edge of investigating. Yet, the agency has consistently refused to implement measures that would investigate, let alone address these risks. As a result, more and more advocates, communities, and states are taking action to protect their pollinator populations. While many are embracing organic land care and eliminating all toxic pesticides, many states have merely restricted the neonicotinoids, permitting use of flupyradifurone, sulfoxaflor, and other equally harmful substitutes to continue. We need a team of pollinator experts to continually review the science and advise EPA, as proposed in the original *Saving America's Pollinators Act* would accomplish. Help pass this law by taking action today and telling your member of Congress to join in as a cosponsor. For more information on the dangers pesticides pose to pollinators and what you can do, see Beyond Pesticides Bee Protective webpage.

SOURCE: Yahya Al Naggar, Bala Singavarapu, Robert J. Paxton, Tesfaye Wubet, Bees under interactive stressors: the novel insecticides flupyradifurone and sulfoxaflor along with the fungicide azoxystrobin disrupt the gut microbiota of honey bees and increase opportunistic bacterial pathogens, Science of The Total Environment, Volume 849, 2022, 157941, ISSN 0048-9697, https://doi.org/10.1016/j.scitotenv.2022.157941; Martin Luther University press release

BEE POLLINATION DISTURBED | NOVEMBER 15, 2022

Synthetic Fertilizers and Pesticides Make Plants Less Attractive to Bumblebees, Research Shows

Spraying a flowering plant with synthetic fertilizers makes it less attractive to bumblebees, according to research published this month in *PNAS Nexus.* "A big issue is thus—agrochemical application can distort floral cues and modify behaviour in pollinators like bees," said study author Ellard Hunting, PhD, of the University of Bristol, UK. The findings underscore the limited understanding that proponents of chemical agriculture have about the complex processes that food production relies on, reinforcing calls for a broad scale transition to regenerative, organic farming practices.

Scientists began with the knowledge that spray applications of various agrichemicals affect the visitation patterns of bumblebees and other pollinators through a range of different processes. Past research finds that notorious bee-killing neonicotinoid insecticides not only kill bees outright, but also result in a range of complex damage, including their ability to impede bees' olfactory senses and adversely affect their vision and flying ability. Other chemicals like glyphosate weaken bees' ability to distinguish between colors.

A growing area of research is investigating the ways in which pollinators use static electric fields surrounding flowers to find food sources. A 2013 study found that bumblebees use floral electrical fields to discriminate between potential food sources. Subsequent reporting shows that bees use "mechanosensory" hairs on their body to detect these fields, that find that other pollinators like the hoverfly also use these cues. Flowers produce these fields "from the negative bio-electric potential within the flower and positive charges in the atmosphere, including the electrosphere and positively charged insects such as bees," the study explains. Pollinators interacting with flowering plants can change a flower's electric field, as the plant responds by producing more sap, for instance.

Past research finds that notorious bee-killing neonicotinoid insecticides not only kill bees outright, but also result in a range of complex damage, including their ability to impede bees' olfactory senses and adversely affect their vision and flying ability.

The authors confirm that applications of synthetic fertilizers and the neonicotinoid insecticide imidacloprid to flowering plants both result in significantly reduced foraging by bumblebees. To make this determination, a series of experiments were conducted to rule out other factors. To test whether the fertilizer was adversely affecting visual cues, researchers observed the reflectance spectra of spray applications with fertilizer, finding that they were no different than simple demineralized water. To rule out odor as a factor in their findings, bees were provided sugar solution with and without fertilizer, and found that the bees showed no preference for one or the other.

Then researchers began exploring the effect of agrichemicals on the electric fields flowers produce. Cut flowers (*Geranium pratense*) were sprayed with simple water, or water with fertilizer, both with the addition of positively charged colored particles in order to observe the electrostatic deposition of the colored particles. The colored particles show significant differences between the two applications. The experiment was then repeated with a rooted, still growing flowering plant (*Jacobaea vulgaris*), and this time researchers measured the electrical field around the flower. Scientists find that fertilizers increase the flower's electric field, which then slowly returns to its previous state.

Digging deeper into the issue, researchers focused on the bio-electric potential energy within a plant's stem. Plants are known to respond to environmental stressors like cutting/herbivory and chemicals by changing the water flow and ion transport within their stems, which can subsequently be measured and manipulated. Moreover, changes observed within the bio-electric potential of a plant's stem are directly proportional to a plant's floral electric field. To test this process, cut *Lavandula angustifolia* flowers were sprayed with either water or a water-synthetic fertilizer solution, and their stem potential changes were measured. While water results in a change in stem potential that lasts up to a minute, synthetic fertilizers change stem potential for 16 minutes, and the neonicotinoid imidacloprid show alterations that last for up to 25 minutes. These measurements align directly with observed declines in bumblebee foraging interest in flowers recently sprayed with the agrichemcials. The authors note, "Since many chemicals used in agriculture and horticulture carry an electric charge, the observed mechanism could potentially be relevant for a wide array of chemicals."

Changes observed within the bio-electric potential of a plant's stem are directly proportional to a plant's floral electric field.

To add additional weight to their findings, scientists conducted another experiment in which they artificially maintained flower stems with altered electrical signals mimicking the changes seen with a fertilizer or insecticide application. Manipulated flowers experience 62 bumblebee approaches, while unaltered control flowers see 47. However, out of these 62, only 35 bumblebees landed on the manipulated flowers, while control flowers received 43 landings. "This suggests altered floral E-fields affect bee foraging when approaching the flower, and that bumblebees can detect and discriminate small and dynamic alterations in the electric landscape induced by agrochemical deposition," the study explains. To provide further context, study coauthor Sam England, PhD adds, "It's much like motorboat noise that hinders the ability of fish to detect their predators, or artificial light at night that confuses moths; the fertilisers are a source of noise to bees trying to detect floral electrical cues."

These chemicals not only interrupt the daily foraging of pollinators, they may also represent a longer-term threat. In a final experiment, researchers replicate a rain event after an initial fertilizer treatment. Plants respond with a similarly prolonged alteration of their electrical signal. The authors note that fertilizer applications may thus chronically reduce pollinator foraging either by recurring electric alterations after a rain event or from learned negative associations with the altered plant.

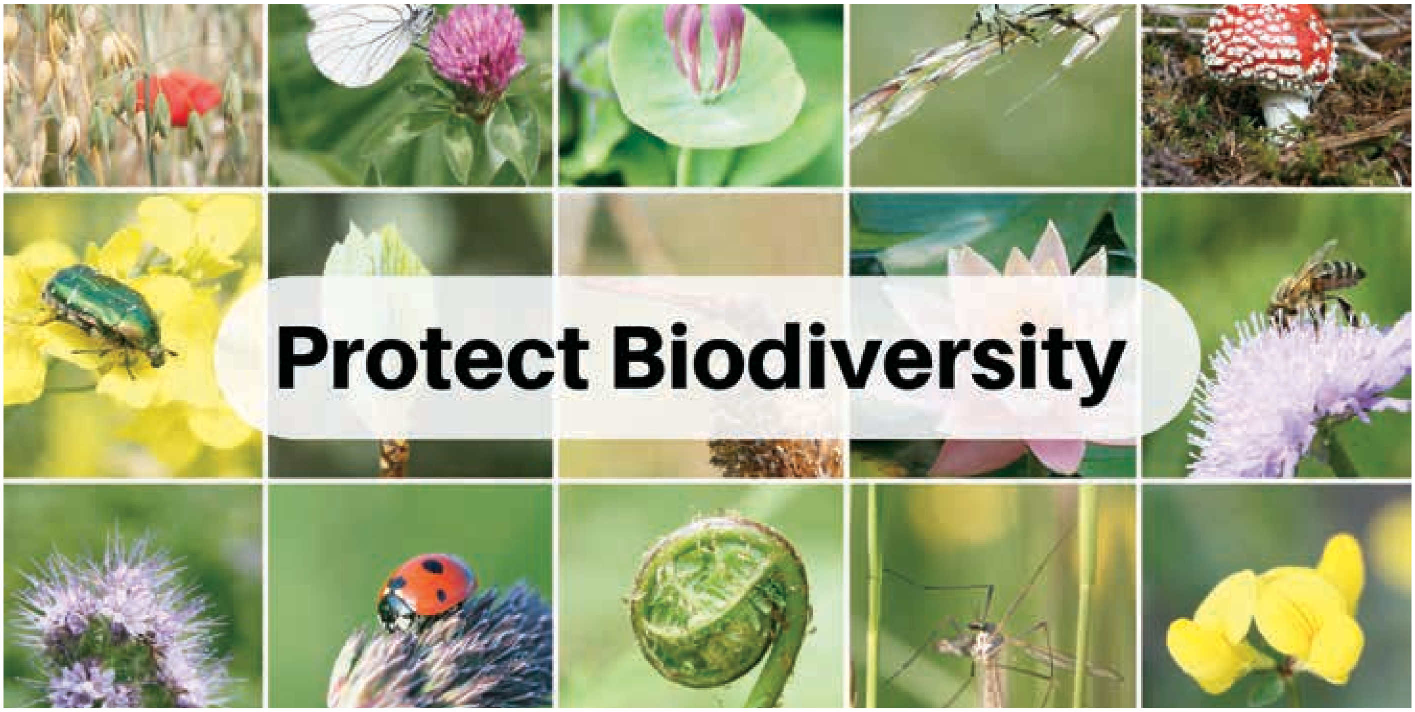
"The fact that fertilisers affect pollinator behavior by interfering with the way an organism perceives its physical environment offers a new perspective on how human-made chemicals disturb the natural environment," Dr. Hunting notes.

These results fly in the face of outdated toxicological approaches that agrichemical companies hide behind when confronted with the on the ground impacts of their dangerous products, such as 15th century Paracelsian concept that "dose makes the poison." As modern science delves deeper into the inner working of plants and insects and the interactions between these critically important groups, it finds the world to be incredibly more complex than an inaccurate adage.

Solutions to the problems of chemical-intensive agriculture exist and provide proof of concept that farming can occur without a range of negative impacts on the surrounding environment. Organic agriculture has never permitted the use of synthetic fertilizers, nor do organic farmers ever use synthetic insecticides like the bee-killing neonicotinoid imidacloprid. Instead, regenerative organic farming embraces a natural systems approach, taking efforts to work with and enhance the existing ecological services in their region.

What to do: Organic farming yields multiple bottom line benefits for wildlife and the wider environment, human health, and the economy. For more information on the dangers of synthetic fertilizers and alternative, organic companies you can support, see Beyond Pesticides page on Fertilizers Compatible with Organic Landscape Management. Eliminate synthetic fertilizers and toxic pesticides in your town by sending a letter to your local officials today.

SOURCE: Ellard R Hunting, Sam J England, Kuang Koh, Dave A Lawson, Nadja R Brun, Daniel Robert, Synthetic fertilizers alter floral biophysical cues and bumblebee foraging behavior, *PNAS Nexus*, Volume 1, Issue 5, November 2022, pgac230, https://doi.org/10.1093/pnasnexus/pgac230; University of Bristol press release



INTERNATIONAL SCIENCE-POLICY PLATFORM WARNING | JULY 15, 2022

UN: Short-Term Economic Gains Harming Well-Being and Integrity of Nature

Nature is too often sacrificed to a global and outsized focus on short-term profits and economic growth, according to a new report by the United Nations Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). The report warns that policymaking, broadly, does not reflect the value of Nature's roles in supporting human life and activity, never mind all the peripheral benefits (aesthetic, emotional, spiritual) people derive from the natural world. The report calls on leaders in all sectors to integrate the contributions of Nature in development and deployment of policy in a more comprehensive way—as *Le Monde* writes, "beyond being 'a huge factory.'" Beyond Pesticides offers a seminal reminder from Fred Kirschenmann, PhD: the prevailing philosophy of maximum efficient production for short-term economic return at the expense of Nature causes havoc in the world and will not work in the future; instead, we must develop a broad ecological conscience that guides all that we do.

The report's Summary for Policymakers was approved on July 11 by representatives from 139 Member States; the report itself is the culmination of four years of effort by 82 collaborating scientists and experts from multiple disciplines. The same member representative approved an additional IPBES report that urges the member governments to sustainably manage the wild plant and animal species on which the world's populations depend for their survival.

IPBES cochairs Patricia Balvanera, Brigitte Baptiste, Mike Christie, and Unai Pascual noted, according to the UN's press release, that examples of "embedd[ing] [N]ature into policymaking are 'in short supply.'" The press release asserts that, although "economic and political decisions have predominantly prioritized market-based values of nature . . . they do not adequately reflect how changes in the natural world affect people's quality of life."

As *Le Monde* reports, for example, re: the biodiversity crisis: "According to IPBES, the value that is predominantly attributed to biodiversity, its market value, does not reflect the value of its contribution to humanity. And furthermore, doing so does not allow us to face the huge challenge of the loss of biodiversity. With their limited vision of what nature gives us, the political and economic decisions being made today are, on the contrary, 'a key factor' in the origin of the crisis." An IPBES webpage leads with this headline about the values assessment: "Decisions Based on Narrow Set of Market Values of Nature Underpin the Global Biodiversity Crisis."

Looking to history to explain some of this situation, we find that a combination of factors is likely at work, not least of which is the Industrial Revolution and its massive impacts—made possible by the extraction and burning of (finite) fossil fuels. Reaching farther back in time, we recall the Enlightenment (and biblical) notions that humans are somehow separate from, and destined to dominate and subdue, Nature. Dr. Kirschenmann argues that these led to people focusing dominantly on humans and their enterprises, and—detrimentally—less and less during the past half millennium on the natural world and its welfare.

From that paradigm—and fertilized by cheap energy, the rising power of corporations during the past 100 years, and their influence on government—have flowed particular approaches to human activity, including specialization, a focus on productivity, and the neurochemical and economic "feel-goods" of short-term profit. Those approaches are easily recognized in what they have wrought—most of the woes and crises of modernity, including:

- galloping climate change
- chemical saturation of humans, other organisms, and the natural world
- depleted resources (which were always finite, but which human hubris has often chosen to ignore)
- massive economic inequality
- increasing "brittleness" in systems' ability to be resilient to a variety of assaults
- emerging civil and economic tensions and crises (historically followed by civil unrest)
- the rise of oligarchic and authoritarian figures in the political landscape

The UN IPBES report is an attempt to call humanity's, and pointedly, global leaders', attention to these matters, and to advocate for the integration of valuations of Nature into decision making. The authors began with a deep dive on valuations of Nature. The Summary for Policymakers identifies four "values-based leverage points"—undertaking valuation, embedding values in decision making, policy reform, and shifting societal goals—that coauthors say may catalyze a transformation to a sustainable and just future.

The more-academic work on the valuations of nature that informed the IPBES report (available in the "Contrasting Approaches to Values and Valuation" document) asserts that the current discursive paradigm tends to emphasize the split between anthropocentric (instrumental) and non-anthropocentric (intrinsic) aspects of Nature. Largely, people cleave to one or the other of those frameworks in their thinking. The authors write, "[M]uch of the policy discourse on the need for valuation of nature's contributions to people heavily relies on either a one-dimensional value lens (value-monism) that derives from a utilitarian economic perspective or on an environmental ethics stance of nature-human relationships, furthering the instrumental vs. intrinsic dichotomy."

Instead, they argue, what's needed in human thinking, and in policymaking, is "value pluralism"—a more dynamic and relational understanding of Nature's values, i.e., one that emphasizes the value of the interactions between people and nature, and those among individuals in society. IPBES cochair Mike Christie explains the focus on values assessment by saying that "'valuation is an explicit and intentional process" that hinges on "how, why and by whom" the valuation is "designed and applied.'" Cochair Brigitte Baptiste added that "recognizing and respecting the worldviews, values, and traditional knowledge of indigenous peoples and local communities allows policies to be more inclusive, which also translates into better outcomes for people and nature."

The press release proffers that "'Living from, with, in, and as nature' means providing resources that sustain people's livelihoods, needs and wants, including food and material goods. . . . It also focuses on non-human life, such as the intrinsic rights of fish in a river to 'thrive independently of human needs,' and sees the natural world as a 'physical, mental and spiritual part of oneself.'"

Beyond Pesticides has written about the value of Nature's ecosystem services and threats to them, including the fragility of ecosystems to chemical assaults. It has covered the biodiversity and climate crises, and the outsize corporate and industry influence on policy at EPA and other federal agencies. It has written about a precautionary approach that would go far in addressing the environmental crises that seriously threaten not only human health, but all life on Earth. And it has researched, written about, and advocated endlessly for the huge role that the transition to organic regenerative agriculture would play in resolution of multiple of the threats humanity faces.

From that paradigm—and fertilized by cheap energy, the rising power of corporations during the past 100 years, and their influence on government—have flowed particular approaches to human activity, including specialization, a focus on productivity, and the neurochemical and economic "feel-goods" of short-term profit.

What every one of those arenas has in common is what this IPBES report identifies: governmental, corporate, and institutional prioritizing of short-term economic gains over the well-being and integrity of Nature and its elegant, complex, and life-sustaining systems. Drawing again from Dr. Kirschenmann in his 2015 article in *Pesticides and You*, he continues:

"This is what we have to do now. It's not enough any longer for us simply to care about our fellow humans. We have to care for all of the life in the biotic community of which, as Aldo Leopold said, we are simply plain members and citizens. [Beyond Pesticides adds that this means all of Nature, including non-biotic elements.) We are not the dominators. We are not the culture. We are not the conquerors. . . . So, we have to find our place in [Nature], because if it is not all healthy and if it doesn't all have the capacity for self-renewal, then none of it will include us."

"This is the new consciousness that we have to develop. Leopold recognized . . . that was a huge challenge. . . . He understood there wasn't much that he could do as an individual to make this happen. He finally concluded that this had to become part of a social evolution."

What to do: This UN report is testament to the need for, and a call to enact, such evolution with all speed. Yet, this is a huge lift, and Beyond Pesticides is but one actor in a huge landscape of people and organizations clamoring for changes in "business as usual," which are at the root of our multiple crises. Please—please—become engaged with Beyond Pesticides or with any other environmental, health, civic, and/or justice organization that recognizes the dangerous follies of our current approaches to policy making. Bringing to policy an ethic of "value pluralism" that integrates the importance of Nature and its integrity is not only critical, but also, one path forward to a functional, equitable, livable future.

SOURCE: UN Report: Value of nature must not be overridden by pursuit of short-term profit

ECOSYSTEM SERVICES INCREASE CROP YIELD | APRIL 13, 2022

Ecosystem Services Provided by Birds and Bees Synergize To Increase Farm Yield and Profit

The combined effects of insect pollination and natural pest control provided by birds synergize to improve yields and income for coffee farmers, finds research published this month in the journal PNAS. Ecosystem services—the positive benefits provided by ecosystems, wildlife, and their natural processes – underpin agricultural production, but are often analyzed in silos, on a case-by-case basis in the scientific literature. The current research finds that the quantitative benefits of ecosystem services can be greater when considering their interactive effects.

"Until now, researchers have typically calculated the benefits of nature separately, and then simply added them up," says lead author Alejandra Martínez-Salinas, PhD of Costa Rica's Tropical Agricultural Research and Higher Education Center (CATIE). "But nature is an interacting system, full of important synergies and trade-offs. We show the ecological and economic importance of these interactions, in one of the first experiments at realistic scales in actual farms."

Researchers base their experiment in Costa Rica, working with 30 shade grown coffee farms owned by small landholders. Eight coffee plants on each farm were selected for the study. Pest control services provided by birds are assessed using a 20mm mesh screen that excludes birds but allows bees and other insect pollinators to forage. Bee pollination is analyzed by choosing four comparable branches on each of the eight coffee plants and using nylon mesh bags to exclude bees during flowering on two of the four branches. With this design, scientists are able to evaluate bird activity alone, pollination activity alone, bird and bee activity combined, and no activity from either birds or bees.

The impacts of these services are evaluated on the fruit set, fruit weight, and economic value of a coffee farm's output. With each of these measurements, ecosynergy, a synergy between ecological services, results in the greatest benefit. While bird activity alone does not increase fruit set or weight, bee activity alone does cause a modest average increase of 11% in fruit set and 4.2% in fruit weight. Combined activity of birds and bees show the highest fruit set and weight among all scenarios, with a 24% increase in fruit set and 6.6% increase in fruit weight.

Increases in fruit weight and set means greater economic benefits for coffee farms. Researchers estimate that farmers generally receive roughly $4,300 US dollars per hectare. The results of the experiment show that excluding birds reduces yield by 13.5%, representing a nearly $600 loss per hectare. Losing bees in the landscape reduces yield by 24.5%, a $1,059 per hectare loss. Losing both birds and bees causes the highest yield and economic loss at 24.7%, representing a $1,066 gap.

"These results suggest that past assessments of individual ecological services—including major global efforts like IPBES—may actually underestimate the benefits biodiversity provides to agriculture and human wellbeing," says Taylor Ricketts, PhD, of the University of Vermont. "These positive interactions mean ecosystem services are more valuable together than separately."

The study underscores the importance of preserving, maintaining, and improving on-farm biodiversity and ecosystem services as a key aspect in considering agricultural yields. These services are critical, yet more vulnerable than one may think. For instance, research published in 2015 by some of the same scientists from the current study found that only a small number of bee species actually provide pollination services, making their continued existence crucial to long-term farm sustainability and profitability. A study published in 2016 found that the loss of microbial diversity in the soil hampers ecosystem services associated with decomposition, nutrient cycling, and carbon fixing, all critical roles needed to maintain food production.

The 2019 report from the United Nation's IPBES (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services) provides a stark warning to the world about the how the decline of biodiversity impinges on society's ability to meet basic needs. But as the authors of the present study note, even these dire calls may underestimate the benefits humanity is provided by natural services, those which are often taken for granted.

Time and again, research has found that increasing on-farm biodiversity decreases the need for pesticide use (by increasing natural pest management services), and improves overall productivity. That is why organic farming represents the best approach for the future of farming. A core component of organic law is the requirement to maintain or improve soil health. From this concept flows the spirit and intent of organic to continuously improve, and promote natural materials and processes over synthetic substances. These practices on the ground, according to Rodale Institute's long running Farming Systems Trial, result in higher organic matter and improved soil health, yields that are competitive with chemical-intensive practices, farm profits 3-6 times higher, and significantly less greenhouse gas emissions and chemical use.

What to do: The benefits of natural systems are difficult to suss out without considerably more investment in the sort of research being conducted in the present study. As the author's note, the available literature on synergies between ecosystem services is particularly thin, and in need of further time and attention. For a review of the importance of biodiversity and ecosystem services to food production and our current way of life, see the articles "Organic Systems The Path Forward," and "Biodiversity in Land Management Integral to Sustainability," published in the *Pesticides and You* journal. In the meantime, it is critical to support organic.

SOURCE: Alejandra Martínez-Salinas, Adina Chain-Guadarrama, Natalia Aristizábal, Taylor H. Ricketts. 2022. Interacting pest control and pollination services in coffee systems. PNAS, 119 (15) e2119959119. https://doi.org/10.1073/pnas.2119959119; University of Vermont press release

BENEFITS OF NATURE | SEPTEMBER 9, 2022

Seeing the Value of Nature through Beavers, as Cattle Ranchers Benefit from These "Ecosystem Engineers"

One kind of solution to the biodiversity crisis that is likely not on most folk's bingo cards comes from a Nevada cattle rancher, who has shifted his relationship with . . . wait for it . . . beavers. As climate change impacts ramp up their toll in the U.S. via intensified droughts, floods, and wildfires, solutions are widely and eagerly sought, if deployed at insufficient pace. In this Nevada case, Agee Smith—unlike his rancher father, who reportedly "waged war against the animals, frequently with dynamite"—welcomes beavers and their industry on his ranch land. Doing so has yielded multiple benefits for his operation, the environment, and biodiversity. As reported by *The New York Times* (NYT),

"Mr. Smith has become one of a growing number of ranchers, scientists and other "beaver believers" who see the creatures not only as helpers, but as furry weapons of climate resilience."

Many landowners, of all stripes, consider beavers to be destructive "nuisance" animals that wantonly fell trees, and in so doing sometimes flood farm fields, back yards, roads, forests, or grazing acreage. Public complaints about such behaviors resulted in the federal government's killing of more than 25,000 beavers in 2021. Such "reduction" is conducted by the Wildlife Services division of the U.S. Department of Agriculture (USDA); the program targets some invasive species that are deemed to threaten ecosystems (e.g., feral hogs or the giant nutria, a swamp rodent). It also kills huge numbers of native species, such as beavers, coyotes, Canada geese, red-winged blackbirds, wolves, black bears, bobcats, foxes, deer, prairie dogs, and others.

In 2021, more than 400,000 native animals were decimated. *The Guardian* reports that in 2021, 1.75 million total animals were killed—an astonishing metric, but lower than in some years; in 2010 the figure was roughly five million; in 2018, the number was northward of 2.5 million. Among the techniques employed is use of noxious M-44 cyanide "bombs," which have resulted in the death of a child, the blinding of another, and deaths of non-target species, such as dogs, opossums, raccoons, a wolf, ravens, and skunks.

When peaceful coexistence just does not work out, advocates encourage relocation of the animals, rather than their destruction.

According to *The NYT*, experts say that when human–beaver conflict does arise, as it will inevitably sometimes, there are non-lethal solutions. For example, fencing and paint can protect specific trees from powerful beaver incisors. There are also devices that stealthily undo the creatures' handiwork via pipes that drain water from beaver settlements—even while the animals keep building. Wildlife advocates say that such tactics are actually highly effective, compared to killing the animals, because new beavers are likely to move into existing and desirable beaver habitat that has been vacated. When peaceful coexistence just does not work out, advocates encourage relocation of the animals, rather than their destruction.

Mr. Smith and some other landowners are seeing real benefits of their welcoming beavers on their land—many related to greater resilience to climate change impacts. The *NYT* reports on Mr. Smith's experience: "When Nevada suffered one of the worst droughts on record, beaver pools kept his cattle with enough water. When rains came strangely hard and fast, the vast network of dams slowed a torrent of water raging down the mountain, protecting his hay crop. And with the beavers' help, creeks have widened into wetlands that run through the sagebrush desert, cleaning water, birthing new meadows and creating a buffer against wildfires."

Beaver dams—constructed to create safe impoundment areas for their lodges—help store water (a real livestock and wildlife "lifesaver" during now-frequent droughts in the West), slow down its flow during heavy rains or rapid snowmelt, reduce erosion from torrential downpours, and help recharge groundwater. The persistent wetlands beavers sometimes create also store carbon, thus, keeping it out of the atmosphere. In addition, beaver activity keeps the surrounding landscape damper, reducing the risk of wildfire. And the cherry on the whipped cream on the sundae is that the beavers' work helps create new or restored habitat for myriad species, including fish, mammals, waterfowl, birds, amphibians, and insects. Plusses for the climate? Check. For biodiversity? Check. For Mr. Smith's hay and cattle? Check. We believe this is called a "win-win-win."

Not for nothing are these creatures considered by some to be consummate ecosystem/environmental engineers. Chris Jordan, PhD, of the National Oceanic and Atmospheric Administration Fisheries, and Emily Fairfax, PhD, of California State University Channel Islands wrote in early 2022: "It may seem trite to say that beavers are a key part of a national climate action plan, but the reality is that they are a force of 15–40 million highly skilled environmental engineers. . . . We cannot afford to work against them any longer. We need to work with them." California's Secretary of Natural Resources Wade Crowfoot sums up the sentiment: "We need to get beavers back to work. Full employment for beavers!" Beaver believer Agee Smith notes that welcoming beavers to work on his land has been one of his best decisions, adding, "They're very controversial still. But it's getting better. People are starting to wake up."

The Orianne Society, which advocates for the conservation of reptiles and amphibians and their ecosystems, describes "ecosystem engineers" well: "Ecosystem engineers are species that modify their environment in a significant manner, creating new habitats or modifying existing ones to suit their needs. Through their activities ecosystem engineers significantly affect other species by providing and maintaining microhabitats that would not otherwise exist. In fact, ecosystem engineers can often (but not always) be defined as keystone species, meaning that they play a critical role in their environments and affect many other species in the ecosystem. Ecosystem function and biodiversity would be significantly reduced without the presence of a keystone species. . . . The beaver is probably the most well-known example of a typical ecosystem engineer that also acts as a keystone species. Beavers cut down trees and build dams in small waterways, backing up water and creating beaver ponds. Beavers manipulate waterways for their own benefit, but these manipulations also provide habitat for many other species. Beaver dams and ponds also play important roles in many abiotic ecosystem processes (e.g., nutrient cycling and siltation). Without beavers to modify existing environments, these important wetlands would not exist and many species would be negatively affected."

The federal Bureau of Land Management (BLM) sees merit in the efforts to "employ" beavers to benefit the creatures themselves, as well as ecosystems and human interests.

However, river scientist Caroline Nash, PhD, who has done research on beaver-related restoration, emphasizes that human cooperation with the engineering activities of beavers should be deployed after case-by-case evaluation, asserting, "It's all about identifying those locations where beavers' survival interests align with humans' survival interests, and they're not always aligned. . . . [S]o suggesting that they're always going to be aligned is creating a recipe, I think, for broken hopes and expectations and a loss of trust."

The federal Bureau of Land Management (BLM) sees merit in the efforts to "employ" beavers to benefit the creatures themselves, as well as ecosystems and human interests. It is working with partners in Oregon, Wyoming, Utah, Montana, Nevada, Idaho, and Colorado to "seed" beaver-like dams that, it is hoped, beavers will inhabit and expand. California's state budget has earmarked roughly $1.5 million annually for restoration of beavers—for their roles in advancing climate resiliency and biodiversity.

As such efforts reference, the biodiversity crisis travels hand in hand with the climate crisis; the causes and solutions are necessarily interactive. And as noted in an article in the European Commission magazine, *Horizon*, "Climate change and biodiversity loss should be tackled together": "In a two-way process, climate change is one of the main drivers of biodiversity loss, but destruction of ecosystems undermines nature's ability to regulate greenhouse gas (GHG) emissions and protect against extreme weather, thus accelerating climate change and increasing vulnerability to it. This explains why the two crises must be tackled together with holistic policies that address both issues simultaneously and not in silos."

The chief causes of the significant global loss of biodiverse organisms are generally acknowledged to be changes in land use (largely for large-scale food production, such as the clearing of Amazonian rainforest land for cattle grazing); overexploitation of organisms for food, wood, and medicines (via hunting, fishing, and harvesting beyond sustainable boundaries); climate change; and chemical overuse (in nearly every sector of human activity, and pointedly, in agriculture) that harms organisms and their ecosystems.

[A brief sidebar on cattle: environment and food system advocates, including the World Wildlife Fund, have pointed repeatedly to the devastation caused by cattle ranching in the Amazon region, where 80% of the deforestation of the "lungs of the world" is caused by the beef cattle sector. Though this is by far the most dramatic example of the unsustainability of this livestock practice, the huge land area and water resources devoted to raising beef cattle in the U.S.—never mind the problematic waste and methane production associated with the CAFOS (concentrated animal feeding operations) on which most domestic livestock is raised—warrant a serious reconsideration of the role of this industry's commodity in the American diet.]

By their very nature, pesticides are designed to reduce biodiversity—to suppress any population seen as a threat to economic enterprise, human health, and/or human convenience. Beyond Pesticides laid out the case, a few years ago, for how pesticide use is ravaging, especially, insects (including many critical pollinators) and soil microorganisms, and their ecosystems and food sources, and how organic agriculture supports biodiversity.

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Indeed, the 2019 United Nation's (UN's) Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) report said that the species extinction rate is accelerating and that Nature, broadly, is declining at a rate "unprecedented in human history." The subheads of the comprehensive report are telling: "Current global response insufficient; 'Transformative changes' needed to restore and protect nature; Opposition from vested interests can be overcome for public good; [and] 1,000,000 species threatened with extinction."

IPBES Chair, Sir Robert Watson, commented at the report's release: "The health of ecosystems on which we and all other species depend is deteriorating more rapidly than ever. We are eroding the very foundations of our economies, livelihoods, food security, health and quality of life worldwide.... The report also tells us that it is not too late to make a difference, but only if we start now at every level from local to global."

There are efforts—in addition to rancher peacemaking with beavers—to restore diverse populations and habitats. In 2021, U.S. House Representatives Joe Neguse, Alan Lowenthal, and Jared Huffman reintroduced a resolution calling for a national biodiversity strategy. Rep. Lowenthal commented, "It is imperative that we work to correct this immediately — not only to protect the world's disappearing biodiversity but because the impacts to our environment and climate also impact our economies, human health, and our ability to live on this planet."

In June 2022, the U.S. House passed the *Recovering America's Wildlife Act* (RAWA), which would invest $1.397 billion per year in state, local and tribal efforts to help wildlife at risk. The Nature Conservancy (TNC) endorses this legislation, which is now in the hands of the Senate, saying that RAWA would "invest in time-tested, locally driven strategies to restore species and the ecosystems that sustain them." In addition, there is, according to TNC, much discussion of pairing this bill with one that would end the abuse of conservation easements for tax shelter purposes [—a favorite ploy of very wealthy landowners, including large corporations]. The bipartisan *Charitable Conservation Easement Program Integrity Act* would put a stop to these fraudulent actions and, in doing so, cover most of the cost of RAWA."

Early in President Biden's term, the administration announced a U.S. Interior Department initiative, 30 by 30, that joins the U.S. with 50 other countries in aiming to conserve 30% of each nation's land and water by 2030. A laudable goal, but the announcement of 30 by 30 underscores an inexplicable fact: the U.S. is the only United Nations (UN) member that has not ratified what is arguably the most important international treaty on biodiversity—the *UN Convention on Biological Diversity*. (See a list of signatories, as well as of those countries that have ratified the treaty, here.)

As reported by *Vox*, the U.S. helped craft the treaty, and signed on to it in 1993, but for nearly three decades, "Republican lawmakers have blocked ratification, which requires a two-thirds Senate majority. They've argued that CBD would infringe on American sovereignty, put commercial interests at risk, and impose a financial burden, claims that environmental experts say have no support." Environmental advocates assert that the U.S. refusal to ratify the treaty causes real harm to biodiversity efforts when, never more than now, the crisis makes them imperative.

What to do: The need for action on protecting Nature's creatures and habitats could not be more urgent. The International Union for the Conservation of Nature (IUCN) quotes UN Secretary-General Antonio Guterres's pithy assessment: "*Making peace with nature is the defining task of the 21st century, it must be the top, top priority for everyone, everywhere.*"

Beyond Pesticides continues to do its part in bringing this issue forward, including through the second session of the 2022 National Forum Series: Meeting the Health, Biodiversity, and Climate Crises with a Path for a Livable Future. The plenary sessions for that day focus on various topics on the biodiversity crisis and solutions. We call attention particularly to the presentation of Lucas Garibaldi, PhD, who is a member of IPBES and contributed to its most recent report. He is also co-chair the Transformative Change Assessment for the Convention on Biological Diversity (CBD); the group is tasked with identifying options for achieving the CBD 2050 vision for biodiversity. Please watch this important series on addressing the related and growing biodiversity, climate, and health crises.

SOURCE: Einhorn, Catrin. 2022. It Was War. Then, a Rancher's Truce With Some Pesky Beavers Paid Off. *The New York Times*. 2022

INERT INGREDIENTS HARM POLLINATORS | APRIL 21, 2022

Literature Review Adds to the Growing Evidence that Inert Ingredients Are Toxic to Pollinators

A literature review published in Royal Society finds that 'inert' ingredients' in pesticide formulations adversely affect the health of bees and other wild pollinators. Inert ingredients, also known as "other" ingredients, and not disclosed by name on pesticide product labels, facilitate the action of active ingredients targeting a specific pest. Although both ingredients have chemical and biological activity, most studies on agricultural chemical toxicity focus on the active ingredient, assuming that inert ingredients are "nontoxic." The U.S. Environmental Protection Agency (EPA), in regulating pesticides, assesses the toxicity of individual active ingredients on bees through various testing methods. However, there are no requirements for EPA to test inert ingredients to the same degree, despite evidence demonstrating these chemicals harm pollinators. Moreover, EPA does not require pesticide manufacturers to disclose to the public the inert ingredients used in any product as the information is considered proprietary.

Both wild and commercial bees and other pollinators encounter multiple stressors, including pesticides, parasites, and poor nutrition, that act together to increase the risk of bee mortality. Therefore, reviews like these highlight the need for pesticide testing to consider the effects of all product ingredients, regardless of perceived toxicity. The researchers caution, "We argue that 'inert' ingredients have distinct, and poorly understood, ecological persistency profiles and toxicities, making research into their individual effects necessary. We highlight the lack of mitigation in place to protect bees from 'inert' ingredients and argue that research efforts should be redistributed to address the knowledge gap identified here. If so-called 'inert' ingredients are, in fact, detrimental to bee health, their potential role in widespread bee declines needs urgent assessment."

In conducting a systemic literature review of studies regarding the effects of inert ingredients on bee health, researchers find no empirical evidence that inert ingredients are nontoxic, despite that often being the assumption. There are only 19 studies that test the effects of inert ingredients on bee health. The results demonstrate that multiple exposure routes act in conjunction and synergistically with other stressors (e.g., disease, climate, habitat destruction, etc.) to cause bee mortality with colony-level consequences.

The United Nations states that 75 percent of the 115 top global food crops depend on insect pollination, with one-third of all U.S. crops depending on pollinators, according to the U.S. Department of Agriculture (USDA). However, research finds that many insect populations are declining, including managed and wild pollinators, mainly due to habitat fragmentation, climate change, and extensive pesticide use. There are various classes of bee-toxic pesticides, such as neonicotinoids, sulfoxaflor, pyrethroids, fipronil, and organophosphates. Research shows that residues from neonicotinoids (including seed treatments) and sulfoxaflor accumulate and translocate to pollen and nectar of treated plants, increasing the potential risk and indiscriminate poisoning to pollinators. Both pyrethroids and fipronil impair bee learning, development, and behavioral function, reducing survivability and colony fitness. However, inert ingredients in these products cause similar or more severe impacts on bee populations, such as disruption in bee learning behavior through exposure to low doses of surfactants. With the global reliance on pollinator-dependent crops increasing over the past decades, a lack of pollinators threatens food security and stability for current and future generations.

The study finds only 19 studies investigate the effects that inert ingredients have on pollinator health, despite the fact that inerts typically make up most of the ingredients in pesticide formulations, up to 99 percent in some cases. Although manufacturers claim inert ingredients, including surfactants, emulsifiers, and other co-formulants, do not harm target pests like active ingredients, inerts can be even more toxic than active ingredients, as these chemicals magnify the effects of active ingredients, sometimes as much as 1,000-fold. Moreover, inert ingredient exposure can occur through many routes, impacting both target and nontarget species. One of the most hazardous ingredients in the commonly used herbicide Roundup, polyoxyethylene tallow amine (POEA), is a surfactant classified as an inert and therefore not listed on the product label. However, researchers find that POEA can kill human cells, particularly embryonic, placental, and umbilical cord cells. Therefore, it is essential for agencies to require manufacturers to disclose inert ingredients to limit adverse health effects in the ecosystem, especially among nontarget species.

This is not the first research to cite inert ingredients as dangerous to pollinators. Inert ingredients in pesticide mixtures, like N-methyl-2-pyrrolidone and Slygard 309 (surfactant), increase baby bee mortality and honey bee susceptibility to deadly viruses. The latest concerning news on inert ingredients revolves around widespread findings that PFAS chemicals contaminate pesticide products. A 2017 study detected PFAS chemicals in bee hives, with another study indicating PFOS (a certain type of PFAS chemical) can increase honey bee mortality and halt brood development.

Although evidence suggests inert ingredients are the primary culprit of pollinator decline, scientists maintain that agency assessments should not disregard the impacts that active ingredients have on pollinator health. A 2018 study found that technical grade (pure) glyphosate disrupts honey bee microbiota, with sublethal effects on honey bee navigation and foraging success. Moreover, science accumulated over the last decade and a half demonstrates that neonicotinoids, and the multitude of pollinator-toxic pesticides, are critical factors in the cause of pollinator declines. Federal law, under the *Federal Insecticide, Fungicide, and Rodenticide Act*, protects as proprietary information on inert ingredients specific to pesticide products, unless the EPA Administrator determines there is a public health issue.

The study concludes, "Evidence of 'inert' ingredients having the potential to cause mortality in bees dates back to the 1970s, yet in the EU and U.S., there is still no regulatorily mandated toxicity testing of 'inert' ingredients. This means that the only currently available research stream is academic testing, which accounts for the small number of studies to date. As a result, this represents a large gap in our understanding of pesticide ecotoxicology. The research collated here demonstrates that 'inert' ingredients are not inert and can pose significant risks to bee health. We call on researchers to devote more attention to 'inert' ingredients and regulators to require testing of 'inert' ingredients to ensure their safety to bees."

As has been widely reported, pollinators (such as bees, monarch butterflies, and bats) are a bellwether for environmental stress as individuals and as colonies. Pesticides intensify pollinators' vulnerability to health risks (such as pathogens and parasites) with pesticide-contaminated conditions limiting colony productivity, growth, and survival. However, ending toxic pesticide use can alleviate the harmful impacts of these chemicals on species and ecosystem health. Beyond Pesticides captured the bigger picture in its introduction to its 2017 annual Pesticide Forum, *Healthy Hives, Healthy Lives, Healthy Land*: "Complex biological communities support life."

What to do: To find out more about what you can do to protect bees and other pollinators, check out information on the BEE Protective Campaign, pollinator-friendly landscapes, pollinator-friendly seeds, pesticide-free zones, bee-friendly habitats, and what you, or your state elected officials can do to protect our pollinators. For more information on the insect apocalypse, see the Beyond Pesticides article in our *Pesticides and You* journal, "Tracking Biodiversity: Study Cites Insect Extinction and Ecological Collapse."

Furthermore, buying, growing, and supporting organic agriculture can help eliminate the extensive use of pesticides in the environment. Organic land management eliminates the need for toxic agricultural pesticides. For more information on how organic is the right choice for consumers and the farmworkers who grow our food, see the Beyond Pesticides webpage, Health Benefits of Organic Agriculture. With Earth Day tomorrow, get ready to grow your spring garden the organic way by Springing Into Action, pledge to eliminate toxic pesticide use by signing the Ladybug Love Pledge and follow up with other actions.

SOURCE: Michelle Z Hotchkiss, Alexandre J Poulain, Jessica R K Forrest, Pesticide-induced disturbances of bee gut microbiotas, *FEMS Microbiology Reviews*, Volume 46, Issue 2, March 2022, fuab056, https://doi.org/10.1093/femsre/fuab056

MULTIGENERATIONAL EFFECTS TO BIRDS | SEPTEMBER 8, 2022

Ingestion of Real-World Pesticide Residues in Grain Threatens Birds' Offspring More than Parents

A study published in *Environmental Pollution* finds parental exposure to real-world, sublethal concentrations of pesticide residues on grains is a major contributor to unfavorable offspring development among foraging birds. Parents' ingestion of grains with conventional pesticide residues, whether from contaminated or pesticide-treated seeds, results in chronic exposure that adversely affects offspring health, even at low doses.

The adverse effects pesticides and other environmental pollutants have on birds are amply documented and researched. Although many studies evaluate acute or chronic health implications associated with pesticide exposure in a single generation, there is a lack of information on multigenerational impacts that can provide vital information on the fundamental survivability or fitness of bird species. Considering this study emphasizes parental exposure to environmental pollutants can have adverse consequences for future generations, it is necessary that future risk assessments for birds address these implications when implementing agricultural pesticide policies. The study notes, "[S]ublethal effects of such compounds [pesticides] on non-target species should be included in the regulation. Moreover, as agroecosystem pollution is not resulting only from pesticides, there is an urgent need to analyze cocktail effects, not only between molecules of pesticides but also between pesticides and other pollutants such as heavy metals."

The study considers the impact that mixtures of different pesticide residues at environmentally relevant levels have on foraging birds, specifically the grey partridge. Researchers fed 24 breeding pairs of birds grain from conventional agriculture containing pesticide residues and organic grains without pesticide residues as a control. The diet of grains mimics that of food availability encountered by wild birds in the environment. The researchers assess how the consumption of grain with pesticide residue impacts offspring growth and health through parental effects upon reproduction. The results demonstrate that while grains with pesticide residues fed to parent birds do not affect their current health (body mass index, red blood cell count, energy conversion) or egg-laying abilities, they do affect the birds' offspring. Researchers find that ingestion of low pesticide residues in grain has consequences on reproduction and offspring quality without altering mortality. Chicks whose parents consume grains with pesticide residues are more petite in size, lack proper skeletal growth, and have lower red blood cell counts with increasing body mass index as a trade-off.

Inheritance of genetic dysfunction relating to hereditary influence on gene expression is a familiar phenomenon. Various studies note that adverse genomic alterations can phase down to future generations. As far back as 15 years ago, a Washington State University study linked pesticide exposure to multigenerational impacts on male fertility in rodents. More recently, researchers found that glyphosate (patented as an antibiotic) has adverse multigenerational effects, causing negligible observable impacts on pregnant rodents, but severe effects on the two subsequent generations, including reproductive (prostate and ovarian) and kidney diseases, obesity, and birth anomalies. New findings suggest exposure to the pesticide atrazine causes multigenerational resistance to the chemical in wasps by altering gut bacteria composition. Even banned pesticides like DDT still impact current and future generations, as the chemical (and subsequent metabolites) can cause multigenerational cancer, multigenerational obesity, and generational reproductive abnormalities via endocrine disruption. Moreover, chemical byproducts made during the pesticide manufacturing process, such as dioxin, have multigenerational consequences on reproductive health.

This study is one of the few to evaluate current levels of multiple pesticide residues in the ecosystem and their potential impact on birds in the wild. However, plenty of research demonstrates the toxicity pesticides pose to bird populations. As far back as 2013, the American Bird Conservancy published a report finding that just a single kernel of neonicotinoid (neonic)-coated corn is toxic enough to kill a songbird, highlighting the acute toxicity of pesticides on bird declines. A 2017 study found that neonicotinoids can disrupt songbird migration, making it more likely that a bird will die during its perilous migration route.

As confirmed in a 2019 study, pesticides like neonics usually are not killing migratory birds outright. Instead, exposure to these pesticides precipitates a cascade of sublethal impacts that reduces songbird fitness in the wild, making them more likely to die or be killed. Thus, this study reflects similar consequences among many foraging bird species, cautioning, "The consequences of parental exposure on chicks might partly explain the decline in wild Grey partridge populations, which raises questions for avian conservation and demography if current ARGOSystems approaches are continued."

Identifying pesticide residues on grain as a source of pesticide exposure is relevant when assessing the future risks pesticides impose on bird species. In addition to toxicity exposure, improper control regulations, poor manufacturing, and high application variability make pesticide residues problematic. The data from this study has implications for many bird species exposed to toxic chemicals at environmentally relevant levels.

What to do: Beyond Pesticides believes that we must eliminate pesticide use to mitigate the multigenerational impacts these chemicals pose on human and animal health. Therefore, future policy decisions on related pesticides should advocate for formidable safeguards on the agrochemical industry that ensure the ecosystem is safe from chemical hazards. In doing so, we can shift away from unnecessary reliance on pesticides. Adopting regenerative-organic practices and using least-toxic pest control can reduce harmful exposure to pesticides. Switch to organic to reduce wild birds' exposure to toxic pesticide residues and replace pesticide-treated seeds with organic seeds from Beyond Pesticides' organic seed directory. Learn more about pesticide-treated seeds and their harm by viewing Seeds that Poison. To see how you can protect your local bird population, learn more about pesticides' impact on birds and how an organic diet can help eliminate pesticide exposure.

SOURCE: Agathe Gaffard, Olivier Pays, Karine Monceau, Maria Teixeira, Vincent Bretagnolle, Jérôme Moreau, Feeding on grains containing pesticide residues is detrimental to offspring development through parental effects in grey partridge, Environmental Pollution, Volume 312, 2022, 120005, ISSN 0269-7491, https://doi.org/10.1016/j.envpol.2022.120005

AQUATIC ECOSYSTEMS THREATENED | SEPTEMBER 23, 2022

Neonicotinoid Insecticides Keep Poisoning California Waterways, Threatening Aquatic Ecosystems

According to a September 15 Environment California press release, California Department of Pesticide Regulation (CDPR) data confirm more bad news on neonicotinoid (neonic) contamination: nearly all urban waterways in three counties show the presence of the neonic imidacloprid at levels above the U.S. Environmental Protection Agency's (EPA's) chronic benchmark for harm to aquatic ecosystems; in five other counties, well over half show its presence at similar levels. Neonic use is strongly correlated with die-offs and other harms to a variety of bees and pollinators, and to other beneficial organisms. These startling metrics will make the state's efforts to protect such organisms even more challenging, according to Environment California (EC). See Beyond Pesticides' *Poisoned Waterways* report for a deep dive on neonics and their impacts in U.S. rivers, lakes, and streams.

The data represent 405 surface water samples taken between 2000 and 2020; those from urban waterways

in Los Angeles, Orange, and San Diego counties show that nearly 92% are contaminated at EPA benchmark violative levels; in Alameda, Contra Costa, Placer, Sacramento, and Santa Clara counties, 58% of waterways show such levels. Many of the counties with significant contamination are in the central coast and southern regions of the state. Some of this contamination no doubt comes from intensive agricultural use of imidacloprid, causing migration of the compound into waterways, but some may also be from nonagricultural uses—such as flea prevention for pets and building pest control products—common in developed urban areas. According to CDPR, there are 253 pesticide products containing imidacloprid registered for use in California.

Environment California's webpage hosts an interactive map of sampling sites (across much of the state) that are represented in those imidacloprid metrics. The percentage of samples from each location that contains the compound range from 0 to 91.67. The EC page notes that "very few samples were tested for imidacloprid prior to 2010. . . . [and that] the percentage of samples that detect imidacloprid remains fairly constant over time." Detailed results can be found in CDPR's Surface Water Database.

The 2017 Beyond Pesticides report mentioned above cites similarly alarming results in another of the state's waterways a decade ago: "A 2012 [CDPR] study using 2010 and 2011 surface water monitoring data from three agricultural regions in the state finds imidacloprid in 89% of the samples collected. . . . In the three agricultural regions studied, imidacloprid was detected in 85% of samples in Salinas, 93% in Imperial Valley, and 100% in Santa Maria Valley. These levels exceed currently established chronic aquatic benchmark concentrations."

No matter how they are deployed, neonics are systemic pesticides, meaning that plants germinate from coated seeds and/or take up the applied compound through their roots, after which it permeates the entire plant. This makes the plant's pollen, nectar, guttation droplets, and fruits toxic to creatures that feed on them.

Neonicotinoids (such as imidacloprid, acetamiprid, thiamethoxam, clothianidin, and dinotefuran) are a family of insecticides that harm the central nervous systems of insects and can paralyze or kill them, as well as have deleterious effects on baby bee brains. They are used as foliar sprays, plant root drenches, and granules to kill or render impotent a variety of pests—particularly sap-feeding insects, such as aphids, and root-feeding grubs. But a very significant vector for these compounds is through seed coatings, often for commodity crops (e.g., corn, soy, cotton). Ironically, years ago EPA released a report concluding that neonic seed coating provides little or no overall benefit in controlling insects or improving yield or quality in soybean production.

No matter how they are deployed, neonics are systemic pesticides, meaning that plants germinate from coated seeds and/or take up the applied compound through their roots, after which it permeates the entire plant. This makes the plant's pollen, nectar, guttation droplets, and fruits toxic to creatures that feed on them. Nontarget organisms, such as birds, bees, butterflies, and bats, are poisoned when they forage among such contaminated plants. In addition to insects' exposures through foraging for food, it turns out that soil contaminated by neonics can also harm ground-nesting bees.

Neonics can persist over long periods of time in soils and are highly water soluble; thus, they can be transported via rain and/or irrigation systems into groundwater and waterways. They are detected regularly in sampling of the nation's waterways at concentrations that exceed acute and chronic toxicity values for sensitive organisms (as laid out in Beyond Pesticides "deep dive" report). Through a 2017 risk assessment, EPA found that "[C]oncentrations of imidacloprid detected in streams, rivers, lakes and drainage canals routinely exceed acute and chronic toxicity endpoints derived for freshwater invertebrates." Imidacloprid, one of the oldest neonics in commercial use, is especially persistent in aquatic environments and does not biodegrade easily; its half-life in water is generally longer than 30 days.

The neonic contamination of waterways—in California and across the nation—is very concerning because these compounds pose serious threats to keystone aquatic organisms, and can result in a complex, cascading impact on ecosystems. Aquatic insects and crustaceans are highly sensitive to neonicotinoids; the mayfly, a keystone species, has been identified as the most sensitive.

As Beyond Pesticides' *Poisoned Waterways* report notes, "Impacts on aquatic invertebrates can have cascading effects on food webs and healthy ecosystem function. [Even] low-level, sublethal exposures can result in decreases in species abundance, altered predator-prey relationships, [and] reduced water filtration and nutrient cycling." In addition, it points out that current federal aquatic life benchmarks for neonics may underestimate the risks: standard test organisms used by EPA to establish these benchmarks are, by orders of magnitude, more tolerant of neonicotinoid exposure than other vulnerable species.

Beyond impacts on aquatic life, terrestrial insects, pollinators, birds, and bats, neonics—touted by the agrochemical industry as safe for mammals—nevertheless are associated with a host of human health issues, including reproductive and endocrine system harms; possible renal, hepatic, developmental, and neurological damage; and possibly, indirect carcinogenic impacts related to the endocrine system.

Beyond impacts on aquatic life, terrestrial insects, pollinators, birds, and bats, neonics nevertheless are associated with a host of human health issues.

In response to this new CDPR dataset, Environment America's Conservation Program Director Steve Blackledge commented, "Every Californian knows the importance of having access to safe, clean water. Neonics like imidacloprid are causing harm not only to our pollinators and birds on land but also to our aquatic wildlife. Neonics are also being found in our bodies and despite being framed as 'mammal-safe,' recent research suggests that neonic exposures may increase the risk of developmental and neurological harms."

EPA has been extremely negligent in taking protective action against the neonic family of insecticides. Indeed, in March 2022, Beyond Pesticides covered its draft decisions on the registration review of five neonics: imidacloprid, dinotefuran, clothianidin, thiamethoxam, and acetamiprid. The organization wrote then, "Despite the agency's own findings of evidence of serious threats to pollinators, aquatic invertebrates, and other wildlife, it issued interim decisions on these neonics . . . that disregard the science on the pesticides' impacts. EPA appears to be prepared to finalize these registrations. . . . [T]his would, barring further action, extend the use of these harmful compounds *for 15 years*." The schedule for the review processes for these compounds can be found here.

California legislators have passed a "Save the Bees Bill," Assembly Bill 2146, which currently awaits the governor's signature. [Update: Governor Gavin Newsom vetoed the bill on September 28, pointing to ongoing regulatory review of neonics.] The bill aims to end nonagricultural uses of neonics on lawns, golf courses, and home gardens, beginning in 2024. News outlet KSBW8 has opined that if signed, the enacted law "could significantly impact the Central Coast and its agriculture." No doubt this would also be true for other regions, watersheds, and waterways in the state.

Environment California is encouraging Governor Gavin Newsom to sign the bill ASAP. Said the organization's state director, Laura Deehan, "We want to make California the next state, and the largest, to take this important step. The bill already passed through the Legislature, so we're now urging Gov. Newsom to sign the bill into law. We must prioritize the preservation of our pollinators over the short-term convenience of massive pesticide use."

What to do: Beyond Pesticide agrees that Governor Newsom should sign this bill, which would enact some protections in the state against the ravages of neonic use. We encourage readers who live in California to contact the governor to advocate for his signature: 916.445.2841 or via the state website. Other states, localities, and entities have taken action to restrict uses of this class of pesticides, including Maine, Maryland, Massachusetts, Vermont, New York, New Jersey, Portland, Oregon, and Emory University. At the federal level, it is imperative that EPA create much stronger regulation of neonics—a ban being the most protective of organisms, ecosystems, public health, and water resources.

SOURCE: Environment California. Pesticide linked to bee die-offs found in California's urban waterways. 2022

CONTAMINATED SEDIMENT HARMS WATER RESOURCES | OCTOBER 4, 2022

Pesticides in Sediment Contribute to Secondary Source of Chemical Pollution in Aquatic Environments

A study published in *Environmental Pollution* finds pyrethroid insecticides contribute to a secondary source of contamination in water resources. Various pyrethroids, including bifenthrin, are detectable in urban catch basins (storm drains) that collect runoff water before draining into the open environment. There is a lack of information regarding the pesticides' presence in urban catch basins. However, pesticide contamination in water resources is historically commonplace and widespread throughout U.S. rivers and streams, with at least five different pesticides present in 90 percent of water samples.

Moreover, thousands of tons of pesticides not only enter waterways (e.g., rivers, streams, lakes, oceans) around the U.S. through urban catch basins, but agricultural and nonagricultural sources as well, contaminating essential drinking water sources, such as surface water and groundwater.

During time frames when pesticide inputs decrease, all pyrethroid residues remain suspended in catch water basin soils, contributing to a secondary source of aquatic ecosystem contamination.

Reports like these are essential for determining appropriate regulatory action to protect human, animal, and environmental health from chemical contamination, especially if it is highly detectable. The study notes, "The high detection frequency of bifenthrin and overall pyrethroid concentrations, especially for particle-bound residues, suggest that underground urban catch basins constitute an important secondary source for extended and widespread contamination of downstream surface waters by pesticides such as pyrethroids in urban regions."

The urban areas contain underground catch basins responsible for collecting runoff for drainage into waterways. Pesticides contaminate runoff into these catch basins, implicating a secondary source of contamination in aquatic environments. Thus, the researchers gathered several water samples from urban underground catch basins throughout various U.S. California regions. (The samples emphasize the occurrence and profile of pyrethroid insecticides during the spring, summer, and fall.) Overall, the study finds that 98 percent of water samples contain detectable levels of pyrethroids. Of the individual pyrethroids, bifenthrin is the most detectable pyrethroid occurring in 97 percent of water samples, while the pyrethroid fenpropathrin is undetectable in samples. In addition to the highest detection frequency, bifenthrin also causes severe toxicity to sensitive aquatic invertebrates in 89 percent of samples. However, during time frames when pesticide inputs decrease, all pyrethroid residues remain suspended in catch water basin soils, contributing to a secondary source of aquatic ecosystem contamination.

Synthetic pyrethroids are toxicologically similar derivatives of naturally occurring pyrethrins, which have dramatically shorter half-lives and extreme sensitivity to light, heat, and moisture. These insecticides can irritate the eyes, skin, and airways, causing high acute toxicity symptoms (e.g., asthma, incoordination, tremors, and convulsions) depending on the chemical formula. However, these chemicals also have links to chronic health problems from developmental and endocrine disruption adversely affecting reproduction and sexual development to immune system dysfunction and increased chances of cancers. Moreover, synthetic pyrethroids are extremely toxic to aquatic organisms, including crustaceans, fish, and macro/microorganisms responsible for ecosystem function and services.

While synthetic pyrethroids pose significant dangers to the environment and human health, there is growing evidence that "inert" ingredients are causing just as much harm or more harm than the active ingredients in pesticide products. Toxic pesticide products can remain in the environment for months, years, and even decades. As the number of pesticides in waterways increases, it has detrimental impacts on aquatic ecosystem health, especially as some chemicals work synergistically with others to increase the severity of the effect. In addition to adverse health effects on marine organisms, these chemicals harm terrestrial organisms relying on the surface or groundwater. Additionally, disease vector pests like ticks and mosquitoes are developing resistance to chemical treatments, prompting the augmented use of chemical control methods, including the addition of toxic synergists like piperonyl butoxide (PBO), known to cause and exacerbate adverse health effects from exposure.

The study highlights how pervasive pyrethroids are in waterways and how these chemicals contribute to secondary chemical pollution through sediments. Pyrethroids are hydrophobic (do not mix with water) and accumulate in soils/sediments in aquatic environments.

Synthetic pyrethroids are toxicologically similar derivatives of naturally occurring pyrethrins, which have dramatically shorter half-lives and extreme sensitivity to light, heat, and moisture.

Soils/sediments can have anaerobic conditions lacking oxygen and slowing the degradation rate of pyrethroids, prolonging their persistence in the ecosystem. Thus, high levels of pyrethroid contamination impair invertebrate communities within sediments. However, this study is not the first to highlight the pervasiveness of pesticide compounds in ecological resources. Previous reports demonstrate the pervasiveness of pesticides, including pyrethroids, in urban watersheds and other waterways and resources from agricultural, household, and community insecticide treatments and pet spray runoff. Moreover, the ubiquity and persistence of certain compounds make it difficult to limit the number of toxicants that enter waterways. Many of the most commonly used pesticides in the U.S. are detectable in both surface and groundwater, which serve as drinking water sources for half of the U.S. population, raising another issue of deficient waterway monitoring and regulations that allow pesticides to accumulate in waterways.

The study concludes, "To improve understanding of pesticide behaviors in urban catch basins and USDSs [underground storm drains systems], further research should characterize runoff before and after it passes through a catch basin, the hydraulic retention of both water and solids in catch basins, and release of water and suspended solids from catch basins into the rest of the USDS. Efforts to design catch basins with reduced contaminant accumulation potential, and pest management practices to prevent the transport of pesticide residues from entering USDSs and catch basins, should be further explored."

What to do: Beyond Pesticides has long advocated for healthier and more environmentally friendly pest management practices to protect the environment and wildlife, particularly water resources. Therefore, toxic pesticides should be phased out and eliminated to protect the nation's and world's waterways and reduce the number of pesticides that make their way into your drinking water. Additionally, Beyond Pesticides has long advocated for regulations that consider potential synergistic and additive threats, to ecosystems and organisms, from admixtures of pesticides —whether in formulated products or "de facto" in the environment. However, advocating for local and state pesticide reform policies can protect you and your family from pesticide-contaminated water. Furthermore, organic/regenerative systems conserve water, nurture fertility, reduce surface runoff and erosion, reduce the need for nutrient input, and eliminate the toxic chemicals that threaten many aspects of human and ecosystem life, including water resources. For more information about pesticide contamination in water, see the Threatened Waters program page and Beyond Pesticides' article Pesticides in My Drinking Water? Individual Precautionary Measures and Community Action.

SOURCE: Nathan D. Sy, Sarah S. Wheeler, Marcia Reed, Eric Haas-Stapleton, Trinidad Reyes, Mir Bear-Johnson, Susanne Kluh, Robert F. Cummings, Tianyun Su, Yaxin Xiong, Qingyang Shi, Jay Gan, Pyrethroid insecticides in urban catch basins: A potential secondary contamination source for urban aquatic systems, Environmental Pollution, Volume 314, 2022, 120220, ISSN 0269-7491, https://doi.org/10.1016/j.envpol.2022.120220.

WEED KILLER DESTROYS SOIL LIFE | NOVEMBER 11, 2022

Weed Killer Use Destroys Soil Life and Ecosystems, Paper Finds

A paper published in *Trends in Ecology & Evolution* in late October sounds an unnerving alarm about the globally ubiquitous use of herbicides and the ecological destruction being caused. It asserts that widespread environmental contamination with these herbicide compounds is influencing soil, plant, and animal microbiomes in ways that are not only not well understood, but also can have significant impacts on the functioning of organisms and their ecosystems—with evolutionary implications. Impacts of herbicides on microbiota in soils include, for example, those on nutrient cycling, and altered organism and plant performance, which can affect pollination and animal consumption of plants. This research reinforces what Beyond Pesticides wrote in covering a 2021 study: "The popular herbicide glyphosate negatively affects microbial communities, indirectly influencing plant, animal, and human health. Exposure to sublethal concentrations of glyphosate shifts microbial community composition, destroying beneficial microorganisms while preserving pathogenic organisms."

Herbicides are a category of pesticide used to control weeds in agriculture and commercial forests, on managed landscapes, byways, gardens, and lawns, and directly on surface waters to control aquatic weeds. They are designed to kill "target" plant species considered undesirable in any of those circumstances. Herbicide use has exploded in the past two decades, in large part due to the advent of the agro-biotech industry's deployment of genetically modified, herbicide-tolerant crop seeds that pair with herbicide use.

This increased use has ramped up the development of weeds' resistance to multiple herbicides. Glyphosate formulations (including the infamous Roundup) are the most commonly used, in agriculture, horticulture, silviculture, and urban environments. In the aggregate, glyphosate contributes mightily to global environmental contamination; other widely used herbicides include [triazines (e.g., atrazine), acetochlor and metolachlor, paraquat, and dicamba. Residues of herbicides are found in soil, water, non-target plants, animals, and humans, and are associated with pollinator and insect declines and biodiversity losses, compromise of other organisms (including keystone species), ecosystem dysfunction, and human health anomalies.

The study authors also note that adjuvant, "inert" ingredients in herbicide formulations can sometimes be even more toxic to nontarget organisms than the active ingredients themselves, and that in the U.S., such co-formulants are not required to be tested for toxicity to nontarget organisms. To make matters worse, information about such adjuvants is usually considered "proprietary" and therefore, is not shared with regulators or the public. Beyond Pesticides has covered this "inert" ingredient phenomenon.

If present patterns persist, the use of herbicides is predicted, by *BusinessWire*, to increase annually by 2–3% through 2025. Most of that increase is expected in the agricultural sector because of (1) increasing resistance to herbicides by weed species, (2) an increase in agricultural intensity in Central and South America and the Asian/Pacific region, and (3) the ongoing development of new herbicide formulations (in part because of #1) and "herbicide use education" in developing markets.

Though herbicides are designed for target species, they also expose nontarget plants, animals, humans, and ecosystem function to risks. This study focuses on the compounds' effects on microbiota in flora, fauna, and soils. The authors assert that, "While many herbicides were initially considered safe for non-target taxa, as their mechanism of action was thought to be absent in these organisms, it has been understood only recently that herbicides may have profound effects on non-target taxa via alterations of microbial communities and microbial function in soil, plants, and animals. Given the imperative role of microbes in driving eco-evolutionary adaptations since the origin of life, and that microbes and their hosts comprise coevolving, multipartite entities [known as holobionts], a comprehensive understanding of the risks associated with altered microbiomes is needed." (A holobiont is an assemblage of a host and the many other species living in or around it, which together form a discrete ecological unit through symbiosis.)

The assumption that herbicides would be safe for nontarget taxa was based on the idea that their modes or mechanisms of action—how the compounds actually work to kill or disable weeds—were lacking in nontarget organisms. More-recent research has shown, however, that these compounds' mechanisms of action can have profound effects on the microbial communities harbored by nontarget organisms. These communities, or microbiota, are present in all living things and are critical to healthy organism function—and to optimal immune response in particular, a primary task being the control of pathogens. When herbicides damage or kill a plant or animal's resident microbes, they alter the organism's ability to execute this protective function.

The study identifies classes or modes of action for a host of herbicide active ingredients, including whether they act directly or indirectly on microbiota, and their respective effects on soil, plant, or animal microbiomes. Among the modes (and sample compounds) that have direct impacts on microbes are:

- ACC (acetyl-CoA carboxylase) inhibitors (e.g., diclofop-methyl, haloxyfop)
- ALS (acetolactate synthase) inhibitors (sulfonylureas, triazolopyrimidines)
- EPSPS (5-enolpyruvylshikimate-3-phosphate synthase) inhibitors in the shikimate pathway (glyphosate)
- glutamine synthetase inhibitors (glufosinate)

Effects on resident microbiomes include those that damage microbes' role in nutrient cycling, compromise immune response, alter soil carbon and phosphorous dynamics, and degrade population levels.

The mechanisms that exhibit indirect impacts, including on cellular metabolism and hormone synthesis, are auxin-like herbicides (2,4-D, dicamba); photosystem (related to photosynthesis) inhibitors (triazines, paraquat, diphenyl ether); and gibberellin (plant hormone that stimulates stem elongation, germination, and flowering) inhibitors (acetochlor, metolachlor, pendimethalin). The indirect impacts on microbiota include those that degrade bacterial diversity, erode microbial community structure, and disable nitrogen-fixing bacteria.

Herbicides alter microbial communities through multiple pathways; factors that influence such alterations include differing vulnerability to the compounds across microbe type; some microbes' utilization of herbicides as nutritional sources; and functional changes that can cascade to have "community-wide" impacts. An example of that last is that healthy microbiomes exhibit successful, long-term self-regulation; herbicide exposures can have damaging effects on that ability.

Soil- and root system–associated microbes are critical to functioning ecosystems, and herbicides' impacts on them depend on several elements: the compounds' chemical composition and mode of action, soil health, and climate, among others. The dynamics of herbicides in soil microbiota are complex, and thus, can be hard to predict. Examples the study cites are these: "Glyphosate negatively affects shikimate pathways present in the majority of microbes, but their genetic resistance to glyphosate varies. Therefore, some of the resistant and glyphosate-degrading microbes that can use glyphosate as a nutrient source may become prevalent in the microbial community. . . . Similarly, in some environments atrazine may not affect the overall microbial community, while in other environments it can decrease soil microbial biomass or increase atrazine-degrading bacteria due to strong selection favoring them, thus leading to atrazine degradation." (The shikimate pathway is one of many physiological pathways that impact plant defense and signaling chemistry.)

The study concludes that the ecological and evolutionary consequences for microbial soil communities are poorly understood and require further research. But the authors posit that other research has demonstrated a negative correlation between pesticide use and (1) beneficial soil- and root-associated microbes, and (2) herbicide-modulated nutrient cycling.

The team also asserts that herbicide residues can cause disruptions in dynamic relations between mycorrhizal fungi and their associated plant communities, and reduction in abundance of nitrogen-fixing bacteria. They note: "As many plant traits, including growth, phenology, and resistance to abiotic stressors and pathogens, are modulated by rhizosphere microbiome, changes in rhizosphere composition and functioning are likely to be reflected in host fitness and growth. . . . [S]ublethal doses of glyphosate [for example] can potentially disrupt virtually all plant above-ground interactions with other coevolving organisms, such as pathogens, plant-mutualistic microbes, herbivores, and pollinators."

The study also points to deleterious impacts on animal gut and skin microbiomes, which play important roles in digestion, pathogen management, and neurobehavioral coordination. Glyphosate, the paper notes, "has been shown to increase pathogenic and decrease symbiotic bacteria, which may affect the susceptibility of bees to viral and fungal pathogens, with survival effects cascading to the ecosystem level.... [H]erbicide-altered plant microbiomes and/or metabolomes in plant leaves, pollen, and nectar may alter the exposure and consumption of pollinators and herbivores, which can have cascading effects on their gut microbiomes and, therefore, the health of the pollinators and herbivores." This is a demonstration of how herbicide-driven alterations in animal-host gut microbiomes can lead to ecosystem-level changes.

Last, the research addresses the "widely known evolutionary consequence of repeated herbicide exposure" —selection for increased herbicide resistance in soil bacteria. This resistance, the authors assert, can feed back to the ecosystem level when changes in the microbial community composition influence soil processes; they cite nitrogen and carbon flows as examples. They add, "Long-term exposure to herbicides may influence not only microbial evolution but also the evolution of the animal hosts driven via microbes," and cite the example of a particular wasp variety's chronic atrazine exposure causing adaptive gut changes that then exerts selective pressure on its host genome.

The health of microbial communities is hugely important. These tiny organizations of organisms maintain individual plant, animal, and human health, and that of ecosystems. Altering these communities—particularly in soils, through prolonged assault with toxic herbicides (and other pesticides)—can have, the authors assert, "far-reaching, long-term, and unforeseen impacts on ecosystems." We are witnessing these chemical impacts unfold in the current trend toward a collapse of biodiversity that threatens all life on Earth. (Other factors contribute, of course—the climate crisis, human-caused development that destroys habitat, pollution, overexploitation of natural resources, and problematic invasive species.)

But this research (and more here) identify a threat that has great potential to accelerate the distortion and potential destruction of organisms and ecosystems. The issue of herbicides' and pesticides' impacts on microbiomes, especially in our soils, needs more research and certainly, should be part of the U.S. Environmental Protection Agency's (EPA's) risk evaluations of herbicides and pesticides.

Meanwhile, as Beyond Pesticides advocates with growing volume and urgency, the "fix" for insect, weed, and animal "pests" (in agriculture, and in other land and building management) is *not* the agrochemical industry's never-ending chase of evolving organisms' resistance to chemical assaults with new, more, and more-intensive chemical applications. This approach will never "win" the contest with the living world's mutation-plus-selection strategy for organismic survival.

What to do: What *can* work is a change in approach, on the order of "work smarter, not harder." Organic approaches to agriculture, in particular, but to all land and pest management, are effective, holistic, protective, and benign ways to deal with pests, and can achieve production and land management goals—without the toxic, systemic, destructive, and sometimes unknown, impacts of chemical saturation of the environment and ecosystems, natural resources, and organisms across the living spectrum. Learn more about the environmental, health, and socio-economic benefits of organic, and please advocate for this critical transition (see our Tools for Change). You can reach out to Beyond Pesticides for assistance with this work in your community: email us at info@beyondpesticides.org or call 202.543.5450.

SOURCE: Ruuskanen, Suvi et al., Ecosystem consequences of herbicides: the role of microbiome. Trends in Ecology & Evolution, vol.38, no. 1, p35-43. October 13, 2023

TREE SPRAYING DESTROYS BIOLOGICAL CONTROL | NOVEMBER 16, 2022

Pesticide Spraying of Urban Trees Found To Disrupt Natural Biological Management of Landscapes

Putting up with moderate pest levels can attract and maintain predators and parasitoids that provide important biological control services throughout the landscape, according to research recently published in *Environmental Entomology*. While scale insects can be a problem in urban areas, dropping sticky "honeydew" on cars and structures, they also play a critical role in maintaining native populations of pest predators. Scientists at North Carolina State University (NCSU) set out to understand just how important these pest populations are at maintaining their own natural enemies.

To do so, researchers worked through a series of three hypotheses on the connection between urban trees, scale insects, and pest predators. Focus was first placed on investigating different oak species and comparing the number of predators between trees infested and not infested with scale. Twigs from willow oaks, sawtooth oaks, and overcup oaks were collected from scale infested and scale uninfested trees on

the NCSU campus over the course of spring and counted for their scale abundance. Then, through the summer, researchers used a sampling tool that effectively shook insects out of the tree and into a funnel collection.

Unsurprisingly, scale infested oaks contain more scale insects. But these trees also host significantly higher numbers of pest predators, with greater numbers of spiders, parasitoids, ants, and lady beetles found in infested oaks.

Scientists next aimed to see whether more predators were disbursing into the landscape from infested oaks than uninfected oaks. This was measured by hanging intercept traps—plastic cups filled with soapy water—under the oaks for two days, repeated for a total of five replicates. Results show no difference between the predators captured in either infested or uninfested trees, with no significant differences between tree types.

The last experiment aimed to test the hypothesis that shrubs underneath infested trees hosted higher levels of pest predators than uninfested trees. This was revealed by the use of a vacuum sampler on holly shrubs located beneath the trees. Vacuuming was repeated for a total of 26 scale infested trees and 23 uninfested trees. Multiple different sampling methods were conducted, including three-, six-, and nine-day comparisons over the course of several months.

In general, shrubs underneath scale infested trees contain significantly more pest predators than those underneath uninfested trees. This difference increased over the course of sampling time, with three-day samples showing less difference than nine-day samples.

These findings underscore the importance of patience and timing within the natural pest management approach. After identifying a tree pest, for many community land managers there is a knee-jerk reaction to spray as soon as it is identified. But as study coauthor Caleb Wilson, PhD, notes in an article discussing the paper, "Treating a tree with pesticides could kill off natural enemies that would otherwise help manage nearby pests. In other words, treating a tree with pesticides could alleviate pest problems within the tree but could result in pest outbreaks in shrubs beneath the tree as natural enemies are killed off."

By taking a broader, systems view of the landscape, rather than focusing on a single tree with a single pest, moderate levels of pest populations in trees can be considered a resource rather than a liability.

What to do: Biological approaches to pest management are critical for a sustainable future yet are in need of considerably more research and investment. The return on investment is sound —biological management has resulted in billions of dollars in benefits to agricultural economies, placing it on equal footing with the impact of the green revolution, according to a 2020 study.

Take steps to move toward a pesticide-free, organic systems approach to pest management on your yard and in your community by learning more and sending a letter to your local elected officials today.

SOURCE: https://academic.oup.com/ee/advance-article/doi/10.1093/ee/nvac081/6763314?login=falseCaleb J Wilson, Steven D Frank, Scale Insects Support Natural Enemies in Both Landscape Trees and Shrubs Below Them, *Environmental Entomology*, Volume 51, Issue 6, December 2022, Pages 1094–1105, https://doi.org/10.1093/ee/nvac081; Entomology Today

ANTIBIOTIC/ANTIFUNGAL RESISTANCE | FEBRUARY 23, 2022

Deadly Fungus Resistant to Fungicide Jumps from Farms to People, as Human Pathogen Spreads

Fungicide use in agriculture is driving the spread of multi-fungicide resistant human pathogens, finds a recent study conducted by scientists at the University of Georgia. While this occurrence has long been an assumption based on the rampant overuse of fungicides in chemical-dependent farming, scientists have now found clear evidence linking the development of widespread fungal resistance to farming practices, rather than health care use. Despite strong evidence that commonly used synthetic pesticides in chemical-intensive farming are driving resistance that threatens human health on a global scale, the U.S. government has not only failed to take action, it has fought against international efforts to slow the crisis, at the behest of the agrichemical industry.

Scientists focused their research on *Aspergillus fumigatus,* a common mold that can infect humans and cause aspergillosis. Although some have problems with mild sensitivity to the fungus, virulent infections, called invasive aspergillosis, can occur in immunocompromised individuals and are on the rise. Cases of invasive aspergillosis increased 3% per annum between 2000 and 2013, and roughly 300,000 worldwide are diagnosed each year. On both farms and in human medical settings, antifungal compounds, called azole fungicides, are used in an attempt to kill off *A. fumigatus* infection.

Samples were taken from soil, compost, or plant debris from 56 farms in Georgia and Florida, with 53 of those sites having previously used azole fungicides. Of the remaining three, two samples were taken from organic farms and one was taken from a compost pile.

Of 700 *A. fumigatus* samples collected, nearly 20% (123) displayed some level of resistance to the commonly used azole fungicide tebuconazole. Twelve of the 123 were highly resistant at clinically relevant levels for human health care. No samples taken from organic sites contained resistant fungi.

It is hypothesized that if the strain of *A. fumigatus* infecting people develop its resistance traits on a farm, that strain would also have developed some level of resistance to other, non-azole, agricultural fungicides. Sure enough, the azole-resistant strains also display resistance to methyl benzimidazole carbamate (MBC) fungicides like carbendazim, and quinone outside inhibitors (QoI) like azoxystrobin.

By sequencing the genomes of *A. fumigatus* samples both from the current study and those taken and stored from clinical tests across the world, researchers were able to create a neighbor-joining tree—a sort of family tree of fungicide resistant *A. fumigatus.* That review shows that genetically, pan-azole resistant strains—those with broad resistance to azole fungicides—match up closely between those discovered on farms and those found in human clinical settings. Of 25 pan-azole resistant samples analyzed, eight farm samples and 12 human clinical samples also display resistance to non-azole fungicides.

"The strains that are from the environment and from people are very closely related to each other," study coauthor Marin T. Brewer, PhD, said. "It's not like there are different strains that are developing resistance in people and in the environment. It's all the same. So people who have these infections that are resistant have likely acquired them from the environment."

Aspergillus fumigatus is commonly found both indoors and outside. Infection can occur by simply inhaling a small amount of the fungi.

This result is merely the latest resistant pathogen to trace its lineage back to on-farm use. Over the last decade, scientific evidence has built around the link between common herbicides and antibiotic resistant bacteria. A 2015 study found that *Salmonella* and *E.coli* exposed to the herbicides glyphosate, dicamba, and 2,4-D triggered a non-specific defense mechanism which, while building resistance to the toxic effects of the herbicides, also resulted in resistance to commonly used antibiotics. Subsequent research has found soil sprayed with these same herbicides to have higher numbers of antibiotic resistant bacteria than areas where the chemicals were not applied. The resistant genes move throughout the environment by "horizontal gene transfer," elevating the importance of land and agricultural management practices that eliminate antibiotics and fungicides.

Another problematic fungal pathogen, the yeast *Candida auris*, continues to rapidly develop treatment resistance in human clinical settings, linked to the excessive use of fungicides. Researchers say their results indicate a need for a shift toward alternatives that do not cause resistance to human pathogens. "This emergence severely limits the usefulness of fungicides to manage plant pathogens while still preserving the clinical usefulness of azoles," Dr. Brewer said. "We urgently need effective agricultural fungicides that aren't toxic to the environment that do not lead to the rapid development of widespread resistance in the clinic."

While the call is laudable, regulators and politicians are neither heeding the science, nor listening to scientists. The U.S. Environmental Protection Agency's recent response to the rise of drug-resistant *Candida auris* is case in point. The agency failed to assess the efficacy of any pesticides that are not used for public health purposes; EPA only evaluates the efficacy of antimicrobial compounds whose use patterns classify them as human-health-related.

At the international level, a *Freedom of Information Act* request reveals officials at the U.S. Department of Agriculture working to downplay the role of synthetic fungicide use in chemical agriculture as a factor in the rise of drug-resistant fungal infections worldwide. Not only do they work to deny the truth on the ground, efforts have been made to halt protective actions. Emails show top level officials at industry trade group CropLife America urging USDA officials to "make certain" that the United Nation's (UN) *Codex Alimentarius*, a set of international guidelines and standards established to protect consumer health, made no mention of how fungicides contribute to antibiotic resistance.

What to do: Organic agriculture, with its strong restrictions on allowed synthetic materials, provides a path forward that does not allow synthetic antibiotics and fungicides. For more reasons to go organic, see Beyond Pesticides' Why Organic webpage.

SOURCE: S Earl Kang, Leilani G Sumabat, Tina Melie, Brandon Mangum, Michelle Momany, Marin T Brewer, Evidence for the agricultural origin of resistance to multiple antimicrobials in *Aspergillus fumigatus*, a fungal pathogen of humans, *G3 Genes|Genomes|Genetics*, Volume 12, Issue 2, February 2022, jkab427, https://doi.org/10.1093/g3journal/jkab427; University of Georgia press release

GLYPHOSATE INDUCES ANTIBIOTIC RESISTANCE | NOVEMBER 18, 2022

Glyphosate Induces Antibiotic Resistance in Deadly Hospital-Acquired Infection

Glyphosate weed killers induce antibiotic resistance in deadly hospital-acquired bacteria, according to a study published late last month in the journal *Scientific Reports*. This is the latest finding connecting commonly used herbicides to the rise of antibiotic resistant bacteria, with prior research showing glyphosate, 2,4-D, and dicamba able to create resistance in *Salmonella* and *E. coli*. Federal regulatory agencies continue to ignore the role of pesticides in the development of antibiotic resistance. This is all happening as antibiotic resistance is rising to dangerously high levels in all parts of the world, according to the World Health Organization. In the May 1, 2022 issues of the *Bulletin of the World Health Organization,* Samira Choudhury, PhD, et al. writes, "Often referred to as the silent pandemic, antimicrobial resistance claims the lives of over 700,000 people annually." The authors continue, "A study suggests that if no actions are taken, antimicrobial resistance will cause 10 million deaths per year by 2050 and an economic impact of over 100 trillion United States dollars."

Scientists focus their research on *Pseudomonas aeruginosa,* a bacteria commonly found in the environment, but able to cause serious disease in humans.

Healthy people can be infected from improperly cleaned hot tubs or swimming pools, resulting in skin rashes and eye and ear infections. However, the greatest risk of *P. aeruginosa* is in the hospital setting. The bacteria is well known to infect those suffering from burn wounds, on a ventilator or other invasive medical device, or with a catheter. Hospital-acquired *P. aeruginosa* is deadly in large part due to the wide spectrum of multi-drug antibiotic resistance the bacteria possesses. The U.S. Centers for Disease Control and Prevention indicates that in 2017 32,600 Americans hospitalized came down with a *P. aeruginosa* infection, with 2,700 passing away as a result.

To better understand the role pesticides like glyphosate are playing in these deadly infections, scientists in the study examine five different strains of *P. aeruginosa,* four retrieved from the environment and one from a clinical setting. All represent strains that were initially sensitive to antibiotics.These strains were exposed to both technical grade glyphosate and a range of glyphosate-based herbicide (GBH) formulations, including the products Roundup Mega, Dominator Extra 608 SL, Gladiator 480 SL (which are sold only in Europe). *P. aeruginosa* was exposed to 0.5% of glyphosate and GBH products per the volume of the medium (equivalent to 1.8–2.8 g/L [glyphosate] acid depending on the type of formulation). "This concentration falls within the recommended dilution range of GBHs [0.2–3.5% (v/v)] for agricultural and household use and similar to those found in water after agricultural practices," the study notes.

At this level, glyphosate and its formulated products significantly increase the minimum inhibitory concentration (the lowest concentration of an antibiotic that would inhibit the growth of a given bacteria) of *P. aeruginosa* to the carbapenem-type antibiotic, imipenem, by between 2-32 fold. This occurred in all strains and under different exposure scenarios. "Considering the worldwide use of [glyphosate] and GBHs, and the simultaneous emergence of antibiotic-resistant bacteria in environmental matrices, the detected interactions between these chemicals may affect microbial communities and possess a potential environmental and human health risk," the authors explain. Future studies will likely determine the mechanism through which this problem is occurring

It is becoming increasingly evident that glyphosate is creating resistance problems in more than merely the weeds on which the chemical is being applied to control. Initial reports on glyphosate's antibiotic resistance properties came in 2015, a week after the chemical was deemed a possible carcinogen by the World Health Organization. Two years later, these reports were confirmed in greater detail by the same team of scientists. In 2018, researchers found that bacteria exposed to glyphosate-based Roundup can develop antibiotic resistance 100,000 times faster than average. The most recent findings indicate that this resistance is developing directly in the field, with soils sprayed with weed killers likely to contain higher amounts of antibiotic resistant bacteria.

The regulatory response to this near-decade of research on the antibiotic resistance properties of commonly used herbicides has been nil. While the U.S. Environmental Protection Agency (EPA) requires herbicide product labels to include information on abating weed resistance, antibiotic resistance is not mentioned.

With inaction from federal regulators, it is up to states and localities to protect their residents from the rise of pesticide-induced antibiotic resistant bacteria. *Pseudomonas aeruginosa* is known to attack the most vulnerable at their weakest stage. Yet, it is perfectly possible for a landscaper to be spraying glyphosate outside of the room of a patient suffering from a *P. aeruginosa* infection.

Resistant bacteria travels throughout the environment through a process called horizontal gene transfer, causing widespread resistance even if the use site of the chemical does not come into direct contact with someone suffering from or vulnerable to an infectious disease. The human pathogenic organisms themselves do not need to be directly sprayed by the antibiotic because movement of genes in bacteria is not solely "vertical" –that is from parent to progeny– but can be "horizontal"—from one bacterial species to another.

What to do: Stopping the use of carcinogenic, antibiotic resistance forming pesticides outside hospitals where individuals are suffering from the diseases these chemicals can cause is common sense. But Beyond Pesticides challenges individuals to find hospitals that are paying attention and considering the connection between their landscape practices and the health of their patients. Although some, like the Adventist Hospital in Takoma Park, MD, stopped their use of pesticides and supported the passage of local laws restricting their use, medical sector involvement is unfortunately rare. More broadly, use of pesticides that cause bacterial resistance to antibiotics in agriculture is contributing to widespread resistance throughout society, making it more and more difficult to treat infectious diseases with antibiotics. Individuals concerned about this problem, who may have had family members or friends poisoned by pesticides or harmed by antibiotic resistant diseases, are encouraged to get active in their community to fight for meaningful protections from toxic pesticides. Tell your local officials to transition your community landscapes to pesticide-free, organic management.

SOURCE: Háhn, J., Kriszt, B., Tóth, G. *et al.* Glyphosate and glyphosate-based herbicides (GBHs) induce phenotypic imipenem resistance in *Pseudomonas aeruginosa*. *Sci Rep* 12, 18258 (2022). https://doi.org/10.1038/s41598-022-23117-9

MONARCHS THREATENED BY STORE-BOUGHT PLANTS | SEPTEMBER 13, 2022

Multiple Pesticides Detected in All Store-Bought Milkweed, Threatening Further Monarch Declines

Every store-bought milkweed sample tested in a recent study contains multiple toxic pesticides, placing monarchs reliant on these plants in harm's way at a time the species can ill afford any further loss to its population. Pollinator declines have influenced many residents throughout the U.S. to take action into their own hands and transform their home yards or businesses into an oasis for bees, birds, and butterflies. Yet, a recent study published in *Biological Conservation* finds that many retailers are dousing their "wildlife-friendly" plants with pesticides that put this vulnerable species in further danger.

"That was the most shocking part," said lead author Christopher Halsch, a doctoral student at University of Nevada, Reno. "The fact that plants labeled as potentially beneficial or at least friendly to wildlife are not better and, in some cases, might be worse than other plants available for purchase. This research sheds light on how pesticides may impact western monarchs, but many other butterflies are facing even steeper population declines, and pesticides are likely one driver."

Testing was conducted by purchasing milkweed plants at 33 different stores spanning 15 different states. A sample of each plant was cut after purchase, and then sent to the lab for chemical analysis. Screening was conducted for 92 different pesticides, including insecticides, fungicides, herbicides, and the synergist piperonyl butoxide.

Out of the 92 pesticides tested, 61 compounds were discovered in milkweed samples. Every sample contains at least two pesticides, though certain plants contain over 25 different chemicals. Despite the importance of this iconic species, data on harmful effects of most pesticides on monarchs is sparse or lacking. Only 9 of the 61 compounds detected have been tested for their impact on monarch health. Yet, for the data that is available, researchers find that 89 samples exceed levels associated with sublethal effects in monarchs—exposures that may not outright kill a monarch, but may increase the likelihood of death in the wild. These sublethal effects are seen in 17 of 25 locations, driven primarily by the elevated presence of the fungicides azoxystrobin and trifloxystrobin.

"In a previous study in California that primarily looked at milkweed in agriculture and urban interfaces, we had looked at a small number of plants from retail nurseries, and found that they contained pesticides," study coauthor Matt Forister, PhD, said. "[W]e were prepared for this much larger sample . . . to again uncover contamination, but it was surprising to see the great diversity of pesticides found in these plants. In many ways,

they are as contaminated or even worse than plants growing on the edges of agricultural fields. That was a surprise, at least to me."

Prior investigations from the same research team did find wild milkweed growing in a range of habitats to be ubiquitously contaminated with pesticides. Published in 2020, their study found 262 different pesticides from over 200 milkweed samples collected from around 20 sites within California's Central Valley. "From roadsides, from yards, from wildlife refuges, even from plants bought at stores—doesn't matter from where—it's all loaded with chemicals" Dr. Forister said of the previous study.

Monarchs on both sides of North America are fairing extremely poorly in the face of multiple interacting stressors, including climate change, habitat destruction, and pesticide exposure. Eastern populations have declined by 80% since 2005, and western monarchs have shrunk an astounding 99.9% from their population of over 10 million in the 1980s. These numbers pose a significant risk of migratory collapse, and with it, potential extinction.

Despite this dismal state of affairs, Aimee Code, study coauthor and pesticide program director at the national nonprofit Xerces Society, notes that, "Everyone can take steps to address the risks we uncovered." She continued: "Consumers can let their nurseries know they want plants that are free from harmful pesticides. Nursery outlets can talk with their suppliers and encourage safer practices, and government agencies can improve oversight."

Instead of immediately ripping out your milkweed, Ms. Code indicates there are steps that can be taken to protect butterflies from the likely contamination. "And it's important to keep gardening for pollinators for the long-term, just take steps to reduce pesticide exposure: cover new plants the first year, water heavily, discard the soil before planting, as it may be contaminated, and avoid pesticide use."

It is critical that every possible step is taken to protect these iconic pollinators before it is too late. While the international conservation group, International Union for the Conservation of Nature (IUCN), is listing the monarch as endangered, the U.S. government has not taken similar action. The U.S. Fish and Wildlife Service (USFWS) determined in 2020 that monarchs were eligible for protection under the *Endangered Species Act*, but their listing was "precluded by higher priority actions." Is the ubiquitous threat of pesticides throughout the monarch habitat the reason USFWS is dragging its feet? In another recent listing, concerning the officially endangered Rusty-Patched bumblebee, USFWS declined to declare the species' critical habitat, precluding rules that could place restrictions that protect the species from toxic pesticide exposure. Some conservationists speculate that the federal government is failing to take action on pollinators as a result of the significant implications that the listing would cause to the pesticide industry.

What to do: Meaningful action at the federal level will take immense pressure from local residents and communities. Join Beyond Pesticides in telling U.S. Fish and Wildlife to officially list monarch butterflies as endangered species, so that they have access to additional protections needed to recover the population.

SOURCE: Christopher A. Halsch, Sarah M. Hoyle, Aimee Code, James A. Fordyce, Matthew L. Forister, Milkweed plants bought at nurseries may expose monarch caterpillars to harmful pesticide residues, Biological Conservation, Volume 273, 2022, 109699, ISSN 0006-3207, https://doi.org/10.1016/j.biocon.2022.109699; University of Reno press release