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Pesticides *and* You

Beyond Pesticides: Protecting Health and the Environment with Science, Policy, and Action

MEETING EXISTENTIAL CHALLENGES: Empowering Action for Change with Science

Meeting Existential Challenges

Empowering Action for Change with Science

This issue of *Pesticides and You*, a compendium of scientific research on pesticide threats to human and environmental health, is a breathtaking warning from the science community that our laws are not protecting us and a shift away from toxic pesticide use is urgently needed.

Included in this issue are scientific reviews of research reported by Beyond Pesticides in 2023, providing a critique of the independent peer reviewed literature with a shocking range of adverse effects, including cancer, neurotoxicity, brain effects, reproductive impacts, diabetes and obesity, chronic kidney and liver disease, Parkinson's, respiratory illness and asthma, learning and behavioral abnormalities, and more, as well as disproportionate harm to people of color. In addition, the science documents pesticides' catastrophic harm to the ecosystems that sustain life. In total, these dramatic findings call for an end to the use of toxic pesticides, incompatible with respect for living organisms and unconscionable given the availability of viable, cost-effective organic practices.

This issue adds to the body of knowledge from two previous issues of *Pesticides and You (Transformative Change: Informed by Science, Policy, and Action,* and *Retrospective 2021: A Call to Urgent Action)* with scientific warnings that keep getting louder.

The abject failure of the law and regulations to respond to the scientific warnings on these pages has contributed to existential crises, including severe health threats, biodiversity collapse, and the climate emergency—and calls for holistic solutions, rather than piecemeal approaches focused on individual chemical restrictions. In this context, articles about organic land management and crop production practices that are ecosystem compatible inform the path forward.

The findings and citations in this issue are supplemented by Beyond Pesticides' *Pesticide-Induced Diseases Database* and other documentation housed on the organization's website. All links to reference material, highlighted in blue text, are available in the electronic version of this issue.

ABOUT THE COVER

We designed the cover of this issue to capture the eyes of living beings, representing all life on the planet, who are watching to see that we as a nation and with the global community take the necessary steps to urgently end our dependency on petrochemical pesticides and fertilizers—which contribute to health threats, biodiversity collapse, and the climate emergency—and transition to regenerative organic practices. For our livable future...
Jay Feldman and Jocelyn Cordell

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MEETING EXISTENTIAL CHALLENGES: EMPOWERING ACTION FOR CHANGE WITH SCIENCE

By Jay Feldman

The year of scientific studies (2023), both human and environmental health, covered in this issue form the foundation of the extraordinarily compelling need for transformative action to end petrochemical pesticide and fertilizer use. To the extent that science is a dispassionate search for the truth, all levels of decision making, from personal to policy, must apply scientific findings with passion in order to protect health and the environment. If local, state, and federal policies and decisions of people, families, and government are informed by science, then this issue of *Pesticides and You* calls for dramatic and immediate changes in practices and policies to protect public health and the ecosystems critical to supporting life.

The illnesses that are the focus of scientific pesticide research compiled in this issue have touched most families with devastating consequences, including cancer, disruption of the endocrine system, neurological damage, gut-brain effects, reproductive dysfunction, learning disabilities and behavioral disorders, Parkinson's disease, and more. Similarly, the devastating impacts of pesticides on biodiversity, from pollinators to endangered species, affect the long-term survival of life on the planet. As health and the environment are in steep decline, the interconnected adverse effects associated with the cycle of dependency on petroleum-based pesticides and fertilizers contribute to the climate emergency by releasing greenhouse gases and diminishing the ability of soil to sequester carbon.

Cycle of Petrochemical Dependency

We have noted previously that chemical-intensive land management and agricultural practices with their dependency on synthetic fertilizer deplete the microbial health of the soil and its ability to cycle nutrients through the breakdown of organic matter, thus contributing to disease and infestations in plant populations that are used to justify toxic pesticide use. As the problems increase, more toxic pesticides are used. This treadmill results in less resilient landscapes and crops that are more vulnerable to drought and swings in the weather. As we study the scientific findings on adverse effects, it becomes clear that the challenges to health and the environment can be ended with the adoption of land management practices that do not use petrochemical inputs—a system that adopts organic practices. This is no longer an unrealistic pipe dream but is based on existing productive and profitable practices in the private sector, and efficacious and cost-effective practices in the public sector—systems already in place that can be scaled up rapidly.

In focusing on the harm to human health and ecosystems, it is critical to evaluate the necessity and efficacy of the toxic products being evaluated. How is the harm wreaked on people and the environment justifiable when end-goals can be achieved without them? In this regard, the science on the resistance of target organisms identified as pests or the lack of product efficacy, discussed in this issue, illustrates a failure in the analysis (regulatory review) to assess the science on ecosystem compatible methods and materials.

When the scientific findings in this issue, which add to a history of similar findings, are evaluated under the policy governing pesticide registration in the *Federal Insecticide, Fungicide, and Rodenticide Act* (FIFRA), the legal standard of "reasonable" adverse effects is not met, given the availability of nontoxic alternatives. The pesticide hazards documented in this issue are devastating and, operationally, the viability of organic alternatives makes them unjustified. The regulatory body responsible for the harm that people and the environment suffer, the U.S. Environmental Protection Agency (EPA), applies limited science—without attention to the robust analyses in the open scientific literature—from laboratory animal studies on discrete and complex interactions and health endpoints. The limitations of the regulatory review have been widely evaluated and discussed in the scientific literature and by the Office of the Inspector General on general population effects as well as those disproportionately harmed. The assumption in regulatory reviews that the chemicals are needed for agricultural productivity and profitability and to ensure quality of life is not borne out by the science. And in light of the catastrophic scientific findings when taken in the aggregate, the reasonable harm test fails. Moreover, the proof of this failure emerges over the 50 years of EPA's existence and the underlying statutes that have guided the agency's action, culminating today in the existential crises to which petrochemical pesticides and fertilizers have contributed significantly.

Compilation of Dramatic Scientific Findings

This hard-hitting compilation contains key scientific research and issues that Beyond Pesticides has tracked over 2023, adding to the body of evidence in support of the urgent need to move away from pesticides that contribute to escalating existential threats—health crisis, biodiversity collapse, and the climate emergency. In addition to the print edition, this issue can be found in a digital format at bp-dc.org/MeetingxistentialChallenges2023.24. As we wrote in the introduction to the previous issue of *Pesticides and You*, "Whether talking about serious health threats from chemical-induced diseases, the collapse of life-sustaining biodiversity, or the dramatic destruction caused by greenhouse gases and rising and erratic temperatures, the interconnectedness of the crises requires strategic solutions that are holistic and nurturing of nature."

Organization of this Issue

The issue is organized to address the crises by cataloging the emerging science over the last year into five categories of petrochemical pesticide and fertilizer effects: (i) Toxicology—Human Health Threats, (ii) Disproportionate Harm, (iii) Threatened Biodiversity and Ecosystems, (iv) Pest Resistance and Failed Efficacy, and (v) Organic and Nontoxic Practices.

In this issue, the body of science describing the specific adverse effects is dramatic—from the perspective of what science is telling us repeatedly with increasing urgency over the last 50 years. At the same time, the organic solution in study after study and operationally in the marketplace charts a clearly viable and cost-effective path forward now. In light of these facts, the delay in the transition away from petrochemical pesticides and fertilizers is truly unconscionable. "Reduction" strategies that tinker with or tweak chemical-dependent land management practices are not defensible any longer. The lack of preventive protection of people and families whose lives are disrupted or destroyed by the diseases and illnesses documented in science journals as being initiated or promoted by pesticide exposure—from production, transportation, use, storage, to disposal—is embedded in federal, state, and local policies. The data clearly finds that the compromises that statutes and regulations make with people's lives and the sustainability of the ecosystems that support life serve corporations that benefit from the sale and use of these toxic substances, not society at-large.

How is the harm wreaked on people and the environment [by pesticides] justifiable when end-goals can be achieved without them? . . . [T]he legal standard of "reasonable" adverse effects is not met, given the availability of nontoxic alternatives. The pesticide hazards documented in this issue are devastating and, operationally, the viability of organic alternatives makes them unjustified.

Beyond Pesticides tracks these studies on a daily basis and publishes reviews of the scientific literature through our *Daily News*. Seeing the range of health and environmental threats collected together in this compendium is shocking and difficult to take in. For that reason, we assemble the reviews in this issue in one place and then organize all the data in our Pesticide-Induced Diseases Database, a relational database available on our website at bp-dc.org/PIDD.

The patterns of diseases and ecosystem destruction linked to a dramatic range of adverse human health and environmental effects are stark and serve as a call for systemic change without delay.

In Section 1, Toxicology—Human Health Threats, studies address breast cancer and other cancers, disruption of the endocrine system (the message system of the body leading

to cancer and other effects), reproductive effects, Parkinson's disease, liver damage, metabolic disorders, chronic kidney disease, diabetes, obesity, shingles, pregnancy and reproductive complications, developmental effects in children, nervous system disruption, neurodevelopmental problems, seizure disorders including epilepsy, gut-brain effects, behavioral effects, asthma and respiratory disorders, mast cells impact (immune system regulators), brain effects, pregnancy and fetal effects, PFAS (polyfluoroalkyl substances) contamination linked to a large range of effects including cardiovascular risks, and issues pertaining to indoor air contamination, highly destructive accidents, and regulatory weakness that questions scientific integrity conflicts of interest, and pesticide dangers at golf courses.

In Section 2—Disproportionate Harm, studies address global malnutrition linked to pollinator decline with highest threat to low-income people, governmental support of environmental justice to ameliorate disproportionate effects of pollution and climate change, history of disproportionate harm on Juneteenth, neurodevelopmental disorders, effects to farmworker pregnancy, and indigenous people's knowledge applied to protecting biodiversity.

In **Section 3—Threatened Biodiversity and Ecosystems**, studies on limits of mitigation measure to protect pollinators, degradation of color discrimination in pollinators, fungicide linked to adverse brain effects through oxidative stress, impacts on bee gut microbiota, adverse impacts on birds, butterfly decline, insect decline, waterway contamination, dying oceans, threatened endangered species, and bee-toxic pesticides.

In Section 4—Pest Resistance and Failed Efficacy, studies on disease transmission through pesticide-resistant mosquitoes, bed bug resistance, resistant Colorado potato beetle attacked with genetically engineered pesticides, incomplete data on RNAi, antibiotic resistance, glyphosate causing reduced crop yields and climate effects, organic compared to glyphosate on yields and climate, EPA failure to conduct pesticide efficacy reviews, and crop failure with genetically engineered plants.

In Section 5—Organic Transition and Nontoxic Practices, studies on soil health in climate debate, perennial crops to fight biodiversity collapse, crop diversification and Intercropping, cultivating natural predators, organic pilot sites in New York City parks, NFL call for end to synthetic turf, strengthened USDA organic enforcement exceeds chemical-intensive agriculture, National Organic Standards Board issues, challenging hydroponic organic, strengthen EPA's Safer Choice with organic compatible practices and products, and California Roadmap weaknesses.

A Holistic Framework for Moving Forward

The intersectionality of the science on health threats, biodiversity collapse, and the climate emergency may not be captured by any one individual study, but, taken as a whole, what emerges from the body of science on pesticides and alternatives contained in this issue is a call to action. Threats in each category of harm are in and of themselves devastating, deadly, and unsustainable, whether the subject matter is health, biodiversity, or climate.

Scientists at Beyond Pesticides 40th National Forums, *Forging a Future with Nature: The existential challenge to end petrochemical pesticide and fertilizer use* (see recording at bp-dc.org/Forum2023), and in the scientific literature have discussed the urgent need for a strategic response to the climate crisis as part of a constellation of public health and biodiversity crises that intersect. Whether a health crisis borne out of chemical-induced diseases, the collapse of life-sustaining biodiversity, or the growing number of catastrophes caused by greenhouse gases and rising temperatures, the interconnectedness of the crises requires solutions that are holistic and nurturing of humans' relationship with nature—an interrelationship that has been neglected as a matter of policy and practice. In October, 2023, an editorial in the *Journal of the American Medical Association* (JAMA) captures the urgency of the climate and biodiversity crisis in Time to Treat the Climate and Nature Crisis as One Indivisible Global Health Emergency. The authors state: "Over 200 health journals call on the United Nations, political leaders, and health professionals to recognize that climate change and biodiversity loss are one indivisible crisis and must be tackled together to preserve health and avoid catastrophe. This overall environmental crisis is now so severe as to be a global health emergency."

Over 200 health journals call on the United Nations, political leaders, and health professionals to recognize that climate change and biodiversity loss are one indivisible crisis and must be tackled together to preserve health and avoid catastrophe.

Taking Collective Action

This may be obvious to those who have eschewed pesticides in their daily lives and their communities by adopting an organic diet and organic land management and still confront one or more of the diseases tied to pesticides in the scientific literature. The change needed requires collective action and a societal embrace of organic systems that put an end to the multiple toxic mixtures and involuntary exposure, from contamination of land, air, water, and food.

Although we recognize the importance of attempts to restrict individual pesticides through improved chemical regulation and effective toxic pesticide use reduction strategies, a crosscutting national grassroots collaboration is critically needed, especially now, to help reframe the public debate to be holistic. A precautionary approach, embraced by organic principles, starts with the premise that we do not need toxic chemicals to achieve food

productivity goals or beautiful landscapes.

As with previous issues, we view this issue as a tool for empowering activism and the necessary dramatic changes in practices and policies. This issue alone does not capture the entire body of the scientific literature (which we strive to accomplish with our web-based databases and program pages), but it adds significantly to the documentation that must compel decision makers to take meaningful action in eliminating petrochemical pesticides and fertilizers. At the same time, it is intended to provide a path forward with organic practices and links to our hands-on development of organic models for land management in communities across the country.

Reorienting the Focus of Change

Two representative examples in the last year illustrate the virtually insurmountable challenges under existing pesticide law. One is a case about the continued use of a brain-damaging pesticide. The other is the escalating threat of a pandemic because of antibiotic resistance, highlighting the importance of eliminating agricultural antibiotic use.

Case Study #1: After decades of campaigning, the deadly insecticide chlorpyrifos remains on the market. The news in November 2023 that a federal Appeals Court had reversed an EPA decision to ban the brain-damaging pesticide chlorpyrifos calls into question the value of the basic structures, processes, and authorities of pesticide law that the public has been told are protective of health and the environment. After decades of review and litigation at considerable expense to government and the public interest community, this reversal, especially on a highly neurotoxic insecticide like chlorpyrifos, identifies a fundamentally flawed system that does not respect the science nor protect the health of people, in this case, children's brains.

It was EPA's finding that chlorpyrifos is destructive of the nervous system, particularly in children, and the functioning of the brain that led to an EPA-negotiated chemical company (Corteva/Dow Chemical) settlement in 1999 (took effect in 2000) that removed residential uses of chlorpyrifos from the market. The 2020 EPA decision, 21 years later, to stop agricultural uses followed another Appeals Court decision, departing from the agency's usually long, drawn-out negotiations that ultimately compromise health and the environment. EPA banned agricultural uses of chlorpyrifos in 2016 at the end of the Obama Administration, but the decision was reversed by the Trump Administration in 2017. Because EPA's decision was not negotiated, but based on scientific facts showing unreasonable harm, the industry sued, which brings us to the current situation.

While litigation against EPA under current pesticide law is needed to call out the problems with inadequate protections, the fundamental inadequacies of the law ultimately need to be addressed. Realistically, however, the power of the chemical industry and its influence in the U.S. Congress has prevented the overhaul of the law that is required to eliminate chlorpyrifos and petrochemical pesticides in favor of organic land management or agricultural practices that are as productive and profitable as chemical-intensive practices.

Background. EPA's action to cancel all agricultural uses of chlorpyrifos was a rare instance when the agency took comprehensive protective action. Required by a 9th Circuit Court of Appeals decision in April 2021 to take action, EPA issued a final rule in August, 2021—in full effect February 28, 2022—after an earlier 9th Circuit decision, concluding that "EPA is unable to conclude that the risk from aggregate exposure from the use of chlorpyrifos meets the safety standard of the *Federal Food, Drug, and Cosmetic Act* (FFDCA). Accordingly, EPA is revoking all tolerances for chlorpyrifos." On November 3, 2023, the 8th Circuit U.S. Court of Appeals decided to vacate EPA's 2021 decision to cancel all food tolerances for chlorpyrifos and sent it back to the agency.

History of Failure. In other cases, EPA has avoided such litigation by taking more limited action. When the industry challenges EPA, the agency almost invariably capitulates through a negotiation process. With the herbicide paraquat, EPA allowed an industry umbrella group—dubbed the Agricultural Handler Exposure Task Force—reduce its assessment of the risks to workers, resulting in the agency changing its position within months. With the synthetic pyrethroid class of insecticides, EPA allowed an industry group to rework its methodology for addressing pyrethroid risks to children and followed the request of another industry group to allow the pyrethroids to be sprayed with smaller buffer zones during windier conditions. With the chemical weed

killer glyphosate, despite overwhelming evidence of its carcinogenic properties, the agency has refused to acknowledge this risk, even after a federal court chastised its review process, and instead has acted at the behest of chemical manufacturers to stop glyphosate from being banned in other countries.

The examples of this pattern are numerous, including the 2022 EPA decision to cancel, with a five-year phaseout, the deadly chlorinated hydrocarbon wood preservative pentachlorophenol, with dioxin contaminants, among others (see Gateway on Pesticide Hazards and Safe Pest Management), after it watched countries around the world one-by-one ban its use under an international treaty—the Stockholm Convention, which was never ratified by the U.S. With a severely diminished market worldwide and difficultly setting up a manufacturing shop in the U.S. after a community and state uproar in South Carolina, the manufacturer withdrew—after 40-plus years of fighting and unthinkable cases of cancer. EPA then announced in March of this year that it was time to cancel the chemical.

And even when EPA suspends the registration of a pesticide, removal from use is very slow because existing stocks are generally allowed to be sold. For example, EPA suspended the registration of the herbicide dimethyl tetrachloroterephthalate (DCPA) (also widely known as dacthal), effective August 22, 2023, leaving existing stocks (products containing DCPA manufactured before August 22) available on the market.

These examples and more demonstrate that a chemical-by-chemical "whack-a-mole" approach cannot adequately protect against the dangers of pesticides. This again speaks to the need for practices and policies at every level of government that adopt organic agriculture and land management practices.

Case Study #2: Inability to head off pandemic crisis due to antibiotic resistance.

Despite successful litigation on EPA's failure to comply with regulatory process that stopped the unnecessary use of an antibiotic (streptomycin) in citrus production in December 2023, the court's reasoning fails to grasp the science behind the biggest emerging threat to U.S. and global health—antibiotic resistance. What is most disturbing and challenging is that EPA, responsible for applying science in the protection of the public's health, misled the court on the overwhelming worldwide scientific consensus on the contribution of agricultural antibiotic use to the human death and disability rate linked to antibiotic resistance.

EPA has the opportunity and responsibility to deem the adverse effects associated with petrochemical pesticide use "unreasonable," given the availability of alternative practices, principally organic land management.

On this subject, Beyond Pesticides has written extensively about horizontal gene transfer, which explains the movement of antibiotic resistant bacteria throughout the environment, ultimately making their way to people, as medically necessary drugs become ineffective. As we have written, "The human pathogenic organisms themselves do not need to be 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."

Regarding the reliance of the court on EPA's misrepresentation of the science, the court found, "EPA emphasized that 'there is no data that antibiotic use in agriculture leads to the presence of antibiotic resistance in bacteria of human health concern,' and that '[a]t the present time, there is little evidence for or against the presence of microbes of human health concern in the plant agricultural environment.'" And yet, on May 19, 2019, *The New York Times* reported, "The agency [EPA] approved the expanded use [of streptomycin] despite strenuous objections from the Food and Drug Administration and the Centers for Disease Control and Prevention [CDC], which warn that the heavy use of antimicrobial drugs in agriculture could spur germs to mutate so they become resistant to the drugs, threatening the lives of millions of people."

The court decision requires us to focus on how the nation's pesticide law FIFRA, and the chemical-intensive agricultural practices it effectively promotes, is contributing to what can already be considered a worldwide pandemic. Yes, antibiotic resistance is another pandemic that some call the "silent pandemic," but the numbers belie that characterization.

It certainly is true that there is a confluence of factors that contribute to this worldwide pandemic, which will be the focus of a United Nations General Assembly (UNGA) High-Level meeting on antimicrobial (e.g. bacterial and fungal) resistance (AMR) in September, 2024 in New York. However, we cannot afford to ignore any cause of resistance, given the health implications of ineffective treatments for bacterial and fungal diseases. While there are many statistics with a range of numbers that we cite, according to the CDC, "More than 2.8 million antimicrobial-resistant infections occur in the U.S. each year, and more than 35,000 people die as a result. When Clostridioides difficile—a bacterium that is not typically resistant but can cause deadly diarrhea associated with antibiotic use—is added to these, the U.S. toll of all the threats in the report exceeds 3 million infections and 48,000 deaths." According to a 2021 article in *Current Research in Microbial Sciences*, "Anti-biotic resistance in agriculture: Perspectives on upcoming strategies to overcome upsurge in resistance," the leading consumers of antibiotics in developed countries are U.S. consumers. So, it would appear that the U.S. population may have the most to lose from antibiotic resistance.

A report evaluating 204 countries published by the University of Wash-

ington's Institute of Health Metrics and Evaluation, "Global burden of bacterial antimicrobial resistance in 2019: a systematic analysis," generated the following statistics:

- **13.66 million people who died** globally had sepsis as an immediate cause of death or in the chain of events leading to their death (intermediate cause).
- **4.95 million people who died** in 2019 suffered from drug-resistant infections, such as lower respiratory, bloodstream, and intra-abdominal infections.
- **1.27 million deaths** in 2019 were directly caused by AMR [antimicrobial resistance].
- **1 in 5 people who died** from AMR was a child under five years old, often from previously treatable infections.

For those who prefer to talk about public health in economic terms, according to the Food and Agriculture Organization of the United Nations, the Global Research on Antimicrobial Resistance study found, "If action is not taken, the rise of AMR cumulatively may result in over 3.4 trillion USD loss in the world's annual gross domestic product (GDP) in ten short years."

ReAct, an independent worldwide network focused on antibiotic resistance, founded in 2005, has characterized the problem from perspectives around the world.

ReAct Africa Director Mirfin Mpundu says:

> *"Addressing antibiotic resistance effectively will require big changes–to governance, financing, systems transformation and the change of behaviors and practices. But at the end of the day the end goal must be to ensure that everyone who has a resistant infection, or requires surgery, or needs cancer treatment, or is born premature can in fact access effective antibiotics in the future—this is the expectation that we should all voice to governments from now to September next year."*

Ultimately, EPA must get out in front and start thinking and acting holistically in its analyses and restrictions of pesticides. The challenge of antimicrobial resistance is an example of the agency moving along with a limited focus that undermines the protection of the environment and people, as existential crises continue to emerge—whether it is the chemical-induced or exacerbated human health crises, biodiversity collapse, or the climate emergency. Even under existing law, EPA has the opportunity and responsibility to deem the adverse effects associated with petrochemical pesticide use related to these existential crises "unreasonable," given the availability of alternative practices, principally organic land management, that are viable, accessible, productive, profitable, and, most importantly, enabling of a livable future.

Transformative Change

None of the studies covered in this issue are theoretical. To operationalize a strategic vision to eliminate the use of petrochemical pesticides and fertilizers, communities with Beyond Pesticides' support are heavily engaged with hands-on work to transition parks, playing fields, and public spaces to organic land management through Beyond Pesticides' Parks for a Sustainable Future program. These programs are models for all managers of public and private property to teach the adoption of methods that eliminate toxic pesticides and fertilizers. The programs apply the same standards that govern certified organic agricultural production under the *Organic Foods Production Act* (OFPA), which focuses on soil management practices that are applicable to all land management. While we advance this approach, we must protect underlying organic standards in OFPA against the ongoing threat to the law's stringent standards by industry groups that want easier access to the organic market. We do this through our *Keeping Organic Strong* campaign.

It is critical to elevate the public's voice for change, even when the target—be it EPA or a member of Congress—appears to be unreachable. While Beyond Pesticides works locally from the grassroots up to transition to organic practices, we are seeking to elevate the public's voice in all policy arenas to codify practices at the local, state, and federal level that reverse the existential health, biodiversity, and climate crises. Join with Beyond Pesticides' *Action of the Week* to raise your voice.

TOXICOLOGY

HUMAN HEALTH THREATS

TOXICOLOGY | ENDOCRINE DISRUPTION | MAY 25, 2023

New Viewpoint on the Historic Link between Endocrine Disrupting Chemicals and Cancer Discussed

A review of the scientific literature published in the *Journal of Endocrinological Investigation* demonstrates exposure to past and current-use endocrine-disrupting chemicals (EDCs), like many pesticides, have a long history of severe adverse human health effects. Endocrine disruptors are xenobiotics (i.e., chemical substances like toxic pesticides foreign to an organism or ecosystem) present in nearly all organisms and ecosystems. The World Health Organization (WHO), European Union (EU), and endocrine disruptor expert (deceased) Theo Colborn, PhD, classify over 55 to 177 chemical compounds as endocrine disruptors, including various household products like detergents, disinfectants, plastics, and pesticides. Endocrine disruption can lead to several health problems, including hormone-related cancer development (e.g., thyroid, breast, ovarian, prostate, testicular), reproductive dysfunction, and diabetes/obesity that can span generations.Additionally, studies related to pesticides and endocrine disruption help scientists understand the underlying mechanisms that indirectly or directly cause infertility, early puberty, and other reproductive disorders, cardiovascular disease, attention deficit hyperactivity disorder (ADHD), Parkinson's, Alzheimer's, and childhood and adult cancers, among other health issues. The review notes, "New evidence supports the role of other EDCs as possibly carcinogenic and pregnant women should avoid risk area and exposure. The relationship between EDCs and cancer supports the need for effective prevention policies increasing public awareness."

The review examines the relationship between EDCs and various hormone-mediated effects (i.e., breast, prostate, testicle, ovary, and thyroid) to determine the carcinogenicity of the chemicals and their impact on public health. Researchers performed a literature review of meta-analyses and human studies between 1958 and 2022, searching for articles on "endocrine-disrupting chemicals," "EDCs," "phthalates," "TCDD," "dioxin," "polychlorinated biphenyls," "PCB," "bisphenol A," "BPA," "nitrate," "nitrite" and "breast cancer" or "prostate cancer" or "thyroid cancer" or "ovarian cancer" or "testicular cancer" on PubMed. Although the review finds many studies establishing a link between EDCs and cancers, there is a lack of current criteria to test new chemicals of endocrine disrupting potential and possible carcinogenic activity. The latent, adverse manifestation of cancers at varying ages makes it difficult to assess the full impact of human exposure to EDCs. For instance, evidence suggests that developing fetuses and neonates are most vulnerable to endocrine disruption, but cancer development manifestation needs more comprehensive research.

EDCs are chemicals that can, even at low exposure levels, disrupt normal

hormonal (endocrine) function. The endocrine system consists of glands (thyroid, gonads, adrenal, and pituitary) and the hormones they produce (thyroxine, estrogen, testosterone, and adrenaline). These glands and their respective hormones guide the development, growth, reproduction, and behavior of animals, including humans. Past research shows exposures to endocrine-disrupting chemicals can adversely impact human, animal—and thus environmental—health by altering the natural hormones responsible for conventional fertile, physical, and mental development. Research demonstrates that endocrine disruption is prevalent among many pesticide products like herbicides, fungicides, insecticides, and pesticide manufacturing byproducts like dioxin (e.g., TCDD). EDCs can enter the body and interfere with normal bodily function by mimicking the action of a naturally produced hormone, such as estrogen or testosterone, thereby setting off similar chemical reactions in the body, blocking hormone receptors in cells and preventing the action of natural hormones; or, affecting the synthesis, transport, metabolism, and excretion of hormones, thus altering the concentrations of natural hormones.

Endocrine disruption is an ever-present, growing issue that plagues the global population. The connection between cancers and EDCs has a historical record. However, this review highlights new perspectives on mechanisms involved in EDC-mediated cancers outside estrogen-receptor pathways, including mutation of damaged (unrepaired) DNA (genomic instability), and changes in the way genes work, which are influenced by behavior and the environment (epigenetic changes). The variations in EDC exposure levels and duration can make it difficult to investigate among humans.

The U.S. Environmental Protection Agency (EPA) fails to evaluate the depth and scope of chronic health and environmental concerns regarding exposure to EDCs. EDC chemicals can wreak havoc not only on humans but also on wildlife and their ecosystems. Hence, advocates maintain that policies stricter pesticide regulations and increase should enforce research on the long-term impacts of pesticide exposure.

Overall, endocrine disruption can negatively impact reproductive function, nervous system function, metabolic/immune function, hormone-related cancers, and fetal/body development. The International Agency for Research on Cancer (IARC) and the U.S. National Toxicology Program (NTP) classify many EDCs as possible carcinogens based on epidemiological studies identifying instances of kidney, ovarian, testicular, prostate, and thyroid cancer, as well as non-Hodgkin lymphoma and childhood leukemia. Considering that EDCs like organochlorines (e.g., DDT, lindane, chlordane, heptachlor, etc.) are structurally similar to fatty acids and may impair fatty acid metabolism and lipid synthesis in the liver, there may be an underestimation of the toxic effects on human, animal, and environmental health. Therefore, advocates say it is essential to avoid toxic chemical exposure to lessen potential acute and chronic health risks. The study concludes, "More studies are needed to clarify these associations, but, despite the uncertainties, the relationship between EDCs and cancer supports the need for effective prevention policies, paying attention to public awareness."

The ubiquity of pesticides in the environment and food supply is concerning, as current measures restricting pesticide use and exposure do not adequately detect and assess total environmental chemical contaminants. For instance, 90 percent of Americans have at least one pesticide biomarker (including parent compound and breakdown products) in their body. One way to reduce human and environmental contamination from pesticides is to buy, grow, and support organic. Numerous studies find that levels of pesticides in urine significantly drop when switching to an all-organic diet. Furthermore, given the wide availability of non-pesticidal alternative strategies, families, from rural to urban, can apply these methods to promote a safe and healthy environment, especially among chemically vulnerable individuals or those with health conditions. For more information on why organic is the right choice for consumers and the farmworkers that grow our food, see the Beyond Pesticides webpage, Health Benefits of Organic Agriculture.

SOURCE: R. Modica et al., A. Endocrine-disrupting chemicals (EDCs) and cancer: new perspectives on an old relationship. *J Endocrinol Invest* 46, 667–677 (2023). https://doi.org/10.1007/s40618-022-01983-4

TOXICOLOGY | ENDOCRINE DISRUPTION | JULY 13, 2023

Deadly Pesticide Poses an Increased Risk of Hormone-Associated Reproductive Cancers in Women

A study published in *Environmental Science and Pollution Research* finds exposure to *paradichlorobenzene*, a chlorophenol compound with uses as an insecticide, disinfectant, repellent, fumigant, fungicide, and deodorizer, can increase the risk of common endocrine (hormone)-mediated reproductive cancers (e.g., breast, uterine, and ovarian) in women. *p*-DCB has carcinogenic (cancer-causing) properties and the chemical has been

banned in the European Union (EU) since 2005 for air fresheners and 2008 for mothballs. Being a chlorinated aromatic hydrocarbon (with benzene) compound (chlorobenzene), in addition to its cancer-causing properties, *p*-DCB can cause acute illnesses like headaches, numbness, sleepiness, nausea and vomiting and chronic effects like nervous system disorders leading to depression, and impact on the brain, birth outcomes, reproductive system, liver, and kidneys.

Pesticides have a long history associated with endocrine-disrupting properties that induce various molecular changes, prompting disease development. Adding to the science, a similar review published in *Environmental Exposure, Biomonitoring, and Exposure Assessment* highlights how specific estrogen-mimicking pesticides increase the risk of disease, particularly hormone-related cancers among women (e.g., breast, ovarian, and endometrial cancer) and men (e.g., testicular, prostate cancer). *p*-DCB contains the carcinogenic benzene and is chlorine-based (a chlorinated aromatic hydrocarbon compound), which in December 2019 gained it the status of the U.S. Environmental Protection Agency's (EPA) "High-Priority Substance for Risk Evaluation" under the *Toxic Substances Control Act*. It is long-lasting in the environment. According to EPA, the chemical is mainly used as a fumigant for the control of moths, molds, and mildews, and as a space deodorant for toilets and refuse containers. Importantly, it is also used as an intermediate chemical in the production of other chemicals, including those for tree-boring insects, and in the control of mold in tobacco seeds. It shows up in ambient air testing, in drinking water, and in factories producing or processing the product.

The study "provides insights on the potential role of environmental exposures in the etiology of gynecological cancers. Further exploration of the epidemiological and pathophysiological interactions between *p*-DCB exposure and endocrine-related female cancers is warranted to expand upon these findings."

Exposure to *p*-DCB can disrupt metabolic and endocrine effects associated with endocrine-related female cancers (breast, ovarian, and uterine cancers). Using the U.S. National Health and Nutrition Examination Survey (NHANES) from 2003 to 2016, the study analyzes the urinary components of 4,459 women aged 20 years or older for concentrations of 2,5-dichlorophenol (2,5-DCP), the primary metabolite of *p*-DCB, to determine the association between *p*-DCB exposure and widespread endocrine-related cancers. Of the participants, 202 women have an endocrine-related reproductive cancer diagnosis with a significantly higher urinary concentration of 2,5-DCP than women without these cancers. Additionally, women experiencing moderate and high exposure to *p*-DCB have urinary concentrations of 2,5-DCP significant enough to increase the risk of endocrine-related reproductive cancers compared to low-exposure groups.

[See previous article for description of the endocrine system.]

This study adds to the sparse scientific literature concerning the probable link between *p*-DCB exposure and female reproductive cancers via endocrine disruption. Although endocrine-related cancers have genetic and behavioral components, the environmental components, like chemical exposure, are also essential to understand, especially since there is an incomplete understanding

of the role the endocrine system plays in the development of these cancers. As an endocrine disruptor, *p*-DCB causes a dose-dependent increase in estrogenic activities, directly affecting the size and function of reproductive organs. Additionally, the International Agency for Research on Cancer (IARC) categorizes *p*-DCB as a possible human carcinogen (Group 2B), warranting further investigations into the carcinogenic potential of this chemical to humans upon chronic exposure.

Studies directly link obesity with an increased risk of hormone-regulated endocrine cancers in women, finding an association between obesity/metabolic disorders and increased 2,5-DCP concentrations. This finding is unsurprising as *p*-DCB is a compound with lipophilic properties, accumulating in adipose (fatty) tissue. Like other EDCs and organochlorines, *p*-DCB may impair fatty acid metabolism and lipid synthesis in the liver, indicating a potential underestimation of toxicity effects on human, animal, and environmental health. Considering that products in the U.S. containing *p*-DCB are frequently used in households and workplaces, the potential risk to the metabolic and endocrine system among individuals is infinite.

See Inspector General Rips EPA for Failure to Test Pesticides for Endocrine Disruption. For a deeper dive into EPA's failure to meet its statutory responsibility to evaluate pesticides for endocrine disruption fully, see While France Bans a Common Endocrine Disrupting Pesticides, EPA Goes Silent: EPA ignores statutory mandate to review pesticides that cause deadly illnesses at minute doses, defying classical toxicology.

SOURCE: Young-Mi Go et al., Exposome epidemiology for suspect environmental chemical exposures during pregnancy linked to subsequent breast cancer diagnosis, *Environment International,* Volume 178, 2023, 108112, ISSN 0160-4120, https://doi.org/10.1016/j.envint.2023.108112.

MORE ON THIS SUBJECT **Erectile Dysfunction Among Younger Males Linked to Pesticide Exposures**— November 16, 2023

TOXICOLOGY | CANCER | AUGUST 11, 2023

Study Cites Multiple Chemical Characteristics, Strengthening Weed Killer Glyphosate Cancer Ranking

Reinforcing earlier findings, a systematic review published in *Chemosphere* finds the popular herbicide glyphosate and its formulations (glyphosate-based formulations-GBF) exhibit five out of the 10 key characteristics (KC) of carcinogens (cancer-causing chemicals). Specifically, glyphosate exhibits strong evidence of genotoxicity, epigenetic alterations (heritable changes in gene expression), oxidative stress, chronic inflammation, endocrine disruption, and disturbs gut microbiota implicated in lymphomagenesis (growth and development of lymphoma). Although organizations like the International Agency for Research on Cancer (IARC) designate glyphosate as a *probable human carcinogen*, and scientific literature supports the findings on these adverse effects associated with glyphosate, the chemical remains on the U.S. market in various formulations.

Glyphosate is the most commonly used active ingredient worldwide, appearing in many herbicide formulas, not just Bayer's (formerly Monsanto) Roundup®. The use of this chemical has been increasing since the inception of crops genetically modified to tolerate glyphosate over two decades ago. The toxic herbicide readily contaminates the ecosystem with residues pervasive in food and water commodities. In addition to this study, the scientific literature finds time and time again that glyphosate has an association with cancer development, as well as human, biotic, and ecosystem harm. Therefore, advocates point to the need for national policies to reassess hazards associated with disease development and diagnosis resulting from or exacerbated by exposure to chemical pollutants. The study highlights, "Our findings strengthen the mechanistic evidence that glyphosate is a probable human carcinogen and provide biological plausibility for previously reported cancer associations in humans, such as non-Hodgkin lymphoma."

Using *in vivo*, *ex vivo*, and *in vitro* human and mammalian mechanistic studies, researchers compare exposure to glyphosate/GBF with little to no exposure counterparts for evidence of the 10 KCs of carcinogens. All known human carcinogens have one or more of the ten KCs, and these mechanisms cause cancer through:

1. Electrophilic (an affinity towards electrons) or metabolic activation (KC1),
2. Genotoxicity (KC2),
3. Alterations in DNA repair, causing genome instability (KC3),
4. Inducing epigenetic changes (KC4),
5. Inducing oxidative stress (KC5),
6. Inducing chronic inflammation (KC6),
7. Immunosuppression (KC7),
8. Reducing receptor-mediated effects/endocrine disruption (KC8),
9. Immortalizing cancer cells (KC9), and
10. Alterations in cell proliferation, death, or nutrient supply (KC10).

Researchers screened all in vivo, ex vivo, and in vitro studies of glyphosate/GBF exposure in humans/mammals, reporting any KC-related outcome available in PubMed before August 2021. The researchers used the selected studies to construct a matrix, analyzing the matrix in program R to determine the strength of evidence and quality assessments. Although only 175 of the 2,537 articles met inclusion criteria, the researchers extracted over 50,000 data points related to the aforementioned KC outcomes.

The results of the analysis find strong evidence for KC2, KC4, KC5, KC6, and KC8, limited evidence for KC1 and KC3, and inadequate evidence for KC7, KC9, and KC10. Specifically, genotoxicity (KC2) and endocrine disruption (KC8) from GBF have the strongest association with carcinogenicity. The reviewed studies demonstrate that the evidence of genotoxicity is stronger among humans than in animal studies, with GBF having a greater impact on both study groups than just glyphosate alone. Additionally, the review indicates glyphosate can alter hormone (endocrine) levels and receptor activity, with the estrogen receptors being most sensitive to glyphosate and GBFs.

The chemical's ubiquity threatens 93 percent of all U.S. endangered species, resulting in biodiversity loss and ecosystem disruption.

Almost five decades of extensive glyphosate-based herbicide (GBH) use has put human, animal, and environmental health at risk. The chemical's ubiquity threatens 93 percent of all U.S. endangered species, resulting in biodiversity loss and ecosystem disruption (e.g., soil erosion and loss of services). Exposure to GBHs has implications for specific alterations in microbial gut composition and trophic cascades. Similar to this paper, past studies find a strong association between glyphosate exposure and the development of various health anomalies, including cancer, Parkinson's disease, and autism. Although the U.S. Environmental Protection Agency (EPA) classifies glyphosate herbicides as "not likely to be carcinogenic to humans," stark evidence demonstrates links to various cancers, including non-Hodgkin lymphoma. Thus, EPA's classification perpetuates environmental injustice among individuals disproportionately exposed to chemicals like farmworkers, especially in marginalized communities. Chemical companies have knowingly failed and continue to fail to warn farmers adequately about the dangers of glyphosate. Additionally, the manufacturer's (Bayer/Monsanto) discredited chemical review conclusions challenge the European Union research.

The territory for research on pesticides' potential carcinogenicity and other impacts on human health is exceedingly complicated. Yet there is some convergence across research that exposure to certain pesticides increases the risk of developing some cancers. The association that has been in the blinding spotlight for the past few years is between exposures to glyphosate and GBHs and the risk of developing cancer, particularly non-Hodgkin lymphoma (NHL). Beyond Pesticides has covered the mounting evidence of the dangers

of glyphosate, including a meta-study that suggests a compelling link between exposures to glyphosate-based herbicides and increased risk of NHL.

In addition, Beyond Pesticides has traced the developments in the science and regulatory arena, including:

- IARC's 2015 landmark designation of glyphosate as potentially carcinogenic,
- Evidence that EPA colluded with Monsanto (maker of Roundup, the most widely used glyphosate-based herbicide) to advantage industry and that Monsanto had ghostwritten research that countered scientific conclusions on the cancer associations of the compound,
- and California's 2017 listing of glyphosate under Proposition 65 as a probable carcinogen and a 2018 Appellate Court affirmation of its ability to do so.

Glyphosate has been the subject of public advocacy, regulatory attention, and the target of thousands of lawsuits. (Beyond Pesticides has covered the glyphosate exposure tragedy extensively; see its litigation archives for multiple articles on glyphosate lawsuits.) In June 2020, facing approximately 125,000 lawsuits for Roundup's role in cancer outcomes, Bayer announced a $10 billion settlement to resolve roughly 75 percent of current and potential future litigation. However, roughly 30,000 complainants ultimately did not sign on to the settlement, so the queue of possible lawsuits is still potentially enormous. Although Bayer tried for a second settlement (~$2 billion) to handle future claims, a U.S. District Court judge for the Northern District of California rejected Bayer's 2021 settlement proposal. The judge stated that the settlement was inadequate for future victims diagnosed with cancer after using the herbicide. Bayer has never acknowledged any harm caused by glyphosate, maintaining the chemical is safe for use. However, in July 2021, Bayer announced its plan to end sales of its glyphosate-based herbicides (including its flagship product, Roundup) in the domestic U.S. residential lawn and garden market in 2023. Under the plan, uses in food production will continue.

The results of the systemic review highlight an all too familiar issues. Despite these concerning data, evidence of widespread exposure to a carcinogen has failed to sway regulators at EPA, necessitating meaningful change by elected officials to reform pesticide law. Scientists identify epidemiologic evidence associating glyphosate with blood cancers like non-Hodgkin lymphoma and strong evidence of carcinogenicity in laboratory animal research brought on by genotoxicity (DNA damage) and oxidative stress.

In 2015, the IARC Working Group demonstrated glyphosate has strong evidence of genotoxicity (KC2) and oxidative stress (KC5). However, recent studies providing additional data supports evidence of KC2 and KC5, chronic inflammation (KC6), and endocrine disruption (KC8) regarding glyphosate and GBF. Thus, glyphosate presents evidence of five KCs of carcinogens. Although there is limited or inadequate evidence for the remaining KCs, the review encourages further examination of the effects of glyphosate and other chemicals through 10 KCs and its relation to lymphoid cancers.

The study concludes, "Overall, the mechanistic evidence for glyphosate and GBFs possessing multiple key characteristics of carcinogens has become stronger since IARC's evaluation in 2015 and implicates several pathways by which these substances could induce cancer, such as lymphoma, in humans. […][O]ur understanding of glyphosate's effects using the KCs paves the way for exploring the intricate mechanisms underlying its potential pathway to lymphoma."

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Cancer is one of the leading causes of death worldwide, with over eight million people succumbing to the disease every year. Notably, IARC predicts an increase in new cancer cases from 19.3 million to 30.2 million per year by 2040.

Cancer is one of the leading causes of death worldwide, with over eight million people succumbing to the disease every year. Notably, IARC predicts an increase in new cancer cases from 19.3 million to 30.2 million per year by 2040. Therefore, studies related to pesticides and cancer will aid in understanding the underlying mechanisms that cause the disease. Beyond Pesticides challenges the registration of chemicals like glyphosate in court due to their impacts on soil, air, water, and our health.

SOURCE: Iemaan Rana, et al., Mapping the key characteristics of carcinogens for glyphosate and its formulations: A systematic review, *Chemosphere,* Volume 339, 2023, 139572, ISSN 0045-6535, https://doi.org/10.1016/j.chemosphere.2023.139572.

MORE ON THIS SUBJECT

Glyphosate Induces Oxidative Stress, A Cancer Precursor, According to NIH Study— January 31, 2023

Study Cites Multiple Chemical Characteristics, Strengthening Weed Killer Glyphosate Cancer Ranking— August 11, 2023

TOXICOLOGY | CANCER | NOVEMBER 7, 2023

Pesticide-Intensive Agricultural Practices Lead to Elevated Childhood Cancer Rates in Brazil

Two decades after the introduction of genetically engineered, herbicide-tolerant crops and the consequential exponential growth in weed killers, Brazil is seeing an increase in childhood cancer. This is the conclusion reached in a comprehensive study spanning 15 years (2004–2019), "Agriculture Intensification and Childhood Cancer in Brazil," published in the *Proceedings of the National Academy of Sciences* (PNAS) in October. For the past 20 years, soybean herbicides have been killing and sickening children in the Cerrado and Amazon regions—where soybean cultivation is concentrated. The study reveals a link between an increase in soy cultivation and a spike in cases of acute lymphoblastic leukemia (ALL), the most common cancer affecting children, among indirectly exposed populations. Researchers identify pesticide-contaminated drinking water as the driving force behind the increased cancer rates occurring downstream from soybean sites.

In 2003, Brazil legalized its first official genetically modified (GM) crop, welcoming the era of GM soybeans and sparking a radical transformation in its agricultural landscape. The introduction of Monsanto's Roundup Ready soybean seed promised farmers an efficient and herbicide-tolerant alternative to traditional crops. A significant shift occurred in the areas dedicated to soy cultivation in the Cerrado region, tripling from five million hectares in 2000 to 15 million hectares in 2019. In the Amazon, the increase was even more staggering, experiencing a 20-fold surge from 0.25 million hectares to five million hectares. With this expansion came an intensive application of pesticides. Brazil's pesticide use per hectare soared to rates 2.3 times higher than the United States and three times higher than China.

The research findings identify that a 10-percentage-point increase in soy cultivation area is associated with an additional 0.40 deaths out of 10,000 due to ALL for children five years of age and lower and an additional 0.21 deaths of children 10 years of age and lower per 10,000 population. The study finds "a strong and persistent relationship between the arrival of high-intensity agriculture in a region and adverse human health outcomes," even after controlling for confounding factors.

The study observes that having a pediatric oncology center within a day's drive—defined as 100 km or less—dramatically lessens fatal outcomes. This is a glaring commentary on the vast inequality in health care access, particularly in countries still navigating the initial stages of agricultural development. These are often low-income and middle-income nations wrestling with instability, and the findings highlight

a concerning disparity and lack of urgency for action.

The apathy toward the absence of access to safe environments, decent working conditions, and health care is starkly visible in what some have referred to as the double standards prevalent in global pesticide laws. Pesticides, deemed too toxic for use in the European Union, are freely exported around the globe and find a ready market in many countries that do not disclose product ingredients and warnings or regulatory restrictions in place that might reduce hazards. Similarly, those harmed by pesticides may not have access to health care.

This discovery is highly relevant, especially for other emerging agrarian nations. Brazil has become a kind of prototype that agrochemical corporations, economists, and policymakers frequently reference.

Brazil's metamorphosis into a large agricultural force has garnered attention and praise from economists and policymakers alike. The country's economy witnessed a surge of over 40 percent between 2000 and 2010, largely attributed to the booming manufacturing sector. This transformation has been used to exemplify the potential of agrochemicals in boosting global food security.

Economists have highlighted the introduction of GM soy as a pivotal moment. It did not just boost agricultural productivity but also set off a chain reaction across the entire economy. Herbicide-tolerant seeds, it was argued, would help Brazil move from an agricultural to a more industrial economy with higher incomes and more spending. Farmers no longer would have to engage in tedious field tilling, allowing farm laborers to find work in other areas and contributing to urban growth.

However, while Brazil is often showcased as a model of success, the study offers a cautionary perspective. It notes, "The combination of restricted oversight, limited healthcare access, a rapidly evolving agricultural production system, and a new chemical technology provides a cautionary tale to regions in similar stages of agricultural intensification."

While many economists laude Brazil's growth, not only are the health consequences becoming increasingly evident, but so are the environmental effects of this rapid industrialization. The Amazon has been facing a series of catastrophic fires and deforestation incidents. The agricultural expansion that came with soybeans also resulted in forest clearing on an immense scale.

As agricultural intensification takes place, droughts are compounding the problem, leading to a noticeable drying of the Amazon River. The extended dry seasons over the past few decades have been taking a toll, making trees less resilient and severely affecting the region's biodiversity. This drying and deforestation have repercussions beyond habitat destruction. In tropical rainforests like the Amazon, the nutrient-rich biomass is crucial for maintaining ecological balance. When this biomass is removed, the tropical soil—poor in nutrients—is unable to sustain life, leading to irreversible damage.

So, while Brazil may be lauded for its economic leaps, the study prompts a critical reassessment. It emphasizes the need for careful consideration of development strategies, urging a nuanced approach that does not solely focus on economic gains, but also weighs the health and well-being of the population.

This story of Brazil is a call for a global rethinking of development models, urging a shift toward practices that are equitable, sustainable, and healthy. Any system that treats the lives of children as collateral is not one that should serve as a global archetype. As we rethink our approach to development models, the indiscriminate use of pesticides should be critically examined along with other discriminatory practice like double standards for banned pesticides.

SOURCE: Marin Elisabeth Skidmore, et al., Agricultural intensification and childhood cancer in Brazil, *PNAS*, Vol 120, No. 45, 2023, https://doi.org/10.1073/pnas.2306003120/

MORE ON THIS SUBJECT

Childhood Leukemia Linked to Pesticides Used in Vineyards—November 1, 2023

Creosote-Induced Health Problems Persist from Springfield, MO Production, Now Superfund, Site—March 7, 2023

TOXICOLOGY | CANCER | MARCH 30, 2023

Research Further Associates Widespread Atrazine Exposure to Breast Cancer

A study published in *Ecotoxicology and Environmental Safety* finds that the commonly used herbicide, atrazine, promotes breast cancer development through suppression of immune cell stimulation (and thus function) and upregulation (increase) of enzymes mediating tumor development. According to the Centers for Disease Control and Prevention (CDC), breast cancer is a disease that causes breast cells to grow out of control, with the type of breast cancer depending on the cells themselves. Several studies and reports, including U.S. Environmental Protection Agency (EPA) data, identify hundreds of chemicals as influential factors associated with breast cancer risk.

Breast cancer is the most common cancer among women, causing the second most cancer-related deaths in

the U.S. Past studies suggest genetic inheritance factors influence breast cancer occurrence. However, genetic factors only play a minor role in the incidence of breast cancer, while exposure to external environmental factors (i.e., chemical exposure) appears to play a more notable role. One in 120 women will receive a breast cancer diagnosis, and genetics can only account for five to ten percent of cases. There are grave concerns over exposure to endocrine (hormone) disrupting chemicals and pollutants that cause adverse health effects. Therefore, advocates point to the need for national policies to reassess hazards associated with disease development from exposure to chemical pollutants. The authors note, "This study demonstrated that atrazine accelerated the cell cycle and encouraged the proliferation and invasion of breast cancer tumor cells. Furthermore, atrazine can reduce anti-tumor immunity by decreasing lymphocyte infiltration and modulating cytokine production inside the tumor microenvironment, thereby promoting tumor immune escape and breast cancer progression. To fully understand the mechanism underlying atrazine's immunosuppression of breast cancers, further research is needed."

Beyond cancer, atrazine is a notoriously toxic herbicide known to cause different health issues, including skin and respiratory diseases, cancer, and cardiovasclar effects, kidney/liver damage. Therefore, it is essential to understand how external stimuli—like environmental pollution from pesticides—can drive breast cancer development.

The researchers examine how exposure to atrazine impacts 4T1 breast cancer cell development, facilitating tumor metastasis (spread from the primary site of origin into different parts of the body) and angiogenesis (the formation of new blood vessels to support tissue growth). Exposure to atrazine significantly increases breast cancer cell spread, tumor size, and the expression/upregulation of MMPs (matrix metalloproteinases) enzymes, mediating precursor tumors to breast cancer. The percentage of lymphocytes in the thymus and spleen responsible for coordinating the immune response by stimulating other immune cells (CD4 + and CD3) are lower in atrazine exposure cohorts, with the CD4/CD8 + immune cell ratio lower than control groups. The abundance of CD4 and CD8 lymphocytes that infiltrate tumors decreases, suggesting atrazine's suppression of the local and systemic immune function on tumors and upregulation of tumor growth promotes breast cancer development.

The connection between pesticides and associated cancer risks is nothing new. Several studies link pesticide use and residue to various cancers, from more prevalent forms like breast cancer to rare forms like nephroblastoma (Wilms' tumor), a form of kidney cancer. The link between agricultural practices and pesticide-related illnesses is stark, with over 63 percent of commonly used lawn pesticides and 70 percent of commonly used school pesticides showing links to cancer. Past research demonstrates the mechanism by which cancer can develop after pesticides enter the bloodstream. An experimental study shows that pesticide exposure produces reactive oxygen species (ROS), which are highly unstable and cause potential DNA and cell damage that propagates cancer development, cancer risk through alternate mechanisms, including genotoxicity (gene damage), epigenetics (gene expression), immunotoxicity, tumors, and endocrine (hormone) disruption.

EPA registers many agricultural uses of the pesticide as "restricted use," allowing only certified pesticide applicators to use the chemical because of its effects on health and ecology. However, the herbicide also is used on residential lawns, school grounds, and golf courses. Encountering pesticides can happen at any point during the pesticide's production, transportation, storage, application, or disposal. The general population mainly encounters atrazine through drinking water, as reports of atrazine contamination demonstrate the chemical's widespread contamination of waterways (e.g., rivers, streams, surface/groundwater). Furthermore, atrazine can volatilize into the atmosphere by up to 14 percent of the applied volume during treatments, resulting in inhalation exposure.

Hormone-related cancers have ties to endocrine disruption and immune disruption. The endocrine and immune systems transmit signals to one another as multiple immune processes are involved in endocrine diseases. Thus, hormones generated by the endocrine system greatly influence breast cancer and other hormonal cancer (e.g., prostate, thyroid, etc.) incidents among humans. Although most types of breast cancers are hormonally responsive and thus dependent on the synthesis of either estrogen, progesterone, or too much of the protein called HER2, G protein-coupled estrogen receptors (GPERs) regulate estrogen through non-genetic cellular pathways—forgoing attachment to standard molecular receptors and leading to triple-negative breast cancer (TNBC). Triple-negative breast cancer has a higher rate of recurrence and worse clinical outcomes than other breast cancers. Xenoestrogens (external estrogen and synthetic compounds sources) like atrazine, can stimulate GPER upregulation and activation in cancer cells. However, although the connection between pesticides and associated cancer risks is nothing new, this study demonstrates the upregulation of MMP enzymes in cancer cells (4T1-Luc) associated with breast cancer development. The researchers consider these cancer cells ideal models to study the immune mechanisms, especially for TNBC, as the cells in TNBC lack receptors for estrogen or progesterone hormones, and TNBC does not respond to hormonal therapy medicines or medicines that target the HER2 protein.

Cancer is a leading cause of death worldwide. Hence, studies concerning pesticides and cancer help future epidemiologic research understand the underlying mechanisms that cause cancer.

SOURCE: Mengqi Wang, et al., Atrazine promotes breast cancer development by suppressing immune function and upregulating MMP expression, *Ecotoxicology and Environmental Safety,*Volume 253, 2023, 114691, ISSN 0147-6513, https://doi.org/10.1016/j.ecoenv.2023.114691

MORE ON THIS SUBJECT **Breast Cancer Awareness Month: Study Finds New Chemicals Associated with Breast Cancer Risk**—October 12, 2023

TOXICOLOGY | PARKINSON'S DISEASE | JANUARY 12, 2023

Pesticides Not Only Linked to Parkinson's Disease Development, But Accelerating Disease Symptoms

Exposure to certain pesticides among individuals diagnosed with Parkinson's disease (PD) can increase the risk of symptom progression. According to a study published in *Science of the Total Environment,* nearly 20 percent of pesticides associated with the onset of PD also increase the risk of faster decline in motor and non-motor function. Several studies find exposure to chemical toxicants, like pesticides, has neurotoxic effects or exacerbates preexisting chemical damage to the nervous system. Past studies suggest neurological damage from oxidative stress, cell dysfunction, and synapse impairment, among others, can increase the incidence of PD following pesticide exposure. Despite the association between PD onset via pesticide exposure patterns, few epidemiologic studies examine the influence pesticides have on worsening motor and non-motor symptoms in PD.

Parkinson's disease is the second most common neurodegenerative disease, with at least one million Americans living with PD and about 50,000 new diagnoses annually. The disease affects 50 percent more men than women, and individuals with PD have a variety of symptoms, including loss of muscle control and trembling, anxiety and depression, constipation and urinary difficulties, dementia, and sleep disturbances. Over time, symptoms intensify, but there is no current cure for this fatal disease. Only 10 to 15 percent of PD cases are genetic, PD is quickly becoming the world's fastest-growing brain disease. Therefore, research like this highlights the need to examine how chemical exposure accelerates disease progression, especially among severe, incurable, and fatal illnesses. The study notes, "Pesticides are not applied in isolation, and people are not singly exposed to one agent over a lifetime. Both scientists and regulators need to consider co- and sequential application hazards and human exposures."

Using a geographic information system (GIS) tool to gather information on ambient exposure to pesticides in

residences and workplaces via California Pesticide Use Report records and land use records, the researchers examine the association between 53 pesticides with links to PD onset to determine PD symptom progression for five years and 2.7 years (respectively) for two patients. Measurements of PD symptom progression include movement disorder specialist-administered Unified Parkinson's Disease Rating Scale part III (UPDRS), Mini-Mental State Examination (MMSE), and Geriatric Depression Scale (GDS). Of the pesticides with links to PD onset, 10 or ~18.8 percent (e.g., copper sulfate [pentahydrate], 2-methyl-4-chlorophenoxyacetic acid [MCPA] dimethylamine salt, tribufos, sodium cacodylate, methamidophos, ethephon, propargite, bromoxynil octanoate, monosodium methanearsonate [MSMA], and dicamba) have associations with faster symptom progression. The study identifies a progressive decline among three endpoints: motor skills, cognitive function, and mental health regarding depression. Individuals living near residential areas or working in occupations with higher exposure to copper sulfate and MCPA experience a rapid decline in all endpoints.

Parkinson's disease occurs when there is damage to dopaminergic nerve cells (i.e., those activated by or sensitive to dopamine) in the brain responsible for dopamine production, one of the primary neurotransmitters mediating motor function. Although the cause of dopaminergic cell damage remains unknown, evidence suggests that pesticide exposure, especially chronic exposure, may be the culprit. Occupational exposure poses a unique risk, as pesticide exposure is direct via handling and application. A 2017 study finds that occupational use of pesticides (i.e., fungicides, herbicides, or insecticides) increases PD risk by 110 to 211 percent. Even more concerning, some personal protective equipment (PPE) may not adequately protect workers from chemical exposure during application. However, indirect nonoccupational (residential) exposure to pesticides, such as proximity to pesticide-treated areas, can also increase the risk of PD. A Louisiana State University study finds that residents living adjacent to pesticide-treated pasture and forests in the agriculture and timber industry have higher rates of PD incidence. Furthermore, pesticide residues in waterways and on produce present an alternate route for residential pesticide exposure to increase the risk for PD via ingestion. Pesticide contamination in waterways is historically commonplace and widespread in U.S. rivers and streams, with over 90 percent of water samples containing at least five or more pesticides. Pesticide exposure can cause severe health problems even at low residue levels, including endocrine disruption, cancers, reproductive dysfunction, respiratory problems (e.g., asthma, bronchitis), and neurological impacts (e.g., developmental effects and Parkinson's), among others. Nevertheless, direct occupational and indirect nonoccupational exposure to pesticides can increase the risk of PD.

This study is one of the few, possibly the first, to identify that pesticides can contribute to the progression of Parkinson's disease. The study identifies 53 pesticides associated with PD onset, with ten directly accelerating declines in motor and non-motor function and mental health from amplified disease progression. However, worsening disease risk following pesticide exposure is not an unfamiliar phenomenon for either physical or psychiatric health. For instance, pesticide exposure can cause

injury to cells responsible for safeguarding against viral infections, inducing more severe disease progression. Since the start of the COVID-19 pandemic, studies evaluating disease outcomes acknowledge excessive and improper use of pesticides, like disinfectants, as a culprit of immunocompromising the respiratory system of COVID-19 patients. COVID-19 is a systemic (general) disease that adversely impacts the respiratory system of many patients. The respiratory system is essential to human survival, regulating gas exchange (oxygen-carbon dioxide) in the body to balance acid and base tissue cells for normal function. Damage to the respiratory system can cause many issues—from asthma and bronchitis to oxidative stress that triggers the development of extra-respiratory, systemic manifestations like rheumatoid arthritis and cardiovascular disease. However, just as the respiratory system is far from the only bodily system affected by the virus, pesticides' adverse effects can span multiple bodily systems, even co-concurrently. Furthermore, underlying medical conditions (e.g., heart/kidney disease, diabetes, cancer, high blood pressure, obesity, etc.) heighten risks associated with severe illness from disease. Additionally, this study is not the first to identify an association between multiple disease risks and proximity to areas with regular pesticide applications. Studies can match disease risk to zip code, with individuals in low-income, indigenous, and people of color communities at the greatest risk of developing pesticide and other environmentally induced diseases.

Over 300 environmental contaminants and their byproducts, including pesticides, are chemicals commonly present in human blood and urine samples and can increase neurotoxicity risk. For instance, 90 percent of Americans have at least one pesticide compound in their body, primarily from dietary exposure, like food and drinking water. These compounds have a global distribution, with evaporation and precipitation facilitating long-range atmospheric transport, deposition, and bioaccumulation of hazardous chemicals in the environment. Thus, exposure to these toxicants can cause several adverse environmental and biological health effects. With the increasing ubiquity of pesticides, current measures safeguarding against pesticide use must adequately detect and assess total chemical contaminants.

The study concludes, "Identifying modifiable risk factors for disease progression may help identify new targets for research, perhaps leading to mechanistic insights important for medication development, and importantly help revise public health policy, aiming to reduce exposure to disease-modifying agents. Our study has implicated individual pesticides in Parkinson's disease progression in several domains. For some, previous epidemiologic or experimental data are supportive of our findings. Further investigation should target both these individual pesticides and the cumulative risk of their mixtures to tease out potential synergistic effects."

SOURCE: Shiwen Li, Beate, et al., Proximity to residential and workplace pesticides application and the risk of progression of Parkinson's diseases in Central California, *Science of The Total Environment,* Volume 864, 2023, 160851, https://doi.org/10.1016/j.scitotenv.2022.160851.

MORE ON THIS SUBJECT

New Study Spotlights Ten Pesticides Implicated in Development of Parkinson's—May 23, 2023

High Frequency of Household Pesticide Exposure Can Double the Risk of Parkinson's Disease Among the General Population—July 11, 2023

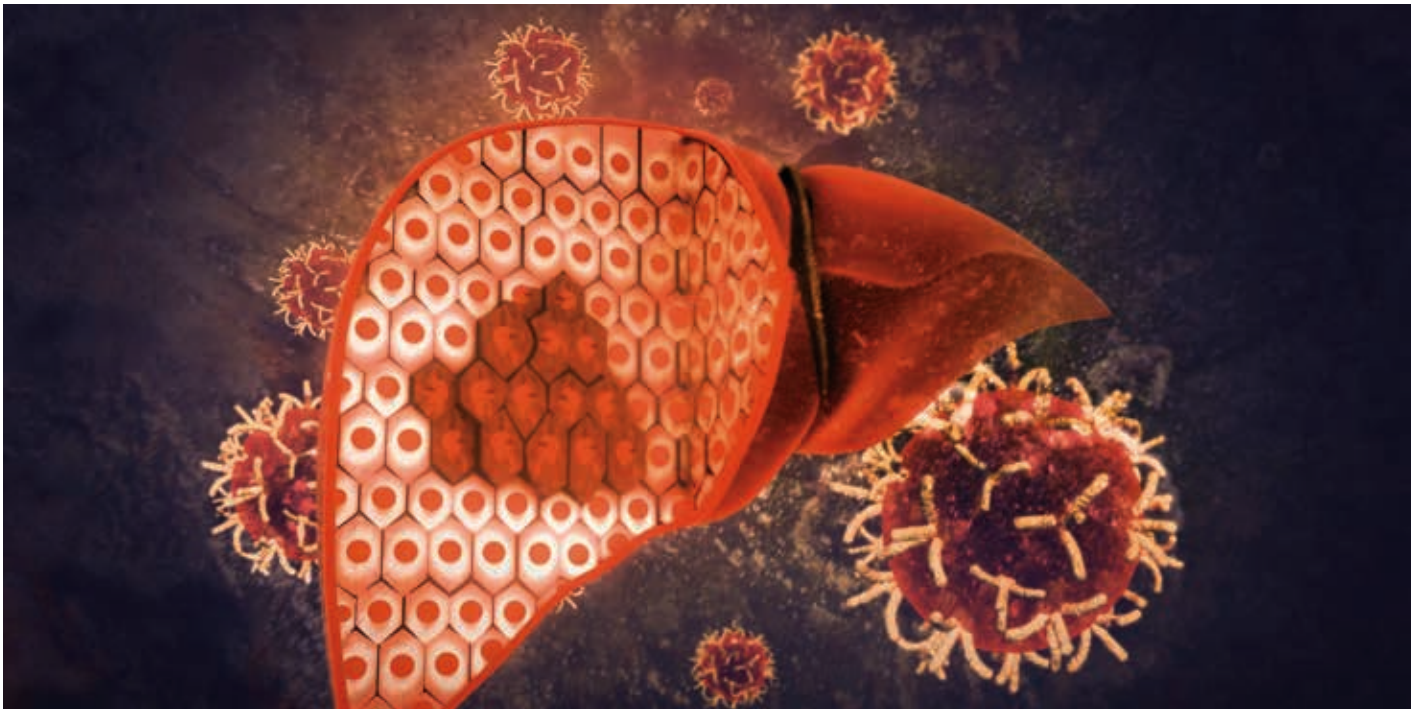
TOXICOLOGY | LIVER DAMAGE/FATTY LIVER DISEASE | JANUARY 11, 2023

Study Connects Neonicotinoids to Liver Damage Ignored by EPA

Neonicotinoid insecticides can have detrimental effects on liver health, according to research published in the Journal of Hazardous Materials. While this is the first study to investigate how these chemicals harm the liver, there is increasing evidence that neonicotinoids, notorious for their effects on pollinators and aquatic life, can cause direct harm to human health. As the U.S. Environmental Protection Agency (EPA) continues to protect the pesticide industry from any measure of meaningful regulation around these hazardous products, the job falls to advocates to place pressure on elected officials to make the changes necessary to safeguard long-term health and well-being.

Scientists postulated that neonicotinoids are neither metabolized by the liver nor excreted by urine. To test that hypothesis, 201 individuals from a hospital in China were enrolled into a study. Of the enrolled, 81 were cancer patients, and 120 were not. These individuals underwent a procedure called endoscopic retrograde cholangiopancreatography, whereby samples of their bile, a fluid produced in the liver, were retrieved and analyzed. Researchers also performed a series of blood tests, measuring a range of biomarkers, including cholesterol, bilirubin, bile acids, white blood cells, platelets, and others. Lastly, scientists determined the amount of eight neonicotinoids in bile samples, including acetamiprid, clothianidin, dinotefuran, imidacloprid, imidaclothiz, nitenpyram, thiacloprid, and thiamethoxam.

Researchers found their hypothesis to be correct. Of all samples taken, at least one neonicotinoid was detected in 99 percent of individuals tested. However, different neonicotinoids



were found to act in different ways. While the detection of acetamiprid was low (1 percent of samples), 97 percent contained nitenpyram. The widely used insecticide dinotefuran was detected in 86 percent of bile. Detections did not appear to differ between participants of different health backgrounds.

The results led scientists to believe that neonicotinoids found in bile will eventually be absorbed again by the intestines, make their way into blood, and eventually one's liver. Biomarkers tested, such as cholesterol, bilirubin, and bile acids, were found to correlate with higher concentrations of certain neonicotinoids. Of the various neonicotinoids, dinotefuran, thiamethoxam, and clothianidin were found to pose the greatest risk to liver health.

In this context, it may be interesting for readers to see how far EPA got in making a determination on liver health and neonicotinoids. Using dinotefuran as an example, here is a link to the Human Health Draft Risk Assessment the agency produced in 2017. As part of tests on the absorption, distribution, metabolism, and elimination studies on dinotefuran, EPA requires one single "special study" on neonatal rat metabolism to determine how the chemical absorbs once in the body. The results (EPA does not provide methodology, only results in its review documents) indicate that in 12-day old rats "absorption was high (absorption could not be adequately determined, but may have approached 80%) and the radiolabel was widely distributed within the body." Furthermore, the results indicate that, "The test material was essentially not metabolized, the parent compound accounting for >97% of the radiolabel in the excreta, plasma, kidneys, and stomach, and nearly 61-83% in intestines (and contents), and liver."

Thus, EPA has enough evidence to show that dinotefuran barely metabolizes at all in one's body. Yet, this result did not tip off EPA in any way. No further testing was conducted to understand or characterize the hepatotoxic (injurious to liver) nature of the insecticide, and it does not appear as though the results influenced any changes in the agency's determination around use patterns. In other words, EPA has enough data to investigate this issue and make even minor protective changes. Instead, after decades of this chemical being on the market, it has taken an independent, peer reviewed study to extrapolate and further investigate the critical details of how a near complete lack of dinotefuran adsorption in the body affects the liver.

This is not the only neonicotinoid health impact that the agency has failed to address. EPA is now being sued for long-term failure to screen and regulate pesticides that have the potential to disrupt the endocrine (hormone) system. In the context of neonicotinoids, there is growing evidence that exposure to these chemicals can result in hormone-dependent breast cancer. A 2019 study found that imidacloprid and thiacloprid can increase expression of a gene linked to breast cancer, and a 2022 study also found associations between neonicotinoid exposure and breast cancer.

In addition to the direct effects of cancer and liver toxicity, the latest evidence also shows these chemicals are indirectly killing hundreds of thousands of people around the world each year as a result of their detrimental impact to pollinator populations relied on for healthy, nutrient-dense food.

SOURCE: Yuanchen Chen, et al., First evidence of neonicotinoid insecticides in human bile and associated hepatotoxicity risk, *Journal of Hazardous Materials*, Volume 446, 2023, 130715, https://doi.org/10.1016/j.jhazmat.2022.130715.

TOXICOLOGY | LIVER DAMAGE/FATTY LIVER DISEASE | MARCH 7, 2023

Glyphosate Exposure Associated with Liver and Metabolic Disorders in Children, Young Adults

Exposure to glyphosate (Roundup) and its breakdown products is associated with an increased risk of liver and metabolic disorders in children and young adults, according to research published in Environmental Health Perspectives. While glyphosate has developed a science-based reputation as a carcinogen, research is finding that cancer is one of a myriad of chronic diseases associated with the notorious chemical. As this body of literature grows, growing awareness by the public is increasing pressure on the U.S. Environmental Protection Agency (EPA) to cancel its allowed uses.

Researchers began their investigation concerned about the rise of liver disorders and metabolic syndrome among young people. This trend has been pronounced among populations of color. The worrying increase has led many to consider synthetic chemical exposure as a contributing factor, as lack of diet and exercise is unlikely to account for the entirety of the increase.

To better understand these impacts, researchers enrolled existing participants in the CHAMACOS (Center for the Health Assessment of Mothers and Children of Salinas) study, a long running cohort of mothers and their children born between the years 2000 and 2002 in the Salinas Valley of California. Enrolled participants consist mostly of farmworker families who were studied (including assessment of body measurements, contaminants in blood and urine, diet, interview questionnaires) at delivery and followed at one to two year intervals. For the present study, 480 participants who completed the 18-year-old follow up visit were enrolled in a nested case-control study. Out of this, 60 cases were selected based on blood tests for liver damage, while 91 controls without liver damage were used as a comparison.

Scientists reviewed urine samples stored from pregnancy, and at ages 5, 14 and 18 years old. These data were considered against an analysis of the amount of agricultural-use glyphosate occurring in and around each enrolled family's residence. The results confirm there is cause for concern among young people's exposure to glyphosate. At age five, urinary levels of glyphosate's primary breakdown product aminomethylphosphonic acid (AMPA) were associated with an increase in transaminases, liver enzymes that can cause harm at high levels in the body, as well as a nearly 2x increased risk of metabolic syndrome. This trend associating glyphosate exposure with adverse effects held throughout early adulthood. Glyphosate and AMPA exposure significantly increased risk of metabolic syndrome in 14-year-olds. When paired with data on the amount of agricultural use of glyphosate in a given area, having lived near a site where glyphosate was applied from birth until five years of

age was associated with contracting metabolic syndrome at age 18.

This is not the first study linking glyphosate to liver damage. A 2015 study determined that chronic exposure to even ultra-low doses of the chemical in drinking water could result in harm to the kidney and liver. A study in 2017 connected the chemical to the development of non-alcoholic fatty liver disease (NAFLD), and a 2019 study built on those findings, showing higher levels of glyphosate in the urine of individuals diagnosed with NAFLD. A 2022 study likewise found that glyphosate exposure before and after birth induces liver damage, posing a significant risk to pregnant women, infants, and children.

NAFLD and other liver disorders can increase the risk of metabolic syndrome. And a growing body of literature has implicated pesticide exposure and the rise of metabolic disorders and obesity, separate from concerns over diet and fitness.

SOURCE: Brenda Eskenazi et al., Association of Lifetime Exposure to Glyphosate and Aminomethylpyhosphonic Acid (AMPA) with Liver Inflammation and Metabolic Syndrome at Young Adulthood: Findings from CHAMACOS Study, *Environmental Health Perspectives*, Volume 131, Issue 3: 037001, https://doi.org/10.1289/EHP11721

MORE ON THIS SUBJECT

Pollution-Associated Liver Disease with Sex-Specific Effects Linked to Persistent Legacy Insecticide, Chlordane— October 4, 2023

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TOXICOLOGY | CHRONIC KIDNEY DISEASE | AUGUST 8, 2023

Chronic Kidney Disease of Unknown Origins Linked to Indoor Pesticide Use, Disproportionally Affecting Women

A study published in *PLOS ONE* finds a positive association between chronic kidney disease (CKD) of unknown origins (CKDu) and the use of indoor pesticides. Longer exposure times have an especially detrimental impact on kidney function, even among individuals without underlying diseases like diabetes mellitus (diseases associated with blood sugar) and hypertension. The innovation of this study's purpose highlights the lack of exposure-related studies on kidney health outcomes associated with indoor pesticide use.

Although CKD risk increases with age and is associated with other health factors like smoking, heart disease, and diabetes, cases without clear causes are increasingly common, indicating that environmental factors are likely playing a role. Over six million people in the U.S. have kidney disease (e.g., nephritis [kidney inflammation], nephrotic syndrome [improper protein filtration], and

nephrosis). Although many studies find an association between exposure to outdoor environmental contaminants like pesticides and CKD, the association between CKDu and indoor pesticides—whose uses are more commonly concentrated in homes—remains unclear. Therefore, studies like this highlight the need for comprehensive information regarding co-occurring exposure patterns and disease prevalence that can have global implications.

The study notes, "Previous research has highlighted the potential harm of pesticides on kidney function, particularly in outdoor uses. Our findings raise concerns about the impact of indoor pesticide use on kidney function in individuals without common risk factors for CKD. Further, longitudinal studies are needed to evaluate the effects of indoor pesticide use on kidney health outcomes and to determine safe dosage levels for these substances."

The growing epidemic of CKDu globally, especially among residents of agricultural communities, has scientists questioning the cause of CKDu and if pesticide use plays a role in disease prognosis. Researchers at the Prospective Epidemiological Research Studies in Iran, using a population-based study, tested individuals to estimate a glomerular filtration rate (eGFR) of less than 60 ml/min/1.73 m^2 to indicate CKDu. Researchers obtained data on indoor pesticide use and duration of exposure through a questionnaire. After excluding subjects with diabetes mellitus and/or hypertension, estimated glomerular filtration rate (eGFR) between 60–89 ml/min/1.73 m^2, and unavailable creatinine measurement, 1079 subjects remained in the study.

The results find that the prevalence of CKD in females was 2.6 times higher than in male subjects. The duration of exposure to indoor use of pesticides is significantly higher in subjects in the CKDu group. Additionally, single women participating in low physical activity, with triglyceride (TG) levels of more than 150 mg/dl, a body mass index (BMI) of more than 25 kg/m^2, non-smoker, and high pesticide exposure time for indoor pesticide use have a greater association with CKDu. The most significant factors in the multivariable analysis are age, sex, TG levels of more than 150 mg/dl, pesticide use, and high pesticide exposure time.

Individuals may encounter malathion through consuming food produced in chemical-dependent agriculture or drinking water or as a result of drift from pesticide application and public use.

Many studies document pesticides' impacts on kidney function, finding a range of chemicals linked to kidney damage. Among the 40 most commonly used lawn care pesticides, 80 percent have associations with kidney or liver damage. These chemicals include widely used herbicides like glyphosate and organophosphate insecticides like malathion. Glyphosate was initially created as a chelating agent (bonding ions and molecules to metal ions) to form strong chemical bonds with metals.

In 2013, the Center for Public Integrity highlighted that glyphosate bonds with toxic heavy metals in the environment, such as cadmium and arsenic, forming stable compounds. These compounds are present in food and water for consumption and do not break down until they reach the kidneys. Thus, farmworkers exposed to glyphosate are likely to have these toxic metals in their kidneys. In 2019, researchers Sararath Guanatilake, MD, and Channa Jayasumana, PhD, were awarded the Freedom and Responsibility Award from the American Association of the Advancement of Science for their work uncovering the link between glyphosate and chronic kidney disease.

Another pesticide, malathion, has recently been cited for its close link to kidney damage. Individuals may encounter malathion through consuming food produced in chemical-dependent agriculture or drinking water or as a result of drift from pesticide application and public use. A study published in October 2021 found significant associations with malathion exposure, low kidney function, and increased risk of CKD. A 2022 study found that 68 percent of well water sampled in Sri Lanka (South Asia) contains at least one pesticide above the global drinking water guidelines, including the organophosphate insecticide diazinon. Individuals reporting drinking well water during their lifetime have significantly (6.7 times) lower kidney health on average than those who never drank well water. With researchers now finding evidence that pesticide-contaminated well water may be a source of kidney dysfunction, it is evident that pesticide mitigation measures must protect those in intensive agricultural areas from pesticide exposure. While there is a desire to neatly separate bad from good actors in environmental "mysteries," including chronic kidney disease and the ongoing decline of pollinators, it is evident that in a world awash in chemicals, it is a combination of these factors that is likely at play. Therefore, protection from pesticide exposure is critical for those working and living in chemical-intensive agricultural areas.

The study finds longer exposure to indoor pesticides is more frequent among patients with CKDu, with a history of indoor pesticide use having 1.36 times higher odds of CKDu. Although previous studies report the prevalence of CKDu is 1.7 times higher among women than men, this study highlights a greater prevalence of CKDu (2.6 times higher) among female patients, demonstrating a possible uptick in CKDu odds. In fact, the study used multivariable models, including indoor use of pesticides (model 1) and duration of exposure to indoor pesticides (model 2), to determine the odds of having CKDu, with the disease odds increasing 7.5 and 8.6 times among the respective models. The study suggests the disproportionate risk of CKDu to women may be because women spend more time

at home in pesticide-treated areas, increasing the risk of pesticide exposure. Moreover, patients who experience the highest quartile of pesticide exposure duration in the study have a 1.64 times higher risk of developing CKDu compared to individuals who never used indoor pesticides.

Thus, the study concludes, "This finding emphasizes the role of cumulative exposure dose at a specific time on kidney function. Although we cannot comment on safe threshold dose of house use of pesticides, as this was not in our study scope, but finding the safe use threshold of these materials could be of great interest that could be evaluated in longitudinal studies."

The kidneys are one of the most important organs for filtering waste out of the human body. However, kidneys are often the main target of pesticide toxicity mediated through oxidative stress.

SOURCE: Saba Alvand, et al., Association of indoor use of pesticides and CKD of unknown origin, *PLOS ONE*, 2023, https://doi.org/10.1371/journal.pone.0277151.

TOXICOLOGY | DIABETES AND OBESITY | SEPTEMBER 27, 2023

Metabolic Diseases, Including Diabetes and Obesity, Driven by Pesticide Exposure

A study published in *Pesticide Biochemistry and Physiology* finds organophosphate (OP), organochlorine (OC), and pyrethroid (PYR) pesticides have links to insulin resistance (IR) associated with metabolic disorders like diabetes, obesity, chronic kidney disease (CKD), and hypertension. Metabolic disorders are among the leading causes of morbidity and mortality, with over 11 percent (>37 million) of individuals in the U.S. having diabetes, and cases are growing by millions annually. Additionally, there is a rise in metabolic disorders among young people. Studies even find low levels of pesticide exposure during pregnancy or childhood cause adverse health effects, including metabolic disorders tied to gut microbiome disruption (dysbiosis). With increasing rates of diabetes and obesity, the two most prominent metabolic diseases in the study, cases among the global population highlight the importance of evaluating how chemical contaminants deregulate normal bodily function through metabolic changes.

To investigate the association between pesticide exposure and insulin-related metabolic disorders in humans, researchers searched the PubMed database for articles, performing a systematic review. The study notes, "IR is defined as a pathological state in which a higher-than-normal level of insulin is required to produce the optimal response in cells." The search generated 4,051 articles related to the topic.

Although general overeating and underexercising are attributed to obesity, researchers find the current obesity epidemic has alternative factors contributing to development. Besides genetics, exposure to obesogenic compounds, like pesticides, can promote obesity development.

However, after excluding duplicates and irrelevant studies, 75 epidemiologic studies linked human exposure to pesticides and IR-related metabolic diseases remained. In total, 30 articles find an association with diabetes, 20 with obesity, seven with hypertension (associated with cardiac issues), seven with chronic kidney disease (CKD), six with metabolic syndrome (i.e., high blood pressure, sugar and serum triglycerides), and three with polycystic ovarian syndrome (POS). The review highlights specific mechanisms of pesticide exposure associated with IR-related metabolic disorders, including liver enzymes and lipid profile alterations, weakening of intracellular insulin signaling from xenobiotic (a foreign chemical in the body) effects, oxidative stress, and inflammation response to chemical exposure.

There are many pesticides linked with the growing global metabolic disorder incidence rates over the past few decades. The World Health Organization (WHO), European Union (EU), and endocrine disruptor expert (deceased) Theo Colborn, PhD, classify over 55 to 177 chemical compounds (e.g., detergents, disinfectants, plastics, and pesticides, etc.) as endocrine disruptors associated with notorious metabolic disorders like diabetes/obesity that can span generations. The obesity rate is increasing and has been over the last five decades. Although general overeating and underexercising are attributed to obesity, researchers find the current obesity epidemic has alternative factors contributing to development. Besides genetics, exposure to obesogenic compounds, like pesticides, can promote obesity development. These compounds routinely cause reproductive, cardiovascular, and endocrine (hormone) issues among exposed individuals, especially farmers.

Obesogenic (obesity-causing) compounds affect the general population and future generational health. For instance, studies demonstrate that legacy DDT exposure increases the risk of breast cancer and cardiometabolic disorder—promoting an epigenetic inheritance of obesity—up to three successive generations. Although the U.S. banned DDT five decades ago, the insecticide (technically, its hazardous metabolite DDE) is still environmentally persistent in all ecosystems and is still used in some countries. Like DDT, exposure to other persistent organic pollutants (POPs), like per- and polyfluoroalkyl substances (PFAS), during pregnancy can increase cardiometabolic disorders, like obesity, diabetes, and cardiovascular diseases, among offspring. Since DDT/DDE residues, current-use pesticides, and other chemical pollutants contaminate the environment, exposure to these chemical mixtures can synergize to increase toxicity and disease effects.

The study is a comparative analysis. This systematic review adds to the growing research indicating pesticides' role in metabolic disorders. Pesticides have long been linked to higher rates of diabetes, as a 2008 study on pesticide applicators in two U.S. states found that every pesticide investigated increased diabetes risk by over 50 percent. A 2017 study zeroed in on one particular class of insecticides, carbamates, finding a propensity to adversely affect human melatonin receptors that regulate sleep, insulin secretion, and glucose homeostasis, increasing the risk of diabetes. A 2017 report commissioned by Gallup-Sharecare found that farmers recorded the second-highest rate of diabetes among all professions. Additionally, a 2019 study from the University of California, Davis, found that South Asian immigrants exposed to higher rates of DDT also displayed higher rates of type 2 diabetes. Regarding obesity, many pesticides are obesogenic compounds that directly impact hormone and receptor function and include pesticides like organochlorines, organophosphates, carbamates, and pyrethroids, as mentioned in this study. These chemicals can negatively affect reproductive function, nervous system function, metabolic/immune function, hormone-related cancers, and fetal/body development.

The study concludes, "Taken together, the link of pesticides with IR-related metabolic diseases can be a wide area of research from different aspects, including epidemiological evidences [of] cellular mechanisms weakening insulin signaling and preventing approaches. However, […] there is a need for studies to evaluate specific mechanisms by which different chemical groups of pesticides can develop IR-related metabolic diseases, especially those with increasing prevalence in the future."

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Pesticides themselves can possess the ability to disrupt metabolic function, especially for chronically exposed individuals (e.g., farmworkers) or during critical windows of vulnerability and development (e.g., childhood, pregnancy). Health officials identify diabetes as one of the most common chronic diseases.

SOURCE: Ali Arab and Sara Mostafalou, Pesticides and insulin resistance-related metabolic diseases: Evidences and mechanisms, *Pesticide Biochemistry and Physiology,* Volume 195, 2023, 105521, https://doi.org/10.1016/j.pestbp.2023.105521.

TOXIOCOLOGY | SHINGLES | NOVEMBER 29, 2023

Study Finds Novel Relationship Between Shingles and Pesticide Exposure

A study published in *Environment International* finds high pesticide exposure incidence associated with shingles, a varicella-zoster virus (the same highly contagious virus that causes chicken pox) that reactivates in the body after having chicken pox. Shingles is a painful condition with a blistering rash that can lead to vision and hearing loss, brain and lung inflammation, and even death if not treated. Since shingles manifest decades after initial exposure, and the association is strongest among individuals already hospitalized for pesticide-related illnesses, researchers find the long-term/chronic effects most concerning. Although dermal pesticide exposure can cause a range of adverse reactions, including dermatitis, allergic sensitization, and cancer, any route of exposure can exacerbate dermal manifestations through immune system response, causing virus-based skin reactions like shingles.

People encounter toxic chemicals daily. However, frequent use of chemicals, including the use of everyday products like cleaning supplies, personal care products, agricultural chemicals, fabrics, non-stick cookware, and general airborne pollution, exacerbates pesticide exposure risks. Dermal exposure is the most common pesticide exposure route, composing 95 percent of all pesticide exposure incidents, and is a significant concern for occupational health.

The study notes, "[The] findings of elevated shingles risk associated with acute, clinically relevant pesticide exposures also highlights potential long-term costs of unintentional high-level pesticide exposures, especially those contributing to poisoning, which is a global problem in agricultural settings."

Using 22,753 licensed private pesticide applicators of 66 years and older with more than 12 consecutive months of Medicare hospital and outpatient coverage between 1999 and 2016, researchers identified patients who experience at least one shingles incident. Additionally, researchers gathered information on whether patients received medical care for pesticide-related illnesses or they encountered high pesticide exposure events (HPEE) and poisoning. The results find that 2,396 pesticide applicators were diagnosed with shingles during the 1996 to 2016 timeframe, with higher shingles rates among patients hospitalized for pesticide-related illness, pesticide poisoning, and HPEE. Thus, these initial findings suggest acute, high-level, and medically significant effects of pesticide exposure can increase shingles risk in individuals years to decades following exposure.

The skin responds to numerous external stimuli that can change its morphological (shape/structure), physiological (function), and histological (tissue) properties. Some responses to external stimuli are typical, including skin exposure to sunlight (UV-light), for tanning, or water wrinkling. However, exposure to excessive stimuli, including environmental contaminants,

can produce adverse permanent changes to the skin. Just as excessive exposure to UV rays can cause skin discoloration and cancer, prolonged dermal contact with disinfectants can cause many adverse reactions, including skin discoloration and cancer. One of the most predominant routes of pesticide exposure is dermal, and most disinfectants are potential skin irritants and sensitizers, suggesting that direct skin contact with these toxic chemicals and the adoption of proper application protocol is critical.

Most pesticides cause some form of acute skin irritation. Although certain pesticides are less harmful through dermal contact than others, many chemicals cause irritant contact dermatitis (ICD) and allergic contact dermatitis (ACD). ICD is a nonimmune response that manifests into localized skin inflammation by directly damaging the skin following toxic agent exposure. ACD is an immune response to skin contact with a dermal allergen that an individual is already sensitized to, causing non-localized skin inflammation and systemic bodily response. However, chronic, cumulative exposure to more mild chemical irritants can elicit a skin reaction. As skin cancer has increased significantly over the past 50 years, many appropriately point to the link between sun exposure and the development of the disease. However, this research indicates that contact exposure to herbicides may be affecting risk. The authors point to studies finding links between dermal exposure of pesticides and exposure to UV radiation, as well as research that finds sunscreen itself may facilitate skin uptake of pesticide residue.

This study is the first to demonstrate the occurrence of shingles associated with pesticide exposure. However, this study is not the first to establish pesticides' relationship with immune system disorders related to the skin. A Dutch tudy found that infants exposed to dioxins (a pesticide byproduct) and PCBs have a higher incidence of recurrent chicken pox, which, as mentioned, is linked to shingles.

Although this study notes that the mechanism involved in shingles incidence is not well understood, studies, including this one, suggest immune system suppression is the main culprit. The immune system offers the best defense against viral infection, as the virus stimulates an innate and adaptive immune response to expel viral particles from the body. Innate immune responses are the first line of defense against viral infections, activating myeloid immunocytes (cells that mediate immune responses against pathogens). These mediating cells create antibodies that the complement system (a network of proteins that eliminate pathogens) enhances. Therefore, review researchers speculate that immunocytes and the complement system can restrict viral infections. However, coronavirus infections can suppress/delay interferon (INF) protein synthesis responsible for defending against viral infections, causing a lapse in the innate defense system. Similarly, an adaptive immune response involves various immune cells and antibodies essential to protect against coronavirus infections. Still, injury to cells responsible for safeguarding against viral infections can induce more severe disease progression. The global rate of shingles over recent decades is increasing despite vaccine availability. Therefore, there is an urgent need to evaluate the effect pesticide exposure and use have on disease health outcomes.

SOURCE: Christine Parks, et al., High pesticide exposures events, pesticide poisoning, and shingles: A medicare-linked study of pesticide applicators in the agricultural health study, *Environment International,* Volume 181, 2023, 108251, https://doi.org/10.1016/j.envint.2023.108251.

TOXICOLOGY | REPRODUCTIVE EFFECTS | DECEMBER 1, 2023

Study Confirms Connection Between Exposure to Pesticides and Male Reproductive Problems

Even though researchers have noted since the 1970s that human fertility appears to be declining globally, doubt is still circulating that it is really happening and that pesticides could have anything to do with it. Recently published studies, however, make it clear that, even without exact elucidation of the mechanisms by which pesticides damage male fertility, there is an unmistakable association with pesticides and many aspects of male reproductive health.

One of the recent studies, a meta-analysis of 25 studies on the connection between pesticides and male reproductive problems, finds that men exposed to organophosphate (such as malathion) and carbamate (such as carbaryl and methiocarb) pesticides have lower sperm concentrations than the general population. This is especially true of men exposed in work settings. The senior author of the study, Melissa J. Perry, ScD of the George Mason University College of Public Health, told HealthNews, "The evidence available has reached a point that we must take regulatory action to reduce insecticide exposure."

Human infertility is defined as "the failure to achieve pregnancy after 12 months or more of regular unprotected

sexual intercourse." Most public attention regarding infertility focuses on women's difficulties in getting pregnant, causing couples to resort to *in vitro* fertilization (IVF) and surrogates. But about a third to half the time, a couple's infertility results from problems with the male contribution. Men's reproductive health is measured by total sperm count, sperm's ability to move, the incidence of malformed sperm or reproductive organ structure, testosterone levels, and other criteria.

The relationships between aspects of male reproductive health, such as sperm count, fertility and testicular cancer, are not perfectly understood, but they are known to be interrelated. Low sperm counts can not only indicate decreased fertility, but also correlate with other markers of declining male reproductive health, including testicular tumors and testosterone levels. In 2017, Shanna Swan, PhD of the Icahn School of Medicine at Mount Sinai and colleagues published a major review of changes in sperm count between 1973 and 2011. They found that sperm counts declined by 52.4 percent over their study period.

Dr. Swan et al. also noted that reduced sperm count is a strong predictor of overall disease and death risk. In other words, sperm count reflects influences on health that go far beyond reproduction, and also that reproductive health is created by proper hormone balance, which many pesticides are well known to disturb.

Dr. Swan and colleagues wrote that chemical exposures, including pesticides (especially the endocrine disrupters) are plausible bad actors in the sperm count decline, but also said "lifestyle factors" such as diet and smoking are likely factors. High body mass index (BMI) and obesity have also been associated with low sperm counts.

Obesity is often cited as a "lifestyle choice" causing reproductive problems, unrelated to factors like pesticide exposures. This is misleading, however, because obesity itself can be an outcome of such exposures. For example, a 2022 review found that two carbamate insecticides and eight organophosphate insecticides were "significantly associated with higher obesity prevalence," suggesting that obesity and low sperm count may have a common cause rather than a direct cause-and-effect relationship.

Pesticides present an especially vexing problem in that they affect organisms through many different pathways, often simultaneously. For example, organophosphates notoriously damage neurotransmitters, but they have also been associated with poor semen quality in exposed factory workers. Similarly, carbamates interfere with neurotransmitters and are known for disrupting thyroid and steroid hormones and increasing the risk of both non-Hodgkin lymphoma and dementia, but they have also been associated with chromosome damage in sperm. Far less scientific attention has been devoted to these chemicals' effects on male reproduction than on their neurological ones, but the reproductive consequences may be even greater. For one thing, many pesticides, including organophosphates, can cross the placental barrier if the mother is exposed during pregnancy. Fetal exposures to organophosphates affect childhood cognition and coordination and predispose the child to develop cancer in later life.

But it gets worse. A father's environmental exposures can alter not only his direct fertility but also his epigenetic patterns, and these can be passed from parent to child. Epigenetics are a suite of cell processes in which gene expression is controlled by molecules that block or open access to genes in the double

DNA helix. In every cell of the body, this process continually operates to orchestrate the cell's biochemistry and its relation to other cells and organs, but it does not change genes themselves. Epigenetic patterns are a kind of template or history of the habits and exposures of the parent, including smoking history, diet, pesticide exposures, alcohol and drug consumption, and social stress. Sperm are major contributors of epigenetic information passed from one generation to the next, and pesticides affect that information.

"It is becoming clear that epigenetic information can function as molecular memory of past environmental exposures and be passed from one generation to another via the germline," according to the authors of a 2022 review by a pair of Georgetown University Medical Center and Lombardi Comprehensive Cancer Center scholars. Descendants of an exposed male may have no direct exposure themselves but be paying for the inadvertent "sins" of their fathers—"sins" such as agricultural or factory work.

A 2023 update of the 2017 review of temporal trends in sperm count, also coauthored by Dr. Swan, expanded the geographical range of the study by including data on men in 53 countries on six continents to get a global picture rather than one focused on industrialized countries where data are more plentiful. They found "strong evidence" that sperm counts have declined globally. Disturbingly, the authors show that the downward trend in sperm counts has become steeper since 2000, accelerating beyond the already worrisome rate seen in the 2017 meta-analysis. From 1972 to 1999, sperm count dropped by about one percent a year; since 2000, the rate has been about 2.6 percent.

The evidence has continued to mount that pesticides affect both male and female reproductive health, yet most of these chemicals remain on the market, contributing to the prospect of agricultural collapse and declining human population worldwide.

View Dr. Swan's talk, Modern Life and the Threat to the Future, at Beyond Pesticides 2021 National Pesticides Forum, Cultivating Healthy Communities.

SOURCE: Lauren B. Ellis, et al., Adult Organophosphate and Carbamate Insecticide Exposure and Sperm Concentration: A systematic Review and Meta-Analysis of the Epidemiological Evidence, *Environmental Health Perspectives,* 2023-11, 10.1289/EHP12678.

TOXICOLOGY | REPRODUCTIVE EFFECTS | JULY 26, 2023

Another Study Adds to Science Indicating Mothers' Exposure to Pesticides During Pregnancy Increases Adverse Birth Outcomes

An exploratory study published in *Environment International* adds to the many studies demonstrating residential prenatal pesticide exposure can result in adverse birth outcomes. Residential exposure to five active pesticide ingredients (AIs) fluroxypyr-meptyl, glufosinate-ammonium, linuron, vinclozolin, and picoxystrobin has adverse effects on gestational age (GA), birth weight (BW), mortality after birth, child's sex, premature development, low birth weight (LBW), including small for gestational age (SGA), and large for gestational age (LGA). Pesticides' presence in the body has implications for human health, especially during vulnerable life stages like childhood, puberty, pregnancy, and old age.

Pesticide exposure during pregnancy is of specific concern as health effects for all life stages can be long-lasting. Birth and reproductive complications are increasingly common among individuals exposed to environmental toxicants like pesticides. The Centers for Disease Control and Prevention (CDC) reports birth defects are the leading cause of infant mortality, with one in every 33 infants born with an abnormality that results in death. Therefore, studies like this can help government and health officials safeguard human health by assessing adverse effects following prevalent chemical exposure.

Pesticide exposure during pregnancy is of specific concern as health effects for all life stages can be long-lasting. Birth and reproductive complications are increasingly common among individuals exposed to environmental toxicants like pesticides.

Using a Dutch birth registry from 2009 to 2013, the researchers selected pregnant mothers over 16 years who were living in non-urban areas (who have never moved addresses or only moved once) as participants. Researchers estimated how many kg of the 139 active ingredients are used within 50, 100, 250, and 500 meters of the mother's home during pregnancy. To determine the association between evidence of reproductive toxicity and gestational age, birth weight, perinatal mortality, child's sex, prematurity, low birth weight, small for gestational age and large for gestational age among select active ingredients, the study employed generalized linear models, adjusting for individual and area-level confounders.

The results demonstrate maternal residential exposure to fluroxypyr-meptyl and vinclozolin has associations with longer GA, exposure to glufosinate-ammonium increases the risk of LBW, and linuron exposure has an association with higher BW and higher probabilities of LGA. Additionally, picoxystrobin has associations with a higher likelihood of LGA.

Environmental contaminants like pesticides are ubiquitous in the environment, with 90 percent of Americans having at least one pesticide compound in their body. Numerous studies indicate chemical exposure mainly stems from dietary exposure, like food and drinking water, and researchers caution that there are hundreds to thousands of chemicals that humans are likely to encounter. Just as nutrients are transferable between mother and fetus, so are chemical contaminants. Studies find pesticide compounds in the mother's blood can transfer to the fetus via the umbilical cord. A 2021 study finds pregnant women already have over 100 detectable chemicals in blood and umbilical cord samples, including banned chemicals. However, 89 percent of these chemical contaminants are from unidentified sources, lack adequate information, or were not previously detectable in humans. Considering that the first few weeks of pregnancy are the most vulnerable periods of fetal development, exposure to toxicants can have much more severe implications. A 2020 study finds prenatal pesticide exposure can increase the risk of the rare fetal disorder holoprosencephaly. This disorder prevents the embryonic forebrain from developing into two separate hemispheres. Moreover, women living near agricultural areas experience higher pesticide exposure rates, increasing the risk of birthing a baby with abnormalities. These birth abnormalities can include acute lymphoblastic leukemia and Attention-Deficit/Hyperactivity Disorder (ADHD). Even common household pesticide use during pregnancy can increase nephroblastoma (kidney cancer) and brain tumor risk in children. Therefore, prenatal and early-life exposure to environmental toxicants like pesticides increases susceptibility to disease for both mother and child's health.

Environmental contaminants like pesticides are ubiquitous in the environment, with 90 percent of Americans having at least one pesticide compound in their body.

The rates of preterm births, miscarriages/stillbirths, and birth malformations are increasing. Additionally, many current-use pesticides and metabolites (or breakdown products) of many long-banned pesticides still impart negative effects on human health that can continue into childhood and adulthood and may have multigenerational consequences. Thus, pesticide exposure poses a risk to mothers, their subsequent offspring, and future generations. Researchers at Drexel University report that higher levels of some organochlorine compounds, like DDT, during pregnancy are associated with autism spectrum disorder (ASD) and intellectual disability (ID). Although the U.S. has banned many organochlorine compounds, the ongoing poisoning and contamination underscore the pervasiveness and persistence of these chemicals, with their continued adverse impact on human health.

This study amplifies the growing body of scientific research evaluating

pesticides' effects on newborns. Exposure to specific pesticides can increase the risk of higher BW, LGA, and longer GA, which other studies have shown to be linked with increased risk of obesity and cardiovascular diseases later in life. Although fluroxypyr-meptyl is one of the only pesticides in the study still approved for use in the European Union (EU), imported products can contain contamination from the remaining active ingredients via countries where currently used. Moreover, some current-use pesticides share similar modes of action with the active ingredients in this study, suggesting future research on the effects of maternal pesticide exposure can use these findings as models. The study concludes, "The underlying mechanism driving these effects are unclear, but the findings warrant more research into the effects of (nonoccupational) exposure to these pesticides on human health, especially in the vulnerable population of pregnant women and their babies. [Active ingredients] that were correlated or that share the same modes of action with the identified in this study may also be considered as leads for further research."

SOURCE: M. Simões, et al., Exploring associations between residential exposure to pesticides and birth outcomes using the Dutch birth registry. *Environ Int.* 2023 Aug; 178:108085. 10.1016/j.envint.2023.108085. Epub 2023 Jul 4. PMID: 37421898.

MORE ON THIS SUBJECT

Residential Areas and Early Postnatal Complications for Pregnant Women Tied to Banned and Current Pesticides—May 31, 2023

Take Action: Involuntary Spontaneous Abortions Linked to EPA-Registered Pesticides—July 31, 2023

Prenatal and Early Life Exposure to Glyphosate Herbicides Induce Hormonal Effects Disrupting Sleep and Neurodegenerative Diseases—December 6, 2023

TOXICOLOGY | EFFECTS ON CHILDREN/DEVELOPMENTAL EFFECTS | MARCH 9, 2023

Prenatal Pesticide Exposure Threatens Children's Language Development at 18 Months after Birth, Study Finds

A study published in *Environmental Research* finds exposure to organophosphate (OP) compounds during pregnancy, or prenatal OP exposure can cause shortfalls in language development abilities at 18 months, stifling preschool-age language expression. Additionally, a timely and co-occurring study published in *Environmental International* finds similar results, highlighting that the insecticide chlorpyrifos (an organophosphate, widely used in agriculture) impedes neurological and psychological development, including language communication and all motor skills of offspring at 12 and 18 months old. Prenatal development is one of the most vulnerable periods of

exposure, as the fetus is most susceptible to the harmful effects of chemical contaminants. Many studies indicate that prenatal and early-life exposure to environmental toxicants increases susceptibility to diseases, from learning and developmental disabilities to cancer. Given research links to pesticide exposure and neurological and cognitive development, studies like this can help government and health officials identify how pesticides' impact on the brain elevates health concerns. The *Environmental Research* authors note, "The etiology [cause] of language development is complex, and this work further highlights the importance of the prenatal environment as a mechanism of influence that are associated with deficits in early language acquisition and ability, which could signal increased behavioral problems and academic difficulties in later childhood that extend into adolescence."

Pesticide use is widespread and direct exposure from applications or indirect exposure from residues threatens human health. Children are more vulnerable to the impact of pesticides as their bodies are still developing and their intake is higher relative to body weight.

The study in *Environmental Research* includes 299 mother-child groups from Norway. Researchers examine chemical exposure in pregnant mothers during gestation week 17 and assessed the related language skills of children at 18 months of age and pre-school age (~4–6 years old). Parents and teachers report the child's language ability and apply it to structural equation models. Prenatal exposure to OP pesticides has a negative correlation with language ability in both 18 months and preschool-aged children. The results published in *Environmental International* mirror those of the Norwegian study as researchers assessing neuropsychological development in 12-month and 18-month-old children find the stages of communication and motor skills among children are underdeveloped relative to age.

Pesticide use is widespread, and direct exposure from applications or indirect exposure from residues threatens human health. Children are more vulnerable to the impact of pesticides as their bodies are still developing and their intake is higher relative to body weight. Many studies indicate prenatal and early-life exposure to environmental toxicants increases susceptibility to disease. A 2020 study finds the first few weeks of pregnancy are the most vulnerable periods during which prenatal pesticide exposure can increase disease risk. A pregnant mother's exposure to environmental toxicants can increase the likelihood of developmental disabilities, as most developmental disabilities begin before birth. Many studies link childhood pesticide exposure to lower IQ, but prenatal pesticide exposure even more so. Moreover, women living near areas of high toxic chemical use have an increased risk of birthing a baby with impaired cognitive function, like Attention-Deficit/Hyperactivity Disorder (ADHD). Many long-banned pesticides still cause adverse effects to human health. Researchers at Drexel University report that higher levels of some organochlorine compounds, like DDT, during pregnancy are associated with autism spectrum disorder (ASD) and intellectual disability (ID).

Both studies add to the growing evidence of the impacts that chemical exposure during pregnancy has on offspring health, specifically neurological development. Additionally, these studies highlight that early childhood developmental pathways are significant for future health. The findings on OP exposure and delayed communication skills are not new. Research underscores one of the mechanisms that allows chemical contamination in a mother's body to affect the fetus. In blood and umbilical cord samples, pregnant women already have over 100 detectable chemicals, and studies find pesticide compounds present in the mother's blood can transfer to the fetus via the umbilical cord. Like these studies, other studies demonstrate that exposure to pesticides, such as organophosphate insecticides like chlorpyrifos, have endocrine disruption properties that induce neurotoxicity via acetylcholinesterase (AChE) inhibition. The number of children with neurodevelopmental disabilities is increasing in the U.S., and many children in rural areas—where pesticide use is most prevalent—have a higher rate of neurological disabilities. Therefore, it is essential to effectively monitor and assess pesticide exposure for the sake of human health.

SOURCES: Amanda M. Ramos, et al., The association of prenatal phthalates, organophosphorous pesticides, and organophosphate esters with early child language ability in Norway, Environmental Research, Volume 225, 2023, 115508, https://doi.org/10.101 j.envres.2023.115508

Hongcheng Wei, Prenatal exposure to pesticides and domain-specific neurodevelopment at age 12 and 18 months in Nanjing, China, *Environment International*, Volume 173, 2023, 107814, https://doi.org/10.1016/j.envint.2023.107814

MORE ON THIS SUBJECT

Father's Exposure to Toxic Chemicals in the Workplace Increases Risk of Heart Disease in Infants—February 23, 2023

Glyphosate Exposure Associated with Liver and Metabolic Disorders in Children, Young Adults—March 7, 2023

The number of children with neurodevelopmental disabilities is increasing in the U.S., and many children in rural areas . . . have a higher rate of neurological disabilities. Therefore, it is essential to effectively monitor and assess pesticide exposure for the sake of human health.

TOXICOLOGY | NEUROTOXICITY | JANUARY 19, 2023

Neonicotinoid Insecticides Adversely Affect Nervous System Health, According to Study

Research published in *Environmental Health Perspectives* finds the presence of nine neonicotinoid (neonic) insecticides and six neonic metabolites within human cerebrospinal fluid (CSF). CSF is essential to the central nervous system (CNS), especially for CNS development. Specific chemical biomarkers (measurable indicators of biological state), like pesticides, found in CSF are useful for diagnosing and evaluating numerous neurological diseases.

The nervous system is an integral part of the human body and includes the brain, spinal cord, a vast network of nerves and neurons, all of which are responsible for many bodily functions—from sensing to movement. However, mounting evidence over the past years shows that chronic exposure to sublethal (nonfatal) levels of pesticides can cause neurotoxic effects or exacerbate pre-existing chemical damage to the nervous system. The impacts of pesticides on the nervous system, including the brain, are hazardous, especially for chronically exposed individuals (e.g., farmworkers) or during critical windows of vulnerability and development (e.g., childhood, pregnancy). Researchers identify the role agricultural chemicals play in CNS impacts causing neurological diseases, like amyotrophic lateral sclerosis (ALS) and Parkinson's disease, dementia-like diseases such as Alzheimer's, and other effects on cognitive function.

The study explores whether the presence of neonics and their metabolites in CSF is an indicator of adverse CNS effects. From April 2019 to January 2021, researchers gathered 314 CSF samples from patients aged one month to 89 years in the First Affiliated Hospital of Shantou University, Shantou, China using a clinical lumbar puncture. Researchers collected CSF samples from patients experiencing similar symptoms with a different disease/clinical diagnosis (e.g., "mostly viral encephalitis, encephalitis other than viral encephalitis, leukemia, cerebral hemorrhage, cerebral laceration, urinary tract infection, respiratory failure, pulmonary tuberculosis, and posterior circulation ischemia"). To analyze the presence of neonics and their metabolites in CSF, researchers used acidification, solid phase extraction, and high-performance liquid chromatography-tandem mass spectrometry (HPLC-MS/MS). Ninety-nine percent of the 314 CSF samples contain at least one neonic. Of the 314 CSF samples, nine percent (28) have a single neonic compound, 84 percent (265) have between 2 and 6, and six percent (19) have between 7 and 10 neonic compounds. Nine of these neonics in CSF samples are nitenpyram (NIT), thiamethoxam, imidacloprid, acetamiprid (ACE), thiacloprid, clothianidin, flonicamid, imidaclothiz, and sulfoxaflor. Additionally, six neonic metabolites are present in CSF: N-desmethyl-thiamethoxam, olefin-imidacloprid, 5-hydroxy-imidacloprid,

N-desmethyl-acetamiprid (N-dm-ACE), thiacloprid-amide, and 6-chloronicotinic acid.

Over the past 20 years, neonicotinoids have served as an alternative for four major chemical classes of insecticides in the global market (organophosphates, carbamates, phenyl-pyrazoles, and pyrethroids). These systemic agricultural pesticides are highly toxic, resembling nicotine, and affect the central nervous system of insects, resulting in paralysis and death, even at low doses. Like other pesticides, neonics readily contaminate water and food resources as traditional water waste treatments typically fail to remove the chemical from tap water, and the systemic nature of neonics allows the chemical to accumulate within plant products. According to the Centers for Disease Control and Prevention (CDC), nearly half the U.S. population encounters at least one type of neonic daily, with children ages three to five having the highest exposure risk. Health impacts of exposure to neonics can include neurotoxicity, reproductive anomalies, hepatic and renal damage, and an increase in gene expression linked to hormone-dependent breast cancer. Additionally, researchers identified that some neonicotinoids play a role in enzyme (aromatase) production that stimulates excess estrogen production, a known event in hormone-dependent cancer development.

Beyond its link to human health effects, neonicotinoids are infamous for their well-documented role in driving mass pollinator declines. However, pollinators are far from the only victims of ubiquitous neonicotinoid contamination. In a recent avian risk assessment, EPA scientists found that neonicotinoids levels in treated seeds exceed the agency's threshold of concern for certain birds by as much as 200-fold. A 2017 study by researchers at the University of Saskatchewan confirmed that tiny amounts of neonicotinoids—the equivalent of just four treated canola seeds, for example—are enough to cause migrating songbirds to lose their sense of direction and become emaciated. Recent research uncovered the endocrine-disrupting health impacts of imidacloprid on white-tailed deer, adding to the concern of the same effect in humans.

This study adds to the growing research on pesticides and neurotoxic consequences. Although past studies on neonic toxicity focus on neurotoxicity among insects and aquatic invertebrates, emerging evidence demonstrates these compounds also adversely impact the nervous system of animals, including humans as well. Not only does research find that exposure to sublethal doses of chemicals affects hormone receptors (endocrine disruption), but neural receptors, such as connections between nerves, the brain, enzymes, and DNA, are affected as well. In addition to this research, several studies demonstrate autism, mood disorders (e.g., depression), and degenerative neurological conditions among aquatic and terrestrial animals, including humans, exposed to pesticides. Pesticides themselves, mixtures of chemicals such as the defoliant Agent Orange (2,4-D and 2,4,5-T) and its dioxin contaminants and therapeutic hormones in pharmaceutical products, possess the ability to disrupt neurological function.

Furthermore, studies suggest that pesticide formulants (adjuvants) such as POEA (polyoxyethylene tallow amine) have both neurological and endocrine-disrupting activity. POEA is present in some glyphosate-based herbicides, like Roundup, and has higher nervous system toxicity than the active ingredient (glyphosate). Although the biological function and mechanism of neurotoxicity related to pesticide exposure is unclear, scientists note synchronized communication within and between cells that have a mechanism of action of "spamming" communication signals. The study concludes, "For continued global use of NEOs [neonics], mechanisms of toxicity, especially to the CNS in humans, need to be more rigorously investigated."

SOURCE: Jing Li, et al., Detection of Neonicotinoid Insecticides and Their Metabolites in Human Cerebrospinal Fluid, *Environmental Health Perspectives*, Volume 130, Issue 12, 127702, https://doi.org/10.1289/EHP1137

TOXICOLOGY | NEUROTOXICITY | MAY 5, 2023

New Study Links Synthetic Pyrethroids to Neurodevelopmental Problems

Low level exposure to pyrethroid insecticides found in common pesticide brands like RAID and ORTHO result in neurodevelopmental damage to laboratory animals, reinforcing evidence of harm found in epidemiologic studies on human exposure to these chemicals, according to research published in PNAS Nexus. In the study, mice exposed to the pyrethroid deltamethrin displayed atypical behavior similar to humans with developmental disorders. "We are not saying these mice have autism or that they have ADHD. That's not the goal here," said James Burkett, PhD, study coauthor and assistant professor of neuroscience in the UToledo College of Medicine. "What we are saying is that something in their brain has been altered by this exposure and it is resulting in the same kinds of behaviors that we see in children with autism."

Scientists arrived at this determination by exposing a group of mouse mothers to consistent low levels of deltamethrin in their food during preconception, pregnancy, and lactation. The study notes that the amount of pesticide provided was "well below the benchmark dose for regulatory guidance."

A separate control group was given no pesticide in its food. Offspring from the female mice were then put through behavioral tests on social behavior, restrictive or repetitive behaviors, cognition and communication.

Results find that mouse pups whose mothers were exposed to deltamethrin increase their repetitive behaviors. In tests, they buried more marbles than control pups, and performed more self-grooming than the control group. Male pups exposed to deltamethrin also produced fewer vocalizations when being separated from their mothers. Pesticide exposure also impaired learning and memory; in a fear conditioning test, exposed mice were less likely to react to a fearful event they encountered previously.

In addition to behavior, scientists observed physiological changes in pups whose mothers were pyrethroid-exposed. These mice exhibited significant changes in dopamine levels and transport around the body. For "autistic" individuals, the metabolite homovanillic acid (HVA) is considered the earliest biomarker for the condition, and exposed mice pups displayed increased levels of the substance. "These are all similar to symptoms human patients with neurodevelopmental disorders might have," Dr. Burkett said.

Synthetic pyrethroids are hazardous pesticides that have flown below radar of those concerned about pesticides for far too long, not receiving nearly as much attention as other dangerous and commonly used pesticides like the weed killer glyphosate.

"If you have someone who comes and sprays in your house, this is likely what they're spraying. It's used in landscaping, it's what they fog in the streets for mosquitoes. It's everywhere," said Dr. Burkett. "Our study, however, adds to the evidence that these chemicals might not be as safe for children and pregnant women as we once believed." In fact, Beyond Pesticides has never believed these chemicals to be safe for children or pregnant women. The depth of historical reporting on these chemicals in the *Daily News* bears this out. As far back as 2008, Beyond Pesticides was reporting on the risk these chemicals pose to children's development.

The research on this class of chemicals has sounded a consistent drumbeat of developmental harm to children. In 2011, research determined that children exposed to higher levels of synthetic pyrethroids are three times as likely to have mental delay compared to less exposed children. A 2014 study associated proximity to pesticide-treated agricultural fields in pregnancy to increased risk of autism to children of exposed mothers. Research published in 2015 finds that deltamethrin increases risk of ADHD in children, with one study finding impacts specifically to boys. Studies published two years later determined that synthetic pyrethroid exposure increases risk of premature puberty in boys, and another associated the chemicals with externalizing and internalizing disorders. Another study found that aerial mosquito spraying, which is most frequently conducted with synthetic pyrethroids, is linked to elevated autism rates.

The impacts seen are not all developmental. A 2012 study associates pyrethroid exposure before, during, and after pregnancy with increased risk of infant leukemia. And a recent study published earlier this year finds that synthetic pyrethroid exposure during mosquito control operations increases risk of respiratory disease and certain allergies.

Rather than rein in use of these chemicals, EPA in 2019 stripped away protections that reduced children's exposure to pyrethroids. In making its decision, the agency allowed a letter from the pesticide industry trade group Croplife America to dictate its approach to protecting children from hazardous, neurotoxic pyrethroids. The model proposed by Croplife eliminated safety factors for children. In a rare instance, EPA conducted an outside literature review to buttress its argument, but instead ignored that research and prioritized the unprotective model proposed by the pesticide industry.

After reducing protection for children's health, the agency then took directions from a group referring to themselves as the Pyrethroid Working Group (PWG), comprised of major pesticide manufacturers Bayer, FMC, Syngenta, BASF, AMVAC, and Valent. At the request of this working group, EPA reduced a proposal from EPA staff scientists to implement 66-foot buffer zones between agricultural fields and water bodies down to 10–25 feet. The agency also agreed that wind speeds up to 15 miles per hour were acceptable for pyrethroid applications, despite previous proposals setting the cut-off at 10 mph.

While further study is warranted, safety advocates urge that it be conducted while this class of chemicals is suspended. Rather than place the burden of proof on scientists to show harm, they say that chemical manufacturers should be required to provide evidence that these chemicals will not harm children's health.

"We have reduced our exposures to many classes of dangerous pesticides over the past few decades through restrictions and regulations," said study coauthor Gary Miller, PhD, vice dean for research strategy and innovation at Columbia University Mailman School of Public Health. "This study adds to a growing body of literature that the widely used pyrethroids are not without adverse effects and should be further evaluated for their safety."

While further study is warranted, safety advocates urge that it be conducted while this class of chemicals is suspended from public use. Rather than place the burden of proof on scientists to show harm, they say that chemical manufacturers should be required to provide evidence that these chemicals will not harm children's health.

SOURCE: Melissa A Curtis, et al., Developmental pyrethroid exposure causes a neurodevelopmental disorder phenotype in mice, *PNAS Nexus*, Volume 2, Issue 4, April 2023, pgad085, https://doi.org/10.1093/pnasnexus/pgad085

MORE ON THIS SUBJECT

Study Finds Glyphosate Exposure Among the General Population Poses a Risk to Neurological Health—August 31, 2023

Popular Pyrethroid Insecticides, Already Linked to Rheumatoid Arthritis, Associated with Osteoarthritis—September 20, 2023

All Pesticide Classes Increase the Risk of Central Nervous System Tumors in Children—September 21, 2023

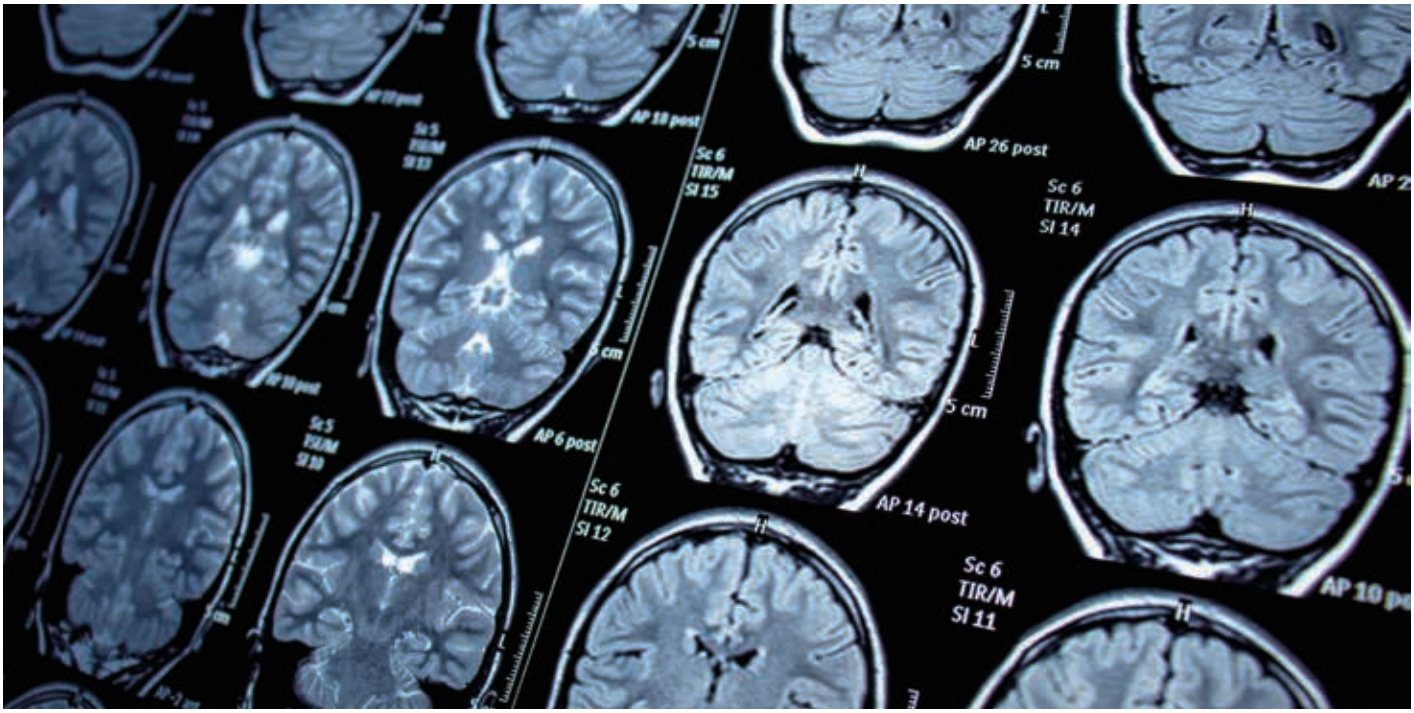
TOXICOLOGY | SEIZURE DISORDERS—EPILEPSY | MAY 11, 2023

Pesticide Exposure Increases the Risk of All Seizure Disorders, Especially Epilepsy

A study published in *NeuroToxicology* finds occupational, chronic exposure to pesticides increases risk factors of epilepsy, a neurological disorder causing unprovoked, reoccurring seizures. Mounting evidence over the past years shows that chronic exposure to sublethal (nonfatal) levels of pesticides can cause neurotoxic effects or exacerbate preexisting chemical damage to the nervous system. Although the mechanism by which pesticides induce disease development remains unclear, this study suggests environmental pesticide exposure increases seizure risk through mechanisms at molecular or subcellular levels.

Approximately 3.4 million individuals in the U.S. live with epilepsy, and mortality from this disorder is rising nationwide. Over 300 environmental contaminants and their byproducts, including pesticides, are chemicals commonly present in human blood and urine samples and can increase neurotoxicity risk when crossing the brain barrier. Considering that half of all epilepsy etiologies (causes) are of idiopathic (unknown) origins, studies like this highlight the importance of understanding how consistent chemical exposure can impact long-term health and disease prognosis. The study notes that their approach of using real-world exposure over extended time and space can be combined with simulations proposed by other authors to give "a better understanding of the real-life risk associated with long-term exposure to multiple pesticides."

To determine work-related risk factors associated with epilepsy among farmers



and pesticide applicators, researchers performed a case-control study on 19,704 individuals from 2000 to 2016 (17 years) to observe epilepsy cases. Researchers gathered data from Almería (South-Eastern Spain) hospital records and the Centre for Prevention of Occupational Risks. Of the 19,704 individuals, 5,091 have a record of epilepsy. The researchers attribute an increase in epilepsy risk among those working in chemical-intensive, enclosed (indoor) agriculture (high-yield greenhouse crops) compared to chemical-intensive, open-air (outdoor) agriculture (open-air crops). However, this study supports previous findings on the association between epilepsy and pesticide exposure in the general population. Epilepsy risk is greatest among individuals living in rural areas with high pesticide use (e.g., farming regions) and individuals without proper personal protective equipment (PPE), including gloves and masks.

Epilepsy is a common neurological disorder that affects a person's brain and central nervous system (CNS). These conditions can disrupt nerve cell communication in the brain and lead to prolonged seizures (*status epilepticus*) due to abnormal electrical activity in the brain. Although the most common cause of seizures is epilepsy, not every person who has a seizure has epilepsy. Although medical treatments can manage epilepsy, typical anti-seizure medication for epilepsy is ineffective in the treatment `of non- epileptic seizures.

Sublethal levels of pesticides can cause neurotoxic effects or exacerbate preexisting chemical damage to the nervous system.

Certain chemicals, including pesticides, can be seizurogenic chemicals or toxic agents that cause seizures by different mechanisms and molecular pathways. The most-known mechanisms include hyperstimulation of nicotinic and muscarinic acetylcholine receptors (neurotransmitters), blockage of voltage-gated sodium channels, altered function of GABAergic neurons, glutamatergic hyperactivity, neuronal excitotoxicity, intracellular calcium overload, oxidative stress, and increased neuro-inflammatory responses, among others. Pesticides with neurotoxic properties include organophosphates, carbamates, neonicotinoids, pyrethroids, and organochlorines.

Despite many studies linking acute pesticide poisonings to seizures, this study is one of the few to address concerns about those chronically exposed to pesticides. A 2016 study in the same region of Spain demonstrates that workers who applied pesticides were more likely to have neurological symptoms lasting more than two days, such as cramps, tremors, muscle fatigue, loss of consciousness, and convulsions. Many pesticides used in the past and present can contribute to the formation of a single seizure or epilepsy due to chronic poisoning. Thus, the study highlights at the very least the importance of PPE as a preventive measure critical to reducing the risk of developing pesticide-related symptoms and diseases. Farmers without gloves and masks have two and three times higher risks of epilepsy, respectively. The Agricultural Health Study (AHS), used to estimate pesticide exposure intensity, finds that farmers experience a 90 percent reduction in pesticide exposure when using proper PPE. However, PPE alone is not

enough to prevent pesticide exposure, especially for everyday exposure from disinfectants, residues on food, and contamination of the ecosystem. The study concludes, "[T]his study supports previous findings suggesting a higher risk of epilepsy in the general population associated [with] pesticide exposure and extends the presumed increased risk to farmers occupationally exposed to pesticides, particularly those with lack of or improper use of PPE."

The impacts of pesticides on the nervous system are hazardous, especially for chronically exposed individuals (e.g., farmworkers) or during critical windows of vulnerability and development (e.g., childhood, pregnancy). Researchers identify the role agricultural chemicals play in CNS impacts causing neurological diseases like amyotrophic lateral sclerosis (ALS) and Parkinson's disease, dementia-like diseases, such as Alzheimer's, and other effects on cognitive function. Therefore, studies related to pesticides and neurological disorders can help scientists understand the underlying mechanisms that cause neurodegenerative diseases.

SOURCE: Raquel Alarcón, et al., Occupational exposure to pesticides as a potential risk factor for epilepsy, *NeuroToxicology,* Volume 96, 2023, Pages 166-173, https://doi.org/10.1016/j.neuro.2023.04.012.

TOXICOLOGY | GUT MICROBIOME HEALTH | JUNE 27, 2023

Study Elevates the Connection Between Pesticides, the Gut-Brain Axis, and Disease

A review article by Irish and Dutch researchers in the *ISME Journal* adds to the emerging scientific literature examining how pesticides affect the relationship between the human gut and the human brain (the "gut-brain axis"). Often called the "second brain" because it houses nerve cells and produces neurotransmitters, the gut-brain axis may be the most important locus where microbes and pesticides meet. The human gut plays host to a variety of microorganisms, ranging from bacteria and archaea to fungi, viruses and yeasts. (see *Daily News*). In a healthy person, these microbes remain in balance and often cooperate both with each other and with human cells.

The gut and the brain are deeply integrated through the vagus nerve and the neuroendocrine system. The vagus nerve is a treelike bundle of fibers extending from the lower part of the brain to nearly every body organ, but particularly the heart, lungs, and digestive tract. The neuroendocrine system comprises specialized cells inhabiting nearly all the organs of the body that respond to signals from the brain and gut to produce hormones that regulate digestive enzymes, the pace of digestion, air and blood flow in the lungs, blood pressure, heart rate, blood glucose levels, and other functions.

Pesticides may exert influence over any or all of these processes. They may

also affect the immune system, and some, such as glyphosate, can cross the blood-brain barrier. Pesticides can affect the production of many chemicals by gut bacteria, including serotonin and gamma-aminobutyric acid (GABA), both important neurotransmitters. They are also notorious for disrupting the endocrine system, including reproductive hormones; a 2020 review by Spanish scientists proposed that xenobiotics such as pesticides should be termed "microbiota disrupting chemicals," as they can interfere with microbes' role in metabolizing steroid hormones such as estradiol, cortisol, and testosterone.

Beyond Pesticides has previously reported on numerous studies elucidating the deleterious effects of pesticides on disease risks involving the gut-brain axis. These include the close association between digestive disruption and Type 1 diabetes in children and Type 2 diabetes in adults, and the ability of azoxystrobin (AZO) fungicide to impair the function of the colonic barrier in nutrient absorption and protection from harmful substances. The digestive problems associated with Type I diabetes have been linked to exposure to antibiotics and some pesticides. Such exposures reduce the numbers of certain bacteria in the gut that can help protect against the inflammation triggered by these chemicals. The effects of pesticides on gut microbes have also been linked to autism spectrum disorder (ASD), as has digestive dysfunction.

Adult-onset neurological diseases also involve digestive disruption, which in turn may be related to disruption of the gut microbe balance. In 2022, Beyond Pesticides reported on a study showing that the gastrointestinal disruptions, including damage to enteric glial cells that lead to Parkinson's disease (the second most common neurodegenerative disease after Alzheimer's), are associated with exposure to the insecticides rotenone and chlorpyrifos, as well as the herbicides 2,4-D, glyphosate, and paraquat. The Irish and Dutch researchers also reviewed a study showing that glyphosate can enter the brain and raise inflammation levels, a process that has been linked to Alzheimer's. A 2022 study suggests that chronic exposure to dietary pesticides can affect gut microbes and trigger a cascade of changes leading to these neurodegenerative diseases.

Pesticides' effects on host-microbe processes are not confined to humans. Importantly, pesticides affect the microbes associated with plants and nontarget insects, often changing the proportions of various species. For example, French researchers in 2022 identified glyphosate's changes to honey bees' immune systems and gut microbiota, demonstrating a plausible mechanism for the bees' susceptibility to certain diseases. Sometimes pesticides have a seemingly perverse—but predictable—Darwinian effect: In 2018, Beyond Pesticides reported on research detailing how insect pests' gut microbiota contribute to the skyrocketing incidence of pesticide resistance. Microbes are nothing if not adaptable.

One common bacterial genus, *Lactobacillus,* which lives in the digestive tract and the female reproductive tract as well as in fermented foods such as yogurt and kefir, demonstrates abilities that could point toward protection from pesticides' damage to the gut-brain axis. *Lactobacillus* species are adversely affected by herbicides, fungicides, and insecticides, according to the authors of the current study. They are known to enhance mood and reduce anxiety and depression, and they also provide vital services in the gut, where they produce mucus that lines the intestinal walls and enhance signaling among different types of immune cells. Thus, their reduced presence in the gut caused by pesticides may contribute to many, if not all, diseases affecting the brain-gut axis.

They may also come to the rescue after pesticide exposure. Interestingly, *Lactobacillus* and other bacterial genera actually degrade pesticides in the foods they ferment. A combination of *L. acidophilus* and *Bifidus animalus* synergistically reduces levels of "up to 48.6% for heptachlor and 54.7% for pp'DDE in goat milk bio-yogurts after 14 days of cold storage when both cultures were used," according to a recent Bulgarian study.

A remarkable Chinese study, reported in the journal *Cell* in 2022, exposed human volunteers to high doses of organophosphorus and organochlorine compounds. These triggered inflammatory responses and increased numbers of pathogenic bacteria in the gut. The researchers then dosed a subset of the exposed group with a proprietary version of a lactobacillus strain called *Lactiplantibacillus plantarum.* Lactobacilli are already present in many probiotic supplements and are used to improve symptoms of eczema, high cholesterol, and bowel inflammation. In the Chinese study's probiotic group, microbial diversity was reestablished, inflammatory markers decreased—including two factors associated with kidney disease—and the bacteria promoted the breakdown of the pesticides and excretion of their metabolites.

Microbes are everywhere—even in the rocks deep below the seafloor. They are certainly everywhere in the human body, not only the gastrointestinal tract—one study found pesticides reduced the flora in the human mouth—and it appears that pesticides may affect microbes wherever they are. Estimates of the total number of microbial cells in a typical human—about 39 trillion—exceed the number of actual human cells—about 30 trillion. This has led many scientists to adopt pioneering microbiologist Lynn Margulis's (PhD) proposal that humans and most other multicellular organisms should be viewed as "holobonts," that is, a single organism comprising a host and one or more symbionts—generally microbes. It would encourage a paradigm shift away from the pesticide industry's assumption that its products' effects are siloed and target only specific agricultural pests. Not even a monoculture field is free of trillions of microbes on its plants, in its soil, and in its water. Many of these are beneficial and may have their own ability to control pests.

SOURCE: R. Matsuzaki, et al., Pesticide exposure and the microbiota-gut-brain axis. *ISME J* 17, 1153–1166 (2023). https://doi.org/10.1038/s41396-023-01450-9

TOXICOLOGY | GUT MICROBIOME HEALTH | NOVEMBER 15, 2023

Glyphosate Exposure Linked to Behavioral and Gut Health Concerns in New Studies

A study previously published in the Federation of American Societies for Experimental Biology (FASEB) is drawing renewed attention to the gut microbiome in the scientific community. The study, involving a team including Demetrio Sierra-Mercado, PhD, of the University of Puerto Rico School of Medicine, initially established a link between glyphosate exposure and increased anxiety and fear-related behavior in rats. Glyphosate, a widely-used herbicide, has been detected in trace amounts in fruits, vegetables, grains, and other food and beverages, according to the U.S. Environmental Protection Agency (EPA). Originally deemed safe for humans due to the way it interacts with the shikimic acid pathway—a metabolic route that is absent in humans—glyphosate's indirect effects on human health are now under scrutiny as the research linking it to anxiety-like behavior grows.

Dr. Sierra-Mercado's team is expanding on his previous research to take a closer look at the compound's potential disruption of the gut microbiome, which plays a pivotal role in regulating both physical and mental health. His upcoming study, anticipated in August 2024, aims to delve into the intricate relationship between glyphosate exposure and the gut-brain axis, with a focus on how this may influence neurological and emotional health in humans. This investigation is critical as it prompts the world to rethink the initial toxicity assessments of glyphosate, accounting for a broader scope on the internal systems that the pesticide affects.

This research emerges as the impacts of glyphosate consumption become clearer with decades of accumulated studies. In recent years, numerous lawsuits have targeted Monsanto (now Bayer), producer of Roundup (which contains glyphosate), alleging that the herbicide contributes to the plaintiffs' cancers. Moreover, the International Agency for Research on Cancer classifies the chemical as a probable carcinogen. Concurrently, research links the chemical to increased rates of toxic body burden, noting adolescents have higher bodily concentrations of glyphosate than adults. An article by Beyond Pesticides on this research spotlights the study finding that over 90 percent of participants, including many child/parent pairs, had recent exposure to glyphosate, with children often showing up to four times the glyphosate levels of their parents. This corroborates evidence that children may be more vulnerable to the chemical's risks. Additionally, an extensive 15-year study associates high rates of childhood blood cancers with children living in Brazil's soy-growing areas—regions that rely on intensive glyphosate inputs. Comprehending the full spectrum of glyphosate's effects on human health,

from its carcinogenicity to its neurological and emotional ramifications, is crucial.

As part of Dr. Sierra-Mercado's revealing insights at the September 25 Keystone Science Lecture, part of the multi-day workshop and lecture series at the National Institute of Environmental Health Sciences (NIEHS), the extended research on glyphosate's impact on behavior has gained substantial depth. In his lecture, Dr. Sierra-Mercado presented findings from his team's rigorous investigation into the effects of prolonged oral exposure to glyphosate, a chemical with an EPA-deemed acceptable risk for humans at a daily exposure rate of 2.0 mg/kg over a lifetime. The team administered glyphosate-contaminated water at the EPA's accepted safe dose, with control rats receiving filtered drinking water. No initial behavioral changes were noted after four weeks of exposure, as determined by an open field test. However, the narrative changed with prolonged exposure. After 14 weeks, the rats displayed significant anxiety-like behaviors, with a pronounced decrease in time spent exploring novel objects and a marked increase in threat response to new stimuli, which could indicate heightened anxiety or negative anticipation. Additionally, Dr. Sierra-Mercado notes increased cellular activity in the bed nucleus of the stria terminalis (BNST), a brain region associated with anxiety—a physiological marker that demonstrates glyphosate's potential effect on neural pathways. Further highlighting the biological impact, a notable decrease in *Lactobacillus* in the feces was observed, pointing to glyphosate's disruption of gut bacteria. This is significant due to the role of *Lactobacillus* in serotonin production, often referred to as the body's "feel-good" hormone.

The research from Dr. Sierra-Mercado and his team demonstrates the intricate interplay between glyphosate consumption and the gut-brain axis, highlighting how even levels deemed safe can lead to anxiety-like behaviors and alter the delicate balance of gut microbiota. These disruptions may initiate a series of events culminating in emotional dysregulation, suggesting that if the research is applicable to all mammals, glyphosate's safety must be reassessed in light of its broader biological impacts.

This study is the first of its kind to understand the connections between glyphosate exposure and gut health. It, along with an ongoing surge of new research into the impacts of pesticide exposure, highlights the significant gaps in the global scientific community's understanding of these chemicals, particularly their long-term implications. The susceptibility of children to glyphosate, with their higher propensity for absorption and retention, is especially concerning. The possibility that even regulated levels of exposure cause unacknowledged dangers necessitates a more cautious approach to such chemicals.

Despite the mounting research and remaining uncertainties, EPA's stance on glyphosate remains firm. The agency continues to classify the chemical as "not likely to be carcinogenic to humans," authorizing its ongoing use. This stance is at odds with the advancing scientific conversation, indicating a concerning gap between science and regulation.

SOURCE: Mauricio Cáceres-Chacón et al., Glyphosate increases anxiety-like behavior and threat response to novel neutral stimuli, *FASEB Journal*, First published: 13 May 2022, https://doi.org/10.1096/fasebj.2022.36.S1.0R100

TOXICOLOGY | BEHAVIOR—MOOD—PSYCHIATRIC | JUNE 7, 2023

Pesticides and Neurotoxicity: The Link Between Mood Disorders and Pesticide Exposures

A systematic review of scientific literature published in *Environmental Research* on the development of mood disorders among pesticide applicators (farmers, landscapers, etc.) finds an increased risk of depression symptoms over the last decade. The evidence in the review highlights the presence of pesticide-specific biomarkers and biomarkers of depression that determine the positive association between pesticide exposure and the development of depressive symptoms. With more high-quality longitudinal studies to control sociocultural variables, researchers can directly pinpoint risks of developing depression, especially among agricultural workers and landscapers who use pesticides.

Research on pesticide-induced diseases commonly investigates pesticide exposure concerning the development of various physical illnesses. However, previous studies show that occupational (work-related) risks of developing depression are high in agriculture, where pesticide use is rampant. Acute exposure to chemicals, including organophosphate, organochlorine, triazine, and carbamate pesticides, tends to put farmers at greater risk of suicide than the general population. There is a lack of information connecting pesticide exposure to the subsequent psychological (psychiatric) effects on the general population. Additionally, household pesticide exposure varies from occupational exposure via exposure frequency, duration, intensity, and type.

According to the World Health Organization (WHO), depression affects 322 million people globally, with the number of diagnosed patients increasing by 18.4 percent from 2005 to 2015. Although the etiology of depression—

and many other psychiatric disorders—is often genetic, studies suggest that other etiological factors, like pesticide exposure, play a role in depression incidents. Poor mental health has a tangible influence on physical health (e.g., depression and cardiovascular disease); therefore, the combination of pesticide exposure and mental illness worsens the adverse effects on human health. If pesticide exposure exacerbates psychiatric disorder symptoms, it is important to evaluate how pesticide exposure affects mental health, in addition to physical health. This research highlights the significance of researching potential mental health effects resulting from pesticide exposure, especially as society tends to rank mental health risks second to physical health. The study notes, "Given the rise in pesticide use in agriculture, the low adherence of farmers to safety training, and the health risks associated with depression, it is recommended to implement stricter surveillance measures on agricultural companies and monitor the mental health of exposed workers. It is also important to actively involve the community in prevention and intervention efforts."

The review conducted a thorough scientific literature search on occupational pesticide exposure and depression symptom development in the *PubMed* and *Scopus* databases for the period 2011 to September 2022. Using guidelines recommended by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement and the Population, Exposure, Comparison, and Outcomes (PECO) strategy, researchers examined the association between occupational exposure to pesticides and symptoms of depression in agricultural workers. Among the reviewed articles, 78 percent indicate a link between exposure to pesticides and the prevalence of depression symptoms. The pesticides most associated with depressive symptoms include organophosphate insecticides, general herbicides, and pyrethroid insecticides.

For over two decades, research concerning pesticide exposure and psychiatric disorders, such as depression, focused on occupational hazards, especially for agricultural farmworkers. Exposure to agricultural pesticides puts farmers at a six times greater risk of exhibiting depressive symptoms, including chronic anxiety, irritability, restlessness, and sadness. Specifically, exposure to organochlorines and fumigants (gaseous pesticides) heighten an individual's risk of depression by 90 percent and 80 percent, respectively. Organochlorines are chemicals of concern as they can induce a myriad of health problems, including reproductive dysfunction, endocrine disruption, cancer, and fetal defects. Though the U.S. has banned the use of most organochlorines, because they are highly persistent, they still present an exposure hazard for people and the environment. Fumigants are a human health concern as many fumigants are gases that can cause acute toxicity upon inhalation and ingestion.

However, other pesticides also affect the nervous system and have psychiatric effects. Organophosphates are a family of insecticides derived from World War II nerve agents. They are cholinesterase inhibitors, meaning they bind irreversibly to the active site of an essential enzyme for normal nerve impulse transmission, acetylcholine esterase (AchE), inactivating the enzyme. Linear models reveal an association between lifelong pesticide poisoning episodes and the increased risk of developing mental disorders among tobacco farmers. Tobacco farmers using organophosphate pesticides have a higher prevalence of minor psychiatric disorders.

Individuals suffering from occupational pesticide exposure face a disproportionate risk of developing depression. However, pesticide exposure from nearby agricultural fields remains a threat to residential (nonoccupational) human health. Previous studies found that populations living near farms are more likely to have high depressive symptoms. Similarly, a 2019 study found that teens and adolescents living in agricultural areas, where organophosphate exposure is prevalent, are at higher risk of depression. Gender (female), physical health, and age (young adult) indicate likelihood of having depressive symptoms, with the most adverse effects in women, those in poor physical health, and children under 14.

Understanding the mental health implications of conventional pesticide exposure can help identify the various physiological mechanisms attributed to psychiatric disorders. Like this review, past research finds that organophosphates have significant associations with depressive symptom development, including disturbing normal nerve impulses. So, scientists can analyze information to determine if the lack of normal nerve impulses contributes to non-pesticide-induced depression.

Whether pesticide exposure is occupational or residential, the development of depression symptoms is of concern. Annually, only half of Americans with a depression diagnosis seek treatment for symptoms. Untreated symptoms of depression can increase the risk of suicide, a severe sign of depression. Commonalities between occupational and household pesticide exposure are suicidal thoughts and pesticide provocation as a suicide agent. A study published in the WHO Bulletin finds that people storing organophosphate pesticides in their homes are more likely to have suicidal thoughts as the exposure rate is higher. The study finds an association between suicidal thoughts and ease of household pesticide accessibility. Geographic areas with more frequent home storage of pesticides have higher rates of suicidal thoughts than the general population. WHO scientists recognize pesticide self-poisoning as one of the most significant global methods of suicide, as increases in pesticide toxicity make them potentially lethal substances. Robert Stewart, PhD, a researcher for the WHO Bulletin, stated that: "Organophosphate pesticides are widely used around the world. They are particularly lethal chemicals when taken in overdose and are a cause of many suicides worldwide." With that in mind, researchers say it is vital to recognize how pesticide exposure and accessibility can influence mental illnesses.

To address health issues regarding pesticide exposure and mental health incidents, health care providers must be sensitive to the signs and symptoms of chemical exposure. Farmers, landscapers, and other individuals encountering chemical exposure through ingestion, inhalation, and skin (dermal) contact are often unaware of the non-physical side effects. Considering that depression related to acute pesticide exposure may persist long after initial exposure, those working with toxic pesticides require adequate protective equipment to minimize exposure.

The study concludes "[…] that governments worldwide bear greater responsibility in addressing this matter, which could help control the various systemic sources of exposure to pesticides and other environmental pollutants and lessen the harm to the health of workers."

SOURCE: Javier Cancino et al., Occupational exposure to pesticides and symptoms of depression in agricultural workers. A systematic review, *Environmental Research*, Volume 231, Part 2, 2023, https://doi.org/10.1016/j.envres.2023.116190

MORE ON THIS SUBJECT

Prenatal Exposure to Organophosphate Pesticides Have Links to Behavior—July 6, 2023

Study Further Strengthens Link Between Common Insecticide Class and Psychiatric Disorders—October 25, 2023

TOXICOLOGY | ASTHMA—RESPIRATORY DISEASE | AUGUST 16, 2023

Pesticide Exposure with Disproportionate Effects Increases Risk of Asthma

A study published in *Environmental Science and Pollution Research* further supports the indication that exposure to organophosphate insecticides (OPs) increases the risk of asthma among the U.S. general population. According to the Asthma and Allergy Foundation of America, "The burden of asthma in the United States falls disproportionately on people with low-income, senior adults, and Black, Hispanic and American Indian/Alaska Native people," making these groups more susceptible to developing this chronic lung disease upon OP exposure.

Organophosphorus pesticides have a wide range of biological uses—from insecticides to flame retardants—that make these chemicals ubiquitous, significantly contributing to ecosystem contamination. Furthermore, while organophosphates have less bioaccumulation potential than organochlorines, residues are consistently present in human and animal blood, urine, tissues, and milk. Although research demonstrates that OPs are highly toxic, there remains an inadequate understanding of how OP exposure impacts body systems like the respiratory system.

The respiratory system is essential to human survival, regulating gas exchange (oxygen-carbon dioxide) in the body to balance acid and base tissue cells for normal function. However, damage to the respiratory system can cause several issues—from asthma and bronchitis to oxidative stress that triggers the development of extra-respiratory manifestations

like rheumatoid arthritis and cardiovascular disease. Therefore, the rise in respiratory illnesses and organophosphate use over the last three decades is highly concerning, especially as research fails to identify an exact cause for the increase in respiratory disease cases.

Focusing on noninstitutionalized U.S. adults, researchers gathered representative information on health and nutritional well-being from the Centers for Disease Control and Prevention's (CDC) National Health and Nutrition Examination Survey (NHANES). In total, 6,009 adults ranging from 20 to 85 years old represent the 313.5 million adults in the noninstitutionalized U.S. population. The study detected OP exposure using the urinary concentrations of six metabolites of dialkyl phosphates (DAPs), an indicator of OP concentration in the body. A survey-multivariable logistic regression (SMLR), a generalized weighted quantile sum (WQS) regression, and Bayesian kernel machine regression (BKMR) evaluated the link between OPs and asthma.

The study finds that of the 6,009 participants, 842 participants have asthma. Upon examining urine samples of the 842 patients, four out of the six DAPs are present—dimethyl phosphate (DMP), diethyl phosphate (DEP), dimethyl thiophosphate (DMTP), and dimethyl dithiophosphate (DMDTP)—demonstrating a positive association with asthma in adults. The strongest associations between asthma and OPs occur among females, non-Hispanic White populations, and individuals lacking physical activity. Thus, OP exposure can elevate asthma risk in the general population.

Working in close contact with pesticides throughout one's lifetime increases the risk of asthma, Chronic Obstructive Pulmonary Disease (COPD), and other respiratory issues. Thus, the connection between pesticides and associated respiratory risks is nothing new, as many studies link pesticide use and residue to various respiratory illnesses. Studies find pesticide exposure can trigger asthma attacks and also cause asthma, as exposure to insecticides before the age of five can increase the risk of an asthma diagnosis, with toddlers twice as likely to become asthmatic.

Chronic inhalation of agriculture-related dust (e.g., particulates from grains, feed, soils, and biological aerosols from plant and animal matter that may harbor synthetic pesticide and fertilizer residues) can increase airway inflammatory diseases, including asthma, chronic bronchitis, and COPD. The particulates in dust play a part in disease development, but so, too, do the various microbiota that may be part of a dusty agricultural environment. A disruption of the homeostasis of the human microbiome (known as dysbiosis) can increase the risk of asthma and other respiratory diseases. In addition, pesticide exposures can alter the gut microbiome, which mediates a significant portion of the human immune response.

Many researchers, including those on this study, suggest an increase in environmental pollutants like pesticides may be responsible for the increase in respiratory diseases. Regarding this study, OPs have a significant influence on respiratory pathology. This chemical class has a similar mode of action as cholinesterase inhibitors, which means they bind to receptor sites for the enzyme acetylcholinesterase (AChE), essential to normal nerve impulse transmission. In binding to these receptor sites, cholinesterase inhibitors inactivate AChE and prevent the clearing of acetylcholine. The buildup of acetylcholine can lead

to acute impacts, such as uncontrolled, rapid twitching of some muscles, paralyzed breathing, convulsions, and, in extreme cases, death. The compromise of neural transmission can have broad systemic impacts on the function of multiple body systems, including the respiratory system.

This study also adds to the growing body of research demonstrating disproportionate risk to certain population groups from chemical exposure. The stronger association between asthma, OPs, and women highlights sex-specific disparities characterized by chemical metabolization (breakdown) and elimination in the body. OPs exhibit endocrine-disrupting properties that may alter estrogen or testosterone activity and receptors, resulting in differences in the clearance rate and toxicity of OPs. For instance, a 2018 study finds female rats manifest airway hyperactivity—a characteristic asthma symptom—at lower OP doses than males. Additionally, CDC data establishes women as having a higher prevalence of asthma incidence compared to men. Low-income popula-tions, people of color, and children living in inner cities also experience disproportionately high morbidity and mortality due to asthma. For instance, African Americans are at least three times more likely than whites to die from asthma. Therefore, any time policies allow regulators to permit the use of pesticides with known asthma effects, a disproportionate impact is felt among these communities.

Despite the difference in methods, the study emphasizes that the data results remain consistent. "Though with different study designs, objectives, and populations, our study found plenty of evidence that is consistent with previous similar studies which explore the complicated associations of OPI [organophosphate insecticide] metabolites with asthma." The study concludes, "Our findings suggest that more urinary OPIs exposure may be associated with an increased risk of asthma in the general US adults. Meanwhile, further prospective studies are needed to confirm the causality between OPIs exposure and asthma and explore the potential harm of low-dose but chronic exposure to OPIs in the development of asthma." In the U.S., over 25 million people live with asthma. The increasing rate of respiratory pathology since the 1980s demonstrates a need for better environmental policies and protocols surrounding contaminants like pesticides. Since respiratory diseases represent a significant health issue for agricultural workers—who often experience pesticide exposure at higher rates due to their occupation—it is essential to understand the association between pesticide exposure and respiratory pathology. Furthermore, with a new report finding an association between air pollution and higher death rates (9 percent) related to SARS-CoV-2 (COVID-19), global leaders should eliminate excessive pesticide use to mitigate respiratory diseases' impacts on human health.

SOURCE: Liang JH et al., Biomarkers of organophosphate insecticides exposure and asthma in general US adults: findings from NHANES 1999-2018 data. *Environ Sci Pollut Res Int.* 2023 Aug;30(40): 92295-92305, Epub 2023 Jul 24. PMID: 37482592.

MORE ON THIS SUBJECT

Organophosphate Pesticides and the Link to Respiratory, Metabolic, and Heart Disease—October 18, 2023

Elevated Asthma Risk from Chlorpyrifos and Organophosphates Reported as Court Rolls Back Protections—November 8, 2023

TOXICOLOGY | IMMUNE SYSTEM EFFECTS | AUGUST 22, 2023

Illness Tied to Petrochemicals' Impact on Body's Essential Mast Cells (Immune System Regulators), Study Finds

A recently completed study (available in preprint before peer review) identifies the development of what the authors term "Toxicant-Induced Loss of Tolerance" (TILT), a constellation of symptoms associated with chemical exposures. The authors describe a two-part process. First, during initiation, a person is exposed at an acute level or repeated low-level doses to a toxicant, such as an organophosphate pesticide or a natural substance like mold, that triggers immune reactions from mast cells, which are crucial immune system regulators. Stage 2, or triggering, is when exposure to previously tolerated substances causes the mast cells to degranulate, or release many inflammatory molecules such as histamines and cytokines into the cellular environment. The work is spearheaded by Claudia B. Miller, M.D., immunology professor emeritus at the University of Texas Health Science Center at San Antonio, along with Nicholas Ashford, PhD, professor of technology at the Massachusetts Institute of Technology, and other researchers. Dr. Miller's talk on the subject is found at Beyond Pesticides 2022 National Forum site (go to 7:50 time stamp).

Western medicine, for all its spectacular successes, has tended to view the human body as separate from its environment. Further, it divides the body into various systems and zones, which, though understood to be interrelated, have their own sets of symptoms, derangements, and diseases. In addition, the discipline of toxicology—especially regulatory toxicology—until very recently has been unable to account for exposure

to multiple toxicants—pesticides, building materials, medical equipment, antibiotics, and molds—simultaneously or in series.

The last couple of decades, however, have begun to shed light on the consequences of exposure to many different chemicals that may affect different body systems and result in constellations of symptoms and disorders previously unconnected in the medical mind. Now people with what has been called Multiple Chemical Sensitivity (MCS) or Chemical Intolerance (CI) have a framework that begins to explain their problems. Some 15 percent to 36 percent of U.S. adults have reported symptoms of these disorders. Medical practitioners do not currently agree on the causes, development, or treatment of MCS/CI.

Dr. Miller finds that clinicians' "failure to ask patients about possible initiating events has caused confusion concerning the origins of other comorbid conditions such as ADHD, autism, asthma, irritable bowel syndrome, migraine headaches, depression, anxiety, brain fog, and other cognitive and mood difficulties." Moreover, Dr. Miller and colleagues note that in concurrent exposures to different toxicants, many symptoms are common to more than one, resulting in a "masking" effect. Once someone develops TILT, intolerances to structurally different chemicals may arise, ranging from pesticides and paints to anesthetics and hairdressing chemicals. Notably, women develop TILT more than men, possibly because women are more likely to use fragranced cosmetics, soaps, sprays, fragranced cleaning, and laundry products, usually in confined spaces. However, men are formally diagnosed with MCS more often, possibly reflecting medical gender bias.

In 2021, Beyond Pesticides reported on a study, "Toxicant-induced loss of tolerance for chemicals, foods, and drugs: assessing patterns of exposure behind a global phenomenon," in which the authors, including the authors on the TILT preprint study, investigated initiating events by studying eight groups with chemical intolerance who had known exposures to different toxicants: EPA workers in offices where new carpet was installed; Gulf War veterans; casino workers exposed to organophosphate pesticides; pilots and cabin crews breathing aircraft oil fumes; World Trade Center first responders and others in close proximity to the buildings; breast and other implant recipients; people exposed to mold at home; and tunnel workers breathing benzene. Among these groups, volatile organic compounds (VOCs), which were present in nearly all the toxicants studied, were the most common initiators.

Some of the most egregious exposures were suffered by military members during the Gulf War, who were required to swallow pyridostigmine bromide to help defend against possible chemical weapons. This compound's effects resemble those of organophosphate pesticides. Some 100,000 soldiers were directly exposed to sarin and cyclosarin when the U.S. blew up an Iraqi weapons depot. In addition, soldiers' uniforms were saturated with lindane, an organochlorine pesticide and member of the Stockholm Dirty Dozen now banned for U.S. agricultural use but still allowed as a second-line treatment for lice and scabies. Permethrin, a pyrethroid insecticide, which was also used on uniforms, and in combination with the insect repellent DEET (also given to soldiers), has neurotoxic effects.

In this previous study, the authors note that the post-World War II expansion of petrochemicals into pesticides, solvents, dyes, and fragrances mushroomed, and in the 1970s building construction became more airtight even as

Americans spent more and more of their time indoors—the latter proportion now at 90 percent. This has resulted in more people being exposed to a staggering array of synthetic chemicals (defined by the authors as compounds not found in nature) and molds, which release naturally-occurring VOCs.

The authors of the current study also take the medical profession and research scientists to task for two things. Many clinicians dismiss chemical sensitivities, which they label as "Medically Unexplained Symptoms" or psychosomatic issues, or "idiopathic environmental intolerance." Dr. Miller and colleagues are pushing to replace these terms with TILT. They provide two questionnaires, available on the University of Texas website, that individuals can complete and present the results to their medical caregivers. The advantage of TILT, they say, is that it provides both a suggested mechanism by which sensitivity is started and an explanation for how exposures to different toxicants result in common symptoms stemming from the activity of mast cells, which have broad influence over immune responses to many different challenges.

Scientific tunnel vision has affected the way medicine defines and diagnoses chemical intolerances. "Allergy and toxicology as currently practiced appear to have overlooked the two steps of TILT and the fact that toxic exposures can sensitize mast cells," according to the current preprint study. Mast cells are part of the innate immune system, which responds to acute or persistent infections or injuries. They signal other immune cells using the inflammatory biomarkers cytokines and chemokines. Dr. Miller and colleagues note that mast cells are present in large numbers in the gut, also home to trillions of microbes that are disrupted by antibiotics and pesticides. They add, "Future research should explore the mechanism by which exposures and/or alterations in the gut microbiome may compromise our ancient mast cells and innate cell-mediated tolerance."

The study is based on 10,981 responses to a 2020 Survey Monkey questionnaire that used the same questions as those available on the University of Texas Health Science Center website. These ask participants about medical diagnoses, exposures to chemicals, antibiotic use, and the timing of the onset of their condition. The survey also asked the participant to identify what they believed was the condition's cause.

A low-carbon civilization, relying on ecosystem-level biochemistry rather than a single protein, might both survive climate catastrophe and enjoy a drastic improvement in human health.

More than half of the respondents are women, most of them under 60. Two-thirds of respondents are unable to identify an initiating event. For respondents reporting more than one initial exposure, each additional event tripled the chance they would have TILT.

Overall, a fifth of respondents met the study criteria for TILT. The most frequent initiating exposure was reported as mold, with pesticides second, and in decreasing order, new construction or remodeling materials, medical procedures, fires, and implants. Antibiotics used for long periods to treat infections in several organs were also associated with the onset of TILT.

The researchers stress the need for "policies and practices that reduce initiating exposures as well as ubiquitous and often unavoidable triggers such as fragranced personal care, cleaning, and laundry products in multi-occupant housing, workplaces, medical settings, schools, places of worship, and all public buildings—literally anywhere air is shared."

The current study does have limitations. Although it does have a large number of participants, it is based on individual self-reporting and not a direct measurement of the physiological processes associated with TILT. The participants were not randomly selected, and there was no control group. Also, only around half of the participants could attribute their initial symptoms to a specific event. Despite these constraints, the cumulative evidence Dr. Miller has produced finds that people in large numbers are suffering the consequences of the "exponential increase in exposures to toxicants derived from fossil fuels and biological sources, coupled with reduced fresh air in buildings" and the authors conclude that "*TILT has become epidemic*." [Emphasis in original.]

Finally, Dr. Miller and colleagues emphasize that fossil fuels "are assaulting humans and other animal species both *from within* via mast cell sensitization and *from without* via climate change." [Emphasis in original.] A low-carbon civilization, relying on ecosystem-level biochemistry rather than a single protein, an insidious and harmful source of energy and materials, might both survive climate catastrophe and enjoy a drastic improvement in human health.

For more information:

- Take the questionnaires used in the studies.
- See a video from Beyond Pesticides' 2022 Virtual Seminar featuring a talk with Dr. Miller and Kaipo Kekona, an indigenous Hawaiian working to restore traditional farming techniques.
- Read a transcript of a talk given by Doris Rapp, MD published in *Pesticides and You*.
- Visit the University of Texas, San Antonio website for the Hoffman TILT program
- View a presentation by Dr. Miller at the Hoffman TILT program.

SOURCES: Claudia Miller et al., What Initiates Chemical Intolerance? Findings from a Large Population-Based Survey of U.S. Adults, *Research Square*, June 15, 2023, https://doi.org/10.21203/rs.3.rs-3064297/v1.

S. Masri,, C. Miller, et al. Toxicant-induced loss of tolerance for chemicals, foods, and drugs: assessing patterns of exposure behind a global phenomenon. *Environ Sci Eur* 33, 65 (2021). https://doi.org/10.1186/s12302-021-00504-z

TOXICOLOGY | POISONING | MARCH 23, 2023

Death Tied to 1,3-D (Telone) Fumigant Highlights Sensitivity of the Brain to Pesticide Exposure

A case report article published in *Frontiers in Public Health* confirms one of the first reported deaths from inhalation of the fumigant 1,3-dichloropropene (1,3-D or Telone) during work, resulting from acute renal (kidney) failure, hyperkalemia (high potassium levels in the blood), and brain edema (swelling). 1,3-D is a highly toxic fumigant used on a variety of crops, but primarily on potatoes, tobacco, strawberries, peanuts, and tomatoes to manage unwanted nematodes in soils. The chlorine-containing compound used in a greenhouse space entered the body of a 50-year-old man in China, being absorbed through the respiratory tract. Despite dilution from his wife, the compound was still strong enough to cause harm to human health. Without proper ventilation and personal protective equipment, he wore only a surgical mask which did not adequately defend against exposure to 1,3-D.

This case represents the broader issue of how toxic chemical compounds can enter the body, causing physiological damage. Specifically, pesticides can increase the permeability of the blood-brain barrier that filters various molecules entering the brain from the circulatory system. The permeation of pesticide molecules elevates the expression and accumulation of soluble proteins in the brain involved in neuroinflammation, which plays a critical role in neurodegenerative diseases, including Alzheimer's disease (AD), Parkinson's diseases (PD), and Huntington's diseases (HD). Therefore, cases like this highlight the importance of understanding how chemicals interact with the body to induce long-term health and disease prognosis.

A 50-year-old man, who worked in the family greenhouse, inspected the greenhouse between the hour of 10 pm to 3 am without proper ventilation, without wearing respiratory protection, and bare-chested. Before these five hours, the man's wife diluted 1,3-D with water at a 1:50 ratio and irrigated the enclosed greenhouse using the diluted 1,3-D on the floor surface at the door and a trench in the field. After application, the man entered the greenhouse alone for inspection. Upon returning home, the man began to experience headaches, dizziness, and other discomforts for three days before other symptoms arose, including blurred vision, unclear speech, and worsened dizziness. By the end of the third day, the man presented to the emergency department of a local hospital with dizziness, nonchalance (out of it), confusion, as well as newly developed irritability symptoms. Despite a cranial CT scan, the brain displayed no abnormalities on the third and fourth days. However, doctors shortly transferred the man to the ICU. By the fifth day, CT examinations showed unclear portions of the brain (sulci and cisternae), suggesting atrophic changes (wasting

or thinning of tissue) in the brain, and on day six, a craniocerebral magnetic resonance examination showed widespread enlargement of the brainstem, uneven nerve signal, and a narrowed fourth ventricle (a series of interconnected hollows within the brain that contain cerebrospinal fluid [CSF]). The brain tissue exhibited widespread swelling, the downward shifting of the cerebellar tonsil, and indistinguishable sulci (brain furrows) and cisternae (brain pouches). Additionally, the three paired main arteries that supply blood to the brain (bilateral anterior, middle, and posterior cerebral arteries) were nearly invisible.

The case determined that: "Walking in the damp climate, high temperature, and poorly ventilated greenhouses, when exposed to 1,3-dichloropropene for a short time, the patient inhaled 1, 3-dichloropropene and quickly experienced dizziness, fatigue, nausea, unconsciousness, breathing difficulties, and other symptoms. Combined with the results of the serological test and brain magnetic resonance imaging, the symptomatic presentation was consistent with the manifestation of acute 1, 3-dichloropropene poisoning."

Exposure to chemical toxicants like pesticides can cause neurotoxic effects or exacerbate preexisting chemical damage to the nervous system. The impacts of pesticides on the nervous system, including the brain, are hazardous, especially for chronically exposed individuals (e.g., farmworkers) or during critical windows of vulnerability and development (e.g., childhood, pregnancy). Mounting evidence over the past years shows that chronic exposure to sublethal (nonfatal) levels of pesticides adversely affects the central nervous system (CNS) and neural receptors, such as connections between nerves, the brain, enzymes, and DNA. Specifically, researchers identify agricultural chemical exposure as a cause of many adverse CNS impacts and neurological diseases, including Alzheimer's, amyotrophic lateral sclerosis (ALS), and Parkinson's disease. Therefore, advocates say it is essential to avoid toxic chemical exposure to lessen potential acute and chronic health risks.

Whether 1,3-D exposure is short-term or long-term, certain concentrations are harmful to the human body in a closed environment, like the greenhouse in this case. Absorption through the respiratory tract may allow the compound to cross the blood-brain barrier, depose in the brain tissue, then inhibit the central nervous system and cause diffuse brain tissue edema, leading to acute damage to the heart (including the vascular system), lung (respiratory), and kidney (renal) function, eventually resulting in death. EPA first classified 1,3-D as "likely to be carcinogenic to humans" in 1985 until the primary manufacturer, Dow Chemical Company, requested EPA conduct the current cancer reevaluation, resulting in 1,3-D downgrading from "likely" to "suggestive evidence of carcinogenicity."

For those who may consider this issue outside of their concern, note that a recent study focusing on the Western United States determined fumigant pesticides have close links to county-level cancer rates. Not only does this compound cause respiratory stimulation response and central nervous system inhibition after inhalation, but the volatile organic compound also contributes to the formation of ground-level ozone and poor air quality.

There is a lack of complete understanding of the etiology of pesticide-induced diseases, including predictable lag time between chemical exposure, health impacts, and epidemiologic data. Pesticides themselves can possess the ability to disrupt neurological function. Pesticides' impact on the nervous system, including the brain, are hazardous, especially for chronically exposed individuals or during critical windows of vulnerability and development.

SOURCE: Zhiqiang Ahou et al., Case report, Death caused by 1,3-dichloropropene, a novel fumigant used in China, *Front. Public Health,* Sec. Occupational Health and Safety, Volume 11, 15 February 2023 https://doi.org/10.3389/fpubh.2023.1088296.

MORE ON THIS SUBJECT **Pittsburgh-Area Pesticide Poisoning: InTown Suites Residents Return After Rat Poison Incident**—October 5, 2023

TOXICOLOGY | PETS | JULY 20, 2023

Despite Nearly 1,700 Pet Deaths from Seresto Pet Collars, Pesticide Product Remains on Market

Despite evidence of toxicity to pets from Seresto pet collars (manufactured with the neurotoxic insecticide flumethrin, as well as the neonicotinoid insecticide imidacloprid), the U.S. Environmental Protection Agency's (EPA) has announced that the popular flea and tick collars will remain on the market, but with new mitigation measures. However, safety advocates say that these measures will do little to protect people and pets from chemical exposure using these collars. The agency will require Elanco—the manufacturer of Seresto—to conduct enhanced reporting for various factors, including adverse symptoms, veterinary community outreach, and place warnings on the product's label. Seresto, developed by Bayer and sold by Elanco, has been linked to nearly 1,700 pet deaths, injuries to tens of thousands of animals, and harm to hundreds of people. There are nontoxic ways to protect pets from fleas and

other pests while protecting human family members.

Children Ignored by the Agency. EPA has a history of ignoring the exposure patterns to children who come into close contact with pets and their flea collars and the potential adverse health threats, opting for warnings instead of regulatory action. In 2017, EPA issued a warning for tetrachlorvinphos (TCVP) flea collars that advised: "not allowing children to play with [the] pet collars; keeping [the] spray and power products out of reach of children; and, washing hands thoroughly with soap and water after handling." Safety advocates point to the unrealistic nature of the precautions being advised, given that children come into contact with collars and other toxicants sprayed on pets when they play and sleep with their pets and through hand-to-mouth contact (ingestion). With TCVP pet collars (not pump/trigger liquid sprays), EPA announced a Notice of Intent to Cancel in October 2022 pending additional manufacturer data. In the case of Seresto collars and the synthetic pyrethoid ingredient, EPA is ignoring a plethora of studies in the independent scientific literature on adverse effects to children, including a 2022 study on prenatal and infant daily exposure effects.

EPA Opts for Warnings and More Information and Monitoring, Not Regulatory Action. EPA's multi-year scientific review of Seresto-related incidents analyzes all reports of death and injury associated with these collars from 2016 to 2020. Although EPA highlights the two percent of Seresto-related incidents that resulted in death, death-related incidents are missing critical details that prevent EPA from determining the cause. Sublethal exposure to chemicals in these pet collars can cause severe adverse effects—from pruritus (itchy skin) and dermal lesions and changes in fur to lethargy, anorexia, and neurological symptoms. Since the removal of the collar can alleviate moderate to severe clinical signs of adverse health incidence, and reapplication of the collar results in a reoccurrence of clinal symptoms, EPA will require the registrant of Seresto to implement the following measures:

Safety advocates point to the unrealistic nature of the precautions being advised, given that children come into contact with collars and other toxicants sprayed on pets when they play and sleep with their pets and through hand-to-mouth contact (ingestion).

"To alert veterinarians and consumers of potential risks, the terms of continued registration require Elanco to include label warnings on Seresto products that describe common adverse effects that have been reported, along with instructions to remove the collar if those effects occur and instructions on how to report the incident. Elanco also must develop an outreach program to more effectively communicate with veterinarians and the public on the risks of using the product and other similar pesticides on pets.

- To improve the quality of data reported when receiving reported incidents from consumers, Elanco must pursue

additional information to the greatest extent possible to ensure that complete details of each event are captured. This information includes whether the pet had any preexisting conditions or previous history of the reported condition. The Seresto pet collar registration has also been split into two registrations, one for cats and one for dogs, to make comparison of incident data across products easier in the future. Elanco must report incident and sales data to EPA on an annual basis.

- To reduce the risk of strangulation, Elanco must evaluate potential changes to the emergency release mechanism of Seresto pet collars to prevent death by strangulation or choking. The company must submit a report detailing the data and analysis collected and performed in pursuit of this effort within one year. Based on this evaluation, EPA may require a modified release mechanism for the Seresto collar.
- To allow for the continued evaluation of reported incidents, EPA has limited its current approval of Seresto collar registrations to five years. EPA will continue to evaluate Seresto incident data over that period."

Background. Seresto collars are plastic pet collars embedded with pesticides designed to kill fleas, ticks, and lice; they contain the active ingredients flumethrin and imidacloprid. Flumethrin, a chemical in the pyrethroid class of synthetic neurotoxic insecticides, has been linked repeatedly to neurological issues, such as seizures and learning disabilities in children, to gastrointestinal distress, and to damage to invertebrates, according to EPA's own analysis. However, this is not the first-time tick and flea pet products have garnered negative attention regarding pet health, as numerous flea and tick prevention products (e.g., collars, topical treatments, sprays, and dust) include pesticides such as TCVP (mentioned above), propoxur, synthetic pyrethroids, and fipronil are toxic, not just to pets and nontarget organisms, but to humans, as well.

Moreover, the agency fails to evaluate the synergistic effects of pesticides as these pest collars can contain more than one active ingredient that can work in tandem with another to exacerbate the adverse health symptoms. For instance, *USA Today* reports, "A 2012 Bayer study found [flumethrin and imidacloprid] have a 'synergistic effect,' meaning they are more toxic together on fleas…." However, a 2016 EPA bulletin concluded, "The risk of the combination of the two active ingredients, flumethrin, and imidacloprid, was not assessed because the two chemicals act in completely different ways." Therefore, the EPA does not adequately evaluate the risks and harms of exposure to multiple pesticide compounds and "inert" or "other" pesticide ingredients.

In 2021, internal emails at EPA show that career scientists at the agency expressed concern about pesticide-laced pet collars, such as the notorious Seresto flea and tick collars, but that EPA managers "instructed them to avoid documenting those worries in publicly accessible records."

EPA's review of these Seresto-related incidents highlights the agency's failure to thoroughly evaluate these products for animal safety with ongoing monitoring. In fact, in 2021, internal emails at EPA show that career scientists at the agency expressed concern about pesticide-laced pet collars, such as the notorious Seresto flea and tick collars, but that EPA managers "instructed them to avoid documenting those worries in publicly accessible records." Additionally, the 2021 internal email revelations are further and unfortunate evidence of the state of EPA's function in carrying out its fundamental mission "to protect human health and the environment." For EPA's Office of Pesticide Programs, this means protection from the broadly damaging impacts of synthetic pesticides. Beyond Pesticides has chronicled EPA's "capture" by industry influence and the corruption that has marked both agrichemical industry behavior and, occasionally, internal EPA actions, as well as specific instances of EPA failures, such as those (like the pesticide pet collars) that put children at risk, and those that continue to allow the devastation of critical species (such as pollinators), ecosystems, and fragile habitats.

Furthermore, the Center for Biological Diversity (CBD) notes that EPA has received more than 75,000 complaints about these pet collars, associating their use with problems ranging from skin irritation to death. Gizmodo puts the current count of complaints to the EPA about Seresto, since 2012, at more than 86,000—with 2,340 of those relating to pet deaths. CBD's environmental health director, Lori Ann Burd, commented that—given EPA's estimate of the ratio of pesticide incidents "in the real world" to complaints filed with EPA as roughly 5:1—a sensible extrapolation is that many more pets wearing Seresto collars have been hurt or have died than are represented by reports filed with the agency. Karen McCormack, a retired EPA scientist and communications officer, notes that these collars have generated the greatest number of incident reports of any pesticide product in her long experience. She says, "EPA appears to be turning a blind eye to this problem, and after seven years of an increasing number of incidents, they are telling the public that they are continuing to monitor the situation. But I think this is a significant problem that needs to be addressed sooner rather than later."

SOURCE: D. Stanneck et al., The synergistic action of imidacloprid and flumethrin and their release kinetics from collars applied for ectoparasite control in dogs and cats. *Parasites Vectors* 5, 73 (2012). https://doi.org/10.1186/1756-3305-5-73.

TOXICOLOGY | EXPOSURE | JANUARY 4, 2023

Neonicotinoid Insecticides Add to the Growing List of Chemicals that Transfer between Mother and Fetus

A study published in *Environmental Science and Technology* finds neonicotinoids (neonics) and their breakdown products (metabolites), like other chemical pesticide compounds, can readily transfer from mother to fetus. The National Health and Nutrition Examination Survey (NHANES) finds U.S. pregnant women experience frequent exposure to environmental pollutants that pose serious health risks to both mother and newborn. Many known pollutants (e.g., heavy metals, polychlorinated biphenyl, and pesticides) are chemicals that can move from the mother to the developing fetus at higher exposure rates. Hence, prenatal exposure to these chemicals may increase the prevalence of birth-related health consequences like natal abnormalities and learning/developmental disabilities. Children are particularly vulnerable to the impacts of pesticide exposure as their developing bodies cannot adequately combat exposure effects. Moreover, a mother's pesticide exposure can have a stronger association with health disorders than childhood exposure, and a newborn can still encounter pesticides. Therefore, it is essential to understand how pesticides impact the health and well-being of individuals during critical developmental periods.

Beyond Pesticides has covered a variety of pregnancy risks from pesticides and other toxic chemicals, including these in just the last three years: pesticides and children's sleep disorders; prenatal exposures to a multitude of chemicals; insecticides and childhood leukemia; insecticides and Attention Deficit/Hyperactivity Disorder.

The study evaluates the transplacental transfer rates (TTR) of neonics from mother to fetus via prenatal exposure. Researchers collected 95 paired samples from mothers' serum (MS) and accompanying (umbilical) cord serum (CS) to measure the levels of five neonics (acetamiprid, imidacloprid, clothianidin, thiacloprid, and thiamethoxam) and two metabolites of acetamiprid and imidacloprid. After calculating the transplacental transfer efficiencies (TTEs) of each neonic and metabolite, researchers focus on three chemical mechanisms: passive diffusion, active transport, and pinocytosis. Lastly, a multilinear regression analysis explores the association between blood biomarkers for neonics in mothers and related birth outcomes among fetuses.

The most abundant neonic in MS and CS samples is imidacloprid, whereas acetamiprid's metabolite is the most abundant in CS and MS. Both parent and metabolite neonics have a high TTE, with imidacloprid having the highest transfer rate (1.61). Even the neonic with the lowest TTE of 0.81, thiamethoxam, is within the high TTE range, indicating proficient placental transfer of

these chemicals from mother to fetus. Researchers identify that transplacental transfer of these chemicals mainly occurs through passive mechanisms depending on chemical structure. Therefore, neonics like acetamiprid and thiacloprid (known as cyanoamidines) have higher TTE values than neonics like clothianidin and thiamethoxam (known as nitroguanidines). Lastly, multilinear regression demonstrates that most neonics in MS samples have associations with blood biomarkers related to hepatotoxicity (liver toxicity) and renal (kidney) toxicity.

Studies find pesticide compounds in the mother's blood can transfer to the fetus via the umbilical cord. A 2021 study finds pregnant women already have over 100 chemicals in blood and umbilical cord samples, including banned persistent organic pollutants. However, 89 percent of these chemical contaminants are from unidentified sources, lack adequate information, or were not previously detectable in humans. Since the first few weeks of pregnancy are the most vulnerable periods of fetal development, exposure to toxicants can have much more severe implications. A 2020 study finds prenatal pesticide exposure can increase the risk of the rare fetal disorder holoprosencephaly. This disorder prevents the embryonic forebrain from developing into two separate hemispheres. Moreover, women living near agricultural areas experience higher exposure rates increasing the risk of neonatal abnormalities like acute lymphoblastic leukemia and Attention-Deficit/Hyperactivity Disorder (ADHD).

Over the past 20 years, neonicotinoids have replaced four major chemical classes of insecticides in the global market (organophosphates, carbamates, phenyl-pyrazoles, and pyrethroids). These highly toxic systemic agricultural pesticides resemble nicotine and affect the central nervous system of insects, resulting in paralysis and death, even at low doses. Like other pesticides, neonics readily contaminate water and food resources as traditional wastewater treatments typically fail to remove the chemical from tap water, and the systemic nature of neonics allows the chemical to accumulate within treated plants. According to the Centers for Disease Control and Prevention (CDC), nearly half the U.S. population encounters at least one type of neonic daily, with children ages three to five having the highest exposure risk. Health impacts of exposure to neonics include neurotoxicity, reproductive disorders, liver/kidney damage, and an increase in gene expression and enzyme production linked to hormone-dependent breast cancer.

Studies find pesticide compounds in the mother's blood can transfer to the fetus via the umbilical cord. A 2021 study finds pregnant women already have over 100 chemicals in blood and umbilical cord samples, including banned POPs. However, 89 percent of these chemical contaminants are from unidentified sources, lack adequate information, or were not previously detectable in humans.

Although previous studies demonstrate pesticide classes like pyrethroids, organophosphate, carbamates, and organochlorines readily transfer from mother to fetus, this study is among the first to document and identify the occurrence and distribution specific to neonics in MS and CS. This finding supports long-known concepts regarding the hazards of pesticides for children's health. Early life exposures during "critical windows of vulnerability" can predict the likelihood or otherwise increase the chances of an individual suffering a range of pernicious diseases. In addition to findings on learning and development, early life exposures have links to increased risks of cancer, asthma, birth disorders, among others. Thus, a parent's exposure to pesticides during these critical periods indicates an increased risk in childhood disease.

Pesticide exposure not only poses a risk to mothers and their subsequent offspring but also to future generations. Current-use pesticides and metabolites (or breakdown products) of many long-banned pesticides still cause adverse effects. These negative effects can continue into childhood and adulthood and may have multigenerational consequences. Researchers at Drexel University report that higher levels of some organochlorine compounds, like DDT (its breakdown product DDE), during pregnancy are associated with autism spectrum disorder (ASD) and intellectual disabilities. Although the U.S. bans many organochlorine compounds, the ongoing poisoning and contamination underscore the pervasiveness and persistence of these chemicals, as well as their continued adverse impact on human health. Moreover, these exposures have real, tangible effects on society. Environmental disease in children costs an estimated $76.8 billion annually. Exposure that harms learning and development also impacts future economic growth in the form of lost brain power, racking up a debt to society in the hundreds of billions of dollars.

The study concludes, "This is the first study to associate maternal hematological parameters with p-NEOs [parent neonics] or their metabolites in MS, and further studies with larger sample sizes are needed to confirm our findings. […]A recent study reported that urinary IMI [imidacloprid] and ACE [acetamiprid] concentrations in pregnant women (n = 296) were significantly negatively associated with neonatal HC. This finding implied the influence of NEOs on cognitive and neurologic development in neonates."

SOURCE: D. Stanneck et al., Neonicotinoid Insecticides and Their Metabolites Can Pass through the Human Placenta Unimpeded, *Environ. Sci. Technol.* 2022, 56, 23, 17143–17152, https://doi.org/10.1021/acs.est.2c06091

TOXICOLOGY | EXPOSURE | MAY 4, 2023

Report Adds to Evidence of Widespread PFAS Contamination; Calls for Removal of Products

One of the most widely used insecticides in California, Intrepid 2F, contains harmful levels of per- and polyfluoroalkyl substances (PFAS), or "forever chemicals," according to a report by the Center for Biological Diversity (CBD) and Public Employees for Environmental Responsibility (PEER). In fact, 40 percent of pesticide products in the report tested positive for high levels of PFAS. PFAS are common in nonstick cookware, cleaning/personal care products, food packaging, and other consumer products. However, these compounds are also in pesticide products. Despite evidence on the dangers of PFAS stretching as far back as the 1950s, federal agencies sat on the sidelines as the plastics industry continued adding the material to new products. From their widespread presence in farm fields and sewage sludge to contaminated water bodies throughout the U.S., PFAS have made its way into the environment and our bodies. PFAS are even present in remote environments like the Arctic, Antarctica, and Eastern European Tibetan Plateau. A study published in 2020 identified PFAS as common chemicals to which U.S. residents are exposed daily.

The U.S. Centers for Disease Control and Prevention (CDC) determined that 98 percent of U.S. residents have some level of PFAS in their bloodstream, with studies reporting that PFAS compounds are detectable in infants, children, and pregnant women. With health risks including developmental, metabolic, cardiovascular, and reproductive harm, cancer, damage to the liver, kidneys, and respiratory system, as well as the potential to increase the chance of disease infection and severity, PFAS presents a chronic danger to people that demands urgent regulatory action. CBD and PEER submitted the test results to EPA and the California Department of Pesticide Regulation (CDPR), advising the agencies to remove these pesticide products from the market until contaminants from supply lines can be removed.

Despite evidence on the dangers of PFAS stretching as far back as the 1950s, federal agencies sat on the sidelines as the plastics industry continued adding the material to new products.

CBD authorized independent, certified lab testing on seven agricultural pesticides with common uses in California to determine the parts per trillion (ppt) of PFAS in pesticide products. The insecticide product Malathion 5EC (active ingredient: malathion) contains 510 ppt perfluorooctanoic acid (PFOA) and 680 ppt perfluoroheptanesulfonic acid (PFHpS), with a PFOA level over 100,000 times higher than the level

EPA considers acceptable in drinking water (0.004 ppt). The insecticide Oberon 2SC (active ingredient: spiromesifin) contains 1,500 ppt perfluorobutanoic acid (PFBA), and Intrepid 2F (active ingredient: methoxyfenozide) contains 50 ppt of perfluorobutanesulfonic acid (PFBS).

PFAS are a group of nearly 10,000 human-made chemicals in various consumer products that people use daily. Although some PFAS compound manufacturing has ceased, these chemicals last forever in the environment as their chemical structure makes them resistant to breakdown. Thus, PFAS contamination is significantly underreported and much more pervasive than previously thought, polluting storage and transportation containers, food and water resources, and other chemical products. For instance, many reports address the high levels of PFAS contamination in the mosquito insecticide Anvil 10+10. Not only is the public exposed to such chemicals, but those who work in factories that create products that include PFAS, or workers who use them regularly, have higher cumulative exposures. Across multiple states, firefighters have begun to bring lawsuits against manufacturers of the foams, charging that the companies knowingly made and sold products with these forever chemicals that put the workers' health at risk. Others at greater-than-average exposure risk include pregnant or lactating people and young children.

Although EPA does not regulate PFAS in pesticide formulations, the agency lists these substances in the inert ingredient database, and product labels do not require disclosure of contaminants fundamental to pesticide products as a result of the manufacturing or packaging process. The ongoing detection of PFAS in various environments and soils also threatens the ability of growers, including organic growers, to produce food that does not harbor these compounds. PFAS do not break down in the environment and are detectable in more than 330 animal species globally, including species at extinction risk. PFAS chemical residues persist in food and drinking water, with over six million U.S. residents regularly encountering drinking water with PFAS levels above the EPA health advisory of 70 ng/L. Therefore, PFAS are detectable in almost all of the U.S. population—disproportionately afflicting people of color communities—and have implications for human health.

Ubiquitous environmental contaminants, like PFAS, have severe consequences, especially on the health of vulnerable individuals. Various pesticide products act similarly to PFAS.

Nathan Donley, PhD, environmental health science director at CBD, states, "I can't imagine anything that could make these products any more dangerous than they already are, but apparently, my imagination isn't big enough. […] The EPA has to take control of this situation and remove pesticide products that are contaminated with these extremely dangerous, persistent chemicals."

Although EPA considers that the primary source of PFAS contamination in pesticides is PFBS and PFHpS leaching from fluorinated containers, they are not known to leach. Thus, this report indicates that PFAS contamination of agricultural pesticide products comes from additional unknown sources. For instance, PFAS in rainwater, surface water, and soil exceeds the planetary boundary for chemical pollution, contaminating above EPA's proposed guideline levels, and exceeding safe limits for humanity.

Despite reductions in the global emissions for PFAS compounds the environmental persistence and hydrological cycling of these toxic chemicals make them an ever-present source of contamination, especially as PFAS compounds do not break down in the environment. Studies from the past year highlight:

1. "Levels of PFOA and PFOS in rainwater often greatly exceed US Environmental Protection Agency (EPA) Lifetime Drinking Water Health Advisory levels, and the sum of the aforementioned four PFAAs (Σ4 PFAS) in rainwater is often above Danish drinking water limit values also based on Σ4 PFAS;
2. Levels of PFOS in rainwater are often above Environmental Quality Standard for Inland European Union Surface Water; and
3. Atmospheric deposition also leads to global soils being ubiquitously contaminated, and to be often above proposed Dutch guideline values."

PEER's science policy director Kyla Bennett, PhD cautions, "While communities around the country are struggling to remove PFAS from their drinking-water supplies, we are spraying millions of acres of our land with the same toxic chemicals. […] It's nonsensical; we can't protect our drinking water unless and until we get PFAS out of all pesticides."

Ubiquitous environmental contaminants, like PFAS, have severe consequences, especially on the health of vulnerable individuals. Various pesticide products act similarly to PFAS. Individuals can encounter these substances simultaneously, resulting in more severe health outcomes. Therefore, advocates urge that policies enforce stricter pesticide regulations and increase research on the long-term impacts of pesticide exposure. Many states are issuing regulatory limits on various PFAS in drinking water, groundwater, and soil. However, safety advocates urge EPA to require complete product testing and disclosure of ingredients for proper PFAS regulation and identify the unreasonableness of exposure to toxic pesticides by citing the productivity and profitability of organic and ecological pest management practices.

SOURCE: Eurofins Lancaster Laboratories Environment Testing, LLC, *Analytical Report: PFAS Pesticide Testing*, 3-28-2023, PFAS Pesticide Testing (biologicaldiversity.org)

TOXICOLOGY | EXPOSURE | OCTOBER 31, 2023

Hidden Volatile Organic Compounds (VOCs) in Indoor Air Cause Adverse Effects

With cooler weather setting in and people heading indoors and closing windows, the issue of COVID-19 transmission escalates, as do concerns about toxic chemicals filling the indoor ambient air. As a recent segment of *60 Minutes* (October 29, 2023) stresses, COVID-19 transmissions elevated public concern and understanding about the importance of ventilation, filtration, and air exchange to indoor air quality. Unfortunately, the concerns about indoor air are not limited to COVID-19 as volatile organic compounds (VOCs) invade most spaces where people live and work. These invisible toxic substances can be found in common household products, furniture, mattresses, and more, including pesticides in and around the house. Recognizing the risks associated with VOCs and the potentially hazardous off-gassing process is crucial for protecting public health.

VOC ingredients in pesticide products are typically withheld from product labels, hidden under the general category of "inerts" or "other" in the ingredients panel. However, the undisclosed pesticide ingredients may cause adverse biological or chemical activity.

VOCs are a group of chemicals that can easily vaporize into the air at room temperature. These compounds are found in many everyday items, including furniture, cleaning products, pesticides, cosmetics, and even air fresheners. Some household products, particularly pesticides, can introduce their own set of risks in addition to the risks they pose due to their VOC content. VOCs can range from harmless to harmful, and their presence can have a significant impact on indoor air quality. VOCs encompass a wide range of chemicals, including formaldehyde, polyurethane foam, phthalates, acetone, and benzene.

VOC ingredients in pesticide products are typically withheld from product labels, hidden under the general category of "inerts" or "other" in the ingredients panel. Manufacturers claim the ingredients to be proprietary and are not required to be disclosed to the consumer under federal pesticide law because the companies argue that they are not in the product formulation to attack the target pest. However, the undisclosed pesticide ingredients may cause adverse biological or chemical activity. This issue has sparked controversy, as environmental and health advocates have unsuccessfully attempted to

change U.S. Environmental Protection Agency (EPA) policy under the *Federal Insecticide, Fungicide, and Rodenticide Act*, which regulates pesticides in the U.S.

While VOC exposure is not a new issue, there is a renewed sense of urgency to improve indoor air quality following notable studies by Joe Allen, PhD, of Harvard University, and Linsey Marr, PhD, of Virginia Polytechnic Institute, which have highlighted the pivotal role of subpar indoor air ventilation systems in increasing the spread of COVID-19. Namely, the studies finds that the aerosolized particles containing the virus were able to spread throughout indoor rooms and increase infection rates without proper air exchange rates. In a demonstration by Dr. Marr, she visualizes how exhaled breath traveled in all directions in a room with stagnant air flow, leading to the increased airborne transmission of COVID and other airborne illnesses. Then, she shows how exhaled breath travels upwards in a uniform path inside a properly ventilated room, showing how the risk of spread decreases significantly under these conditions.

These findings are significant in the context of harmful VOCs in indoor spaces. As most indoor spaces meet bare minimum requirements of air circulation and refresh rates, places like living spaces and school classrooms are especially susceptible to locking in and spreading harmful VOCs and illnesses alike.

Poor ventilation indoors can exacerbate symptoms of VOC exposure. Short-term exposure symptoms include headaches, dizziness, nausea, and irritation of the eyes, nose, and throat. Prolonged exposure to harmful VOCs can result in more severe health problems, including damage to the kidney, liver, and central nervous system. Some VOCs are classified as carcinogens, increasing the risk of conditions like lung cancer.

These effects are exacerbated by a process called off-gassing, which is of critical concern when it comes to VOCs and furniture. It refers to the process by which materials containing VOCs release these chemicals into the air over time. Off-gassing is particularly prevalent in new furniture, as the VOCs have not yet been released, leading to higher emission rates.

The primary sources of off-gassing in homes are plywood and particle board furniture (which often contain formaldehyde), electronic devices, mattresses, carpets, couches, paint, and construction materials found in newly built homes. Plywood and wood furniture are especially significant contributors to off-gassing because they are highly porous, absorbing substantial amounts of VOCs. This high porosity results in a prolonged release of these harmful compounds into the indoor environment, making them notable culprits in diminishing indoor air quality.

The off-gassing process is especially concerning, given that EPA has expressed concerns about VOCs due to their potential health impacts. According to information on the EPA's website, a study called the "Total Exposure Assessment Methodology (TEAM) Study," which was completed in 1985, discovered that approximately a dozen common organic pollutants were two to five times more concentrated inside homes compared to outdoor environments. This held true regardless of whether the homes were situated in rural or highly industrial areas. The TEAM studies also reveal that when people use products containing organic chemicals, they can expose themselves and others to high levels of pollutants. Even after the activity is finished, these elevated concentrations can persist in the air. The New York State Department of Health also addresses this issue in its publication titled "Volatile Organic Compounds (VOCs) in Commonly Used Products."

The widespread presence of these harmful chemicals in furniture and other household goods can be traced back to California's old flame retardant regulations. In 1975, California implemented a regulation requiring all upholstered furniture in the state to contain flame-retardant chemicals. As California was a substantial market, manufacturers opted to adopt these standards for furniture sold nationwide, which led to the pervasive use of these toxic chemicals.

The chemicals used in flame retardants have been linked to cancer, endocrine disruption, neurobehavioral function issues, and adverse effects on fetal development. Eventually, this regulation was revised under the California flammability standard. SB 1019, which passed in 2014, allows furniture manufacturers to cease using harmful flame retardant chemicals in polyurethane foam, offering a safer option for consumers. Furniture manufactured after January 1, 2015 is less likely to contain these harmful flame retardants, while products purchased between 1975 and 2014 may expose families to these toxic chemicals.

Poor ventilation indoors can exacerbate symptoms of VOC exposure. Short-term exposure symptoms include headaches, dizziness, nausea, and irritation of the eyes, nose, and throat. Prolonged exposure to harmful VOCs can result in more severe health problems, including damage to the kidney, liver, and central nervous system.

However, other harmful VOCs are still present in furniture and other household items. Newborns and infants are especially vulnerable to the effects of the resulting off-gassing, as their developing bodies are more sensitive to environmental toxins. Mattresses and baby items can emit harmful VOCs, potentially affecting the health and well-being of children. Parents should exercise caution when choosing products for their nurseries and opt for those labeled with Greenguard certifications, which indicate low or no levels of hazardous VOCs.

Despite the well-documented adverse effects of certain VOCs that permeate

household products, EPA refrains from implementing regulations concerning these chemicals within the home. This is in stark contrast to their oversight of outdoor air quality, where VOCs are regulated. EPA maintains that its jurisdiction does not extend to indoor air quality and it regulates only under section 183(e) of the *Clean Air Act* (Act), while states have plans approved by the agency.

EPA explicitly notes that "[E]ven if we had the authority to regulate indoor air quality, it would be difficult to regulate household (or other) products because we have no authority to collect information on the chemical content of products in the marketplace (nor does any Federal Agency)."

In fact, EPA has a history of approving harmful aerosol air sanitizer pesticides for use against COVID-19 and other bacteria and viruses. In October 2022, EPA approved 32 varieties of a new pesticide for air sanitizers. The formulation contained 14 percent dipropylene glycol, with the other 86 percent of the formulation not specified. This action, while intended to decrease pathogens in indoor air, fails to do so by not taking into account that disinfectants and sanitizers emit VOCs and negatively affect the immune system, thus reducing resistance to disease. Instead of exercising jurisdiction over improving indoor air ventilation, EPA turned to harmful pesticides once again, putting people with preexisting conditions, the elderly, and children at elevated risk from exposure.

Therefore, given the lack of protective action from government agencies, it is crucial to make informed choices and protect families. Consider these steps when shopping for furniture and household items:

1. Check Labels: With pressed-wood products, look for furniture items that meet ultra-low emitting formaldehyde (ULEF) or no added formaldehyde (NAF) standards. Products labeled as "Zero VOC" and "Low VOC" are also safer choices.
2. Look for organic furniture and mattresses that are certified free from VOCs and flame retardants. With mattresses, check whether materials meet the Global Organic Textile Standard.
3. Increase Ventilation: Proper ventilation can help reduce indoor air pollution. Ensure your living space is well-ventilated, particularly when introducing new furniture or items.
4. Filter Your Air: Air purifiers with activated carbon filters can help remove VOCs from the air, improving indoor air quality.
5. Choose Safer Alternatives: When possible, opt for solid wood furniture, used furniture that has had time to air out, and electronic devices with low VOC emissions.

Products containing harmful VOCs or flame retardants can be disposed of responsibly, such as disposing of them at hazardous waste facilities or contacting manufacturers. Some manufacturers offer take-back programs for their products, which can be an environmentally responsible way to dispose of old items.

SOURCE: Jon LaPook, Indoor air systems crucial to curbing spread of viruses, aerosol researchers say, 60 minutes, CBS News, 10-29-2023, Indoor air systems crucial to curbing spread of viruses, aerosol researchers say—CBS News

TOXICOLOGY | EXPOSURE | OCTOBER 31, 2023

Train Tragedy Highlights Law's Failure to End Use of Needless Toxic Pesticides and Co-formulants

The February 3 derailment of a Norfolk Southern train in Ohio has been huge news. Less well known perhaps is that 20 of the 50 cars involved were carrying hazardous materials, defined by the National Transportation Safety Board as "cargo that could pose any kind of danger 'including flammables, combustibles, or environmental risks.'" The incident resulted in a huge fire, evacuations, and worries about explosions and discharge of toxic chemical gases; on February 6, officials conducted "controlled releases" of some of the chemicals. Some of the toxic chemicals involved are precursors to production of synthetic pesticides.

[Eds. Note: We are deeply concerned for the victims of this terrible crisis who are asking legitimate questions about contaminated drinking water and the effects of both the initial acute exposure after the derailment, resulting in the release of toxic chemicals, and long-term exposure to low levels of toxic residues in homes and the environment.]

Among the compounds on board those 20 cars were "inert" pesticide ingredients (vinyl chloride, ethylhexyl acrylate, and isobutylene), an antimicrobial compound (ethylene glycol monobutyl ether [EGBE]), benzene (a carcinogenic solvent), and butyl acrylate. This event brings into high relief the cradle-to-grave issues that travel with pesticide (and broad chemical) dependency, including disasters such as this one, and subsequent threats to health and the environment—which are never part of the U.S. Environmental Protection Agency's (EPA) calculus in registering pesticides. The Ohio derailment also adds to the case for getting off the toxic pesticide treadmill, which would reduce transport of such compounds.

Air quality readings within a mile of the site began soon after the event.

Evacuation orders were lifted on February 8 because officials indicated that air quality was safe enough for people to return to their homes. *The Washington Post* reports that environmental officials, as of February 14, were saying that ongoing "air monitoring done for the railroad and by government agencies—including testing inside nearly 400 homes—hasn't detected dangerous levels in the area since residents were allowed to return. The U.S. Environmental Protection Agency has shared air monitoring results online."

Nevertheless, some residents continue to have concerns not only about contaminated air, but about potential contamination of their drinking water; Ohio Environmental Protection Agency officials insist the water has been protected and is safe. Yet, others, including Ohio Governor Mike DeWine, delivered a different message, leading to heightened confusion and frustration among residents. As *The New York Times* (*NYT*) reported, "State officials have continued to recommend that some residents drink bottled water as testing continues in private wells, municipal water, and streams, and fears have percolated over the possible dangers of long-term exposure to the chemicals."

Understandably, area residents are worried about toxic chemicals in their air or water or soils. And as with many concerning public events, social media has spread both sound information and some that is decidedly not. In speaking to *The Washington Post*, one resident summed up what many people are feeling and thinking: "For a small town, we have to trust them [i.e., officials], because what else do we have to do? We have to trust that they are not lying to us." The paper quoted Peter DeCarlo, an environmental health professor at Johns Hopkins University: "The biggest question remaining is what, if anything, is still being released from the site, first and foremost. If there are still residual chemical emissions, then that still presents a danger for people in the area."

Understandably, area residents are worried about toxic chemicals in their air or water or soils. And as with many concerning public events, social media has spread both sound information and some that is decidedly not.

Indeed, just prior to publication of this *Daily News* article, the *NYT* reported that hundreds of residents gathered in a school gym on the evening of February 15 for what had been billed as a "town hall" meeting about the disastrous event. But Norfolk Southern officials failed to show up, and the format was changed to one of state, county, and local agency officials sitting at separate tables around the room and fielding individual questions so that the whole group was not privy to the questions or answers. None of this went over well with the crowd, which was animated in demanding answers to their concerns and angry at railroad officials' absence; the mayor ultimately switched back to a town hall format.

The *NYT* elaborated: "We have become increasingly concerned about the growing physical threat to our employees and members of the community around this event stemming from the increasing likelihood of the participation of outside parties, a spokesman for the railroad company

said, though the nature or origin of the threats was unclear. The spokesman added: 'We are not going anywhere. We are committed to East Palestine and will continue to respond to community concerns.' On Wednesday, that was clearly not enough to satisfy the throngs of people gathered in the gym, who shouted demands to know where the company was. Citing the statement from the company, one man stood up and declared, 'We're scared, too.'"

Possibly caused by an overheated wheel bearing, the derailment in East Palestine, Ohio (near the Pennsylvania border) has been described by some experts as a potentially huge, unfolding environmental disaster, with much about the health and environmental impacts still to be determined via ongoing investigations. The incident looms as even more alarming, given that at least one train derails every day in the U.S. Although most trains carry multiple kinds of cargo—the Norfolk Southern had frozen vegetables, autos, and medical cotton balls on board—they also typically have one or more hazardous materials in tow. According to *The Guardian*, "About 4.5m tons of toxic chemicals are shipped by rail each year and an average of 12,000 rail cars carrying hazardous materials pass through cities and towns each day, according to the U.S. Department of Transportation." In 2022, train accidents resulted in releases of hazardous chemicals 11 times, down from 20 times in 2018 and 2020.

Perhaps the most memorable recent rail disaster was the 2013 explosion and fire from 72 rail tankers of petroleum crude oil that erupted in Lac-Megantic, Quebec (near the western Maine border). In that event, 47 people died and 26,000 gallons of oil contaminated the Chaudiere River. Also in 2013, a crude oil train exploded on collision with a derailed train full of grain; luckily, this happened in a relatively unpopulated North Dakota area. 2005 saw the crash, in South Carolina, of a train carrying chlorine gas (a chemical highly poisonous to skin and the respiratory tract).

California's worst train debacle happened in 1991 near Dunsmuir, when roughly 19,000 gallons of metam sodium, a highly toxic pesticide still used as a fungicide and herbicide, flowed into the Sacramento River near the iconic Mt. Shasta. Nearly every living organism in a 38-mile stretch of the river died from the chemical's toxicity; fortunately, the river and its inhabitants were largely restored within three to four years, according to California Department of Fish and Game spokesperson Mark Stopher. These are just a handful of transportation accidents that released toxic chemicals, harming (and sometimes killing) people, and contaminating the environment.

Rail has often been considered preferable to (and cheaper than) trucking or flying. Long-haul trains, after all, do much of their travel through non- or less-populated areas, whereas trucks on crowded highways present their own significant safety risks, and planes filled with toxic chemicals would be, more or less, flying bombs.

The menu of toxic chemicals on board the Norfolk Southern train was an unsavory one. Of greatest concern has been vinyl chloride, a highly flammable compound used to make polyvinyl chloride (PVC) plastics; when exposed to sunlight, it generates toxic gases, including formaldehyde. When burned, vinyl chloride becomes hydrogen chloride and phosgene; the latter is a deadly gas that was used in World War I chemical warfare and is used in the manufacture of plastics and pesticides.

To boot, any vinyl chloride that seeped into the trench soil can persist for long periods and continue to volatilize, and can migrate into groundwater. Exposure to it has acute effects on people, and can lead to cardiovascular, developmental, hepatic, and immune problems, and to some nasty cancers. After three rounds of evacuation efforts, the five cars carrying it were breached by emergency responders who discharged the chemical to a trench and burned it.

Northeast University environmental toxicologist Kimberly Garrett, PhD explained the extreme concern about phosgene: "It disrupts the interaction between the lungs and the bloodstream. It makes it so oxygen can't get into the blood and carbon dioxide can't get out." The wildlife deaths in the area, including fish, squirrels, turtles, and foxes, were likely caused by phosgene. She added, "The risk of exploding was so high and the consequences so severe that it's better to do it under controlled conditions," and suggested that, because of the potential for long-term effects of vinyl chloride (with its carcinogenic impacts) migrating into groundwater (where it is notoriously difficult to clean up), officials likely opted for one of two bad options—a controlled burn rather than the explosive and migratory risks of leaving it alone.

Butyl acrylate is an explosive and flammable liquid used in manufacturing sealants, adhesives, and paints; it can lead to skin, eye, and respiratory irritation. Ethylhexyl acrylate is used similarly, and can cause the same kinds of irritation, as well as gastrointestinal problems if ingested; it is also a potential human carcinogen. Ethylene glycol monobutyl ether (EGBE) is neurotoxic; it can lead to irritation of the skin, nose, and throat, damage to red blood cells, hepatic, renal, and reproductive harms, and vomiting after exposure. Isobutylene is used in many industrial applications, is highly flammable, and is neurotoxic.

One might reasonably wonder why such dangerous chemicals (some of which are on their way to becoming pesticides) are allowed to be transported by rail through populated areas and vulnerable environments alike. The reality is that this is the chemically dependent state of the world (and for pesticides, of most agriculture and land management).

The manufacture of pesticides and plastics (and many other products) requires that toxic chemicals be transported . . . somehow.

Rail has often been considered preferable to (and cheaper than) trucking or flying. Long-haul trains, after all, do much of their travel through non- or less-populated areas, whereas trucks on crowded highways present their own significant safety risks, and planes filled with toxic chemicals would be, more or less, flying bombs (and a very pricey form of transport). In the wake of this tragic derailment, some public health advocates say it should be a wake-up call on the potential for far-more-deadly freight rail accidents, particularly in light of the petrochemicals (e.g., ethanol and other fuels) and their chemical derivatives that are transported by rail.

The Guardian reports, "By one estimate, 25 million Americans live in an oil train blast zone, and had the derailment occurred just a few miles east, it would be burning in downtown Pittsburgh, with tens of thousands of residents in immediate danger. Ineffective oversight and a largely self-monitoring industry that has cut the nation's rail workforce to the bone in recent years as it puts record profits over safety is responsible for the wreck, said Ron Kaminkow, an Amtrak locomotive engineer and former Norfolk Southern freight engineer.

"The Palestine wreck is the tip of the iceberg and a red flag," said Mr. Kaminkow, who is secretary for the Railroad Workers United, a nonprofit labor group that coordinates with the nation's rail unions. 'If something is not done, then it's going to get worse, and the next derailment could be cataclysmic.'"

These toxic chemicals are generally deemed necessary to "modern life." But there are, at least for pesticides and their precursor and ingredient compounds, other and better options. One would be for EPA to take into account, in its evaluation of pesticides for registration, the very real cradle-to-grave issues related to pesticide use—including transportation disasters that seriously threaten health and the environment.

These toxic chemicals are generally deemed necessary to "modern life." But there are, at least for pesticides and their precursor and ingredient compounds, other and better options. One would be for EPA to take into account the very real cradle-to-grave issues related to pesticide use—including transportation disasters that seriously threaten health and the environment.

The *Federal Insecticide, Fungicide, and Rodenticide Act* (FIFRA)—the base federal statute that controls pesticide regulation—requires that pesticide use "will not generally cause unreasonable adverse effects on the environment." The statute defines "unreasonable adverse effects," in part, as "any unreasonable risk to man [*sic*] or the environment, taking into account the economic, social, and environmental costs and benefits of the use of any pesticide."

A protective reading of this statute and definition would cause EPA to evaluate such risks from "cradle to grave," meaning from the sourcing of chemical ingredients through their manufacture, transportation, use, and ultimate disposal. The disaster in Ohio is a glaring example of EPA's failure to use a protective and precautionary approach; instead, the agency's history often shows an industry-friendly reluctance to do so.

SOURCE: Department of Environmental Protection, State of Pennsylvania, *East Palestine Train Derailment: What DEP Is Doing*, Ohio Train Derailment (pa.gov)

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Toxic Train Derailment Raises Need for Systemic Change—February 21, 2023

Train Tragedy Highlights Law's Failure to End Use of Needless Toxic Pesticides and Co-formulants—February 17, 2023

TOXICOLOGY | SCIENTIFIC INTEGRITY | MARCH 31, 2023

Office of the Inspector General Slams EPA for Betraying Scientific Integrity . . . Again

A report from the Office of the Inspector General (OIG) for the U.S. Environmental Protection Agency (EPA) identifies the most recent event in the very long chronicle of EPA dysfunction that—put charitably—constitutes failures to enact its mission, and more accurately, sometimes crosses the line into malfeasance. In the report, OIG concludes that EPA's 2021 PFBS Toxicity Assessment failed to "uphold the agency's commitments to scientific integrity and information quality," and that the agency's actions "left the public vulnerable to potential negative impacts on human health." PFBS (perfluorobutane sulfonic acid) is a member of a larger group of per- and polyfluorinated substances (PFAS). As reported by *The Guardian*, "Trump administration appointees at . . . EPA meddled in agency science to weaken the toxicity assessment of a dangerous chemical." Last year, Beyond Pesticides' concerns about the myriad risks and harms of pesticides intersected with those about the PFAS family of chemical compounds, when a study found very high levels of PFAS in multiple pesticide products.

The EPA OIG explains why it undertook the evaluation that led to this report: "[T]o determine whether the EPA followed applicable policies and procedures to develop and publish the January 19, 2021 perfluorobutane sulfonic acid toxicity assessment. Two weeks after publication, the EPA removed the toxicity assessment from its website, citing political interference and Scientific Integrity Policy violations. . . . The EPA's Scientific Integrity Policy, established in 2012, states that science is the backbone of the EPA's decision making and that the Agency depends on the integrity of its science to protect human health and the environment. All EPA employees—including scientists, managers, and political appointees—must follow the Scientific Integrity Policy."

PFBS is one of thousands of PFAS "forever chemicals" that are emerging as a ubiquitous and serious threat to human and organismic health. These compounds do not break down in the environment, and can move through soils, contaminate water resources, and bioaccumulate in aquatic and terrestrial organisms. *The Guardian* writes that PFBS "is toxic at low levels. Research has linked the chemical to kidney disease, reproductive problems and thyroid damage, and it has been found throughout the environment, including in an estimated 860,000 Americans' drinking water."

Concurrent with the recent Biden administration's EPA announcement of new proposed federal standards for PFAS compounds in drinking water, the Environmental Working Group published an interactive map of the nearly 3,000 (and rising) number of sites in the U.S. (and two territories) contaminated by PFAS chemicals. EPA warned, in June 2022, that PFAS

compounds, linked to reproductive, immune, cardiovascular, and endocrine (especially thyroid) anomalies and to several kinds of cancer, are an even greater health threat than was previously known. Many advocates have noted that the proposed new federal standards are still inadequate because they are less stringent than the interim advisory levels for safe consumption EPA set out last year—lifetime exposures of no more than 0.004 to 0.02 ppt (parts per trillion), depending on the type of PFAS compound.

The OIG report notes "unprecedented" interference on the part of Trump EPA Administrator Andrew Wheeler and other political appointees in the PFBS assessment. At the 11th hour, Mr. Wheeler ordered the insertion of a range of toxicity values, rather than a specific limit. The compromised assessment, which would have guided drinking water standards for the chemical, as well as targets that polluters would need to meet in pollution cleanup—thus, allowing companies to remediate PFBS to higher, more-dangerous levels—was published just four days prior to the inauguration of President Biden. The OIG report notes that, "The new numbers were inserted without being fully scientifically vetted, and they lacked 'technical and quality assurance review.'" Kyla Bennett, PhD, of Public Employees for Environmental Responsibility (PEER), notes that "[t]hey were trying so hard to get [the assessment] out before Trump left office."

The Biden administration yanked the 2021 PFBS assessment in February 2021 because of its determination that there had been political interference. According to *The Guardian*, it was republished several months later "using what it said is sound science, and declared it had resolved the issue." But some EPA scientists related to the newspaper that "several employees willingly worked with the Trump appointees to weaken the assessment, and they were never reprimanded or fired. The scientists say the controversy is part of a deeper problem afflicting EPA: industry influence on career staff, and an unwillingness from the EPA to address it.

"'The issue is part of the larger rot at the agency of career staff working with industry to weaken the EPA,' a current agency scientist familiar with the situation said. The scientist did not use their name for fear of reprisal."

After the 2021 assessment was pulled, the Biden administration declared in a statement that the EPA evaluation of PFBS had been "compromised by political interference as well as infringement of authorship." *The Guardian* reports that, "During its review, the administration took no action against career employees who implemented the political appointees' changes. Those employees 'made the changes happily,' according to [Dr.] Bennett, but remained at the agency."

According to *The Guardian's* coverage, internal emails from the ebbing days of the Trump EPA, as well as comments in the OIG report, indicate that career employees in the agency's OCSPP [Office of Chemical Safety and Pollution Prevention] either asked for the toxicity metric changes or did not object to them. Reportedly, the sole career employee who opposed the order for changes to the PFBS assessment was Orme-Zavaleta, who told *The Guardian* that Administrator Wheeler's order "flew in the face of scientific integrity." Former EPA scientist Betsy Southerland told the paper that the changes were "something that industry has always wanted."

Beyond Pesticides has repeatedly highlighted the too-cozy relationship between the chemical industry and EPA, with particular attention to the impacts on EPA's registration and regulation of pesticides. A 2021 press release on a letter sent to the Biden Administration by Beyond Pesticides and PEER (with 35 other groups) summarized the issues: "The Office of Pesticides Programs within the U.S. Environmental Protection Agency has become so captured by industry that it has lost sight of its health and environmental mission. . . . [T]he groups are urging the Biden administration to adopt reforms within OPP to ensure pesticide approval and use decisions are science-based." It continues, "Inside OPP [EPA's Office of Pesticide Programs], marginalization of science remains cause for celebration and the result has been repeated ecological and public health disasters. . . . The letter recounts a litany of improper pesticide approval decisions, some of which were blocked in court, while still others are being reversed under Biden. But the groups say these cases are symptomatic of a larger institutional illness that calls for thoroughgoing reforms. The cumulative effects of years and decades of this regulatory abuse are untold human deaths, disabilities, and illnesses. Industry has been forced to pay out billions of dollars for damages claims over OPP-approved products. The groups also point to the decline of pollinators—the key to American food security—due to the indiscriminate application of highly potent pesticides. The health of non-target wildlife, as well as our soil and waters, is under chemical siege."

Beyond Pesticides has covered many of the transgressions of EPA during the Trump administration, including those related to pesticides (e.g., dicamba, pyrifos), scientific integrity, lack of transparency and accountability, poor enforcement of regulations, and water protection, among others. Investigative journalists Cary Gillam, Sharon Lerner, and PEER have all bird-dogged EPA on its chemical and pesticide policies and regulations; Beyond Pesticides has featured their work (and others') in various *Daily News* entries. See, for example, coverage on EPA's ongoing failures and malfeasance: EPA reliance on industry research; the "revolving door" between industry and EPA; chemical industry influence on the agency; the corrupt alteration of scientific information, as related to the pesticide dicamba; and so many instances of EPA disregarding scientifically demonstrable harms that they cannot reasonably be listed here.

Beyond Pesticides' three-part series, based in part on Ms. Lerner's work, goes directly to these issues: undermining of EPA function by industry influence, the susceptibility of EPA officials and managers to corrupt behavior, and the ongoing failure of the agency to align

its efforts with its own 2012 Scientific Integrity Policy, here and here. Further, the many transgressions of the Trump EPA are a dramatic demonstration of how whipsawed EPA's operations and approach can be with the advent of administrations whose politics harbor animus toward regulation—even though the agency's job is to protect human and environmental health.

As is the practice for the offices of federal Inspectors General in reports on their internal agency investigations, the EPA OIG made recommendations to the agency. Three of those are directed to the Assistant Administrator for Research and Development; they (1) "aim to reduce procedural confusion and strengthen existing policies, procedures, and guidance by clarifying if and when comments expressing scientific disagreement can be expressed; (2) making clear if and when toxicity ranges are acceptable; and (3) using the OIG as a resource for high-profile scientific integrity concerns that relate to political interference or that assert risk to human health or the environment." Another is directed to the assistant administrator for Mission Support: "to update policies and procedures on environmental information quality to require additional quality assurance reviews for EPA products." The last goes to the deputy administrator of EPA: "to strengthen the EPA's culture of scientific integrity, transparency, and accountability of political leadership actions when changes occur as a result of policy decisions."

Whether and how EPA chooses to adopt these recommendations remains to be seen. Yet even this OIG report—though potentially helpful in righting EPA's ship—does not address the comprehensive overhaul needed at EPA to ensure it pursues its mission with integrity, based in science, and with protection of health and environment at the helm.

As Beyond Pesticides recently wrote, "[EPA's] track record, on so many pesticides [and chemicals broadly], is to deal with one compound (under a narrow range of circumstances and/or narrow time frame and/or specific exposure levels) at a time. Beyond Pesticides has dubbed this the 'whack-a-mole' struggle on pesticides. Each regulatory baby step at EPA, each judicial settlement or knock-down of a particular pesticide, each bit of research demonstrating harms—these represent small, incremental advances on a pesticide [and broad "chemical saturation"] problem that is vast in scope. But this approach is wholly inadequate to the devastation that [dangerous chemicals] are causing, and it continues the "collision course" we are on re: human health and well-being, biodiversity collapse, and the climate crisis. A precautionary approach . . . is far more suited to the task of genuinely protecting public health and the environment."

SOURCE: Office of Inspector General, U.S. Environmental Protection Agency, *The EPA's January 2021 PFBS Toxicity Assessment Did Not Uphold the Agency's Commitments to Scientific Integrity and Information Quality*, Report no. 23-E-0013, March 7, 2023.

TOXICOLOGY | SCIENTIFIC INTEGRITY | DECEMBER 15, 2023

Int'l Group of Scientists Calls for Restraints on Conflicts of Interest in Publications and Regulation

Drawing on a recent gathering of international scientists, a group of 34 scientists published a call for much stricter scrutiny of researchers' conflicts of interest by agencies that regulate and register chemicals, with recommendations for the newly formed Intergovernmental Science Policy Panel. Writing in *Environmental Science & Technology*, the authors, led by Andreas Schäffer, PhD of Aachen University in Germany and Martin Scheringer, DSc of Masaryk University in the Czech Republic, cite an abundance of examples of chemical companies and their trade associations manufacturing doubt via an array of techniques, resulting in agencies such as the U.S. Environmental Protection Agency (EPA) dropping certain provisions from rulemaking, ignoring scientific consensus, and keeping chemicals on the market—and in the environment—that many scientists say should be entirely banned. The authors produced the article in response to this webinar to discuss how to ensure that United Nations' panels dealing with global crises get the most sound scientific advice conducted by the International Panel on Chemical Pollution.

Over the last four decades or so, the notion that conflicts of interest affect the validity of scientific research and professional opinions has been steadily eroded. Regulators wallow in compromised research, hamstrung by political pressure and pinched funding even as they face some 350,000 chemicals registered for use globally, only a tiny fraction of which have been tested for safety. Arguments in favor of enforcing rigorous conflict of interest (COI) policies in evaluation and registration of pesticides and other industrial chemicals have been repeatedly emphasized in scientific journals and the press, yet almost nothing has reduced the amount of industry influence over that process. In 2022, the United Nations Environment Assembly decided to create a new advisory group called the Intergovernmental Science Policy Panel to provide expert advice to the U.N.'s existing intergovernmental panels on climate change and biodiversity.

The problem of industry interference applies to almost every industrial

chemical, including pesticides, pharmaceuticals, plastics, flame retardants, and asbestos. The tactics remain the same across fields, and are derived from the campaigns waged by climate deniers, tobacco companies, and fossil fuel companies as detailed in 2010 in Merchants of Doubt by Naomi Oreskes and Erik M. Conway.

One of the most obvious routes to affect policy, namely lobbying, cost chemical interests $65.9 million in 2022, according to an Open Secrets report. The American Chemistry Council's pressure on legislators accounted for $19.8 million of that.

But more subtle industry influences also pervade the regulatory process. There are at least 24 strategies industry uses to disguise its conflicts of interest and further its economic goals, according to Rebecca Goldberg and Laura Vandenberg, researchers at the University of Massachusetts Amherst. These include, the authors write, "'revolving doors' between a regulatory authority and the industry it is meant to regulate; reliance for safety data on unpublished industry documents while largely ignoring publications by independent scientists; and covert influence by the industry." They also often threaten lawsuits against researchers whose work conflicts with their goals.

More types of industry manipulation were offered in 2019 by Xaver Baur, MD, Colin Soskolne, PhD, and Lisa Bero, PhD in *Environmental Health*: Practices of corporate malfeasance include the orchestrated contamination of editorial boards of peer-reviewed scientific journals with industry apologists; interference with activities of national regulatory bodies and international review panels engaged in safeguarding occupational and public health; constructing roadblocks by capitalizing on uncertainty to undermine scientific consensus for much-needed government regulation of carcinogenic, endocrine-disrupting and/or immunotoxic agents; promoting "causation" criteria that lack foundation and effectively block workers' access to legal remedies for harms from occupational exposures resulting in morbidity and premature mortality; and violating standards of professional conduct by seducing reputable scientists with financial incentives that make them beholden to corporate agendas.

And yet another perspective on the problem was offered by University of Notre Dame biologist Jason Rohr, PhD in a 2021 article: The first tool is shaping science, which is the art of creating research to produce a desired outcome, often referred to as outcome-oriented research. When efforts to shape science fail, advocates will often attempt to hide science associated with unwelcome information or attack this science by launching illegitimate critiques in an effort to turn reliable science into "junk" [references omitted]. To discourage future damaging research, advocates will also harass or bully scientists who produce damaging research. Packaging science is the art of assembling an expert group to advance a favored outcome, whereas spinning science is the art of manipulating public perception about credible science.

For a painful example of the personal toll such practices take on individual scientists, read Herbert Needleman's (MD) 1992 story of persecution by fossil fuel interests when he published research showing that inner-city children's teeth contained high levels of lead. This was 14 years *after* lead was banned in paint, but just the beginning of the fight to further reduce children's lead exposure, which has seen considerable

success. However, the lead industry was still lobbying against regulation by 1996, and today there are still nearly half a million U.S. children with elevated levels.

Beyond Pesticides has covered many aspects of industry influence at EPA, FDA, USDA and other regulatory agencies. See the organization's 2017 commentary for more details. That year Beyond Pesticides also critiqued the nomination of Michael L. Dourson, PhD to be assistant administrator for chemical safety on the grounds that he had spent years "helping companies resist constraints on their use of potentially toxic compounds in consumer products." Dr. Dourson founded a consultancy whose clients included Dow Chemical Company, Koch Industries, Inc. and Chevron Corporation. His research funders included the American Chemistry Council, which endorsed his EPA nomination. However, vigorous resistance from Beyond Pesticides and many other advocate groups and unflattering press coverage led Dr. Dourson to withdraw his nomination. Thus, the revolving door did not operate as intended this time.

Pesticide regulation is a major target for industry influence. For example, the herbicide atrazine, which EPA acknowledges is an endocrine disrupter, is very common in U.S drinking water. The E.U. banned it in 2004, but it remains the second most-used herbicide in the U.S. Atrazine's manufacturer, Syngenta, notoriously attacked University of California Berkeley professor and researcher Tyrone Hayes, PhD, when he published results of atrazine's hormonal effects on frogs. The company went so far as to hire a public relations flack to gin up rumors about Hayes's mental health in order to discredit his work.

One of industry's most appalling successes has been keeping asbestos on the market despite reams of evidence that it is extremely damaging to humans, causing mesothelioma, asbestosis, and other respiratory diseases, and it has been associated with ovarian, colorectal, stomach and pharyngeal cancers. In an especially scurrilous turn of events, from 2012 to 2016 an international corporate intelligence firm called K2 hired a former television producer to misrepresent himself as a crusading filmmaker eager to document the tragic effects of asbestos in India. The firm was working for asbestos interests. The so-called filmmaker, Robert Moore, ingratiated himself with anti-asbestos activists, recording phone calls and meetings and reporting to K2. The World Health Organization hired him to make a film called "Victims of Chrysotile Asbestos." The whole story unraveled in court in 2018, but even this outrage did not overcome industry influence. EPA tried to ban asbestos in the U.S. in 1989 but caved to political pressure from the George H.W. Bush administration. It remains importable and usable in the U.S. today.

Not all biases create conflicts of interest. The Schäffer group distinguishes three different conditions that affect scientific validity, namely conflicts of interest, bias and just plain interest. The latter two are unavoidable, as they arise from professional obligations or participation in the work of activist groups advocating for public health. The authors cite the Intergovernmental Panel on Climate Change's definition of bias as "a point of view or perspective" that "every expert holds" by virtue of his or her expertise. They support IPCC's statement that "Holding a view that one believes to be correct, but that one does not stand to gain from personally, is not a conflict of interest." In contrast, a true conflict derives from "a direct and material gain" in the form of money, political loyalties, or social connections. The conflicts that do the real damage are those associated with for-profit entities, their linked nonprofit trade groups, and the consultancies they hire. Money, prestige and power are tempting rewards.

Funding source has been identified numerous times as an indicator of industry influence. For example, a 2016 analysis of 39 studies of atrazine's effects on reproduction found that only 9.1 percent of industry-funded studies showed evidence of harm, compared to 50 percent of non-industry sponsored studies.

In the late 1990s bisphenol A (BPA) was shown to disrupt prostate development in animals. After these results were successfully replicated, the American Plastics Council paid the Harvard Center for Risk Analysis to produce an argument that the evidence of endocrine disruption was very weak. A subsequent analysis of the BPA literature by Frederick vom Saal, PhD and Claude Hughes, MD, PhD revealed that the 19 studies considered by Harvard were a small and cherry-picked fraction of the full range of studies available. Further, Drs. vom Saal and Hughes showed that out of 115 *in vivo* studies conducted by academic scientists, 94 found evidence of significant effects at low doses, yet none of the industry studies did so.

Clearly there has not been widespread progress on eliminating corporate and industrial interests' influence on chemical policies, including pesticides. But the body of evidence is large and eloquent. The newly-formed Intergovernmental Science Policy Panel proposes that its own membership be subject to rigorous conflict of interest disclosure and that experts who have such conflicts should participate only as observers. To ensure that the panel's work is "transparent, impartial, credible and scientifically robust," as specified by the United Nations resolution establishing the panel, monitoring by an independent audit team is typically needed for credibility. If scientists who are free of industry tentacles join with environmental groups and the global public to push back against manipulation and misinformation, progress will be achieved.

SOURCE: Andreas Schäffer et al., Conflicts of Interest in the Assessment of Chemicals, Waste, and Pollution, *Environ. Sci. Technol.* 2023, *57*, 48, 19066–19077, https://doi.org/10.1021/acs.est.3c04213.

MORE ON THIS SUBJECT **EU and U.S. Pesticide Regulators Ignore Developmental Neurotoxicity of Pesticides, Industry Hides Data**—June 9, 2023

TOXICOLOGY | ELEVATED RISK AT GOLF COURSES | MARCH 22, 2023

Pesticide Dangers at Golf Courses Much Higher in the U.S. than Europe, Study Finds

Pesticide use on golf courses in the United States poses significantly more risk to human health than those in Europe, according to a study published in Science of the Total Environment. The findings highlight yet another area of land management where the U.S. is dangerously behind the European Union, as these countries are set to ban pesticides in parks, playgrounds, and playing fields, and have established a 50 percent reduction goal for agriculture by 2030.

Researchers found that pesticide risks from golf courses in the U.S. were on average 15 times higher than those in the EU. In order to come to that conclusion, surveys were sent out to courses in eight regions: East Texas, Florida, the Midwest, Northeast, and Northwest in the U.S., and the United Kingdom, Denmark, and Norway in Europe. Recorded answers (including product applied, date, rate, and area of application) were incorporated into the development of a hazard quotient (HQ), a ratio of pesticide exposure to a chemical's toxicity. High hazard quotients indicate high acute risks to human health.

The highest single HQ for a golf course was found in Florida at 40,806. While the region with the highest average hazard quotient was U.S. Northwest at 13,696, with the lowest found in Norway and Denmark at 64. In East Texas and Florida pesticide greens represented the greatest risk, but in all other locations fairways had the highest HQ. Fungicides pose the greatest health risk in Florida, the Midwest, Northeast, and Norway, while herbicides filled this role in East Texas, the Northwest, and Denmark. Insecticides posed the greatest risk for golf courses in the UK.

As the study explains, "Golf courses in regulatory environments where <100 pesticide products were available had a median CWA-HQ [component-weighted-average hazard quotient) of 248, which was significantly lower than mean pesticide risk on golf courses located in regulatory environments which allowed >100 pesticide products, which had a mean CWA-HQ of 7031."

"The risk based system used by the EPA has led to a much higher number of pesticides being available for golf courses in the US," the study notes.

SOURCE: MAH Bekken et al., Analyzing golf course pesticide risk across the US and Europe—The importance of regulatory environment. *Sci Total Environ.* 2023 May 20; 874:162498. https://doi:10.1016/j.scitotenv.2023.162498.

DISPROPORTIONATE HARM

DISPROPORTIONATE HARM TO PEOPLE OF COLOR COMMUNITIES | JANUARY 10, 2023

Pollinator Decline Leads to Crop Losses, Malnutrition, and Highest Threat to Low-Income

Pollinator losses are responsible for reducing the global production of nuts, fruits, and vegetables by three to five percent, and this loss of healthy, nutrient-dense food is resulting in over 425,000 excess human deaths each year, according to research published late last year in Environmental Health Perspectives. While the connection between pollination, food production, and health is intuitive, the study traces shocking impacts that are directly harming the well-being of people now, and is a clear sign that pollinator losses requires serious attention and meaningful action. To those who consider the decline of pollinators to be a vague, amorphous future threat, this study challenges that myth. According to researchers, "Today's estimated health impacts of insufficient pollination would be comparable to other major global risk factors: those attributable to substance use disorders, interpersonal violence, or prostate cancer."

Per a United Nations report, 75 percent of the world's food crops depend at least in part on pollination, with pollinators contributing an estimated $235 to $577 billion to global crop production annually. Pollinator declines are already adversely impacting food production. A 2016 paper by many of the authors of the current study determined that in general, when there is a difference between high and low production on a farm, regardless of crop type, lack of pollinator populations account for 25 percent of the yield gap. This translates to a reduction of income for farmers with devastating impact in low-income countries and on low-income farmers. However, no study had yet investigated how these losses translate into real world impacts. Thus, the authors ask: If there were no pollinator losses, how much food would have been produced, who would have eaten it, and would that have averted any diet-related diseases or deaths? Further, the authors consider the economic cost of lost yields, particularly on low-income countries.

To answer how much food would have been produced were pollinators still thriving, scientists compare current yields to what they term "attainable yields," which represent the 90th percentile of yield within a given region on a global scale. Having determined the yield gap, an average weight is then assigned to determine the contribution of pollinators to this disparity. Economic impacts are more complicated, as there are a multitude of variables for both supply and demand; on the supply side farmers may change what or how much they plant, and demand is determined by price and consumers ability or willingness to pay. Researchers focus their economic review on three low-income countries—Nepal, Honduras, and Nigeria.

When cost increases, many consumers will not be able to afford to eat enough nutrient-dense, pollinator-

dependent foods like fruits, vegetables, and nuts. To determine how this translates to health outcomes, a global risk-disease model is utilized, looking at risk factors associated with low consumption of fruits, vegetables, legumes, and nuts. Diseases used in the model include stroke, type 2 diabetes, cancer, heart disease, and an aggregated "all cause mortality" associated with weight changes.

Final calculations show that pollinator declines account for losses of 4.7 percent of all fruit production, 3.2 percent of vegetables, and 4.7 percent of nuts. Yield gaps are determined to be independent of other variables like geography and other landscape characteristics. Low-income countries (as defined by the World Bank) are experiencing the most pronounced yield gaps, with an estimated 26 percent and 8 percent loss in overall vegetable and nut production on average.

Pollination declines also hit the economy of low-income countries hard. The annual lost economic value of all agricultural crops, as determined by researchers, is 12 percent in Honduras, 17 percent in Nigeria, and 31% in Nepal. Economic losses do not match up directly with production losses, which are 3 percent, 15 percent, and 19 percent, respectively, for the same countries. "The greater percentage economic loss compared with production loss (by weight) suggests that pollinated crops constituted high-value commodities for these countries," the authors note, indicating that most value is lost through declines in fruit and vegetable production. In sum, these impacts result in annual lost value per farmer of $209, $250, and $325 (U.S. dollars) for the same countries, respectively. Such losses are staggering in the context of these countries, where per farmer annual income tops out at less than $1,500.

Not only are pollinator losses throwing farmers into financial turmoil, the impacts also result in a shocking 427,000 excess deaths each year, primarily from chronic disease. Interestingly, it is middle and high income countries where these excess deaths are most pronounced. According to the study, 1% of total annual mortality in upper-middle and high income countries can be attributed to loss of pollination. Lower fruit and vegetable intake accounts for 189,000 and 151,000 deaths, respectively, from stroke, heart disease, and cancer, and a reduction in nut consumption is resulting in an estimated 99,000 deaths each year.

Prior studies have shown that pollinator declines will result in increased malnutrition from lost micronutrient consumption and nutrient deficiencies. But this latest research deals less with the potential impacts and makes determinations based on what is happening currently. To be clear, this study shows that people today, in the United States and around the globe, are dying because the loss of pollinators has resulted in them being unable to afford to eat healthy fruits and vegetables on a consistent basis. These data paint a dismal future picture should society not act on a coordinated basis to revive pollinator populations.

The authors note that there is hope, writing that, "Diverse research investigating the optimal policies to benefit pollination have shown remarkable consensus around a short list of highly effective strategies: increase flower abundance and diversity on farms, reduce pesticide use, and preserve or restore nearby natural habitat." In order to reverse pollinator declines, these practices must be translated and institutionalized into enforceable policies.

SOURCE: Matthew R. Smith, et al., Pollinator Deficits, Food Consumption, and Consequences for Human Health: A Modeling Study, *Environmental Health Perspectives,* 130(12) December 2022. https://doi.org/10.1289/EHP10947.

DISPROPORTIONATE HARM | COMMENTARY | FEBRUARY 6, 2023

Taking a Holistic, Community-Based Approach to Toxic Pesticide Use to Achieve Environmental Justice

During Black History Month, it is of note that on January 10 the Biden-Harris Environmental Protection Agency (EPA) announced funding of approximately $100 million for "projects that advance environmental justice in underserved and overburdened communities across the country" through its Environmental Justice Government-to-Government (EJG2G) program. While viewed as assistance for those communities "disproportionately impacted by pollution and climate change," it is important to recognize that the same communities are also disproportionately impacted by activities that produce pollution and climate change. During this period, Beyond Pesticides called on EPA, governors, and mayors to support environmental justice by eliminating activists leading to pollution and climate change.

Beyond Pesticides points out a historical bias against preventive action to ensure the protection of those disproportionately poisoned by toxic chemicals. While critically important to clean up contaminated communities, stopping the flow of toxic pesticides at the front end is important because of the disproportionate poisoning effects of use, handling, transportation, and disposal. EPA regulates based on the acceptability of harm (which it calls risk), despite its limitations in (i) recognizing comorbidities and preexisting health conditions, (ii) considering a combination of multiple chemical exposure interactions, and (iii) citing extensive missing health outcomes

information (e.g., on endocrine disruption) and a resulting high level of uncertainty.

On the community level addressed by this funding project, EPA could assist communities to transition to organic land management. The EJG2G program could assist communities to manage local parks, playing fields, and greenways without unnecessary toxic pesticides.

But EPA's assistance must go beyond funding. EPA's pesticide registration decisions promote contamination of communities where pesticides are manufactured, stored, used, and disposed of. By ignoring impacts of pesticides on soil health, EPA's pesticide registration decisions promote the climate crisis. EPA's pesticide program must incorporate in all of its registration decisions an analysis of impact on the climate crisis, with particular attention to the protection of soil health.

A recent report, Exposed and At Risk*: Opportunities to Strengthen Enforcement of Pesticide Regulations for Farmworker Safety*, by the Center for Agriculture and Food Systems at Vermont Law and Graduate School, in partnership with the nonprofit advocacy group Farmworker Justice, again highlights the systemic racism of U.S pesticide policies. The nation depends on farmworkers, declared "essential workers" during the COVID-19 pandemic to ensure sustenance for the nation and world. Yet, the occupational exposure to toxic pesticides by farmworkers is discounted by EPA, while study after study documents the disproportionate level of illness among farmworkers. EPA must eliminate systemic racism in its pesticide program.

SOURCE: Biden-Harris Administration Announces Availability of $100 Million through Inflation Reduction Act for Environmental Justice Grants, EPA Press Office, January 10, 2023.

DISPROPORTIONATE HARM | JUNE 16, 2023

This Juneteenth, We Highlight the Ongoing Fight for Environmental Justice

Juneteenth is a celebration of freedom for the last 250,000 enslaved people in Galveston, Texas, but it is also a reminder that justice has not historically been "swift" or complete for Black Americans. The holiday commemorates the abolition of slavery in Texas on June 19, 1865, two and a half years after the Emancipation Proclamation.

According to a 2022 Gallup Poll, 40 percent of Americans know "a little bit" or "nothing at all" about Juneteenth. While this is a significant improvement in comparison to the 60 percent for the aforementioned metric in the previous year (when the holiday was federally recognized), greater public awareness is needed. This holiday is a time for individuals and organizations to acknowledge and reflect on their past and current actions or inactions that perpetuate systemic racism.

As known from the history books, the Emancipation Proclamation was signed

on January 1, 1863, and the civil war ended on April 9, 1865. Juneteenth is a lesser-known anniversary commemorating the emancipation of enslaved people who received news of their freedom two and a half years after President Abraham Lincoln's freedom proclamation. While the technologies in the 19th century had a much slower travel time, there were concerted efforts to withhold and delay the communication that "all slaves are free." The Congressional Research Service acknowledged the efforts to delay and keep enslaved plantation laborers for "one last cotton harvest."

The father of environmental justice, Robert Bullard, PhD, defines environmental racism as any policy or practice that unequally affects or disadvantages individuals, groups, or communities based on their race. Dr. Bullard states that, until the 1980s, environmental conservation and pollution were separate. Many environmental organizations prioritized the preservation of "wilderness" rather than urban areas, predominantly comprised of people of color (POC), who continuously experience the disproportionate impacts of pollution and the effects of environmental racism.

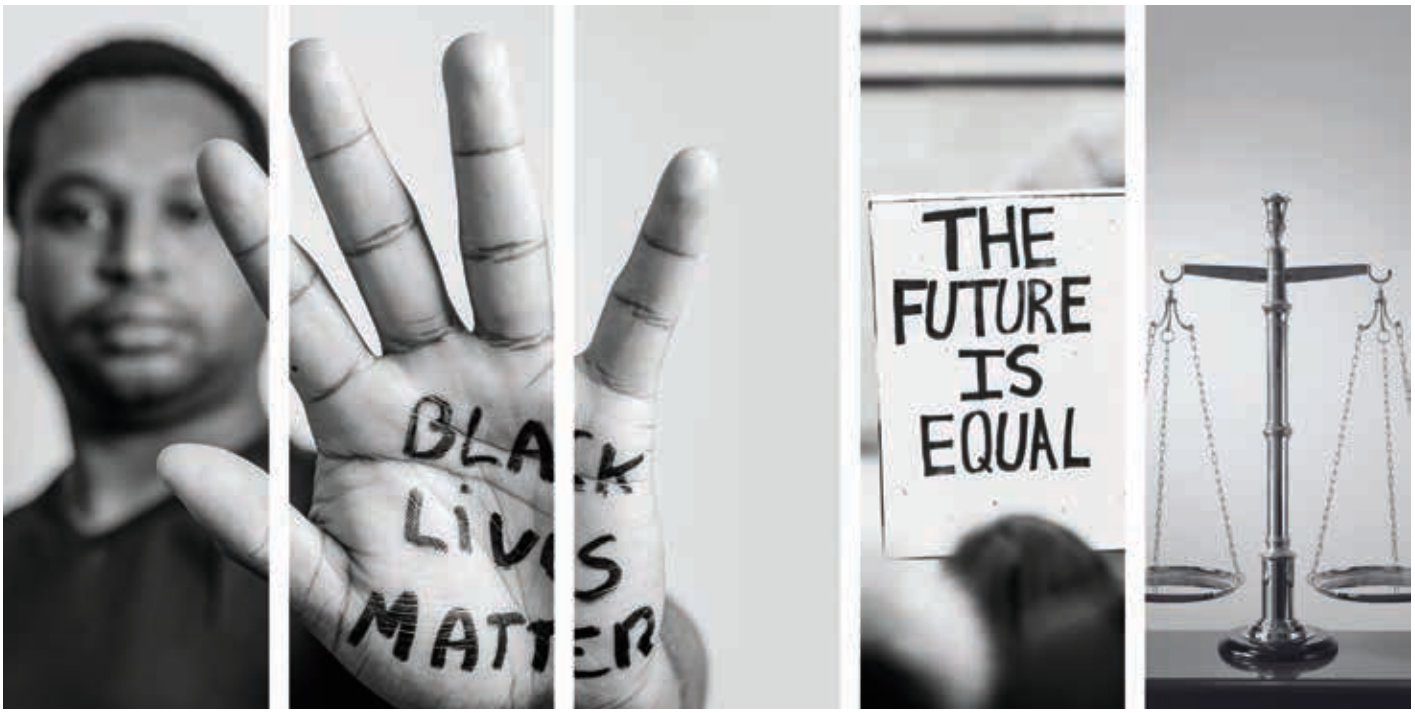
During the Jim Crow Era—following slavery—segregation propagated disparities between black and white communities, causing justice-related priorities to vary between demographic divides. Both the civil rights and environmental justice movements spread nationwide during the 60s and 70s. However, the two movements rarely coincided, and the implications are felt today. This division amplified the perception among civil rights advocates that environmentalism catered to white organizations and populations while ignoring POC and their struggles. However, this does not mean environmentalism was completely void of addressing racial inequalities. Many early environmental justice leaders came out of the civil rights movement, bringing the same tactics they had used in civil rights struggles—marches, petitions, rallies, coalition building, community empowerment through education, litigation, and nonviolent direct action.

The 1960s saw some of the first localized protests of environmental inequalities, such as:

- Latinx farm workers, led by Cesar Chavez, fought for workplace rights and against harmful pesticides in the farm fields of California's San Joaquin Valley.
- African American students took to the streets of Houston, TX to oppose a city garbage dump in their community that had claimed the life of a child.
- Residents of West Harlem, New York City fought unsuccessfully against a sewage treatment plant in their community.

Despite the localized attempts to mitigate environmental racism, it was not until 1982 that the gap between the environmental and civil rights movement started to narrow: This is the story of Warren County, NC, an impoverished, rural county that became the epicenter of the growing environmental justice movement—drawing nationwide attention to racial disparities.

In 1978, employees of Ward PCB (polychlorinated biphenyls) Transformer Company deliberately dripped 31,000 gallons of PCB-contaminated oil along approximately 240 miles of soil lining highway shoulders in North Carolina throughout 14 counties. By 1982, North Carolina had announced a plan to move soil contaminated with PCBs



from alongside 210 miles of the state's roadsides to a newly developed landfill located in Warren County—one of the few counties in the state with a majority African American population. PCBs are toxic chemicals that have links to birth defects, liver diseases, skin disorders, and cancers. The decision triggered a wave of protests, one of which resulted in the arrest of a U.S. congressman and dozens of activists who tried to block the PCB-laden trucks at the landfill's entrance. Unfortunately, the pressure against PCB soil dumping did not deter the decision and 60,000 tons of contaminated soil were dumped in the landfill and buried 7 feet, only 3 feet above many groundwater tables.

Because of the outrage over Warren County, the U.S. Government Accountability Office (GAO) evaluated the correlation between landfill locations with the racial demographics of surrounding communities. The report concluded that three of every four landfills in the Southeast U.S. were in or near communities with majority non-white populations—with more than a quarter living below the poverty line. Although officials eventually removed the PCB-laden soil from Warren County, 25 years later, race remains the predominant indicator of proximity to pollution in the United States (more than socioeconomic factors). Today, numerous reports and public awareness of environmental racism continue to build on the movement that originated in Warren County, North Carolina.

Beyond Pesticides is working in coalitions to eliminate the disproportionate burden of pesticide use in communities of color. The Black Institute, a member of Eco-Friendly Parks for All, published a groundbreaking report on disparate pesticide application in public parks near Black and Brown communities. This injustice in parks, as well as disproportionate occupational risk to farmers and landscapers, is particularly concerning when it leads to pesticide-induced diseases (e.g., respiratory illness, neurological disorders, endocrine disruption, cancers, etc.).

This injustice in parks, as well as disproportionate occupational risk to farmers and landscapers, is particularly concerning when it leads to pesticide-induced diseases (e.g., respiratory illness, neurological disorders, endocrine disruption, cancers, etc.).

Examples of disproportionate risks include:

- African American women are 40 percent more likely to die from breast cancer than women of any other racial group. Even more concerning, incidences of triple-negative breast cancer—an aggressive breast cancer subtype lacking remediation—is approximately three-fold higher in non-Hispanic Black women compared to non-Hispanic White women. Although past studies suggest genetics produce these demographic differences in breast cancer outcomes, scientists now believe genetic factors only play a minor role compared to external factors (i.e., chemical exposure).
- The death of a young boy with leukemia highlighted yet another instance of environmental injustice. The incidents of acute lymphoblastic leukemia in the boy's community were nearly five times higher than the national average. Thousands of Black residents are suing Union Pacific Railroad Company for contaminating their properties with highly hazardous creosote wood preservatives with known carcinogenic properties.
- More than five decades prior to chlorpyrifos revocation (removal of chemical for all uses later rescinded), the toxic organophosphate insecticide disproportionately harmed low-income African American and Latinx farmworkers (and their families) who harvested much of the domestic—and contaminated—crops of grapes, citrus, and sugar beets, among others. Risks of exposure to chlorpyrifos impact neurological, reproductive, and endocrine systems.
- The Black Institute aggregated information from numerous public records and reported on the disproportionate risk to communities of color regarding the distribution and concentration of toxic pesticides. The Poison Parks Report found dangerous concentrations of pesticides in Idlewild Park. Surrounding communities, 90 percent of which were African American, had concentrations of glyphosate at 50 percent in 2018 (compared to "normal concentrations" at 0.5–3 percent). No concentration of glyphosate has been demonstrated to be safe for human health and the World Health Organization's International Agency for Research on Cancer identifies glyphosate as a probable carcinogen.

Although there are regulatory systems in place to evaluate and monitor pesticide use and exposure limits (i.e., the *Federal, Insecticide, Fungicide, and Rodenticide Act* [FIFRA] and the *Food Quality Protection Act* [FQPA]), pesticide-related illnesses continue to disproportionately harm communities of color. Regulations ignore people with increased vulnerabilities due to preexisting health conditions—most often associated with racial and socioeconomic factors. For example, federal pesticide law does not consider the cumulative effect of high-exposure and high-risk occupations.

Partnering with activists in communities of color to address agrochemicals' impacts can be a start to alleviating inequalities. However, changes in policy are required in the food system so that the burdens placed on POC communities are no longer overlooked. More reporting on environmental justice can be found in "Disproportionate Pesticide Harm Is Racial Injustice: Documenting Victimization: Structural Racism" in *Retrospective 2021: A Call to Urgent Action*.

SOURCE: Juneteenth: Fact Sheet, Congressional Research Service, Updated May 30, 2023.

DISPROPORTIONATE HARM | OCTOBER 9, 2023

On Indigenous Peoples' Day, Highlighting Indigenous Knowledge to Address the Biodiversity Crisis

On this Indigenous Peoples' Day, the world turns its attention to the invaluable wisdom that Indigenous communities possess, highlighting their crucial role in addressing the global biodiversity crisis. While facing disproportionate harm from unjust policies and practices that pollute, Indigenous communities are gaining federal and international recognition as key players in preserving the planet's ecological balance.

Many Indigenous communities have a profound connection to, and unique relationship with, their land, carrying with them ancestral wisdom that has sustained their ecosystems for generations. Indigenous knowledge, passed down through centuries, emphasizes the intricate relationships among species, the balance of ecosystems, and the importance of coexistence with nature. This knowledge has allowed Indigenous Peoples to thrive sustainably for millennia.

In the face of the growing biodiversity and climate crises, Indigenous wisdom and traditional insights are a part of the solution. During the 2022 White House Tribal Nations Summit, the White House Office of Science and Technology Policy (OSTP) and Council on Environmental Quality (CEQ) unveiled historic guidance for federal departments and agencies regarding Indigenous Knowledge. This guidance, accompanied by an implementation memorandum, acknowledges the importance of valuing and adopting Indigenous Knowledge into federal decision making to enhance scientific and policy decisions. "As the original stewards of the natural environment, Tribes and Indigenous communities have expertise critical to finding solutions to the climate crisis and protecting our nation's ecosystems," said CEQ Chair Brenda Mallory. "The guidance released today will help ensure that their voices are included across the Federal Government for the collective benefit of our communities and the planet."

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Examples of traditional knowledge being used to improve biodiversity include:

- Traditional knowledge is being utilized to improve biodiversity in the largest dam removal project in U.S. history, along the California-Oregon

border. The Klamath River restoration and dam removal project is collaborating with the Lower Elwha Klallam Tribe, the Karuk Tribe, the Yurok Tribe, and other Native American tribes to plant and monitor nearly 17 billion seeds to recreate the pre-dam ecosystem. Upon completion, this project will open more than 400 miles of river for threatened species and contribute to a diverse native ecosystem.

- Scientists are partnering with tribes to study traditional practices that improve biodiversity in ecosystems. One study was conducted on black oaks with interviews and workshops involving tribal members with ancestral knowledge of black oak burning practices. The study revealed opportunities to reintroduce low-intensity fires, along with thinning, to restore black oak stands that are conducive to acorn gathering. The findings also highlighted examples of overcoming challenges in restoring the socio-ecological benefits of black oak ecosystems for indigenous tribes.

Encroachment on Indigenous lands, the expansion of extractive industries, and shifting climate patterns have threatened the delicate balance that many Indigenous Peoples maintain with nature. The global biodiversity crisis mirrors these interdependent systemic issues as species extinction, habitat degradation, and ecosystem imbalances become more urgent.

For more examples of tribes that are having positive environmental impacts, visit this Smithsonian website. To learn about international examples of indigenous knowledge to improve biodiversity, see this video.

Encroachment on Indigenous lands, the expansion of extractive industries, and shifting climate patterns have threatened the delicate balance that many Indigenous Peoples maintain with nature. The global biodiversity crisis mirrors these interdependent systemic issues as species extinction, habitat degradation, and ecosystem imbalances become more urgent. Recognizing the importance of Indigenous knowledge remains an essential first step, and President Biden's proclamation on Indigenous Peoples' Day in 2022 underscored the significance of respecting Indigenous sovereignty and incorporating Indigenous voices into government decisions. As President Biden said, "On Indigenous Peoples' Day, we honor the sovereignty, resilience, and immense contributions that Native Americans have made to the world; and we recommit to upholding our solemn trust and treaty responsibilities to Tribal Nations, strengthening our Nation-to-Nation ties. . . [T]oday, they remain some of our greatest environmental stewards." For more information on the proclamation, read Beyond Pesticide's reporting here. Such recognition from the U.S. government signifies an awareness of the critical role Indigenous Peoples play in the conservation of biodiversity.

- The restoration of the Elwha River by the Lower Elwha Tribe, featured in the image above, serves as a shining example of how Indigenous and scientific partnerships can contribute to environmental restoration and conservation. The project began after the removal of two large hydropower stations.
- Kawerak, an Indigenous organization in western Alaska, issued a call for knowledge sovereignty and the indigenization of knowledge. Their concerns center on how research, research funding, and research prioritization have historically excluded Indigenous and local communities. The organization laid out a practical plan for repositioning research agendas to be more inclusive and respectful of Indigenous and local perspectives.

Biodiversity decline is a global problem that requires international collaborations and diverse perspectives. The Indigenous Peoples' Alliance of the Archipelago (AMAN), an independent organization representing over 2,500 Indigenous communities and approximately 20 million individual members across Indonesia, estimates that the nation is home to 50 to 70 million Indigenous individuals within its 250 million population. AMAN has played a pivotal role in advocating for Indigenous rights and knowledge. Despite legal recognition of Indigenous rights in the Indonesian Constitution, there have been challenges in fully implementing the Indigenous Peoples Law, which remains a bill in Parliament—leaving Indigenous communities vulnerable to land grabs and discriminatory regulations.

Some of the challenges in utilizing traditional knowledge reflect broader issues of land rights. Indigenous communities frequently experience marginalization and discrimination within national legal systems, exacerbating their vulnerability to violence and mistreatment. When Indigenous Peoples lack human rights, it is not only unjust and inhumane, but it also undermines resource management and conservation practices that help sustain a livable world for all. Land return, also known as land reparations, land restitution, or land repatriation, refers to the process of recognizing land theft, the loss of lives, and the devastation of cultures.

In alignment with environmental justice as a human rights issue, Marcos Orellana, PhD, Special Rapporteur on toxics and human rights and National Forum Series speaker, emphasized the legacy of severely contaminated sites on indigenous lands at the Permanent Forum on Indigenous Issues in 2022. From pesticide drift to exposure through contaminated waterways, "the list of toxic exposures on indigenous peoples is long," despite the Declaration on the Rights of Indigenous Peoples and International Labour Organization (ILO) Convention No. 169. Dr. Orellana further noted that "toxics are a form

of violence against the land and its people."

There is growing evidence of the role of Indigenous knowledge at the international level, yet despite this recognition, roadblocks remain that prevent genuine collaboration with Western science for effective conservation and resource management. One such challenge discussed in the opinion piece "Science Must Embrace Traditional and Indigenous Knowledge To Solve Our Biodiversity Crisis" is the "gatekeeper" problem, when a few individuals become the sole experts on a particular community or issue, potentially drowning out the diverse knowledge streams and grounded perspectives of Indigenous and traditional communities.

Chief Edwin Ogar of the Ekuri Initiative, ICCA Consortium Honorary Member Gretta Pecl, and Council Member Tero Mustonen, the opinion piece authors, explain that it is crucial to shift the link between policy and research away from simplistic, one-size-fits-all solutions and slogans and toward the needs on the ground. This includes investing in training and learning from past successes and failures.

As the United States commemorates Indigenous Peoples' Day, it is a moment to celebrate the resilience and wisdom of Indigenous communities. Their traditional knowledge offers solutions to the biodiversity crisis, emphasizing the importance of preserving sovereign Indigenous lands and communities—working collectively to protect and preserve the planet's rich tapestry of life for future generations.

SOURCE: Honoring Original Indigenous Inhabitants: Land Acknowledgment, Native Knowledge, Smithsonian: National Museum of the American Indian, accessed 2023; Natural Wisdom: Indigenous communities and defending biodiversity, Earthrise, YouTube Aljazeera, 2021.

DISPROPORTIONATE HARM | OCTOBER 26, 2023

Neurodevelopmental Disorders Studied as an Environmental Justice Concern

The increasing prevalence of neurodevelopmental disorders (NDDs) in the United States has raised concerns about the impact of toxic exposures on child development. A comprehensive review by lead author Devon Payne-Sturges, PhD and colleagues in *Environmental Health Perspectives* analyzes the literature about disparities in NDDs in vulnerable and marginalized populations. The review investigates over 200 studies and reveals that fewer than half of these studies actually examine disparities, and most fail to provide a rationale for their assessments. The authors also offer practical suggestions for improving future research, including better methods for characterizing race and socioeconomic status and interpreting effect modification in environmental

epidemiologic studies of health disparities.

Dr. Payne-Surges, associate professor at the University of Maryland's School of Public Health and a former policy specialist at the U.S. Environmental Protection Agency (EPA), said, "FDA and EPA can act now—not later—to protect families from neurotoxic chemicals in consumer products and in the environment."

Tanya Khemet Taiwo, PhD, the other lead author and assistant professor at Bastyr University in Seattle, said, "We need more stringent environmental standards to address pollution that is disproportionately impacting low-income communities and communities of color, but it's just as important that we find a way to improve the unjust systems and social policies that create harmful conditions in the first place."

Given the disproportionate toxic burden in the U.S., children from marginalized groups and low-income families are more likely to face a variety of harmful exposures that can negatively affect childhood development. These disparities are linked to neurodevelopmental disorders. NDDs are defined as conditions related to the functioning of the nervous system and the brain, including: attention-deficit/hyperactivity disorder (ADHD), autism, learning difficulties, intellectual disability (cognitive impairment), conduct disorders, cerebral palsy, and challenges related to vision and hearing.

Among the 218 studies written between 1974 and 2022 that were investigated by Dr. Payne-Stuges, et al., the following patterns emerged:

- Black and Hispanic children have higher exposure to organophosphate pesticides, commonly used in agriculture.
- Black and Hispanic mothers have elevated levels of phthalates, chemicals found in food packaging, personal care products, and other environmental sources.
- Low-income and Black children have more significant lead exposures compared to their higher-income and white counterparts.
- Communities of color and low-income neighborhoods experience a disproportionate exposure to air pollution.
- Babies residing in economically disadvantaged neighborhoods exposed to air pollution during their first year of life are at a higher risk of being diagnosed with autism compared to those in more affluent areas.

Environmental justice scholars have connected the unequal and disproportionate toxic exposures to discriminatory policies and practices, including racial residential segregation. With decades of executive orders addressing environmental justice, the recognition of unequal pollution distribution in historically marginalized communities has recently gained federal research funding through the Justice40 Initiative and other policies. However, there has been a history of commitments that have not played out, as envisioned by its supporters. A U.S. General Accountability Office (GAO) report, Environmental Justice: Federal Efforts Need Better Planning, Coordination, and Methods to Assess Progress (2019), found, "Most of the 16 agencies that are members of the interagency working group on environmental justice—created by Executive Order 12898 in 1994—reported taking some actions to identify and address environmental justice issues, such as creating data tools, developing policies or guidance, and building community capacity through small grants and training." However, GAO concluded that ". . . few agencies have measures or methods for assessing progress, and the working group has not provided guidance to help agencies with such assessments."

Beyond Pesticides issued an action in 2021 that points to a generation of EPA neglect of farmworker children's exposure to the neurotoxic insecticide chlorpyrifos. The pesticide and the family of organophosphates, of which it is a part, targets the nervous system in humans. EPA had negotiated a withdrawal from the market of all residential uses of chlorpyrifos in 2000 because of the neurotoxic effect on children, but left the agricultural uses on the market, with a few exceptions. This left farmworker children exposed to chemical drift in their communities and schools, while EPA took no action for nearly two decades. Children are particularly at risk because they take in greater amounts of pesticides relative to their body weight than adults, and their developing organ systems are typically more sensitive to toxic exposures. The agency finally negotiated a withdrawal of agricultural uses in 2022, which was reversed.

The Payne-Sturges, et al. review emphasizes the potential shortcomings of relying solely on models of "effect modification" to assess health disparities because it often addresses only one aspect of the problem. Many studies in the review focus on lead and air pollution exposures, which often affect under-resourced communities housing marginalized populations. These communities may face multiple hazardous exposures from sources like high-traffic roads, industrial facilities, deteriorating municipal infrastructure, and substandard housing. Such conditions can have cumulative effects, and historical and continued segregation contributes to repeated toxic exposures. Despite this, most studies in the review assessed these exposures independently.

The review highlights that children continually exposed to known neurotoxic substances often experience delayed diagnoses and barriers to necessary services. Moreover, cognitive impairments and poor academic achievement can exacerbate economic hardship. Consequently, measures of neurodevelopmental delay and impairment might be more effective in assessing the impact on underserved groups. While many environmental studies consider socio-demographic factors tied to health disparities like race, income, education, and other sociodemographic factors, there is a recent shift toward evaluating NDD factors in collecting data. Yet, solely looking at individual race and ethnicity might not capture the full extent of structural racism.

According to the authors, looking at area-based indicators of structural racism, such as unemployment rates, rental percentages, segregation metrics, and police activity frequency, could improve understanding of racial disparities.

The authors of the study consider the complex paradigms and racist structures underlying the toxic disparities. They note that greater diversity in research teams and collaboration with community members with firsthand experience is vital. The authors stress the importance of stakeholder engagement in interventions and addressing the structural barriers contributing to environmental health disparities. The Equal Protection Clause of the 14th Amendment is cited as a potential tool to protect children from hazardous exposures and reduce community exposure through regulation and public health practices.

The review aligns with a history of awareness of the disproportionate exposure to neurotoxic chemicals experienced by children of color and those from low-income families. Ultimately, this research aims to reduce the burden of hazardous exposures on children's health and promote more equitable protection against neurotoxic chemicals.

SOURCE: Devon C. Payne-Sturges, et al., Disparities in Toxic Chemical Exposures and Associated Neurodevelopmental Outcomes: A Scoping Review and Systematic Evidence Map of the Epidemiological Literature, *Environmental Health Perspectives,* 131(9) September 2023.

DISPROPORTIONATE HARM | DECEMBER 4, 2023

Protection of Pregnant Farmworkers Under Civil Rights Protection; Will There Be Enforcement?

With a history of neglect of farmworker protection in the workplace, advocates are pointing to the need for ensuring stringent enforcement of regulations that took effect in April 2024 under the Pregnant Workers Fairness Act (PWFA). In addition to weak laws and protections that typically exempt farmworkers, enforcement for farmworker protections that do exist has been criticized as inadequate. A report on enforcement of wage and hour law under Wage and Hour Division of the U.S. Department of Labor (DOL) has documented diminished capacity to detect and enforce against violations. A report by the Economic Policy Institute (2020) shows the dramatic failures of DOL, which is underfunded and understaffed, to enforce the law. As the agency charged with operationalizing the new law to protect farmworkers, the Equal Employment Opportunity Commission (EEOC) will be up against a federal pesticide law enforcement system that is dependent on agreements with state agencies, mostly departments of agriculture, that have a history of failing to enforce the limited protections provided for farmworkers. The EEOC

is headquartered in Washington, D.C. and operates 53 field offices in every part of the country.

Farmworkers have endured a long history of discrimination in the United States. The enforcement of pesticide law and protection of farmworkers has been criticized for decades. When the U.S. Environmental Protection Agency (EPA) was formed in 1970, it was given the responsibility for farmworker protection, instead of DOL. Enforcement authority was then delegated to the states under the *Federal Insecticide, Fungicide, and Rodenticide Act* (FIFRA). According to Exposed and At Risk, the current "complex system of enforcement . . . lacks the capacity to effectively protect farmworkers.... [and] the cooperative agreement[s] between federal and state agencies makes it nearly impossible to ensure implementation of the federal Worker Protection Standard."

With the passage of PWFA, new standards will need to be enforced to ensure that pregnant farmworkers are protected. The law applies to workplaces with 15 or more employees, extends protection for pregnant workers for disability (including temporary or short-term disability) associated with childbirth, miscarriages, or related conditions. The legislation was passed as part of the *2023 Omnibus Spending Bill* and signed into law by President Biden in December 2022.

This law should, according to health advocates, be used to improve protections for farmworkers and other high-risk employees from the elevated adverse impacts on reproductive health associated with pesticides. One of the law's key provisions is an anti-retaliation clause that protects workers asking for "reasonable accommodation." In addition, accommodations for pregnant workers cannot be imposed by the employer, but must be agreeable to the worker as well.

Barriers for pregnant farmworkers have been demonstrated in California, where farmworkers—regardless of citizenship status—who are exposed to pesticides can take time off during the pregnancy as a preventive measure if other accommodations are not available, receiving 70 percent of their wages to make up for lost income (to be increased to 90 percent for low-wage workers in 2025). Farmworkers in California who are exposed to pesticides can access this program practically from the time they find out they are pregnant because of the risk pesticide exposure poses. However, farmworkers have historically been shut out of these programs due to language and access barriers, lack of information for workers and their medical care providers, and racism.

The nation depends on farmworkers, yet the occupational exposure to toxic pesticides by farmworkers has led to criticism of EPA, while study after study documents the disproportionate level of illness among farmworkers. Many farmworkers are migrant workers, and are subject to conditions that would not be permitted for U.S. citizens.

The nation depends on farmworkers, yet the occupational exposure to toxic pesticides by farmworkers has led to criticism of EPA, while study after study documents the disproportionate level of illness among farmworkers. Many farmworkers are migrant workers, and are subject to conditions that would not be permitted for U.S. citizens. The U.S. is not a signatory to the International Convention on the Protection of the Rights of All Migrant Workers and Members of Their Families, which would set a moral standard to treat migrant workers like workers who are citizens. More information on farmworker protection can be found at Beyond Pesticides' Agricultural Justice webpage.

SOURCE: U.S. Equal Employment Opportunity Commission, What You Should Know About the Pregnant Workers Fairness Act | U.S. Equal Employment Opportunity Commission (eeoc.gov).

MORE ON THIS SUBJECT

Hazardous Fumigant in Food Production Harmful to Farmworkers, Groups Call for Ban—January 3, 2023

Building Collective Action with a Call for Justice, Equity, and Safety on Martin Luther King, Jr. Day—January 16, 2023

EPA Proposes Reinstating Obama-era Farmworker Protections and Adds Compromises with Industry—February 28, 2023

Take Action: Farmworker Protections Fall Short—March 6, 2023

Take Action: Air Contamination from Agricultural Fumigants Threatens Farmworkers and Their Communities—May 22, 2023

EPA's Failure to Assess Multiple Chemical Exposure Threat Creates Environmental Injustice, Says Inspector General—September 6, 2023

Second Session of National Forum on Environmental Justice; Recording of Forum Talks by Dave Goulson and André Leu Released—September 22, 2023

Chicago PCBs Lawsuit Seeks Pesticide Corporation's Accountability for Harm to Marginalized Communities—October 3, 2023

New Federal Law Seeks to Protect Pregnant Workers, Farmworkers at Elevated Risk—November 28, 2023

DISPROPORTIONATE HARM | OCTOBER 19, 2023

U.N. Special Rapporteur on Toxics and Human Rights and Environmental Justice Historian to Speak at Forum

The second session of the 40th National Forum, Forging a Future with Nature, focused on environmental justice and offered a unique conversation with the United Nations Rapporteur on Toxics and Human Rights and an environmental justice history professional.

Beyond Pesticides brought together this Forum session with the inspiration of the words of Dr. Martin Luther King, Jr., who wrote in Letter from a Birmingham Jail (1963), "Injustice anywhere is a threat to justice everywhere. We are caught in an inescapable network of mutuality, tied in a single garment of destiny. Whatever affects one directly, affects all indirectly

The Forum takes place in the context of widespread toxic chemical exposure throughout communities and all strata of society, but with the recognition that there is disproportionate harm in society to people of color from high-risk occupational exposures (e.g., farmworkers, landscapers, chemical manufacturing), chemical manufacturers' emissions in fenceline communities, pesticide drift in agricultural communities, and toxic exposure to essential workers, and those with preexisting and multigenerational illness.

Speakers: Marcos Orellana, PhD, the Special Rapporteur on toxics and human rights, addressed the toxic legacy of severely contaminated indigenous sites at the Permanent Forum on Indigenous Issues (1992), saying, "Highly hazardous pesticides sprayed by the agro-industrial complex and irresponsible Governments. . . .reflect the alienation between humanity and nature." Jayson Maurice Porter, PhD wrote in Agrochemicals, Environmental Racism, and Environmental Justice in U.S. History (2022), "Robert Bullard defines environmental racism as any policy or practice that unequally affects or disadvantages individuals, groups or communities based on their race. Vann Newkirk II adds that environmental racism is the opposite of environmental justice and often ignores or belittles input from the affected communities of color." In "Cotton, Whiteness, and Poisons" (*Environmental Humanities*, Nov. 2022), coauthor Dr. Porter writes about a U.S. history of "labor exploitation conditioned by racist ideologies" underpinning plantation agriculture.

Having witnessed attempts to establish risk reduction measures that allow continued and disproportionate harm, Beyond Pesticides through its program advances the elimination of petrochemical pesticides and fertilizers by 2032 and a shift to organic management of land and the built environment. A recording of the session is available on the Beyond Pesticides website.

SOURCE: 40th National Forum Series: *Forging a Future with Nature—The existential challenge to end petrochemical pesticide and fertilizer use,* Session 2—Environmental Justice, Oct. 24, 2024. See video of session.

THREATENED BIODIVERSITY and ECOSYSTEMS

BEES/POLLINATORS | JULY 27, 2023

Insufficient Scientific Evidence on Mitigation Measures To Protect Pollinators from Pesticides, Study Finds

A study published in the *Journal of Economic Entomology* calls into question the scientific literature on measures established to protect bees from pesticides. The study analyzes actions taken by pesticide users to reduce the risk of pesticides on non-target organisms, known as "mitigation measures." Ultimately, the study finds that there is insufficient evidence to support the effectiveness of bee-protecting mitigation measures.

"Almost all research was centered around protecting honey bees. However, honey bees are a managed species that is not endangered," Edward Straw, PhD, a postdoctoral researcher in the School of Agriculture and Food Science at University College Dublin in Ireland and lead author on the study, says, "When we try to protect bees, we really want to be protecting wild, unmanaged bee species, as these are the species which are in decline."

The study includes a chart of mitigation methods that have been tested in the scientific literature. The mitigation measures under evaluation include: restricting pesticide application to certain times of day, restricting the application of pesticides during weather events, removing flowering weeds that attract pollinators, applying repellents to deter pollinators, and more. The researchers find that there are few empirical tests on the most widely used mitigation measures, and they conclude that more and stronger scientific evidence is required to justify existing mitigation measures to help reduce the impacts of pesticides on bees while maintaining crop protection.

With bees playing a crucial role in pollinating crops, it is important to ensure that they are adequately protected from the harmful effects of pesticides. Beyond Pesticides has long advocated to protect and enhance biodiversity, prevent crop loss, as well as protect pollinator populations, human health, and wildlife.

The study also finds that only one category of mitigation measure appears to be more thoroughly covered with 12 studies—repellents, which are used to repel bees from visiting crops recently treated with pesticides. "It is an interesting idea, but it is not yet ready to be used," says Dr. Straw. "It would need to be tested on a diversity of bee and insect species, and if it is only repellent to one or two species, all the other bees would still be exposed to the pesticide."

However, the researchers caution that the number of studies alone is not

a sufficient measure of the effectiveness of a mitigation measure. The quality of the research is also important, and evidence from multiple continents and multiple species is needed to determine whether a measure works. Jay Feldman, executive director of Beyond Pesticides, says, "Even the most effective mitigation measures are not adequate to protect pollinators and human health." Beyond Pesticides has documented drift through air and the migration of pesticides into groundwater with toxic runoff.

With bees playing a crucial role in pollinating crops, it is important to ensure that they are adequately protected from the harmful effects of pesticides. Beyond Pesticides has long advocated the protection and enhancement of biodiversity, prevention of crop loss, and safety of pollinator populations, human health, and wildlife. For more information, see Beyond Pesticides' organic agriculture and Bee Protective page.

SOURCE: Edward A Straw and Dara A Stanley, *Journal of Economic Entomology*, Volume 116, Issue 5, October 2023, pages 1604–1612, https://doi.org/10.1093/jee/toad118.

BEES/POLLINATORS | JULY 8, 2023

Degradation of Color Discrimination Associated with Glyphosate Exposure Impairs Bees' Foraging Ability

A study published in *Science of the Total Environment* finds glyphosate can adversely impact sensory and cognitive processes in bumblebees (*Bombus terrestris*). Glyphosate exposure impairs bees' learning of aversive stimuli like electric shocks paired with specific color discrimination. Additionally, the pesticide reduces attraction to UV (ultraviolet) light, specifically the color blue, and temporarily impacts locomotion and phototaxis (movement in response to light). These impairments to sensory and cognitive processes render foraging difficult for these glyphosate-exposed pollinators and make them vulnerable to predators. The study highlights that symptoms of widespread chemical exposure may reduce foraging efficiency and adversely affect ecosystems, especially those dependent on insect pollinators.

Pollinator decline directly affects the environment, society, and the economy. Without pollinators, many plant species, both agricultural and nonagricultural, will decline or cease to exist as U.S. pollinator declines, particularly among native wild bees, limit crop yields. In turn, the economy will take a hit, since much of the economy (65 percent) depends upon the strength of the agricultural sector. As the science shows, pesticides are one of the most significant stressors for pollinators. In a world where habitat loss and fragmentation show no sign of abating, scientists have

concluded that the globe cannot afford to continue to subject its critically important wild insects to these combined threats. Therefore, studies like these emphasize the need to establish monitoring and conservation to protect species that provide essential ecosystem services. The study notes, "The high-throughput paradigm presented in this study can be adapted to investigate sublethal effects of other agrochemicals on bumblebees or other important pollinator species, opening up a critical new avenue for the study of anthropogenic stressors."

Glyphosate-based herbicides (GBHs) are the most common herbicides used globally. Previous studies evaluating chronic glyphosate or GBH exposure assessed the survival, development, physiology, colony thermoregulation, or gut microbiota specific to honey bees. However, few studies have tested field-realistic exposure to glyphosate on non-honey bees' (e.g., bumblebees) cognitive performance. This study investigates how long-term glyphosate exposure affects locomotion, movement in response to light, and learning in bumblebees using an automated high-throughput assay with a control UV and green or blue light.

Control bumblebees in the study prefer UV light to blue light. Yet, glyphosate-treated bumblebees' attraction to UV light decreases, with these treated bees having no preference between UV light or an alternative color. Additionally, control bees who experienced electric shocks when paired with blue wavelengths (CS+) vs. UV light always chose UV light. In contrast, glyphosate-treated bees could not differentiate between blue and UV light regardless of electric shock when in blue light. The study highlights, "Our results raise the question of whether an impairment in the detection of the sky compass could also have played a role. Furthermore, UV reflectance and UV patterns are important parameters of flower coloration, strongly influencing the foraging efficiency and flower choices of bees. To sum up, even a slight shift in UV sensitivity could have broad implications for these pollinators."

Clean air, water, and healthy soils are integral to ecosystem function, interacting between Earth's four main spheres (i.e., hydrosphere, biosphere, lithosphere, and atmosphere) to support life. However, toxic pesticide residues readily contaminate these spheres, frequently in soils, water (solid and liquid), and the surrounding air at levels exceeding U.S. Environmental Protection Agency (EPA) standards. The scientific literature demonstrates pesticides' long history of adverse environmental effects, especially on wildlife, biodiversity, and human health. Most notably, pesticides are immensely harmful to pollinators. Over the last decade and a half, increasing scientific evidence shows a clear connection between the role of pesticides in the decline of honey bees and wild pollinators (e.g., wild bees, butterflies, beetles, birds, bats, etc.).

The agricultural industry relies on insect pollinators for plant pollination and crop productivity. Globally, the production of crops dependent on pollinators is worth between $253 and $577 billion yearly. Hence, pesticide use fails to support sustainability goals, decreasing agricultural and economic productivity and social (human/animal) and environmental well-being.

Almost five decades of extensive glyphosate use has put animal, human, and environmental health at risk as the chemical's ubiquity threatens 93 percent of all U.S. endangered species. Although the direct effects of pesticides on pollinators are concerning, the indirect impacts on pollinator habitats are equally troublesome. Glyphosate use in mono-crop agriculture and genetically engineered crops can drift onto and destroy adjacent habitats. Habitat destruction results in the loss of species biodiversity and stable ecosystem processes integral to sustainability.

When looking at pesticide exposure, glyphosate represents only one class out of thousands of agrichemicals that pollinators may encounter. Pesticide use poses one of the most significant threats to bumblebees and places their entire life cycle at risk. A 2018 study found that commonly used neonicotinoid insecticides begin to kill off bumblebees during their nest-building phase, as exposure makes it more difficult for a queen to establish a nest. Exposure to neonicotinoids results in bumblebee colonies that are much smaller than colonies not exposed to these systemic insecticides. Moreover, a 2017 study finds that neonicotinoid exposure decreases pollination frequency and results in fewer social interactions. That is likely because neonicotinoids alter bumblebee feeding behavior and degrade the effectiveness of bumblebees' classic "buzz pollination" process. Research published in 2017 determined that fungicides also play an essential role in bumblebee declines by increasing susceptibility to pathogens. Additionally, EPA assesses the toxicity of individual active ingredients on bees through various testing methods when regulating pesticides. However, EPA does not require the testing of multiple active or "inert" ingredients to the same degree, despite evidence demonstrating these chemicals harm pollinators.

While it is evident that factors like pesticides, parasites, habitat destruction, and poor nutrition contribute to the decline of the American bumblebee, the combined stressors can act together (synergistically) to increase bee mortality.

The study shows chronic exposure to glyphosate can reduce bumblebees' ability to connect aversive stimuli like an electric shock with visual indications when partaking in learning tasks. The inability of bumblebees to learn these warnings puts these pollinators at risk of predation and disease when looking for food. However, this study only adds to the scientific literature on the adverse effects of chemical exposure on pollinator health, especially in sublethal concentrations. A lack of fine-color discrimination skills can threaten bumblebee survivability through a decrease in colony fitness and individual foraging success. Much research attributes the decline of insect pollinators (e.g., commercial and wild bees and monarch butterflies) over the last several decades to the interaction of multiple environmental stressors, from climate change to pesticide use, disease, habitat destruction, and other factors. In the U.S., an increasing number of pollinators, including the American bumblebee and monarch butterfly, are being added or in consideration for listing under the *Endangered Species Act*, with specific chemical classes like systemic neonicoti-

noid insecticides putting 89 percent or more of U.S. endangered species at risk.

Furthermore, this study shows the potential of a fully automated, high throughput assay for sublethal effects testing on wild and solitary bees for chemical exposure, not just honey bees. The study concludes, "Glyphosate exposure impacted bumblebee physiology and nervous system function in several ways, from sensory perception to cognition. This could result from a broad disruption of brain maturation or function. Further research will be needed to elucidate glyphosate's mechanism of action on insect cognition, as well as to evaluate if this effect is temporary or permanent."

Pollinator protection policies need improvement to safeguard not only all pollinators but the crops they pollinate as well. Beyond Pesticides holds that we must move beyond pesticide reduction to organic transition and commit to toxic pesticide elimination in agricultural systems to prevent the crop loss presented in this study. Pesticide elimination can alleviate the effect of these toxic chemicals on humans and wildlife.

SOURCE: Morgane Nouvian, et al., Glyphosate impairs aversive learning in bumblebees, *Science of The Total Environment*, Volume 898, 2023, https://doi.org/10.1016/j.scitotenv.2023.165527.

BEES/POLLINATORS | AUGUST 29, 2023

Pollinator Health: Common Fungicide Linked to Changes in Honey Bees' Brain through Oxidative Stress

A study published in *Insect Biochemistry and Molecular Biology* finds the widely used azole fungicide, tebuconazole, has damaging impacts on the redox homeostasis (the process of maintaining balance between oxidizing and reducing reactions) and fatty acid composition in honey bees' brain via oxidative stress. Acute, field-realistic sublethal exposure to tebuconazole decreased the brain's antioxidant capacity, key antioxidant defense systems, and oxidative degradation and alteration of lipids (fats) in the brain. Thus, this study adds to the scientific literature on the adverse effects of chemical exposure on pollinator health, especially in sublethal concentrations. Degenerating cognitive skills can threaten honey bee survivability, decreasing colony fitness and individual foraging success. Much research attributes the decline of insect pollinators (e.g., domesticated and wild bees and monarch butterflies) over the last several decades to the interaction of multiple environmental stressors, from climate change to pesticide use, disease, habitat destruction, and other factors.

Pollinator declines directly affect the environment, society, and the economy. Without pollinators, many plant species, both agricultural and nonagricultural, will decline or cease to exist, as U.S. pollinator declines, particularly among native wild bees, depress crop yields.

In turn, the economy will take a hit, since much of the economy (65 percent) depends upon the strength of the agricultural sector. As the science shows, pesticides are one of the most significant stressors for pollinators. Additionally, the devastating impacts of pesticides on bees and other pollinators is part of a larger pattern of what has been called by scientists as the "insect apocalypse." In a world where habitat loss and fragmentation show no sign of abating, scientists have concluded that the globe cannot afford to continue to subject its critically important wild insects to these combined threats. Therefore, studies like these emphasize the need for improved assessment for environmentally relevant levels of chemical exposure to honey bees.

The study notes, "[R]edox imbalance and oxidative stress-related negative consequences may be factors of crucial importance in the background of neurotoxicity and cognitive impairment observed by the abovementioned research groups in tebuconazole-exposed bees. Therefore, it is vital to understand whether tebuconazole may have a negative impact on the redox homeostasis of honeybees, possibly contributing to the development of further pathological conditions."

Using adult honey bees, the researchers exposed the bees to acute sublethal, field-realistic concentrations of tebuconazole in high, medium, and low doses. The researchers analyzed the fatty acid composition and oxidative factors in the brain of honey bees, including total antioxidant capacity (TAC), state of the glutathione defense system, the activity of glucose-6-phosphate dehydrogenase (G6PDH), superoxide dismutase (SOD), and xanthine oxidase (XO), and the production of malondialdehyde (MDA).

The results show tebuconazole has a profound impact on oxidation in the brain. It decreases antioxidant capacity, reducing the ratio of oxidized glutathione for preventing damage to important cellular components and disrupting antioxidant enzymatic defense systems, inducing lipid (fat) peroxidation (oxidative degeneration of fats) through elevated malondialdehyde levels. This alters the fatty acid profile in honey bee brains.

The scientific literature demonstrates pesticides' long history of adverse environmental effects, especially on wildlife, biodiversity, and human health. Most notably, pesticides are immensely harmful to pollinators. Over the last decade and a half, increasing scientific evidence shows a clear connection between the role of pesticides and the decline of honey bees and wild pollinators (e.g., wild bees, butterflies, beetles, birds, bats, etc.). Pollinators' decline directly affects the environment, society, and the economy. Globally, the production of crops dependent on pollinators is worth between $253 and $577 billion yearly. Hence, pesticide use fails to support sustainability goals, decreasing agricultural and economic productivity and social (human/animal) and environmental well-being.

The study emphasizes the role of oxidative in pesticide toxicity among nontarget species. An alteration in redox homeostasis has an association with many diseases and neurodegenerative disorders and is a significant factor in regulating cell growth and senescence (aging cells). Tebuconazole is a (tri)azole compound that can directly impact cellular metabolic processes like antioxidation. The chemical has a history of affecting bee behavior, foraging effectiveness, pollination, learning, and colony development, indicating impact on the brain. Behavioral changes and a decrease in cognitive function have a strong correlation with triazole-induced oxidative stress.

Although literature on oxidative stress, neurodegenerative disorders, and honey bees is lacking, this study provides evidence that future studies must assess how pesticides impact cognitive function among invaluable insects. Additionally, triazole fungicides can work synergistically with other bee-toxic pesticides, like neonicotinoids (insecticide), amplifying adverse effects on health. In fact, systemic neonicotinoid insecticides put 89 percent or more of U.S. endangered species at risk. The study attributed pesticide toxicity to the ongoing pollinator crisis, highlighting that more extensive research on triazole-mediated health effects is essential for the conservation of honey bees and endangered pollinators. The researchers say, "The present study highlights the negative impact of tebuconazole on honeybees and contributes to the understanding of potential consequences related to azole exposure on pollinator insects' health, such as the occurrence of Colony Collapse Disorder (CCD)." Pollinator protection policies need improvements to safeguard all pollinators and the crops they pollinate.

SOURCE: Máté Mackei, et al., Detrimental consequences of tebuconazole on redox homeostasis and fatty acid profile of honeybee brain, *Insect Biochemistry and Molecular Biology,* Volume 159, 2023, https://doi.org/10.1016/j.ibmb.2023.103990.

MORE ON THIS SUBJECT

Western Bumblebee Declines a Result of Pesticides and Climate Change, No End in Sight—January 25, 2023

Study on National Pollinator Declines Blames Pesticides, Pests, and Extreme Weather—February 1, 2023

Neonicotinoids Combined with Other Pesticides Elevate Hazards to Honey Bee—February 22, 2023

Pesticides and the Climate Crisis: Bumble Bee Behavior Thwarted by Temperature and Chemical Exposure—April 6, 2023)

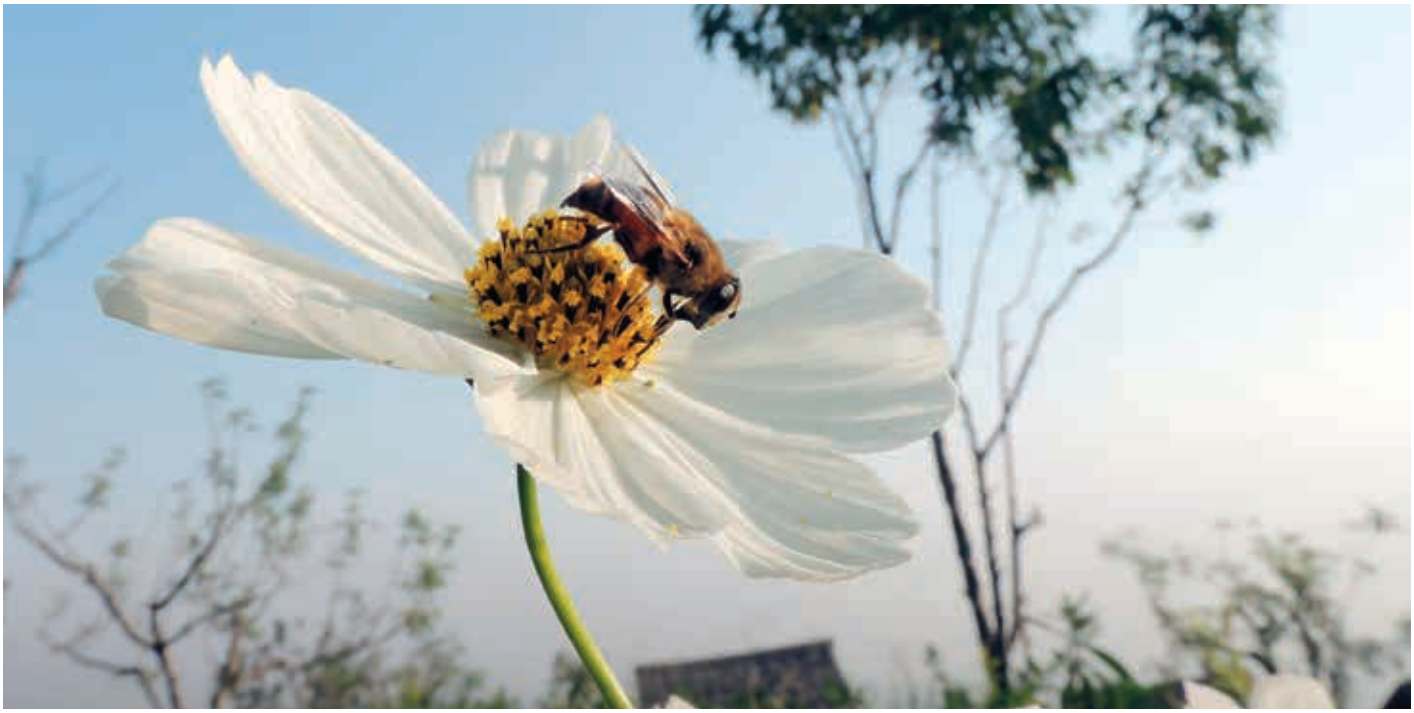
Soils in Urban and Natural Lands Equally Contaminated, Study Finds—April 11, 2023

Beehive Products Contain Concentration of Pesticide Residues High Enough To Be a Risk to Consumer Health—May 18, 2023

Pesticide Threat to Pollinators Decreases Agricultural and Economic Productivity, and Food Security—June 22, 2023

Ecosystem Critical to All Pollinators: Popular and Unpopular Pollinator Guide—2023

Pollinator Health: The Climate Crisis Weakens Bees' Ability to Withstand Pesticide Exposure—September 13, 2023



MICROBIOME HAZARDS | DECEMBER 12, 2023

Scientific Literature Review Again Identifies Pesticide Disruption of Bee Gut Microbiota

A review published in *Nature Reviews Microbiology* finds pesticides can disrupt honey bee (*Apis mellifera*) microbiota (bacteria) in their gut, altering the immune system, metabolism, behavior, and development. Many studies emphasize that chemical-driven agricultural systems harm or kill the sensitive pollinators on which they are dependent. Previous studies have linked adverse impacts on bee microbiome to pesticide exposure. Toxic pesticides readily contaminate the ecosystem with residues that have become pervasive in food and water commodities. In addition to this study, the scientific literature commonly associates pesticides with human, biotic, and ecosystem harm, as a doubling of toxic effects on invertebrates, like pollinators, has been recorded since 2004.

Pollinator declines directly affect the environment, society, and the economy. Many agricultural and nonagricultural plant species will decline or cease to exist without pollinators. In turn, the economy will take a hit, since much of the economy (65 percent) depends upon the strength of the agricultural sector. As the science shows, pesticides are one of the most significant stressors for pollinators. Additionally, pesticides have a devastating impact on bees,

Pollinator declines directly affect the environment, society, and the economy. Many agricultural and non-agricultural plant species will decline or cease to exist without pollinators. In turn, the economy will take a hit, since much of the economy (65%) depends upon the strength of the agricultural sector.

other pollinators, and insects generally, resulting in what scientists call the "insect apocalypse."

The review explores the relationship between microbiota in the gut of bees and the effects on bees' health and biological function, including microbial interactions within the stomach, processes in bee biology and health, and impact of agricultural practices. Since bacteria in the bee's gut occupy differing niches, their interaction with the host and each other can vary. Gut microbiota protects against pathogens and parasites, processes dietary or bodily components, and interacts with species within the host. Decreased microbial abundance and diversity can negatively affect honey bee health and survival. Without these microbiota, gene expression (a gene relaying information to produce a function) can change, weakening immune response, metabolic process, and development. Additionally, antibiotic exposure is a concern among agricultural exposure, since antibiotic treatments

lessen microbial abundance in the gut, hampering the absorption of nutrients, weight gain, immunity, and development of bee larvae.

The intestines host a group of microorganisms (microbiota) that form the gut microbiome. Gut microbiota, including bacteria, archaea, viruses, and fungi, play a crucial role in regulating lifelong digestion, as well as the immune and central nervous system. Ample evidence demonstrates environmental contaminants like pesticides negatively affect gut microbes. Through the gut microbiome, pesticide exposure can enhance or exacerbate the adverse effects of additional environmental toxicants to the body. Since the gut microbiome influences metabolism, it can mediate some toxic effects of environmental chemicals. However, with prolonged exposure to various environmental contaminants, critical chemical-induced changes may occur in the gut microbes, effecting adverse health outcomes. However, honey bees are not the only insects facing harm from environmental contaminants like pesticides, as all pollinators are in peril from exposure to environmental pollutants.

Like gut microbes, soil microbes are essential for the standard functionality of the soil ecosystem. Toxic chemicals damage the soil microbiota by decreasing and altering microbial biomass and soil microbiome composition (diversity). Pesticide use contaminates soil and causes changes in soil composition that results in "vacant ecological niches, so rare organisms become abundant and vice versa." The resulting soil ecosystem is unhealthy and imbalanced, with a reduction in the natural cycling of nutrients and resilience. Thus, plants grown in such conditions are more vulnerable to parasites and pathogens.

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.

Like previous literature, this review shows that pesticide use can disturb and shift the abundance of specific microbes in the bee gut microbiome. Pesticide-induced disturbances occur primarily in one of two ways—either directly harming microbes or indirectly harming the host's (bee) health and subsequently shifting the microbiome. An unfavorable environment produced by the bee's gut can create an environment less suitable for certain microbes. Moreover, 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. A 2018 study found that exposure disrupts honey bee microbiota, and a 2015 study found that it results in sublethal effects on honey bee navigation and foraging success. Moreover, studies suggest "inerts" may play a role in pollinator harm.

SOURCE: E.V.S. Motta, The honeybee microbiota and its impact on health and disease. *Nature Reviews: Microbiology,* 22, 122–137 (2024). https://doi.org/10.1038/s41579-023-00990-3.

MORE ON THIS SUBJECT

Common Fungicide Adds to Growing List of Pesticides Linked to Gastrointestinal and Microbiome Damage—January 26, 2023

Chemical-Driven Agriculture Damages Microbial Health of Bee Colonies—March 21, 2023

BIRDS | FEBRUARY 8, 2023

Garden Pesticide Use Harms Local Bird Populations, Study Authors Say "We Should Simply Ban These Poisons"

Spraying pesticides around one's garden negatively impacts local bird populations, according to research published by scientists at the University of Sussex, UK in Science of the Total Environment. Although this reasoning sounds common sense to those versed in the works of Rachel Carson, it underscores the immense importance of carrying on the legacy of her work and continuing to educate the public about the ongoing dangers posed by modern pesticides. As the study authors write, "Overall, our study shows that garden bird abundance and richness is strongly influenced by both extrinsic and intrinsic factors, and suggests that garden management, particularly regarding pesticide use, has a significant effect on bird life."

Researchers collected data by partnering with the British Trust for Ornithology, which conducts annual citizen-science counts of bird populations in UK gardens. Nearly 24,000 residents participate in the survey, which also includes information about the urbanization level surrounding their gardens, and other habitat characteristics. A group of these volunteers were provided with a questionnaire about their pesticide practices between 2020–2021, recording information on how often the pesticides were

applied, as well as the pesticide brand name. After removing incomplete or unusable data, 615 individual gardens were incorporated into the study.

To determine the factors impacting bird populations, researchers created a garden quality index (GQI) and surrounding quality index (SQI). GQI scores include factors such as the type and number of trees, the proportion of the garden planted with flowers, shrubs, vegetables, or allowed to be wild, the quality of shrubs and hedges, and the presence of water features. SQI scores include aspects like the type of nearby habitat (ex. woodland, scrubland, marsh) or nearby water body. To determine impacts to birds, researchers analyze both bird abundance (total number of birds) and richness (total number of bird species) per recorded bird counts.

In general, bird abundance is found to be highest in rural areas when compared to urban and suburban areas. Gardens that have higher GQI scores also record more bird abundance and richness, while SQI appears to only affect richness.

Among study participants, 34.1 percent indicate they applied pesticides, with over 60 percent of that use being herbicides, followed by molluscicides (slug killing products) around 35 percent, insecticides at roughly 30 percent, and fungicides at 10 percent. Pesticide spraying impacts the effect a positive SQI factor has on bird richness. Specifically, "species richness increases with the surrounding quality, both for gardens that do not use pesticides and for gardens that applied pesticides, but this effect is significantly less strong when pesticides are applied," the study finds. Scientists zeroed in on three active ingredients—the weed killer glyphosate, the neonicotinoid insecticide acetamiprid, and the synthetic pyrethroid deltamethrin—resulting in the most damaging pesticide impacts to bird species' richness.

While abundance is not impacted on an overall basis, individual species do show population declines with the use of specific pesticides. The house sparrow, for example, although perhaps the most established invasive bird in the United States, is in steep decline in the UK. Results show that house sparrow abundance declines by 12 percent in gardens applying any pesticide, but is nearly 25 percent lower in gardens specifically using glyphosate.

While abundance is not impacted on an overall basis, individual species do show negative relationships with the use of specific pesticides.

The study authors, including world renowned entomologist Dave Goulson, PhD, say their results support the need for restrictions on pesticide use. "The UK has 22 million gardens, which collectively could be a fantastic refuge for wildlife, but not if they are overly tidy and sprayed with poisons. We just don't need pesticides in our gardens. Many towns around the world are now pesticide free. We should simply ban the use of these poisons in urban areas, following the example of France," Dr. Goulson told The Guardian.

As Beyond Pesticides reported in 2022, France enacted sweeping restrictions on both public and private use of toxic pesticides in sensitive landscaped areas. The policy implemented throughout populated areas in France generally tracks with similar restrictions enacted in most Canadian provinces, but only by a

small but growing number of U.S. cities like South Portland and Portland, ME.

That pesticides are locally harming bird populations should come as no surprise; what is perhaps most concerning to advocates is that over one in three well-intentioned gardeners regularly apply toxic pesticides that put the birds they undoubtedly appreciate at risk.

In *Silent Spring*, Rachel Carson in the first chapter writes *A Fable for Tomorrow*: "There was a strange stillness. The birds, for example—where had they gone? Many people spoke of them, puzzled and disturbed. The feeding stations in the backyards were deserted. The few birds seen anywhere were moribund; they trembled violently and could not fly. It was a spring without voices. On the mornings that had once throbbed with the dawn chorus of robins, catbirds, doves, jays, wrens, and scores of other bird voices there was now no sound; only silence lay over the fields and woods and marsh."

Already, data show that the U.S. has lost three billion birds since the 1970s –29 percent of the abundance seen during that decade. This study and its authors have a loud and clear message to all readers to relay to their friends and family: Stop the home and garden use of pesticides. The choices people make, whether to address a pest through chemical or ecological pest management, have a major impact on the health of the wildlife in their immediate area; wildlife that many residents come to know well, and care about, as they watch their comings and goings in their ecosystem.

SOURCE: Cannelle Tassin de Montaigu and Dave Goulson, Habitat quality, urbanisation and pesticides influence bird abundance and richness in gardens, *Science of The Total Environment*,Volume 870, 2023, https://doi.org/10.1016/j.scitotenv.2023.161916.

MORE ON THIS SUBJECT

Agricultural Pesticide Use the Primary Driver of Bird Declines in Europe—May 19, 2023

Study Confirms Continued Bird Decline as EPA Fails to Restrict Neonicotinoid Insecticides—July 21, 2023

BUTTERFLIES | MAY 26, 2023

Study Shows 50 Percent Decline in Butterfly Population Across the European Union, 1990–2011

The use of pesticides in agriculture, transportation, and domestic settings has created a disastrous conflict for the human species. Two irreconcilable facts confront humans as they try to adapt to the consequences of earlier choices: One, industrial civilization came to believe that because some insects, fungi, and other organisms like to eat the same plants humans eat, humans can kill them with impunity; two, because some insects and other organisms are necessary to the health and reproduction of plants, humans need to protect them. At no point in

history have people acknowledged that it is very difficult to kill the "bad" actors while protecting the "good" ones. There are not really two sides to the biological fact; rather, pesticides and biodiversity meet each other on a single plane, like a Möbius strip.

Among the most dire effects of pesticides are their ruination of pollinators. Bees spring to mind as the primary pollinators, but they are by no means the only ones. Butterflies, often regarded as mere ornamental additions to a landscape, are actually significant pollinators themselves. Monarchs pollinate many flowers, including calendula and yarrow. Other butterflies pollinate dill, celery, fennel, cilantro, lettuce, peas, and basil, among other important food plants. Butterflies are also known to be excellent indicators of ecosystem health, so if an environment has lots of butterflies it is reasonably robust.

The European Union has just released a report, the European Grassland Butterfly Index in Europe, 1991–2020, as part of the EU's attempt to "halt the loss of biodiversity and the degradation of ecosystem services in the EU . . . and restore them, in so far as feasible, while stepping up the EU contribution to averting global biodiversity loss." The Grassland Butterfly Index is one of the EU's tools to identify trends in "genetic, species and ecosystem/landscape diversity." The survey includes counts of 17 species of butterflies from 19 countries. Results show that, "Grassland butterflies have undergone a huge overall decrease in numbers. Their populations declined by almost 50% from 1990 to 2011" across the EU member states. This is derived from the Indicator, which has declined by 32 percent over the last decade. Intensification of farming is the major culprit for grassland butterflies, and climate, especially heat waves and drought, is close behind. Industrial farming not only destroys habitat, but it uses poisonous chemicals as well.

In addition to documented declines in Europe, research documents declines of 58 percent between 2000 and 2009 in the U.K. and of 33 percent over 1996–2016 in the state of Ohio in the U.S. Even steeper declines have been documented for Monarch butterflies, with an 80 percent decline of Eastern monarchs and 99 percent decline of Western monarchs.

Butterflies and moths belong to the order *Lepidoptera*. Unfortunately, some 70 percent of agricultural pests—many of them moths at various life stages—also belong to this order. This puts butterflies smack in the bullseye for many pesticides. As Beyond Pesticides has repeatedly reported, the neonicotinoid pesticides destroy insects' nervous systems, and they are not picky as to species. Their effects on bees caused the EU to ban three neonicotinoids in 2013—clothianidin, thiamethoxam and imidacloprid—but in the U.S. the Environmental Protection Agency (EPA) is just getting around to pondering whether they are harmful enough to ban.

Until the last few years, EPA had never considered a pesticide's effects on endangered species in its registration process. In 2019, the Center for Food Safety sued EPA, and a California federal judge ruled that "EPA had unlawfully issued 59 pesticide registrations between 2007 and 2012 for a wide variety of agricultural, landscaping and ornamental uses," according to the Center for Food Safety.

Last year, EPA admitted in response to that ruling that these three neonicotinoid pesticides are "likely to adversely affect from two-thirds to over three-fourths of America's endangered species—1,225 to 1,445 species in all," including many butterfly species. On May 5 of this year, EPA released new analyses of these neonics' effects on endangered species. These more fine-grained analyses focuses on the species most at risk of extinction, and the results represent a "five-alarm fire," according to the Center for Biological Diversity's environmental health director, Lori Ann Bird. EPA identifies 25 insect species and upwards of 160 plants dependent on insect pollination whose existence is most perilous. This step by EPA is one in a long line of glacial movements that may result, if the winds of fate do not reverse, in the removal of these chemicals from the market.

Clothianidin is used on cotton, but cotton growers may be shooting themselves in the foot by using it. In 2021, *Science* reported on a study of cotton pollination showing that the services of butterflies and hoverflies add approximately $120 million annually to the $1.8 billion cotton industry in Texas. They do this by visiting different cotton flowers and appearing at different times than bees do. The researchers counted 40 bee species, 16 fly species, and 18 butterfly species in the cotton fields they examined. The study estimates that about 50 percent more flowers are visited by all pollinators than if bees were the sole actors. More broadly, according to the Center for Regenerative Agriculture and Resilient Systems at California State University Chico, the efforts of wild native bees and other pollinators are worth $3 billion.

Change at the federal level is too slow, according to environmental advocates, but many efforts at smaller scales, from scientists to farmers to individual citizens, are afoot. Butterflies may have been left out of much consideration of the pollinator crisis and development of ways to assess ecosystem health in general, but they are great poster children for both problems. They are what might be called "charismatic minifauna"—beautiful and beloved by people all over the world. In the U.S., many citizens participate in butterfly counts every year, organized by the North American Butterfly Association. These can be very helpful to researchers trying to assess how quickly ecosystems are collapsing. Home gardeners can help pollinators in many ways, with one caveat: Milkweed, the mainstay of monarch support, may contain pesticide residues that harm monarch caterpillars if the milkweed plants come from a nursery. Some caterpillars do eat foods humans like, but most of these are moth larvae, and the damage butterflies may cause is surely outweighed by their insects' benefits.

There are also moves to modify farming practices. As Beyond Pesticides

has noted, hedgerows are a good way to help many species of native pollinators. Hedgerows of small trees, low shrubs and native plants provide refuges for these insects and can also help control pesticide drift across field boundaries.

In Oregon's Willamette Valley, vineyards are starting to incorporate pollinator habitat between their rows of vines. Buzz Cover Crop Seeds of Philomath, Oregon sells seed packets for pollinator-friendly field cover crops and pathways between grapevine rows that have multiple benefits and help reduce chemical applications. Oregon also offers a "pollinator paradise" license plate, the fees for which support pollinator research at Oregon State University.

Some state and federal transportation agencies are acting. The Federal Highway Administration (FHA) and numerous state departments are incorporating pollinator-friendly policies. FHA publishes a handbook, "Roadside Best Management Practices that Benefit Pollinators." Even airports, some of the most habitat-destroying and contaminated lands in the world, may be changing: the National Academy of Sciences has published a report, "Considerations for Establishing and Maintaining Successful Pollinator Programs on Airports."

The pollinator crisis makes it clear that the template for sustainable human life must change. The toxic Möbius strip of pesticide use versus biodiversity must be broken and reassembled to promote the smooth flow of life. Without drastic reduction in the creation and use of pesticides, the plant and animal systems needed to survive will collapse. It is not enough to preserve European honey bees and not the plethora of other volunteer pollinators that exist all over the world. People and policymakers must practice "what's good for the bee is good for the butterfly" agriculture without delay. For details on issues in organic agriculture, see Beyond Pesticides' Keeping Organic Strong webpage.

SOURCE: European Environment Agency, *Grassland Butterfly Index in Europe* (1991–2021), 2023.

INSECT DECLINE | FEBRUARY 15, 2023

More Dramatic Insect Decline Confirms Inadequate Action on Looming Biodiversity Collapse

Areas designated to protect insects fail to do so for over 75 percent of global species, according to a study, "Three-quarters of insect species are insufficiently represented by protected areas," published in the online journal *One Earth*. Protected Areas (PAs) act as a safeguard for biodiversity. However, PAs in North America, Eastern Europe, Southeast Asia, and Australia do not meet the minimum coverage requirements to safeguard global insect species assessed in the study. PAs are discussed in the 2020 *Nature* article, "Area-based conservation in the 21st

century," in which the authors state that, in view of the global biodiversity crisis, national governments must do much more to increase protected areas with "coverage across different elements of biodiversity (ecoregions, 12,056 threatened species, 'Key Biodiversity Areas' and wilderness areas) and ecosystem services (productive fisheries, and carbon services on land and seas)." The authors write, citing the UN Convention on Biological Diversity (to which the United States is not a signatory), "To be more successful after 2020, area-based conservation must contribute more effectively to meeting global biodiversity goals—ranging from preventing extinctions to retaining the most-intact ecosystems—and must better collaborate with the many Indigenous peoples, community groups and private initiatives that are central to the successful conservation of biodiversity." [Note that Beyond Pesticides' community-based program, Parks for a Sustainable Future, eliminates petrochemical pesticides and fertilizers and develops land management programs in sync with nature and biodiversity.]

The lack of coverage in PAs leads to underestimates of global insect distributions. The study reports, "Given this substantial local variation, the extent to which insect species are covered by PAs globally remains obscure, meaning we are unable to track the progress of insect conservation globally."

All insects encounter multiple stressors besides pesticides, including parasites and poor nutrition, that act together to increase the risk of mortality. Despite being the driver of many ecosystem processes and functions/services, insects lack adequate consideration in global conservation assessments. Additionally, insects only constitute eight percent of the assessed species in the International Union for Conservation of Nature (IUCN) Red List of threatened species. Therefore, reviews like these highlight the need to address all factors that can exacerbate adverse impacts on insects, especially when threatened by uninhibited chemical pollutants. Lead researcher Shawan Chowdhury, PhD cautions, "Many insect species are declining within protected areas because of threats such as rapid environmental change, loss of corridors, and roads inside protected areas."

Using the Global Biodiversity Information Facility (GBIF), researchers measure global insect representation, mapping the distribution of all existing insect species that appeared at least three times in GBIF records (89,151 species). Study researchers compare insect coverage in protected areas to the geographical range of species to determine:

1. "[t]he extent of occurrence (EOO; area within the shortest continuous boundary encompassing all known occurrence records) and,
2. area of occupancy (AOO; the area within the EOO estimated to be occupied [by said species]."

The resulting map of designated protected areas for species shows that "76% of 89,151 insect species assessed globally do not meet minimum target levels of PA coverage," inadequately protecting at least 76 percent of global insect species. Thus, the researchers caution this study as a call for the expansion of PAs for insects to ensure worldwide biodiversity.

The United Nations states that 80 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 in decline, including managed and wild pollinators. Monarchs are near extinction, and commercial beekeepers continue to experience declines that are putting them out of business. The continued loss of mayflies and fireflies disrupts the foundation of many food chains. Additionally, the decline in many bird species has links to insect declines. Since the 1970s, three billion birds have vanished.

Despite habitat fragmentation and climate change, extensive use of pesticides, like neonicotinoids, sulfoxaflor, pyrethroids, fipronil, and organophosphates, increase the potential risk and indiscriminate threat to all insects. Research shows that residues from neonicotinoids (including seed treatments) and sulfoxaflor accumulate and translocate to pollen and nectar of treated plants. 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 insect 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 geographical range of species varies from small to large. Thus, some species can have high coverage within PAs, while others have little to no coverage in PAs, depending on range size. Despite the growth in PAs for endangered species, insects still face existential risk factors like habitat destruction, chemical exposure, and food insecurity. The study researchers link the lack of data on surveying insect species and an underestimation of geographical range size attributes to gaps in PAs conservation. Even animals in larger protected areas, like U.S. wildlife refuges, experience similar health risks from chemical pesticide exposure. Additionally, the U.S. Geological Survey (USGS) routinely finds widespread pesticide contamination of surface waters throughout the U.S. Scientists warn that neonicotinoids, and other pesticides, pose a direct threat to both insect and non-insect wildlife, including birds, aquatic animals, and other wildlife, which absorb pesticide sprays and vapors through respiration, as well as ingestion via food. Pesticide spraying in or around PAs threatens the survivability and recovery of species that reside there, as many pesticides are highly toxic to human and animal health. Therefore, studies like these are significant, especially since the globe is going through the

Holocene Extinction, Earth's 6th mass extinction, with one million species of plants and animals at risk of extinction.

Most animals on this Earth are insects, who play a significant role in sustaining the ecosystem despite their size. Insects found in nature preserves are consistently contaminated with over a dozen pesticides, calling into question the ability for these areas to function as refuges for threatened and endangered species. With rampant pesticide use and ubiquitous contamination, it is imperative that lawmakers and regulators embrace stronger measures to reverse the ominous trajectory society continues to follow, especially with the ongoing global insect apocalypse.

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 National Pesticide Forum, *Healthy Hives, Healthy Lives, Healthy Land*: "Complex biological communities support life." 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.

SOURCE: Shawan Chowdhury, et al., Three-quarters of insect species are insufficiently represented by protected areas, *One Earth*, 6, 139–146 February 17, 2023, https://doi.org/10.1016/j.oneear.2022.12.003.

AQUATIC CONDITIONS | FEBRUARY 14, 2023

Harming Wildlife, Pesticides in Waterways Run into the Great Lakes Year-Round

The waterways that flow into the Great Lakes are experiencing year-round pesticide contamination that exceeds benchmarks meant to protect aquatic life, according to research published in Environmental Toxicology and Chemistry by scientists at the U.S. Geological Survey (USGS). "What you use makes it into the water," study coauthor Sam Oliver, PhD told the *Milwaukee Journal Sentinel*. These data buttress growing calls from pesticide reform advocates that new laws are needed to protect the nation's increasingly threatened waters.

USGS scientists conducted their analysis on 16 tributaries that feed into the Great Lakes, including sites that correspond to urban, agricultural, and undeveloped land. Samples were taken at locations closest to the lake the tributary flowed into over a period of roughly one year from October 2015 to September 2016. Each sample was tested for 231 pesticides and their breakdown products. Researchers used aquatic life benchmarks set by the U.S. Environmental Protection Agency (EPA) and created a relative hazard index (RHI) for the study to evaluate whether specific sites should be prioritized for further protections.

Across every sampled tributary, pesticides were found. Accordingly, 96 percent (190 out of 198) of samples taken contained pesticides or their breakdown products. Scientists detected 104 of the 231 pesticide and breakdown products analyzed, with 80 percent of samples containing at least 10 different compounds. Herbicides represented the most frequently detected chemicals, with the hormone disrupting weed killer atrazine and its breakdown products (deethylatrazine and hydroxyatrazine) the most common of the bunch, detected in more than 75 percent of samples. Among insecticides, the neonicotinoids imidacloprid and clothianidin were most frequent, in 44 percent of samples. The most commonly detected fungicide was carbendazim, found in 51 percent of test samples. Notably, researchers detected 31 breakdown products that were of unknown hazard that are not captured by current EPA toxicity databases.

The presence of pesticide compounds exceeding aquatic life thresholds was found to occur throughout the entire year. This speaks to the dangers of pesticide breakdown products. The study notes, "For some individual parent pesticides, transformation products extended the 'exposure season,' or the proportion of the year that aquatic biota are exposed to pesticides at a given site." Based on analysis of the samples collected, the toxicity of breakdown products extends exposure hazards an average of nearly two months after the detection of the parent pesticide.

Researchers indicate that human disturbance in the form of urban and agricultural pesticide use represents the most polluted sites, but even samples in undeveloped land along the St. Louis River experience several instances where aquatic toxicity benchmarks are exceeded. The most contaminated site is along the Maumee River that flows into Lake Erie, where 72 different chemicals were detected during the study's duration.

Prior research shows the Maumee River to be particularly contaminated, with evidence that pesticide use is affecting the fertility of minnows in the stream, though this finding is likely just the tip of the iceberg. Likewise, Lake Erie is perhaps the Great Lake with the most sickened ecology, subject to a long history of contamination and toxic algae blooms.

While agricultural practices appear to correlate with peaking pesticide contamination during the growing season, urban runoff represents a larger overall proportion of the contamination flowing into waterways. With little to no natural soils to filter contamination, and impervious surfaces creating massive outflows of polluted water, this finding is unsurprising. Research conducted by USGS and EPA on urban runoff across the country in 2019 found 215 of 438 sampled toxic compounds present in the water. The sheer number of different chemicals and thus potential for even more toxic mixtures presents significant risks to health and the environment.

It is evident that the toxic soup that many U.S. waterways are carrying is unsustainable and threatens the foundation of many food chains. Imbalances in aquatic environments can ripple throughout the food web, creating trophic cascades that further exacerbate health and environmental damage.

SOURCE: Samantha K. Oliver, et al., Pesticide Prioritization by Potential Biological Effects in Tributaries of the Laurentian Great Lakes, *Environmental Toxicology and Chemistry*, Volume 42, Number 2, pp. 367–384, 2023.

AQUATIC CONDITIONS | MARCH 10, 2023

193 Countries in the United Nations Approve Treaty to Stop the Oceans from Dying

Following years of discussions and negotiations, 193 United Nations member countries have just approved—for the first time—a draft treaty for protection of the globe's "high seas" and their denizens. The March 4 adoption of the draft marks the achievement of a potential legal framework for such protections, but is also the beginning of "a long journey to ensure the world's oceans are adequately protected for future generations," according to coverage by *New Scientist*. As research out of Boston College identifies, the oceans are badly polluted by multiple substances—including pesticides and other agricultural runoff; industrial and petrochemical waste; and the synthetic chemicals embedded in plastics—that threaten human health. The treaty, which must be adopted by member states and then ratified by at least 60 countries to take effect, could be a critical development for meeting the COP15 "30 by 30" goal of protecting 30 percent of the world's land and sea by 2030 to slow and arrest global biodiversity losses. Beyond Pesticides has long covered the ecological harms of ocean pollution.

The treaty represents a step toward implementation of President Biden's 2021 "America the Beautiful Initiative," proclaiming "the first-ever national conservation goal established by a President—a goal of conserving at least 30 percent of U.S. lands and waters by

2030." That said, the U.S. has a poor track record on approval of UN environmental treaties; approval requires a two-thirds majority affirmative vote in the Senate, and failure on that would block a Presidential signature and ratification.

Consensus on the draft treaty—titled "Agreement under the United Nations Convention on the Law of the Sea on the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction"—was not easy. Since 2004, nations have been in discussions about how to create environmental protections for international waters, but these repeatedly got bogged down around issues related to fishing rights, resource rights, funding, and allocation of the benefits of marine genetic resources (MGRs) derived from deep-sea corals, seaweeds, sponges, krill, and bacteria—in which the pharmaceutical and cosmetic industries are very interested. Since 2022's COP15 summit, pressure from global NGOs and the so-called "high ambition coalition" (the U.S., United Kingdom, European Union [EU], and China) has mounted, and is credited with helping to get consensus on the treaty "over the line." Promises of more funding, including roughly US$857 million from the EU, also greased the wheels.

The world's oceans occupy 70 percent of the planet's surface. They generate half of the oxygen humans breathe, host 95% of the biosphere of the Earth, and are, in the aggregate, the largest carbon sink.

This treaty addresses the world's "high seas," defined as oceans that lie in international waters and thus, are not subject to national regulations. Stockholm University's Frida Bengtsson was quoted by *New Scientist*: "The high seas belong to everyone; juridically, they're seen as 'the common heritage of mankind,' just as space or the moon." The high seas include the Pacific, Atlantic, Indian, and Southern oceans, which host important areas of unique marine habitat and significant biodiversity that are under real threat from pollution, overfishing, and climate change. Roughly two-thirds of our oceans—covering about half the planet—are in the "high seas" category, which also means there are few legal protections in place for them, especially related to environmental threats or risks.

The world's oceans occupy 70 percent of the planet's surface. They generate half of the oxygen humans breathe, host 95 percent of the biosphere of the Earth, and are, in the aggregate, the largest carbon sink. They are a primary regulator of global climate; and they are in trouble.

The research referenced above was the first to conduct a focused examination of ocean pollution's impacts on human health; it reviewed nearly 600 scientific reports on various aspects of maritime contamination. Published in *Annals of Global Health* and released at the Monaco International Symposium on Human Health & the Ocean in a Changing World, the research paper concluded that ocean pollution is worsening, and that when the toxins from that pollution return to terra firma, they threaten the health and well-being of more than three billion people worldwide.

Lead researcher Philip Landrigan, MD, director of the Boston College Global Observatory on Pollution and

Health, and the university's Global Public Health Program and Global Observatory on Planetary Health, commented in a news release: "People have heard about plastic pollution in the oceans, but that is only part of it. Research shows the oceans are being fouled by a complex stew of toxins including mercury, pesticides, industrial chemicals, petroleum wastes, agricultural runoff, and manufactured chemicals embedded in plastic. These toxic materials in the ocean get into people, mainly by eating contaminated seafood. . . . We are all at risk, but the people most seriously affected are people in coastal fishing communities, people on small island nations, indigenous populations, and people in the high Arctic. The very survival of these vulnerable populations depends on the health of the seas."

The research team's central findings were these:

- Mercury pollution is widespread in the oceans, accumulating to high levels in predator fish; once in the food chain, this poses documented risks to people who consume these fish.
- Burning coal is the primary source of mercury contamination; mercury toxins vaporize as coal burns and eventually land in ocean waters.
- Coastal pollution—industrial waste, agricultural runoff, pesticides, and human sewage—has increased the incidence of damaging algal blooms, which produce toxins associated with neurological harms, dementia, amnesia, and death.
- Plastic waste in the oceans (to the tune of 8 to 10 million tons a year) is ubiquitous; it breaks down mechanically into microplastic particles that contaminate and can kill fish, seabirds, and other marine organisms; virtually all humans now harbor these microplastics in their bodies.

The 5 Gyres Institute has amplified very recent research (published on March 8) that identifies a shocking metric: there is now a great and growing "plastic smog" in the world's oceans, comprised of 170 trillion plastic particles. From the paper abstract: "Today's global abundance is estimated at approximately 82–358 trillion plastic particles weighing 1.1–4.9 million tonnes. We observed no clear detectable trend until 1990, a fluctuating but stagnant trend from then until 2005, and [then] a rapid increase until the present. This observed acceleration of plastic densities in the world's oceans, also reported for beaches around the globe, demands urgent international policy interventions."

Plankton, which comprise small and microscopic plant, animal, bacterial, and fungal organisms, are the basis of the ocean food chain. They are consumed by krill, which are eaten by fish, which are then consumed by larger ocean creatures, and by terrestrial animals—including billions of human beings.

Read recent Beyond Pesticides coverage of the damaging impacts of ocean pollution (from plastics, synthetic agricultural pesticides and fertilizers, pharmaceutical waste, etc.) on marine biodiversity, and on plankton, in particular. Plankton, which comprise small and microscopic plant, animal, bacterial, and fungal organisms, are the basis of the ocean food chain. They are consumed by krill, which are eaten by fish, which are then consumed by larger ocean creatures, and by terrestrial animals—including billions of human beings. Plankton could credibly be considered "über-keystone species" for their function as the basis of the marine (and a significant part of the terrestrial) food chain. Their plummeting numbers—a global population drop of 40 percent since 1950—should sound a dire alarm.

The researchers' recommendations on mitigating the pollution pipeline to the oceans include:

- Create, expand, and safeguard marine protected areas.
- Shift rapidly from use of fossil fuels for energy to renewables (wind, solar, tidal, and geothermal).
- Eliminate coal combustion entirely, and tightly control all industrial uses of mercury.
- Reduce plastics production and ban production of single-use plastics.
- Promote effective waste management and recycling.
- Reduce agricultural releases of nitrogen, and phosphorus, as well as animal waste, industrial discharges, and discharge of sewage into coastal waters.
- Execute robust monitoring of ocean pollution and extend pollution control programs to cover all countries.
- Support research on the extent, severity, and human health impacts of ocean pollution.

Given the state of the world's oceans, and the peril represented by their intensive contamination, this treaty cannot happen fast enough. In 2022, the United Nations' Intergovernmental Oceanographic Commission outlined the variety of threats the oceans face:

- Climate change warms and acidifies waters, causing death of coral reefs and threats to other ocean organisms, as well as thermal expansion of sea water (water molecules become more distant from one another) because of warmer temperatures, leading to more wetland flooding, erosion, and contamination of littoral agricultural lands.
- Plastic pollution causes physical damage to ocean creatures (entanglement, suffocation, lacerations, infection, and internal injury); 80 percent of ocean plastic originates with terrestrial human activity, largely littering/inappropriate plastic disposal; 8 million tons of plastic end up in the oceans *every year*.
- Nonpoint source pollution is the runoff from land to ocean (including pesticides and fertilizers from agricultural lands and other managed turf), precipitation, and atmospheric deposition.

- Petrochemical/oil spills.
- Ocean dumping is intentional discharge from industry, sewers, oil tankers, and entities that discard trash into the seas.
- Shipping and transport "contribute" waste and trash to the oceans; these activities account for a big chunk of the economic activity supported by oceans (90 percent of global trade uses sea routes); dredging to expedite shipping disturbs ecosystems; maritime transport generates 30 percent of global emissions of nitrogen oxides and sulfur oxides; the shipping industry also generates noise pollution that harms marine organisms.
- Extractive industries, such as deep-sea mining and offshore oil drilling.
- Fishing and fishing gear contribute significantly to ocean pollution by leaving behind harmful (often plastic) debris; industrial fishing nets (usually plastic), abandoned or lost, are a chief problem.

A critically important impact of the treaty would be the creation of international marine protected areas in which destructive activities, such as industrial fishing, deep sea mining, or offshore/deep water petroleum drilling could be restricted. Among the general principles embedded in the draft treat are:

- The Precautionary Principle.
- The polluter pays.
- The common heritage of humankind
- Equity, including the fair and equitable sharing of benefits.
- Integrated, ecosystemic approaches.
- Recognition of the special circumstances of small island developing states and least-developed countries.

In response to affirmation of the draft treaty, UN Secretary-General Antonio Guterres said that it would prove "crucial for addressing the triple planetary crises of climate change, biodiversity loss, and pollution." World Wildlife Fund's Jessica Battle commented, "What happens on the high seas will no longer be 'out of sight, out of mind.' . . . We can now look at the cumulative impacts on our ocean in a way that reflects the interconnected blue economy and the ecosystems that support it."

Dr. Landrigan sounds a hopeful note, saying, "The key thing to realize about ocean pollution is that, like all forms of pollution, it can be prevented using laws, policies, technology, and enforcement actions that target the most important pollution sources. Many countries have used these tools and have successfully cleaned fouled harbors, rejuvenated estuaries, and restored coral reefs. The results have been increased tourism, restored fisheries, improved human health, and economic growth. These benefits will last for centuries."

Beyond Pesticide emphasizes that the transition from conventional, chemical-intensive agricultural and land management practices and products to organic would all but eliminate one important source of toxic ocean pollution.

SOURCE: United Nations General Assembly, United Nations Convention on the Law of the Sea on the conservation and sustainable use of marine biological diversity of areas beyond national jurisdiction, March 4, 2023; Madeleine Cuff, What is the UN high seas treaty and will it save the world's oceans?, New Scientist, March 6, 2023; Philip J. Landrigan, MD, et al., Human Health and Ocean Pollution, Annals of Global Health, 2020; 86(1): 151, 1–64. DOI: https://doi.org/10.5334/aogh.2831.

AQUATIC CONDITIONS | AUGUST 4, 2023

Transport of Pesticides through Waterways Raises Serious Contamination Problems

The results of an Australian study published in *Nature* strike a contrast between land and water contamination with pesticide active substances (PAS), highlighting contamination as pesticides are transported through waterways. The study results on water transport raise serious contamination issues. Only about one percent of the pesticides entering rivers degrade, so that long stretches of waterways and the oceans suffer the direct impact of a pesticide's active ingredient. The lack of degradation also means that water organisms are being exposed to levels of pesticides exceeding many of the regulatory threshold limits set by governments. Although observation data are highly variable, the authors note that measured concentrations of pesticides in some river reaches of North America, East Asia and Europe exceed one or more regulatory threshold limits "at least once a year." Further, the pesticides can bioaccumulate at each level of the aquatic food web, which can multiply concentrations by a thousand or more in the highest trophic levels, according to the study authors.

The study finds that more than four-fifths of PAS are degraded in the soil, leaving about 10 percent of the original chemical in the soil as residue. Nearly half of these residues migrate into deeper layers of the soil where there are fewer microorganisms to break down the active ingredient. This means that a PAS accumulates in aquifers, mostly in its original chemical form. Aquifers are the source of most well water.

The authors of the study, through their assessment of hydrology and

biogeochemistry, have developed their estimate of how much pesticide remains on land, how much reaches the oceans, and how pesticides behave in both ground and surface waters along the way. Understanding how pesticides behave in the global water cycle, from wells and ponds to rivers and the oceans, has been lacking.

The authors note, "[I]n many observed cases PAS may degrade into a cascade of daughter substances which can be as toxic as the parent and occasionally even more persistent." For example, in 2021 Beyond Pesticides covered a study of pesticide metabolites, stating that "neonic [neonicotinoid] metabolites, such as desnitro-imidacloprid and descyano-thiacloprid, are more than 300 and ~200 times more toxic to mammals, respectively, than the parent compound imidacloprid."

Globally, approximately 3.3 million tons of pesticides are applied to crops every year. While most of these pesticides are applied on land, some portion of everything on land gets into water and ends up in the ocean eventually. Pesticides are no exception.

The scientists assess the hydrology and biogeochemistry of PAS for the 92 most-used pesticides based on 2015 data. The PAS are a fraction of the total mass of pesticide compounds applied to crops, amounting to 1.1 million tons—a third of the total global usage. Of this, the researchers calculate that 783 tons of PAS are released to the oceans annually. So, according to this study, a fraction of the total reaches the oceans. Active ingredients are virtually the only component of pesticide compounds whose toxicity is tested and regulated, so both the "inert" or "inactive ingredients" and chemicals resulting from geochemical or microbial action or disinfection processes are omitted from calculations of pesticide harms. For example, as Beyond Pesticides noted in its coverage of the pesticide metabolites study, "Nearly half of all breakdown products (transformation products) from four common-use environmental pesticides produce stronger endocrine (hormone) disrupting effects than the parent compound."

The rivers receiving the most pesticide runoff from land include the Mississippi and the Sacramento in the U.S., the Parana in Argentina, the Ganges in India, the Yangtze, Pearl and Yellow, in China, and the Irrawaddy and lower Mekong in South Asia. These are not all of the rivers that discharge the most PAS into the oceans, however. The Danube and the Amazon joined the group in that category. In all, fifteen of the most important rivers in the world discharge at least 5,000 kg of PAS each to the oceans annually. The effects of pesticides on the oceans—unlike those of fertilizers, which deplete oxygen and cause harmful algal blooms—are not well understood.

The researchers calculated another measure of the pesticide burden by comparing their estimates to actual observations in specific locations in North America, the European Union, and Australia. They found that their model "generally underestimated observations," which means that the burden on rivers and oceans is likely also heavier than they had predicted.

The most common chemicals in the modeled waters are glyphosate, metam potassium (a soil disinfectant), chlorothalonil and chlorpyrifos. The ratios of pesticide types in rivers were estimated at just over half as herbicides, about 36 percent multipurpose pesticides, about 11 percent fungicides and 0.6 percent insecticides. The ratio reaching the oceans was even more unbalanced,

with about 63 percent herbicides, a little over a quarter multipurpose pesticides, about 10 percent fungicides and 0.7 percent insecticides.

A final result of the study: The group analyzes which variables exert the most control over how much PAS remain unchanged in soils and how much is discharged to the oceans. In both cases, the main predictor is the rate of application to fields. For soil residues, annual soil water saturation, temperature and organic carbon content come next. For the oceans, the next most controlling variables are the surface area of the crop treated with pesticides, the surface area of the watershed, and the length of the river.

The study is a first approximation of the scale of the problem posed by pesticides traveling through planetary waters. Its results suggest that pesticides' deleterious effects on the biosphere extend much farther than manufacturers claim. Over time, the global water cycle ensures that everything on land, including mountains, reaches the sea, and putting anything into water diminishes any control humans might have over it. To interrupt the cascade of pesticide catastrophes, understanding the source is critical: the fields where the pesticides are applied. Stopping the process there is the most direct and effective way to start recovering from the damage pesticides cause.

The U.S. Supreme Court is not making the task any easier. As Beyond Pesticides observed last June, President Biden said the Court's recent ruling in *Sackett v. Environmental Protection Agency (EPA)* "will take our country backwards" because it "dramatically limits the EPA's ability to protect critical wetland ecosystems," which are integral parts of continental watersheds. This means the burden of pesticides on waterways will increase, and, according to the Australian researchers, part of their active ingredients will traverse rivers all the way to the ocean.

Government agencies are not monolithic in their failure to press for improved regulation. Beyond Pesticides has covered the U.S. Geological Survey's critique of the EPA's regulation of pesticides in water. The USGS reported in 2020 that of its 110 National Water Quality Monitoring Network sampling sites, only 2.2 percent of the water samples were free of detectable pesticides. It is firmly established that humans are exposed to pesticides and their various related compounds through drinking water and carry body burdens of these chemicals that threaten their health.

SOURCE: F. Maggi, et al., Agricultural pesticide land budget and river discharge to oceans. *Nature* (2023), https://www.nature.com/articles/s41586-023-06296-x.

MORE ON THIS SUBJECT

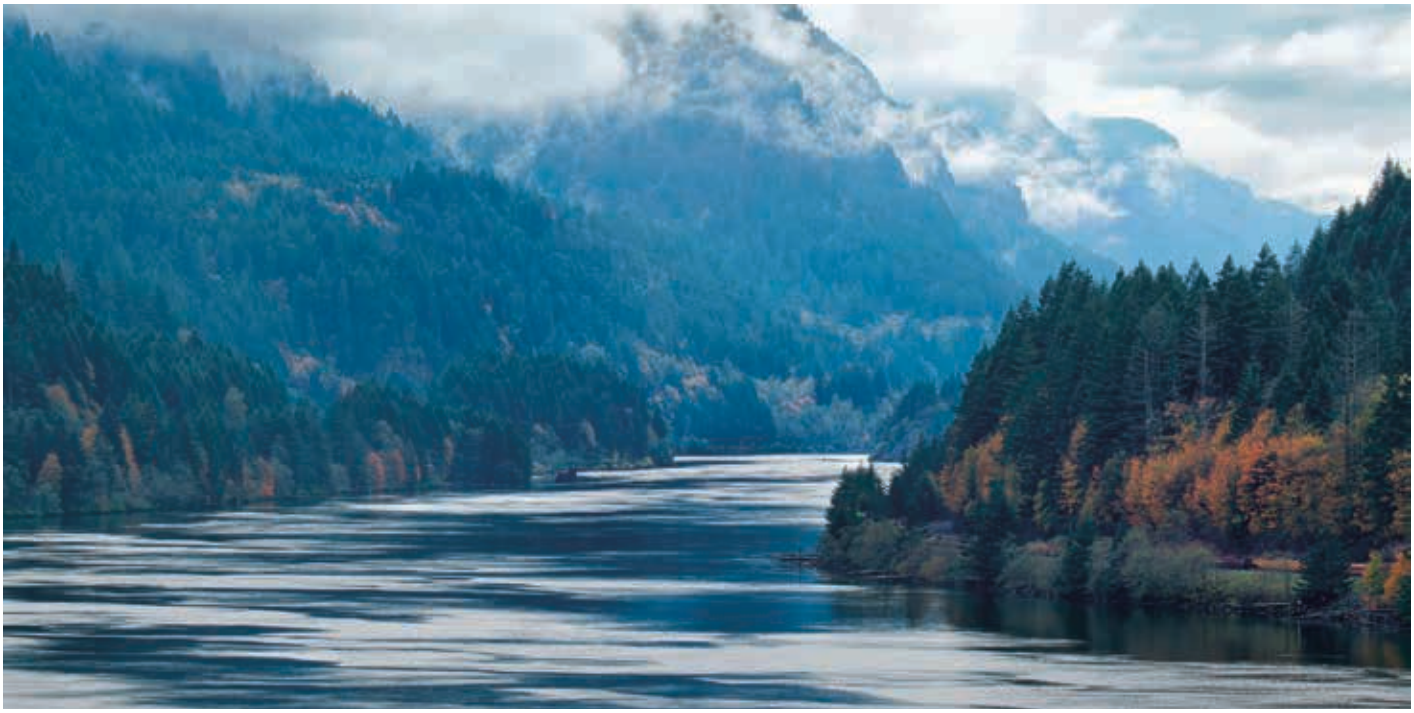
Four Pesticides Restricted to Protect Salmon, Thousands of Other Endangered Species Imperiled— February 10, 2023

United Nations and White House Calls for Action to Protect the Oceans— March 13, 2023

Legacy of Chemical Contamination and Weak Environmental Law Seen in DDT Dump Off California's Coast— March 28, 2023

Feds To Evaluate Endangered Species Impacts under Clean Water Act's General Pesticide Permits— August 9, 2023

Harmful Pollutants in Minnesota Waterways Highlights the Continuing Issue of Water Source Contamination— August 22, 2023



ENDANGERED SPECIES | APRIL 14, 2023

Two Pesticides Threaten Dozens of Endangered Species, EPA Proposes Failed Risk Mitigation Measures

In March, scientists at the National Marine Fisheries Service (NMFS) issued a draft Biological Opinion (BiOp) stating that carbaryl and methomyl—two commonly used carbamate insecticides—cause significant harm to dozens of already-endangered fish species in the Pacific Northwest's Columbia, Willamette, and Snake rivers. The BiOp indicates that these toxic compounds, in wide use on orchards and field vegetables throughout the Willamette Valley, the Columbia River Gorge, and southeastern Washington, will likely threaten scores of species on the Endangered Species list: 37 species at risk from carbaryl and 30 from methomyl. In addition, the BiOp says, "both are likely to harm or destroy many areas designated as critical habitat for endangered species." The mitigation measures proposed by NMFS and the U.S. Environmental Protection Agency (EPA), in light of this BiOp, are likely to be inadequate to the problem, given that both compounds can drift through air and/or migrate into groundwater and generate toxic runoff.

These two neurotoxic insecticides, carbaryl and methomyl, are very toxic to bees, birds, fish, and other aquatic organisms. In addition, carbaryl is a likely human carcinogen and an endocrine disruptor, and has harmful impacts on multiple bodily systems. Methomyl is also an endocrine disruptor and can cause renal and hepatic (liver) damage.

When EPA makes a determination that a pesticide product may so affect such species or habitats, the agency must initiate formal consultation with NMFS, the FWS, or both. Those agencies may then develop and issue their own BiOps on the jeopardy a pesticide presents to listed species and/or critical habitats.

NMFS and U.S. Fish and Wildlife Service (FWS) are the lead federal agencies tasked with implementing the Endangered Species Act (ESA). Under the law's requirements, EPA must evaluate any pesticide it registers to make sure it is not likely to result in jeopardy to the "continued existence of any listed species or result in the destruction or adverse modification of designated critical habitat of such species."

When EPA makes a determination that a pesticide product may so affect such species or habitats, the agency must initiate formal consultation with NMFS, the FWS, or both. Those agencies may then develop and issue their own BiOps on the jeopardy a pesticide presents to listed species and/or critical habitats. The new NMFS draft BiOp is open to public comment until May 15; at some

point after that date, EPA will provide official comments to NMFS for consideration in developing its final opinion.

Beyond Pesticides has noted—in its 2020 comments on the draft ESA Biological Evaluations for carbaryl and methomyl—that the ESA embodies a more precautionary approach than does the *Federal Insecticide, Fungicide and Rodenticide Act* (FIFRA), federal pesticide law. The consultation requirement means that scientists at FWS and/or NMFS, who have greater expertise in evaluating harms to species and their habitats than do EPA scientists, have the chance to influence EPA pesticide regulation.

The EPA website indicates that it and NMFS are particularly interested in public comments relating to (1) additional risk reduction options beyond those described in the biological opinion; (2) the general feasibility of drift reduction measures based on wind direction; and (3) runoff and/or spray drift reduction technologies.

The draft BiOp suggests measures to "avoid jeopardy, including a flexible list of chemical-specific measures to reduce loading of pesticides into aquatic habitats to protect them from adverse effects of pesticide exposure. It also includes measures to minimize take and impacts to critical habitats, such as the development of ESA educational materials, reporting of label compliance monitoring, and inclusion of label information about ecological incident reporting." (Under ESA, "take" means unintentional harm or killing of an individual of a protected species.) According to *Oregon Public Broadcasting*, FWS "recommends either prohibiting the chemicals within 300 meters (about 325 yards) of species' habitat or implementing mitigation practices, like expanding vegetation ditches as buffers or using tools that reduce runoff."

The EPA website indicates that it and NMFS are particularly interested in public comments relating to (1) additional risk reduction options beyond those described in the biological opinion; (2) the general feasibility of drift reduction measures based on wind direction; and (3) runoff and/or spray drift reduction technologies. Clearly, EPA is aware that drift and runoff represent ongoing vectors for listed species' exposures to these two compounds; a between-the-lines read might reasonably conclude that EPA understands that current measures do not adequately protect the Northwest species at risk from carbaryl and methomyl.

As background: According to the EPA website, in March 2021, the agency completed its final biological evaluations for carbaryl and methomyl—resulting in determinations of "likely to adversely affect" (LAA) for 1,640 listed species and 736 designated critical habitats for carbaryl, and 1,098 listed species and 736 designated critical habitats for methomyl. Carbaryl continues to undergo the every-15-years registration review required by FIFRA, the federal statute governing all things "pesticide"). In October 2022, EPA announced revisions to the proposed interim registration decision on methomyl.

In late December 2022, EPA proposed new mitigations to attempt to curb some of the harms of carbaryl's use, including:

- Some use cancellations for residential dust formulations, residential granular formulations on turf, use on rice, and backpack applications to control tree boring beetles.
- Additional personal protective equipment for some uses.
- Longer restricted entry intervals for some uses.
- Mandatory spray drift language that prohibits application within 25 feet of aquatic habitats for ground applications and 150 feet for aerial applications.
- Mitigation to reduce runoff through protection statements and application restrictions during rain.
- Measures to protect pollinators from carbaryl exposure, including restrictions on applications during bloom.

EPA also proposed at the time a "pilot" set of measures for protection of four endangered species, one of which was—notably—steelhead trout in the upper Columbia River. It also offered a number of "reasonable alternative measures" intended to protect listed salmon and steelhead species in Washington, Oregon, Idaho, and California; those included vegetated filter strips, retention ponds, water control structures, no-till/reduced tillage practices, riparian hedgerow, and no-spray buffers. As of publication, no evidence of the enactment of these measures was publicly and readily available.

As for methomyl, EPA issued (in 2022) Proposed Revisions to the Methomyl Proposed Interim Registration Review Decision—on the heels of a successful lawsuit brought by the Center for Biological Diversity and Pesticide Action Network. EPA had made LAA determinations for 1,098 species and 281 designated critical habitats in its BiOp on the compound's impacts. In response, the agency proffered another set of mitigation measures (roughly analogous to those for carbaryl), including a three-species pilot. Remarkably, EPA concluded that the proposed FIFRA mitigation largely addresses the potential effects on Pacific salmon and steelhead species, of the use of methomyl.

In February 2023, Beyond Pesticides reported on other chemical pesticide assaults on Northwest salmonid species (which include steelhead trout); previously, Daily News covered the harms of three organophosphate pesticides (chlorpyrifos, malathion, and diazinon) on these same species. (The organophosphate insecticide malathion and methomyl have a similar mode of action—acetylcholinesterase inhibition.) These fish species are economically, culturally, and ecologically critical to the region.

The multiplicity of pesticides to which they are exposed, given intensive agricultural pesticide use in the region, contributes significantly to the well-documented decline of salmonid species. Subject simultaneously to impacts of pesticides, habitat loss, and climate change, these species are in trouble.

EPA has a history of continuing to allow use of pesticides that are demonstrably harmful, and taking relatively anemic measures to amend the compounds' use, in an attempt to reduce harms; examples fairly abound. In the current biodiversity crisis, for which pesticides bear some responsibility, the agency's lack of robust protective action is unacceptable.

In March 2022, EPA—succumbing to industry pressure—continued the registration of the organophosphate insecticide malathion, despite the agency's own findings that this class of insecticides has negative impacts on more than 1,000 endangered and threatened species, and that malathion, specifically, threatens 1,284 species. In 2021, EPA reregistered paraquat, the most acutely dangerous herbicide on the market, with some additional constraints on its use. (It subsequently went to a federal court in October 2022 to request permission to return and reconsider its decision to reapprove paraquat.)

In 2016, EPA registered sulfoxaflor, a so-called "novel," systemic, neurotoxic insecticide that, like neonicotinoids, acts on nACh (nicotinic acetylcholine) receptors, and is very toxic to bees. Beyond Pesticides wrote at the time, "This decision is the final result of a long-fought legal battle over the chemical's registration, spearheaded by beekeepers and public health organizations concerned with what has been identified as EPA's inadequate and flawed pesticide review processes. The agency claims that amendments made to the original registration . . . will protect pollinators. However, scientific studies have shown that there is no way to fully limit exposure to bees, especially native species that exist naturally in the environment, given that the chemical, being systemic, is found in pollen, nectar, and guttation droplets."

Sulfoxaflor is used to kill aphids and another sucking/piercing insects on many crops, including vegetables, fruits and tree fruits, and nuts. In 2019, EPA granted approvals for sulfoxaflor to be used extremely widely *on crops that are highly attractive to pollinators*—an astonishing move, given the toxicity to bees. Research suggests that beneficial insects are exposed to sulfoxaflor at relatively high concentrations in agricultural environments. In a late 2021 win for bees, a California Superior Court ruled that this "field legal but bee lethal" pesticide could no longer be used in the state.

In its comment to EPA on registration of sulfoxaflor, Beyond Pesticides wrote, "EPA is proposing to repeat missteps of the past by registering a pesticide known to be toxic to nontarget organisms without all required data to ensure its safety. As already seen with the neonicotinoid clothianidin, and the herbicide aminocyclopyrachlor, conditional registration without relevant ecological data can be detrimental to nontarget species." Indeed, according to *The Chicago Tribune*, attorneys general from Illinois and 12 other states have now called on EPA to restrict use of sufloxaflor because of its toxic impacts on bees and other pollinators.

Beyond Pesticides Executive Director Jay Feldman notes that, "EPA is consistently unrealistic and downright misleading about the real effects of the pesticide risk mitigation measures it enacts. They do not meet the agency's statutory mandate to protect health and the environment; what result are agency decisions that allow harm to those people and ecosystems EPA is charged with protecting."

Beyond Pesticides has repeatedly critiqued EPA for its abject lack of appropriate protective action on toxic pesticides—especially in the face of species on the brink of extinction, the unfolding pollinator and insect collapse, endemic human health impacts, and widespread contamination of natural resources and ecosystems. Many health and environmental advocates see EPA as an irresponsible federal agency falling far short of meeting its mission, as the nation (and world) face those extreme challenges.

"EPA is proposing risk mitigation measures that the agency knows do not work. It's shameful," said Mr. Feldman. He continued, "EPA knows that nothing short of cancellation is adequately protective, and the agency should know that we no longer need these toxic chemicals to produce food and manage landscapes."

Conventional, chemical-intensive U.S. agriculture—and the huge network of businesses, trade groups, and government agencies and programs that inform, support, and help fund it—is incredibly "dug in" to pesticide use as the way to do business.

Conventional, chemical-intensive U.S. agriculture—and the huge network of businesses, trade groups, and government agencies and programs that inform, support, and help fund it—is incredibly "dug in" to pesticide use as the way to do business. This grave and recklessness addiction to chemical pesticides in agriculture can be genuinely solved through a solution that is known, demonstrable, executable, and scalable: the transition to organic, regenerative agricultural practices. Organic agriculture can not only maintain productivity and profitability, but also increase societal resiliency, sustain living beings and Nature's functional integrity, and liberate everyone and everything from the toxic impacts of pesticides.

SOURCE: U.S. Environmental Protection Agency, EPA Posts Draft Biological Opinion for Carbaryl and Methomyl for Public Comment, March 16, 2023.

POLICY | APRIL 27, 2023

Nevada Assembly Votes Unanimously To Protect Pollinators, Recognizes Deficiencies of EPA Regulations

[Eds. Note: Subsequent to this article, the Nevada legislature passed the legislation that is the subject of this article.]

The Nevada Assembly, by unanimous vote, took the state one step closer to banning the use of neonicotinoid insecticides used on plants, with a waiver for commercial agricultural purposes. Despite dramatic declines in bee populations linked to neonicotinoid pesticides and other toxic pesticides, the U.S. Environmental Protection (EPA) and state regulatory authorities have for the most part ignored beekeepers and the independent scientific literature by allowing widespread toxic pesticide use—forcing elected officials to take protective action. Portions of the bill take effect upon passage or no later than January 1, 2024. Maine and New Jersey have adopted similar legislation.

The failure to adequately regulate pesticides under federal law, the *Federal Insecticide, Fungicide, and Rodenticide Act* (FIFRA), and EPA inaction is viewed by environmentalists as a shocking disregard for the importance of biodiversity to sustaining life. The inadequate restriction of pesticides and slower than necessary transition to organic land management practices are viewed as major contributors to the "insect apocalypse." The legislation (A.B. 162), led by Assemblywoman Michelle Gorelow and a group of nine other Assemblymembers, illustrates a growing trend of local and state legislative bodies asserting their authority to protect against health, biodiversity, and climate crises, linked to petrochemical pesticides and fertilizers, that are escalating out-of-control to devastating levels—with the U.S. Congress and federal agencies standing silent.

A systematic review of insect population studies worldwide in Biological Conservation magazine (2019) reports on "the dreadful state of insect biodiversity in the world, as almost half of the species are rapidly declining and a third are being threatened with extinction."

"We applaud the Nevada Assembly's initiative to protect pollinators and urge elected officials nationwide to see the pending biodiversity collapse as reason for broader action to eliminate petrochemical pesticides and fertilizers with organic systems that are effective and cost competitive," said Jay Feldman, executive director of Beyond Pesticides.

A systematic review of insect population studies worldwide in *Biological*

Conservation magazine (2019) reports on "the dreadful state of insect biodiversity in the world, as almost half of the species are rapidly declining and a third are being threatened with extinction." The study concludes with the dire prediction that insects as a whole will go extinct in the next few decades if patterns of pesticide use and other factors continue. Many systemic pesticides, like neonicotinoids, are taken up by the vascular system of the plant and expressed through pollen, nectar, and guttation droplets, causing indiscriminate poisoning and death to pollinating and foraging insects, including bees, butterflies, and birds. The chemicals also move through soil, killing terrestrial and aquatic organisms.

The complexity of pesticide hazards is captured in a statement by biology professor Matthew Forister, PhD, University of Nevada (Reno), who told the Natural Resources Nevada Assembly Committee: "[T]he extreme and prolonged droughts of recent decades are reducing the densities of beneficial insects in . . . open lands. This new reality elevates the importance of all decisions that we make about managed lands, and chief among these decisions is the use of pesticides."

As is typical, pesticides often cause a mixture of environmental and public health effects. According to Drew Toher, former community resource and policy director, Beyond Pesticides, "Emerging data shows neonicotinoids can act as hormone disruptors, increasing the risk of breast cancer; they can readily transfer from mother to fetus through the placenta, increasing risk of birth defects; they are associated with liver damage, and neurological impacts like memory loss."

The Toiyabe Chapter of the Sierra Club said, "The good news is that there are many safe alternatives to using neonicotinoid pesticides. If we switch to these safer methods, we could save the pollinators, other animals, and improve human health."

The New York State Assembly passed a similar bill (A03226), the *Birds and Bees Protection Act*. The Act bans neonicotinoid use on outdoor ornamental plants and turf, with a general exemption for agriculture except for treated seed. The bill, opposed by the New York Farm Bureau, contains a ban on seeds treated with neonicotinoids, but includes an "emergency" override by the State Commissioner of Agriculture, based on a written determination that (i) a valid environmental emergency exists; (ii) the pesticide would be effective in addressing the environmental emergency; and (iii) no other, less harmful pesticide or pest management practice would be effective in addressing the environmental emergency. The bill would immediately ban chlothianidin or dinotefuran, leaving the most widely used neonicotinoid imidachloprid, as well as thiamethoxam or acetamiprid, on the market until July 1, 2025.

SOURCE: Assemblywoman Michelle Gorelow, Assembly Bill No. 162, February 14, 2023.

POLICY | JUNE 15, 2023

Recent Supreme Court Ruling on Clean Water Act "Will Take Our Country Backwards"

The Supreme Court's recent ruling in *Sackett v. Environmental Protection Agency (EPA)* on the *Clean Water Act*'s jurisdiction dramatically limits EPA's ability to protect critical wetland ecosystems. On May 25, in a 5-4 majority decision, the Supreme Court ruled that EPA has authority to protect only "wetlands with a continuous surface connection to bodies that are 'waters of the United States' in their own right." Wetlands must appear "indistinguishable" from larger waterways at a surface-level perspective. Wetlands next to a large waterway are no longer protected if they are separated by a manmade or terrestrial barrier. Water flows underground from upstream to downstream sources and exits the confines of its customary boundaries during periods of flooding, so to declare waterways distinct based merely on a surface-level perspective defies scientific understanding of ecosystem health.

Critical Nature of Wetland Ecology

The conservation of wetland ecology is critical to the health of the environment. The United States Geological Survey (USGS) states, "Wetlands are among the most productive habitats on earth" given their role in flood resilience, improvement in water quality, and coastal erosion control. Wetlands are essential nursery grounds for many species of fish and oases for migratory birds en route to their final destinations.

Not only are wetlands one of the most crucial ecosystems on the planet, but they are also particularly vulnerable to stressors such as habitat loss, pollution, and climate change. Both sea level rise and rapid human development are quickening the pace of their disappearance. Upstream runoff can carry destructive chemical pesticides and fertilizers that wreak havoc on downstream ecosystems. Many wetlands are brackish, meaning they are a mixture of fresh- and saltwater. When sea levels rise, coastal wetlands are inundated with massive amounts of seawater, throwing off their careful salt concentrations and spelling out death for organisms reliant on a narrow range of water chemistry.

History of Clean Water Act and Court Cases

The *Clean Water Act* (CWA) has played an integral role in the preservation of environmental health over the last few decades. Prior to the passing of CWA, jurisdiction of the nation's waterways was left in the hands of the states and very few regulations were imposed. The federal government finally took action after Ohio's Cuyahoga River spontaneously caught fire in 1969 due to a substantial amount of pollution in the waters. Passed in 1972, CWA "aimed to restore and maintain the chemical, physical, and biological integrity of the nation's waters." The law forbids "unpermitted discharges of pollutants to 'navigable waters,'" which are defined as "the waters of the United States." A few years later, authority was broadened to encompass waters "adjacent" to navigable waterways. CWA sets industrial wastewater standards, requires a strict permitting process regarding wetland development, and outlines safety limits for contaminant concentrations in drinking water. EPA and the Army Corps of Engineers are tasked with the protection of wetlands and enforcement of CWA regulations to defend water quality against polluting industries.

Despite the success of CWA in improving the quality of waterways, decades-long debates have pitted politicians against each other over the ambiguity of exactly which "waters of the United States" fall under EPA jurisdiction. Under constitutional law, the legislative branch is granted the power to regulate interstate commerce. This detail found in Article I, Section 8, allows a federal agency (e.g., EPA) to impose waterway regulations within states since "navigable waters" play an important role in interstate commerce. Historically, wetlands neighboring a large waterway, despite an interrupted surface connection, were under EPA's jurisdiction. Even the smallest creeks, however, run downstream to larger lakes and rivers, so many believe the original wording of CWA does not clearly portray the extent of the EPA's authority. EPA and the Army Corps of Engineers often consider potential regulatory infractions on a case-by-case basis, but court cases in years since have attempted to clarify these uncertainties.

One such landmark case brought before the Supreme Court in 2006, *Rapanos v. United States,* highlighted key issues related to CWA's scope in a case brought by a land developer. Half of the Court supported a broad interpretation of "waters of the United States" that includes smaller tributaries that eventually flow into larger bodies of water. The opposing justices, led by Justice Antonin Scalia, favored more limited EPA authority, arguing for the protection of what they referred to as only "traditionally navigable waters" or those "indistinguishable" from such. To qualify, neighboring tributaries would have to be "relatively permanent" bodies of water with a "continuous surface connection" or uninterrupted by any terrestrial barriers. A contentious case, the ruling concluded with a 4-1-4 plurality. The court finally decided on a resolution by Justice Anthony Kennedy, the concurring vote, in which he deemed EPA jurisdiction extending to "traditionally navigable waters," as well as any U.S. waters serving as a "significant nexus," meaning wetlands that "either alone or in combination with similarly situated lands in the region, significantly affect the chemical, physical, and biological integrity" of the navigable waters. Ambiguity, however, remained, as one could endlessly debate what qualifies as "significant."

In 2015, the Obama administration took a position on the not fully defined language of the amended

CWA. The administration's stance, known as WOTUS (waters of the United States), and later the Clean Water Rule, asserts that any waterway active for at least part of the year (implying seasonally flowing or ephemeral streams) qualifies as a protected wetland and is therefore under EPA jurisdiction. EPA had spent years studying the effects of upstream pollutants on downstream waters and, based on its in-depth scientific reports, found that protecting all tributaries and wetlands is necessary to the preservation of the quality and health of larger waterways. This position generated immediate backlash, as the industrial, mining, and agricultural sectors, as well as property rights activists, fought the protection of seasonally active waterways. The rule was stayed in federal court as lawsuits began piling up in states around the country, and the administration looked to adjust the rule in response.

EPA had spent years studying the effects of upstream pollutants on downstream waters and, based on its reports, found that protecting all tributaries and wetlands is necessary to the preservation of the quality and health of larger waterways.

The statutory intent of CWA was then entirely turned upside down with the Trump administration. In a 2019 reversal of Obama-era protections, the Trump administration maintained that justices led by Scalia in the *Rapanos* case had gotten it right, limiting protections to tributaries with a direct surface connection to larger waterways.

In an attempt to compromise, the Biden administration set standards similar to those prior to 2015, falling between the broad protections of the Obama administration and the extremely limited protections of the Trump administration. This approach meshes "traditional navigable waters" with adjacent waterways, including "inter-state waterways and upstream water sources that influence the health and quality of those waterways." With this interpretation, a small land divide does not render two nearby wetlands separate. Environmentalists generally support this effort and affirm that this rule is "central to efforts to restore the health of impaired waterways and fragile wildlife habitats because it gives federal and state governments powers to limit the flow of pollutants, including livestock waste, construction runoff and industrial effluent."

Present-Day Supreme Court Case

So now for the case at hand: Chantell and Michael Sackett, a couple beginning construction of a house on an area of wetlands near Priest Lake in Idaho, were alerted by EPA that their land fell under the protection of CWA. The Sacketts disagreed with the EPA's stance and took the issue to court. After the case made its way to the Supreme Court, the justices concluded that the Sacketts' land did not fall under the protections granted by CWA and then curtailed the reach of the law by limiting CWA to larger bodies of water, such as lakes and oceans.

Objecting to the perspective of the majority, Justice Elena Kagan, joined by Justices Sonia Sotomayor, Ketanji Brown Jackson, and Brett M. Kavanaugh, compares this case to one last year limiting EPA's authority to limit greenhouse gas emissions under the *Clean Air Act*. In both cases, the Court voted to vastly limit the EPA's jurisdiction, with dangerous implications for the future health and safety of people and the planet.

Consequences of the Ruling

The dissenting justices highlight the destructive effects this ruling will have on nationwide water quality and flood control, as EPA is now drastically limited in its "ability to extend protections to upstream waters in order to protect downstream water quality for drinking and wildlife." Wetlands are a filtration system, trapping many pollutants and preventing them from traveling downstream into major waterways. Environmental advocates say that this will cause broad adverse effects, from the Everglades to maintenance on the levee systems along the Mississippi River to cleanup projects along the Chesapeake Bay. According to some estimates, about 50 percent of wetlands will lose federal protection. The environmental law firm Earthjustice estimates that federal protections will be withheld from 118 million acres of wetlands.

President Biden has warned that the Supreme Court decision "will take our country backwards," and assured the public he will continue to fight for clean water. In his statement, the President continued, "Today's decision upends the legal framework that has protected America's water for decades. It also defies the science that confirms the critical role of wetlands in safeguarding our nation's stream, rivers, and lakes from chemicals and pollutants that harm the health and wellbeing of children, families, and communities." EPA Administrator Michael Regan said that the ruling has "ripped the heart out of the law." The Natural Resources Defense Council cited the "incalculable harm" that will come of the decision.

Multiple legal observers predict that the two court rulings in the past year regarding the EPA's authority under the *Clean Water* and *Clean Air Acts* may be the start of a pattern of restrictions on federal authority in the environmental sector. At a time when an immediate response to climate change and chemical pollution is more urgent than ever, these decisions are seen by environmentalists and public health advocates as undermining action necessary for a sustainable future by opening the door to widespread and unrestricted contamination of wetlands and waterways necessary to support life.

SOURCE: U.S. Supreme Court, Sackett v. Environmental Protection Agency, Docket No. 210-454, May 25, 2023.

POLICY | OCTOBER 20, 2023

Take Action Today: Tell EPA To End Pesticide Dependency, Endangered Species Plan Is Inadequate

The U.S. Environmental Protection Agency's (EPA) plan to "protect" endangered species, its *Draft Herbicide Strategy Framework*, continues a legacy of failed risk assessment and mitigation measures that do not meet the moment of looming biodiversity collapse. This is a critical time for the agency to embrace real fundamental change in how it regulates pesticides, recognizing that land management strategies, including in agriculture, exist that are no longer reliant on pesticides. This is not a time to tinker with strategies that EPA admits fall short.

Recognizing that its Pesticide Program has failed to meet its obligation to protect endangered species from registered pesticides, EPA has come up with a strategy to redefine its responsibilities to protect endangered species in its pesticide registration and registration review program. According to EPA, "The proposed Strategy is structured to provide flexibility to growers to choose mitigations that work best for their situation. Additionally, the draft Strategy may require more or less mitigation for growers/pesticide applicators depending on their location."

Understandably, EPA has taken this approach, finding it virtually impossible to meet the statutory obligations of the *Endangered Species Act* (ESA)—given the fact that the agency itself admits, "EPA's Pesticide Program has been unable to keep pace with its ESA workload, resulting not only in inadequate protections for listed species but also successful litigation against the Agency." And, "Even if EPA completed this work for all of the pesticides that are currently subject to court decisions and/or ongoing litigation, that work would take until the 2040s, and even then, would represent only 5% of EPA's ESA obligations."

EPA starts with the position that farmers must use toxic chemicals, an assumption that clouds and undermines the regulatory process and keeps farmers on the pesticide treadmill. EPA says, "Without certain pesticide products, farmers could have trouble growing crops that feed Americans and public health agencies could lack the tools needed to combat insect-borne diseases." This is not true. Organic farmers are not reliant on these pesticides.

EPA recognizes that it needs to fundamentally change. But to EPA, the "fundamental change" means risk mitigation measures that have failed miserably over its history—drift mitigation being one of many key failures. In fact, the fundamental change that is needed is change of agricultural practices that have kept farmers dependent on chemical-intensive practices. Fundamental change requires EPA in every pesticide registration and registration review to ask whether there are practices that can eliminate the harm, not reduce risk with high degrees of uncertainty.

The planet faces an existential biodiversity crisis, with a rising number

of species on the brink of extinction. The goal of ESA is to address the broader issue of biodiversity loss by protecting habitats of species most at risk, or, as stated in ESA, to "Provide a means whereby the ecosystems upon which endangered species and threatened species depend may be conserved, to provide a program for the conservation of such endangered species and threatened species, and to take such steps as may be appropriate to achieve the purposes of the treaties and conventions set forth. . ." in the law.

On the contrary, EPA's language about its proposed changes includes phrases like "draft Strategy may require more or less mitigation for growers/pesticide applicators depending on their location." That is not a plan to avoid biodiversity collapse.

Pesticide use is a major cause of declining biodiversity, which is manifested in extinctions, endangered species, and species vulnerable to environmental disturbances—including climate change, habitat fragmentation, and toxic chemicals. If EPA is serious about protecting biodiversity, it must look first to the ways it has created the crisis in the first place. Yet EPA admits the limitations of its own proposal, saying, "The scope of this document is limited to spray drift, aqueous runoff, and runoff of sediment-bound residues (erosion)." Moreover, EPA fails to recognize that the agency does not have toxicological data for key endpoints or health outcomes like endocrine disruption, an effect that can wipe out a species by undermining its ability to reproduce.

Pesticides are a major contributor to the loss of insect biomass and diversity known as the "insect apocalypse," posing a threat to life on Earth. EPA's registration of insecticides has always endangered insects, but herbicides destroy the food and habitat of insects. Similarly, pesticides threaten food webs in aquatic and marine environments.

Pesticides threaten frogs and other amphibians in a way that demonstrates the potential to warp the growth and reproduction of all animals. Agricultural intensification, in particular pesticide and fertilizer use, is the leading factor driving declines in bird populations. Industrial agriculture eliminates habitat—either through outright destruction or through toxic contamination. In much of the U.S., agricultural fields are bare for half the year and support a single plant species for the other half. As opposed to industrial agriculture, organic producers are required to conserve—protect and increase—biodiversity.

In other words, a major reason that species are endangered is that EPA has registered pesticides that harm them. If EPA is to really protect endangered species, it must eliminate the use of toxic pesticides and encourage organic production.

SOURCE: U.S. Supreme Court, *Sackett v. Environmental Protection Agency,* May 25, 2023.

POLICY | NOVEMBER 3, 2023

States Step In To Restrict Bee-Toxic Pesticides, California the Latest in Absence of EPA Action

California joined 10 other states that have laws partially restricting use of bee-toxic neonicotinoid (neonic) insecticides with the enactment of CA AB 363 into law in October, 2023. California's new law will ban over-the-counter sales of lawn and garden neonics by 2025, limiting their use to licensed pesticide applicators. The legislation gives the state's Department of Pesticide Regulation (CA EPA) until June 30, 2029 to take broader action on neonics, if it determines restrictions are necessary. CA 363 will take neonics out of the hands of homeowners, while allowing lawn care companies to continue use. The California law falls short of the strongest state laws in Nevada, New Jersey, and Maine that eliminate all outdoor (nonagricultural) uses of these chemicals, even by lawn care companies. In June 2023, Nevada became the third state to ban lawn and garden uses of neonics, while Colorado prohibited homeowner use of land and garden neonic products, similar to laws in Maryland, New York, Massachusetts, Rhode Island, and Vermont. Minnesota recently banned neonic use on state lands and granted its home rule subdivisions the authority to ban "pollinator-lethal pesticides" (those with bee warning labels) under its state law preempting local authority to restrict pesticides. All of these state-level restrictions pale in comparison to the robust protections currently implemented in the European Union (EU), where the EU has banned neonicotinoid pesticide use on all outdoor areas, allowing use only in enclosed greenhouses.

The actions of the 11 states acting on neonics and asserting their authority in the absence of action by the U.S. Environmental Protection Agency (EPA) are positive steps, but fall short of meeting escalating and devastating health, biodiversity, and climate crises that are linked to neonicotinoids and other petrochemical pesticides and fertilizers. Evaluating individual hazardous pesticides has been dubbed a process of the "whack-a-mole." Professor and author David Goulson, PhD, who studies the enormity of the pollinator and biodiversity crisis, author of Silent Earth: Averting the Insect Apocalypse (2021),

and speaker at Beyond Pesticides' September National Forum Series (2023), urges a rejection of this "whack a mole" approach in favor of a systemic change to stop all pesticide and synthetic chemical use. The solution, he said, can be found in a systems approach like organic land management; it is effective and will safeguard pollinators, food production, wildlife, water quality, and the environment, while reducing risks to human health.

Beyond Pesticides advocates for the transition from chemical dependency to organic land management in food production, and in parks, playing fields, and all recreational and public spaces. "We urge elected officials nationwide to see the looming biodiversity collapse as reason for broader action to eliminate petrochemical pesticides and fertilizers with organic systems that are effective and cost competitive," said Jay Feldman, executive director of Beyond Pesticides. "Each ban or partial regulation of a particular pesticide, each bit of research demonstrating harms—these represent small, incremental advances on a pesticide problem that is vast in scope and requires a shift to organic," says Mr. Feldman.

Neonics more toxic than DDT

Dr. Goulson said, "One of the properties of neonicotinoids is that they are phenomenally toxic . . . you certainly heard of DDT. Imidacloprid . . . is much, much more toxic than other insecticides that went before. It takes just four nanograms . . . to kill a bee," making imidacloprid and this new generation of insecticides about 7,000 times more poisonous to a honey bee than DDT. "That means that a teaspoon of imidacloprid would be enough to kill one and a quarter billion honey bees. So the fact that we are applying hundreds of tons of these chemicals to the landscape is quite concerning."

Treated seeds loophole remains (CA 1042 and NY Birds and Bees Protection Act)

California Governor Gavin Newsom declined to sign into law AB 1042, which could have taken a modest step toward addressing the neonic-treated seeds loophole that allows neonic-coated seed to go unregulated by either EPA or state regulatory agencies, despite proven deadly effects and well documented harm to biodiversity, human health, and widespread contamination of groundwater and surface waters. The New York State Assembly passed a similar bill (A03226), the *Birds and Bees Protection Act*, that awaits NY Governor Kathy Hochul's signature. [The bill was amended and signed by the Governor at the end of 2023.] The NY bill would ban neonicotinoid use on outdoor ornamental plants and turf, with a general exemption for agriculture, except for treated seeds [to be regulated by 2029]. The coated seed provision of the act would be suspended if the Commissioner of Agriculture determines that neonic-free seeds are not commercially available. With chemical companies controlling the seed market, the effectiveness of this provision remains to be seen. A phaseout of treated seeds would incentive and help grow the neonic-free seed market. The bill would leave the most widely used neonicotinoid, imidacloprid, as well as thiamethoxam or acetamiprid, on the market until July 1, 2025. [For update on final bill, see Bill to Protect Birds and Bees in New York Raises Political Challenges to Addressing Ecosystem Collapse.]

Meanwhile, the intensive use of neonics as seed treatments continues despite a stark lack of efficacy. EPA itself (in 2014) reported that "seed treatments with neonicotinoid insecticides provide little or no overall benefit in controlling insects or improving yield

or quality in soybean production." (See the detailed EPA letter on the underlying research here.) Research in 2019, as reported by Beyond Pesticides, found that neonic-treated soybeans provide negligible benefits to farmers in terms of yield and overall economic benefit. EPA ought, in its neonic registrations and reregistration, to evaluate whether pesticide compounds—especially those with such demonstrated harms as neonics cause—are necessary and effective before introducing them into the environment or allowing their continued deployment.

Minnesota took a small step in regulating pesticide-treated seeds, including neonicotinoid coated seeds, and their disposal, after treated seeds were used in ethanol production, creating toxic waste with disastrous consequences. Because of a regulatory loophole, EPA does not monitor or otherwise regulate treated seed use and disposal. In the absence of any federal regulation, Minnesota laws HF1317/ SF1339 will now direct state officials to develop rules and consumer guidelines for the proper use and disposal of "waste" pesticide-treated seeds.

Because the use of neonics is widespread, from agriculture to parks, playing fields, to lawns, public exposure is dramatically high. As reported in January, the Centers for Disease Control and Prevention (CDC) cites half the U.S. population encountering at least one type of neonic daily, with children ages three to five having the highest exposure risk. Health impacts of exposure to neonics can include neurotoxicity, reproductive anomalies, hepatic and renal damage, and an increase in gene expression linked to hormone-dependent breast cancer . . . mounting evidence over the past years shows that chronic exposure to sublethal (low) levels of pesticides can cause neurotoxic effects or exacerbate preexisting chemical damage to the nervous system. The impacts of pesticides on the nervous system, including the brain, are hazardous, especially for chronically exposed individuals (e.g., farmworkers) or during critical windows of vulnerability and development (e.g., childhood, pregnancy).

Pollinator losses have broad implications for reducing the global production of nuts, fruits, and vegetables by 3–5 percent, and this loss of healthy, nutrient-dense food is resulting in over 425,000 excess deaths each year, according to research published in December 2022 in Environmental Health Perspectives. According to researchers, "Today's estimated health impacts of insufficient pollination would be comparable to other major global risk factors: those attributable to substance use disorders, interpersonal violence, or prostate cancer." The availability of nontoxic alternative materials and practices, as are used in organic management, raises questions about EPA's determination that neonic use is "reasonable" for registered crops under federal pesticide law, given competitive productivity and profitability without it. Beyond Pesticides advocates for organic land and agriculture management as precautionary approach to pest prevention and management.

SOURCE: American Bird Conservancy, Failing to come to grips with a predictable environmental disaster, June 2023.

MORE ON THIS SUBJECT

Calling for Reform of Pesticide Regulation to Address Health, Biodiversity, and Climate Crises—January 9, 2023

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Protect Bees, Trees, You and Me This Earth Day 2023—April 20, 2023

Take Action: U.S. Geological Survey Critical to Pesticide Monitoring and Regulatory Action—May 1, 2023

Colorado Limits Bee-Toxic Pesticide Use, as EPA Details Harm to Endangered Species—May 9, 2022

Groups Announce Intent to Sue Fish and Wildlife Service Over Failure to Protect Manatees—May 16, 2023

Take Action: Pesticide Restrictions Do Not Match EPA Rhetoric to Protect Endangered Species—May 30, 2023

Take Action: Pesticide Restrictions Do Not Match EPA Rhetoric to Protect Endangered Species—May 30, 2023

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National Pollinator Week 2023—Preserve and "BEE-Protective" of Pollinators!—June 20, 2023

A Reminder for Pollinator Week: Protect Pollinator and Habitat and Well-Being Against Dramatic Declines—June 21, 2023

Take Action: The Protection of Birds Linked to Mosquito Management—July 3, 2023

Advocates and Scientists Urge that USGS Pesticide Data Program Be Elevated, Not Eliminated as Proposed —July 25, 2023

Insufficient Scientific Evidence on Mitigation Measures to Protect Pollinators from Pesticides, Study Finds—July 27, 2023

Beyond Pesticides Celebrates the 50th Birthday of the Endangered Species Act—Please add a date.

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Confronting Dramatic Biodiversity Loss on 50th Anniversary of Endangered Species Act—October 2, 2023

Take Action Today: Tell EPA to End Pesticide Dependency, Endangered Species Plan Is Inadequate—October 20, 2023

PEST RESISTANCE and FAILED EFFICACY

RESISTANCE | AUGUST 2, 2023

The Growing Insecticide Resistance Issue Increases Concerns Over Deadly Disease Transmission Through Mosquitoes

A study published in *Pest Management Science* finds resistance to insecticides like pyrethroids are challenging attempts to control the mosquito *Aedes aegypti* (*Ae. aegypti*), the primary transmitter (vector) of dengue fever. While this study takes place in Bangladesh, resistance to biocides—whether to antibiotics, antimicrobials, or pesticides—is growing globally. Prevention of disease outbreaks is threatened by reliance on chemical biocides to which pathogens and their vectors develop resistance. In fact, resistance is predicted by elementary population genetics, and the speed of its evolution is directly related to the toxicity—that is, the strength of selection pressure—and inversely related to the generation length of the organism. (See PAY articles here and here, a PBS article here.)

Insecticide resistance has been an issue since the introduction of DDT (dichlorodiphenyltrichloroethane) in the 1940s. Although most countries currently ban DDT use, the compound is not the only chemical pesticide promoting pest resistance. Several current-use insecticides pose the same threat. Areawide, indiscriminate spraying of insecticides is causing resistance to develop among many pests. Mosquitoes have become increasingly resistant to synthetic pyrethroids, in addition to other classes of insecticides, such as carbamates and organophosphates. Thus, this study demonstrates the need for sustainable and practical strategies to combat the growing disease burdens.

The study notes, "Intensive use of pyrethroids in Dhaka has selected for highly resistant mosquito populations, which was confirmed through bioassays. This pyrethroid resistance is associated with high frequencies of the *V1016G kdr* mutation and activities of detoxifying enzymes. As evidenced from our free-flight experiments, the effective operational use of pyrethroids in control programs is compromised and, therefore, requires reconsideration. […] Ultimately, scalable and sustainable non-insecticide-based approaches such as Wolbachia-based population replacement could have an important role in curbing Aedes-borne diseases in Bangladesh."

Researchers from the QIMR Berghofer Medical Research Institute, Australia, examined the common insecticides used in Dhaka, Bangladesh, to determine the mechanisms and intensity of insecticide application driving resistance. The pyrethroid insecticides tested include permethrin and deltamethrin. Using a bottle assay, the research measures the mortality percentage of mosquitoes after insecticide exposure. The study finds *Ae. Aegypti* mosquito colonies display significantly higher levels (high-intensity) of resistance to pyrethroids. Although the mortality rate of mosquitoes exposed to permethrin is much lower than deltamethrin (2–24 percent mortality and 48–94 percent mortality, respectively), the metabolic mechanisms involved are the same. Specifically, responses to the synergistic reaction between pyrethroids induce multifunction oxidases, esterases, and

glutathione S-transferases. Moreover, a high frequency of knockdown resistance (kdr) alleles for resistance indicates a V1016G mutation, conferring resistance to deltamethrin. Although exposure can replace host-seeking behavior, this effect is only temporary. Since over 74 percent of mosquitoes from colonies in Dhaka survive initial exposure to pyrethroids, increased disease prevalence is likely.

Associate Professor Gregor Devine, PhD, at the Mosquito Control Laboratory, said, "'The use of pyrethroids in Dhaka is no longer effective, and the control program needs to switch to a different approach. The study suggests the presence of high levels of insecticide resistance among *Ae. aegypti* populations may have contributed to the escalating dengue burden."

This study is part of an all too familiar phenomenon of resistance among pest populations. Scientists note that resistance is an entirely normal, adaptive phenomenon: organisms evolve, "exploiting" beneficial genetic mutations that give them a survival advantage. However, resistance is growing in all sectors of pest control, including agriculture and medicine. For nearly a century, the chemical industry response to resistance is the development of a compound that kills the resistant organism (whether insect or weed or bacterium or fungus), which works for a while. However, the dependence on chemical solutions is increasingly failing. Whether it is antibiotics for bacterial infections, herbicides for weeds/pests, or insecticides to mitigate vector-borne diseases, organisms are becoming resistant to usually toxic compounds. Once an organism inevitably becomes resistant to a particular chemical control strategy, people—the chemical industry, researchers, applicators, farmers, public health workers, clinicians, et al.—will have typically moved on to the subsequent chemical "solution." Pesticide Action Network North America (PANNA) notes, "The World Health Organization underscored the problem in their 2012 guidance on policymaking for Integrated Vector Management (IVM): 'Resistance to insecticides is an increasing problem in vector control because of the reliance on chemical control and expanding operations.... Furthermore, the chemical insecticides used can have adverse effects on health and the environment.'"

Beyond Pesticides has written extensively on the issue of resistance, particularly the relationship to the use of agricultural and other land management pesticides, with the central message: resistance is a symptom of the ineffectiveness of chemical-intensive agriculture and leads to increased use of more and more toxic pesticides. In addition, resistance in one of the "sectors" mentioned above can "crossover" to become problematic in another. Growing pesticide resistance often leads to an increase in chemical inputs to control pests. Exposure to permethrin already has implications for human health, including cancer, endocrine (hormone) disruption, reproductive dysfunction, neurotoxicity, and kidney/liver damage. Mosquito resistance can lead to the increased 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. Therefore, researchers need to understand the mechanisms prompting pesticide resistance among mosquito populations to safeguard human health from disease.

The use of permethrin and deltamethrin through fogging and aerial application plays a significant role in the high intensity of resistance among the *Ae. aegypti* colonies from Dhaka. The study highlights that pyrethroids act on the nervous system of insects, using a "knockdown" effect to cause death. Although this study suggests mosquitoes can recover from the knockdown (KD) effect via a mutation in the kdr alleles, this KD effect is dose-dependent. Thus, pyrethroid increases the frequency of kdr mutation to prompt resistance. The study highlights, "[...] the substantial recovery seen after KD suggests poor binding of the pyrethroid to the mutated VGSC and a key role for metabolic mechanisms in 'mopping up' the pyrethroids."

This study is not the first to demonstrate metabolic mechanisms driving genetic resistance among mosquito populations. A Colorado State University study finds two types of pyrethroid resistance: VGSC and detoxification metabolism. Similar to this study, the Colorado researchers suggest mosquitoes who recover from the initial insecticide knockdown contribute to resistance in the field. Sublethal exposure may be responsible for the mosquito's ability to recover. Rather than dying from dehydration and predation, recovery mechanisms allow mosquitoes to develop resistance over time. This study enables researchers to fully understand the genetic differences between mosquitoes who exhibit resistance and those who recover or die. Knowing how genes factor into pesticide metabolism can help researchers understand how resistance evolves under field-realistic conditions. Therefore, it is essential to understand insect behavior that increases vector-borne disease transmission, exacerbating the widespread public health crisis.

In the context of deadly pesticide use in developing countries, Jay Feldman, executive director of Beyond Pesticides, has noted, "We should be advocating for a just world where we no longer treat poverty and development with poisonous band-aids but join together to address the root causes of insect-borne disease because the chemical-dependent alternatives are ultimately deadly for everyone." He also said, "We should focus on the deplorable living conditions and inequitable distribution of wealth and resources worldwide that give rise to squalor, inhumane living conditions, and the poor state of development that, together, breed insect-borne diseases like malaria."

Even if dengue is not a local concern, there remains general concern surrounding the diseases mosquitoes can transmit, including the West Nile and Zika viruses. Beyond Pesticides provides valuable information on mosquito management and insect-borne diseases in the Mosquito Management and Insect-Borne Diseases section devoted to these issues. Keep up on pesticide-related science and news, including mosquitoes and pesticide resistance, on Beyond Pesticides' *Daily News*.

SOURCE: Hasan Mohammad Al-Amin, et al., Insecticide resistance compromises the control of *Aedes aegypti* in Bangladesh, Pest Management Science, 2023;79: 2846–2861.

RESISTANCE | OCTOBER 17, 2023

Paris's Worrying Bed Bug Surge Linked to Insecticide-Resistance

In the past month, Paris, France has witnessed a surge in bed bug populations. From public transportation to hotels, hostels, and movie theatres, bed bugs are posing a threat to the city's two million residents and potentially a broader global population as the infestation spreads.

This resurgence of bed bugs in Paris is not unique. For centuries, these pests have been both adaptable and persistent, presenting an enduring challenge to pest control. However, the current surge in bed bug infestations is not merely a revival of a longstanding problem; it is a complex issue intertwined with the development of resistance to insecticides, mainly through a mechanism known as knockdown resistance. This mechanism, along with three other main resistance mechanisms, has enabled these insects to defy chemical-intensive control methods. Knockdown resistance is a significant factor contributing to the resistance exhibited by bed bugs to insecticides, especially pyrethroids. The mechanism plays a central role in countering the action of these insecticides, which target the nervous system of bed bugs, causing paralysis and eventual death. Knockdown resistance provides the genetic adaptation that provides bed bug populations with resistance to insecticides, inhibiting the effectiveness of certain insecticides. Bed bugs with the mutation have a genetic advantage that allows them to survive exposure to these chemicals.

Insecticides have been utilized to quell bed bug populations for over a century, with DDT initially used to combat these pests before the 1950s. By 1956, the effectiveness of DDT in controlling bed bug populations began to diminish, as the insects developed resistance to the once-potent chemical. The repetitive exposure of bed bugs to DDT led to the survival of bed bugs with genetic mutations that allowed them to survive DDT exposure, giving rise to newer generations with the same mutations.

The banning of DDT in 1972 compelled the United States to turn to organophosphates and, more recently, the commonly used pyrethroids—synthetic insecticides widely used for residential pests. However, there was an unforeseen consequence of DDT resistance: bed bugs with DDT resistance demonstrated resistance to other pesticides, including pyrethroids, even if they had never encountered pyrethroids. This phenomenon, known as cross-resistance, paved the way for a global resurgence of bed bugs and posed challenges for pest control worldwide.

Knockdown resistance is linked to the voltage-gated sodium channels (VGSC) within a bed bug's nervous system. These channels serve as conduits for transmitting electrical signals, enabling nerve cells to communicate and control the bug's movements. Knockdown resistance arises from mutations within the VGSC gene.

Scientists have identified three specific mutations in the common bed bug, *Cimex lectularius:* V419L, L925I, and 1936F. In modifying the function of sodium channels, these mutations make the insect less responsive to the effects

of pyrethroid insecticides. As a result, the nerve cells of resistant bed bugs can continue to function despite exposure to these chemicals.

Research has revealed that knockdown resistance is prevalent in bed bug populations, particularly those closely linked to human environments. Most bed bug populations associated with human environments exhibit the L925I mutation, which equips them with resistance to pyrethroids.

This widespread distribution of knockdown resistance raises concerns about the continued use and efficacy of pyrethroids in treating infestations. Bed bugs with knockdown mutations possess the capacity to withstand exposure to insecticides, reducing the effectiveness of these treatments. As a result, infestations persist, inflicting discomfort, economic burdens, and health concerns upon those affected.

Moreover, bed bug resistance to insecticides has extended to new classes of insecticides. The developing resistance of bed bugs to neonicotinoid insecticides raises similar questions about chemical-dependent control strategies for infestations. Research has found that neonicotinoids, once thought by the pest control industry to be the silver bullet solution for bed bug infestations, are losing their efficacy as bed bugs from different regions are becoming resistant to them.

In a study led by Alvaro Romero, PhD and Troy Anderson, PhD, bed bugs collected from homes in Cincinnati and Michigan were exposed to four different neonicotinoids: acetamiprid, dinotefuran, imidacloprid, and thiamethoxam. The study also tested these neonicotinoids on bed bugs that had never been exposed to insecticides. They found that bed bugs previously exposed to neonicotinoids show higher levels of resistance to these insecticides, when compared to the levels of resistance exhibited by the bed bugs that had never been exposed to the neonicotinoids. It took over a thousand times more acetamiprid to kill half of the bed bug population with prior exposure to neonicotinoids, as opposed to the population that had never been exposed to neonicotinoids. This means the bed bugs in the Michigan and Cincinnati study proved to be hundreds or even thousands of times more resistant to neonicotinoids compared to the lab control group.

As insecticide usage continues in response to growing issues of invasive species migration and insect infestations, the infestation problem will only grow worse. The situation in Paris is just one example of what is to come if pesticide dependency continues. The best method for handling infestations is by skipping the chemicals and following a defined integrated pest management system that prioritizes ecologically balanced solutions, and only allows organic-compatible products.

SOURCE: Ondřej Balvín and Warren Booth, Distribution and Frequency of Pyrethroid Resistance-Associated Mutations in Host Lineages of the Bed Bug (Hemiptera: Cimicidae) Across Europe, *Journal of Medical Entomology,* Volume 55, Issue 4, July 2018, Pages 923–928, https://doi.org/10.1093/jme/tjy023.

MORE ON THIS SUBJECT **Regulators Ignore Mosquito Resistance to Pesticides, Promoting Disease Transmission**—August 7, 2023

RESISTANCE | OCTOBER 30, 2023

Despite a Beetle's History of Resistance to Insecticides, EPA Is Pushing Genetically Engineered Pesticide

It is said that the definition of insanity is doing the same thing over and over again and expecting a different result. And so it goes with the U.S. Environmental Protection Agency's (EPA) proposal to register a new genetically engineered pesticide for the Colorado Potato Beetle (CPB); this time with a pesticide that has not been fully evaluated for its adverse effects to people and the environment.

Chemical-intensive agriculture has failed to control CPB since resistance to DDT was identified in 1952 and has continued with every family of pesticides since then. CPB has been dubbed the billion-dollar-bug because of the investment in failed attempts of chemical manufacturers to control the insect, the profits generated by chemical companies despite this failure, and the resulting losses for chemical-intensive farmers—not to mention government expenditures for the registration of chemicals that have short efficacy, pollution costs associated with chemical production and use, and lost ecosystem services. But EPA is at it again, registering a new novel pesticide active ingredient, Ledprona, which raises the stakes on potential harm. The only winners in this ongoing failure are the chemical

The Colorado potato beetle has been dubbed the billion-dollar-bug because of the investment in failed attempts of chemical manufacturers to control the insect, the profits generated by chemical companies despite this failure, and the resulting losses for chemical-intensive farmers.

manufacturers that continue to reap huge economic benefits from the sale of their highly toxic pesticides.

Meanwhile, according to research published in Molecular Biology and Evolution (2022) and hundreds of other scientific articles over the years, "This is the case with insect "super-pests," which repeatedly evolve insecticide resistance even as they are faced with completely novel insecticides, thus perpetuating the arms race that defines the pesticide treadmill." And yet EPA is still at it, despite the success of alternative strategies with organic management systems.

While researchers and the chemical industry keep trying to develop new "silver-bullet" chemicals for controlling CPB, EPA has ignored methods of agricultural management that work without reliance on toxic chemicals. Environmental advocates say that this newest proposed pesticide exemplifies the worst of EPA's pesticide registration program, governed by its Office of Pesticide Programs, because there are alternative methods and the risks of Ledprona have not been found to be "reasonable"—under a weak federal pesticide law, the *Federal Insecticide, Fungicide, and Rodenticide Act* (FIFRA).

The University of Minnesota Extension, in its publication "Organic management recommendations for Colorado potato beetle," describes the range of methods that are integrated into an organic systems approach not reliant on pesticides. It includes crop rotation, early maturing varieties, mulching systems and habitat for natural enemies like ladybugs and parasitic wasps, trapping, and a naturally occurring soil bacterium.

FIFRA requires that EPA register a pesticide only if it determines that the pesticide "will perform its intended function without unreasonable adverse effects on the environment." EPA admits that it is basing its proposed registration decision solely on data the registrant GreenLight Biosciences submitted to fulfill requirements for its prior application for an experimental use permit (EUP), without any additional data. However, there are far fewer data requirements for approval of an EUP than are required for a full registration.

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Ledprona's use of RNAi makes it unique and unlike any other insecticide sprayed on fields. The use of new technology makes it especially imperative to examine all required data for any potential unintended consequences. Since these novel pesticides may be applied by plane, EPA should thoroughly assess the real-world impacts of pesticide drift. This technology, which penetrates plant tissues and leaves traces in the soil, can cause widespread indiscriminate poisoning—as has been seen with bees, butterflies, birds, and the larger catastrophic decline of insect populations, called the "insect apocalypse." The effects, especially on threatened and endangered species like the American burying beetle, Hungerford's crawling water beetle, the Northeastern beach tiger beetle, and the Puritan tiger beetle, must be evaluated. These species are found near potato production areas close to where the Experimental Trials were being conducted and could be

direct casualties of this new biopesticide.

It should be noted that the EPA's definition of "biopesticide" is broad and includes genetically engineered organisms. EPA says, "Biopesticides are certain types of pesticides derived from such natural materials as animals, plants, bacteria, and certain minerals. . . . Biopesticides include naturally occurring substances that control pests (biochemical pesticides), microorganisms that control pests (microbial pesticides), and pesticidal substances produced by plants containing added genetic material (plant-incorporated protectants) or PIPs."

In addition, researchers from the U.S. and Switzerland have published findings, a beginning assessment of how the use of this new category of pesticides—RNAi, delivered in double-stranded RNA (dsRNA) molecules—might impact soils and nontarget microorganisms in the soil. The coauthors (Kimberly M. Parker, PhD, et al.) note that, "The ecological risk assessment of these emerging pesticides necessitates an understanding of the fate of dsRNA molecules in receiving environments, among which agricultural soils are most important." Their research has continued, finding that "Due to the ability of DOM (dissolved organic matter) to both bind and suppress the enzymatic degradation of RNA, RNA biodegradation may be slowed in environmental systems with high DOM concentrations, which may increase its persistence."

SOURCES: Benjamin Pélissié, et al., Genome Resequencing Reveals Rapid, Repeated Evolution in the Colorado Potato Beetle, *Molecular Biology and Evolution*, Volume 39, Issue 2, February 2022, msac016, https://doi.org/10.1093/molbev/msac016.

MORE ON THIS SUBJECT

Insecticidal Bed Nets Contribute to Resistance in Bed Bug Populations—January 5, 2022

Scientists Zero In on "Rapidly Evolving" Human Pathogenic Fungi, May Be Tied to Widespread Fungicide Use—May 10, 2023

Pollution-Associated Liver Disease with Sex-Specific Effects Linked to Persistent Legacy Insecticide, Chlordane—October 4, 2023

Insecticide-Resistant Mosquito Sets Africa's Malaria Fight Back to Square One—October 10, 2023

RESISTANCE | OCTOBER 27, 2023

EPA To Allow Genetically-Based Pesticides, Incomplete Testing, and Documented Adverse Effects

In a predictable move, EPA proposes to greenlight a type of genetic engineering to solve a problem created by the industrial paradigm for pest control, i.e. vast acreages of monoculture treated with millions of tons of toxic pesticides leading to rapid resistance among crop pests. In this case EPA wants to approve using a nucleic acid—double-stranded RNA (dsRNA)–called "interfering RNA," or RNAi—to silence a gene crucial to the survival of the Colorado Potato Beetle (CPB), the scourge of potato farmers around the world. But EPA has skipped over important steps in its decision-making process and rushed to judgment.

Like chemical pesticides, genetically-based pesticides are regulated under the *Federal Insecticide, Fungicide, and Rodenticide Act* (FIFRA). In 2020, Massachusetts-based GreenLight Biosciences applied for registration of its RNAi active ingredient, Ledprona, and its end-use product, Calantha. The company executive heading the effort is an alumnus of Monsanto and several other major chemical companies. Last May EPA, granted GreenLight an Experimental Use Permit (EUP) authorizing field studies in states that produce tons of potatoes. A mere five months later, EPA announced its decision to approve the registration based almost entirely on incomplete EUP data and giving the public very little time to comment.

Formally titled "Colorado Potato Beetle (CPB)-specific recombinant double-stranded interfering Oligonucleotide GS2 *Leptinotarsa decemlineata*," Ledprona disrupts an RNA process inside cells to block expression of a particular CPB gene. This prevents the gene from specifying an important protein. When a CPB ingests Ledprona on a potato leaf, the RNAi nucleotide spreads into the cells of the beetle's gut. The cells die, which shortly kills the beetle.

Unfortunately, dsRNA molecules may wander from their intended targets. Inside a cell, the long dsRNA strand gets clipped into small pieces called siRNAs ("small interfering RNAs"), whose configuration may also align with many other sections of a genome and affect nontarget genes, with entirely different effects. One experiment with interfering RNA found complete matches in 17 percent of off-target sequences. Neither EPA nor Greenlight has addressed this risk.

According to EPA's Environmental Risk Assessment (ERA), Greenlight intends Calantha to be applied in ground spray, aerial spray, and in irrigation water—in other words, very broadly, and in a manner that will inevitably entail some spray drift.

The Center for Food Safety (CFS) prepared a blistering comment to EPA noting the agency's extreme disregard for both known biological processes and the unknowns of losing a novel piece of cellular machinery into the

wild. According to the CFS, the EUP field trials granted to Greenlight remain incomplete and will not expire until April 30, 2025, yet EPA admits that its approval of Ledprona and Calantha relies solely on data Greenlight submitted with its application for the EUP–whose data requirements are considerably lower than those for new use approvals. FIFRA requires, for example, data on toxicity to fish, birds, and plants. GreenLight has not provided that data so far.

EPA assumes that only organisms that resemble the CPB might be susceptible to Ledprona's interference with their cellular machinery. EPA states that "there is a reasonable expectation of no discernible effects to occur to any non-coleopteran nontarget organisms exposed to Ledprona.... EPA analysis also examined the 19 federally listed threatened and endangered ('listed') beetle species and determined that no exposure is expected for 15 of the 19 federally listed threatened and endangered ('listed') beetle species from a section 3 registration of Calantha containing Ledprona." (The CPB, in the order Coleoptera along with 400,000 other beetle species known to science. Many coleopterans provide beneficial services.)

We can expect more pesticide products to be based on genetic processes such as RNAi's regulation of gene expression as farmers and chemical companies get more desperate with each passing report of pests' ability to evade pesticides. It is unsurprising that the CPB is an early target because it is notorious for its rapid development of resistance.

Additionally, EPA says, "Physiological barriers are present within vertebrate species that prevent the dsRNA such as Ledprona from reaching and penetrating the gut in vertebrate species." Given the unpredictable alignments of the small interfering RNAs in a genome, this too is an iffy assumption. The CFS comment notes that, although EPA has not provided any information to the public about Ledprona's nucleotide length, that data is an important factor in assessing the product's potential toxicity. EPA has designated the dsRNA in Ledprona as "non-coding," which it takes to mean that it would not function in a human body, but, in fact, nobody knows whether or how many such "long, non-coding RNAs" function in many species. What *is* known, according to CFS, is that human innate immune systems respond to such sequences, which often come from viruses or from the body's own damaged cells, with inflammation.

We can expect more pesticide products to be based on genetic processes such as RNAi's regulation of gene expression as farmers and chemical companies get more desperate with each passing report of pests' ability to evade pesticides. It is unsurprising that the CPB is an early target because it is notorious for its rapid development of resistance. Currently it is resistant to more than 50 pesticides.

In the long run CPB will win. It is already ahead. In 2021, a research team, three of whom are employed by Monsanto, found that CPB "can develop high levels of resistance against insecticidal dsRNA" when the dsRNA is applied to leaves. The study also found that the dsRNA affected more than one gene. Various analyses of

CPB's response to a range of doses led the scientists to conclude that, after a few generations, resistance to dsRNA reached 11,100 times that of the founding generation of beetles. The researchers attributed CPB's virtuosic ability to resist pesticides partly to the beetle's highly flexible and transposable genetic elements. This indicates that creating precise and effective products using genetics is fraught with risks. A plain hydrocarbon molecule is understood vastly better than the interplay of the trillions of genes in the world.

Pesticide resistance was first noted in 1914, but the industry still fails to recognize that it cannot bet against the house. To cope with the inevitable triumph of natural selection, pesticide manufacturers are promoting the use of dsRNA products in combination with traditional pesticides, with the idea that their mechanisms of action will alternate and prevent pests from adapting. Combining pesticides with RNA interference can be framed as part of "integrated pest management," although as a 2018 review in *Science* noted, the notion that "such combinations will slow [the development of] resistance is theoretically controversial and lacks empirical support."

Beyond Pesticides chronicled in 2019 the promotion of interfering dsRNA technologies by pesticide companies despite the recognition that their effects on nontarget organisms cannot be predicted.

"With the allowance of gene-manipulating RNAi pesticides, EPA is repeating a pattern of allowing uncertainty that has historically resulted in serious unexpected and uncontrolled hazards, despite the availability of organic practices and products that are currently available," said Beyond Pesticides' executive director, Jay Feldman. Mr. Feldman continued: "The agency has failed to fully evaluate the fate of genetic material and its degradation products on nontarget species and the likely potential for indiscriminate poisoning. We are calling for a moratorium on RNAi pesticides until these questions can be fully answered."

An expert at another federal agency once observed that it is not a good idea to rely on "a conclusion drawn from a consensus" rather than from empirical evidence when making important decisions. In this case, EPA has done exactly that, mistaking suppositions for facts. EPA's decision rests on a foundation of uncertain assumptions, many of which are implicit in EPA's evaluation rather than explicitly enumerated, and whose reliability EPA did not examine.

SOURCES:

EPA Opens Public Comment Period on Proposal to Register Novel Pesticide Technology for Potato Crops, https://www.epa.gov/pesticides/epa-opens-public-comment-period-proposal-register-novel-pesticide-technology-potato

Environmental Risk Assessment for a FIFRA Section 3 Registration of the New Product GS2 Formulation (Calantha) Containing Ledprona, https://www.regulations.gov/document/EPA-HQ-OPP-2021-0271-0006

Human Health Risk Assessment, Review of Product Characterization and Manufacturing Process for the New end-use product, Calantha Human Health Risk Assessment, Review of Product Characterization and Manufacturing Process for the New end-use product, Calantha, https://www.regulations.gov/document/EPA-HQ-OPP-2021-0271-0005

POLICY | JANUARY 24, 2023

Legal Case Opens To Stop Antibiotics in Citrus and Advance Organic, Given Resistant Bacteria Crisis

[Eds note: update on court decision—Litigation successfully stopped antibiotic use in Florida citrus in December 2023. However, the decision was reached on EPA failure to comply with the Endangered Species Act not on the issue of antibiotic resistance. Despite the scientific literature on horizontal gene transfer (movement of genes in bacteria from one bacterial species to another) through agricultural use of pesticides, the court found, "EPA emphasized that "there is no data that antibiotic use in agriculture leads to the presence of antibiotic resistance in bacteria of human health concern," and that "[a]t the present time, there is little evidence for or against the presence of microbes of human health concern in the plant agricultural environment." And yet, on May 19, 2019, The New York Times reported, "The agency approved the expanded use despite strenuous objections from the Food and Drug Administration and the Centers for Disease Control and Prevention, which warn that the heavy use of antimicrobial drugs in agriculture could spur germs to mutate so they become resistant to the drugs, threatening the lives of millions of people."]

Oral arguments began in January in a lawsuit challenging the U.S. Environmental Protection Agency's (EPA) approval of the antibiotic streptomycin as a pesticide on citrus crops. Brought forth by a coalition of farmworker, health, and environmental groups, the lawsuit aims to stop the use of a critical medical treatment for agricultural purposes. "Humanity's dwindling supply of medically effective antibiotics is not worth sacrificing for an industry that has safer alternatives avail-able," said Drew Toher, former community resource and policy director at Beyond Pesticides. "Despite the challenges, we know from the elimination of this material in organic production that we don't need antibiotics in order to produce a glass of orange juice."

In 2020, *The Lancet* published an article that identifies several of the

multiple and interacting crises the U.S. and world face, with a focus on another "looming potential pandemic . . . [a] rise in multidrug-resistant bacterial infections that are undetected, undiagnosed, and increasingly untreatable, [whose rise] threatens the health of people in the USA and globally." It calls on leaders in the U.S. and beyond, asking that even as they address the current coronavirus pandemic, they also attend to the antimicrobial resistance (AMR) problem, which is a growing threat to public health. The coauthors outline a number of strategies for progress on AMR, including banning of medically important antibiotics in agribusiness, and promoting consumer, and supplier and private sector, awareness and action on food choices.

The growing threat of antibiotic resistance is a major health care issue. Beyond Pesticides has written, "Many bacterial infections are becoming resistant to the most commonly prescribed antibiotics, resulting in longer-lasting infections, higher medical expenses, the need for more costly or hazardous medications, and the inability to treat life-threatening infections. The development and spread of antibiotic resistance is the inevitable effect of antibiotic use. Bacteria evolve quickly, and antibiotics provide strong selection pressure for those strains with genes for resistance."

EPA registered streptomycin as a tool for citrus growers because it can suppress Huanglongbing (HLB) disease, also known as citrus greening, caused by a bacterial pathogen transmitted by the invasive Asian citrus psyllid. HLB results in citrus fruit becoming green, misshapen, and bitter. The agency also claims streptomycin "will aid resistance management" for citrus canker disease, a contagious pathogen that can be spread by wind, rain and human activity. Once infected, citrus canker is incurable. Growers may use copper pesticides to delay the inevitable, but there is growing concern of resistance to copper compounds.

Data show that over 35,000 Americans die each year because of antibiotic resistant bacteria. And antibiotic-based pesticides present a significant risk to endangered animals in citrus growing regions, like Florida panthers and Joaquin kit foxes, in addition to dwindling pollinator populations.

While both diseases represent legitimate concerns for the citrus industry, it is clear that the answer cannot be to take an important human medical treatment and broadcast spray hundreds of thousands of pounds across upwards of 650,000 acres of U.S. cropland. EPA's shortsighted response may help the industry in the short term, but most of these benefits will be seen not by farmers but top-level executives, with the long-term risk of exacerbating the pre-existing epidemic of antibiotic resistance.

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The health risk of this decision is greatest to the essential workers who manage citrus groves. "The use of streptomycin as a pesticide continues to be an ongoing threat to the health and safety of our farmworkers, who are

at the frontlines of feeding our nation," said Jeannie Economos, coordinator of the Pesticide Safety and Environmental Health Program at Farmworker Association of Florida. "We're urging swift resolution of this case and an end to the misuse of medically important antibiotics within our food systems. Every day of delay means more farmworkers are exposed, putting themselves and their families at risk."

The lawsuit against EPA's decision includes Beyond Pesticides, U.S. Public Interest Research Group, Environment Confederation of Southwest Florida, Farmworker Association of Florida, Farmworker Justice, Migrant Clinicians Network, represented by Natural Resources Defense Council, Earthjustice, and Center for Biological Diversity. Petitioners argue that EPA failed to ensure that the approved uses of streptomycin as a pesticide would not result in unreasonable adverse effects on human health or the environment, and say that EPA failed to adequately assess risks streptomycin poses to endangered species.

EPA's decision puts it at odds with other agencies, as officials with both the Centers for Disease Control and Prevention and the Food and Drug Administration have raised concerns about using medically important antibiotics as pesticides.

Concerns over turning medical treatments into pesticides are not conjecture but borne out of experiences already concerning on the ground. There is significant evidence available now that widespread use of human-important antifungal drugs as antibiotics is resulting in resistance to dangerous fungal pathogens that are now infecting humans. *Aspergillus fumigatus*, a common mold found in soils and composts, has become increasingly virulent to humans.

Between 2000 and 2013, cases of invasive aspergillosis increased 3 percent per annum, and roughly 300,000 worldwide are diagnosed each year. Data show that roughly 20 percent of *Aspergillus fumigatus* samples are resistant to azole fungicides used in agriculture, but also critical for human treatments.

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By finding evidence that the same infections strains of *Aspergillus fumigatus* were also resistant to non-azole agricultural fungicides, scientists provided a direct link from hospital infections to on-farm fungicide applications. In the same vein, the emerging fungal pathogen *Candida auris* displays 90 percent of infections resistant to one drug, and 30 percent to two or more, with this resistance tracing back to farm use.

Nearly 10 years ago, Beyond Pesticides' galvanized action on the National Organic Standards Board to eliminate the use of antibiotics like streptomycin in organic apple and pear production. At issue was the destructive bacterial disease fire blight, which can turn blossoms, leaves, twigs, and branches of affected trees black, having the appearance of being hit by fire. Despite the challenges, farmers were able to transition to resistant varieties and craft system management plans to better address outbreaks without resorting to antibiotic use.

Unlike the challenge to organic apple and pear growers, chemical-based citrus farmers already have proof of concept that citrus crops can be grown to market without the use of medically important antibiotics. Organic citrus farmers are prohibited from employing not only antibiotics, but other toxic pesticides such as the systemic neonicotinoids that are often used on chemical-intensive farm operations. Organic growers like Uncle Matt's in Florida discuss the importance of breeding programs for tolerant rootstock, the use of botanical insecticides such as neem and clove oil, and the release of the biological control agent Tamarixia wasps, which feed on Asian Citrus Psyllids. Watch Uncle Matt's Benny McClean, production manager, speak about organic citrus production in Florida at Beyond Pesticide's 33rd National Pesticide Forum.

While the organic approach shows the wisdom and value of organic's drive toward "continuous improvement," EPA's response to industry executives crowing about the potential for declining profit margins represents a short-sighted, knee-jerk reaction. There is no need to steal from our health future to protect the inability of the citrus industry to responsibly manage its problems; what's needed is a strategy that represents a long-term investment in the future of citrus production. Rather than bringing new chemicals to the market, environmental advocates urge EPA to work with growers and the U.S. Department of Agriculture to deploy resistant rootstocks, new biologicals, and truly least-toxic pesticides.

SOURCE: U.S. Court of Appeals, Migrant Clinicians Network, Beyond Pesticides, et al., Case: 21-70719, 12/13/2023, ID: 12836809, 2023; Steffanie Strathdee, et al., Confronting antimicrobial resistance beyond the COVID-19 pandemic and the 2020 election, *The Lancet,* September 20, 2020, https://doi.org/10.1016/S0140-6736(20)32063-8.

MORE ON THIS SUBJECT **As Bacterial Resistance to Antibiotics Grows, There Are Continued Calls for Immediate Action**—January 30, 2023

ORGANIC TRANSITION and NONTOXIC PRACTICES

SOIL MANAGEMENT | JANUARY 23, 2023

EPA, USDA, and Interior Challenged To Incorporate in All Decisions Impact on Climate Crisis, from Soil to Pesticides

There is no doubt that the climate crisis is being experienced worldwide. And the consequences are undeniably grave. Beyond Pesticides advocates incorporating scientific understanding of the grave health and environmental effects into the deliberations on all policy decisions regarding petrochemical pesticide registrations and synthetic fertilizer use in agriculture and nonagricultural land management. Of critical importance, in this context, is the effect of policy decisions on soil health—in particular, soil organic carbon, which sequesters atmospheric carbon and reduces its damaging atmospheric effects.

The broad perspective embodied in President Biden's Executive Memorandum (EM) *Modernizing Regulatory Review* issued on his first day in office, creates a mandate across all federal agencies for future-oriented public health and safety protections. As well as environmental stewardship, more protections are urgently needed to abate the climate crisis. A separate executive order, *Tackling the Climate Crisis at Home and Abroad*, states, "The United States will also move quickly to build resilience, both at home and abroad, against the impacts of climate change that are already manifest and will continue to intensify according to current trajectories."

A comprehensive resiliency policy requires EPA to cease allowing the continued degradation of soil and ecosystems that are so critical to abating the climate crisis when alternatives are available and could be promoted. Missing from EPA's registration program are the steps necessary to reduce and eliminate the contribution of petrochemical pesticides and fertilizers to the climate, recognizing the viability of the $63 billion organic industry that is growing, despite EPA's continuing commitment to the status-quo allowance of chemicals unnecessary to achieve agricultural productivity and land management goals. EPA's failure in this regard constitutes a public health threat, a reneging of the agency's responsibility to environmental stewardship, and a missed opportunity and mandate to ensure a livable future.

A key missing element of EPA's review is the impact of pesticide registration decisions on soil health—in particular, soil organic carbon, which sequesters atmospheric carbon away from damaging atmospheric effects. Although the soil is commonly recognized as a sink for atmospheric carbon, there is a false narrative that says carbon can be sequestered in the soil through chemical-intensive no-till agriculture. Now the Rodale Institute's 40-Year Report on their *Farming Systems Trial* should end the myth of the toxic, petrochemical-based, GMO-herbicide, no-till systems. Rodale's scientific trials clearly show that these degenerative no-till systems are inferior to Regenerative Organic Agriculture on every key criterion.

The highest yields of corn in the tilled organic manure system and the best increases in soil organic carbon were produced with an organic manure system and limited tillage (tilled every other year). Of importance to climate resilience, organic corn yields have been 31 percent higher than chemical-intensive/industrial farming systems in drought years.

The trials show that herbicide no-till systems do not produce higher levels of soil organic carbon (SOC) than tillage systems. This result is consistent with reviews of 194 studies comparing no-till and tilled fields.

According to André Leu, international director at Regeneration International, "The main reason for the loss of soil carbon in farming systems is not tillage; it is synthetic nitrogen fertilizers. Research shows that there is a direct link between the application of synthetic nitrogenous fertilizers and a decline in soil carbon." In addition, those same nitrogenous fertilizers act as potent greenhouse gases when volatilized to the atmosphere.

Thus, chemical-intensive agriculture and nonagricultural land management contribute to climate change in multiple ways. If we are to be serious about combating climate change and mitigating its impacts, all agencies must consider climate impacts when making decisions. This means that the U.S. Environmental Protection Agency (EPA) must not approve registrations of pesticides that harm the soil or facilitate agricultural practices that interfere with carbon sequestration. It means that the U.S. Department of Agriculture (USDA), in a much more aggressive way, must lead the transition to organic agriculture as a replacement for chemical-intensive practices and should cease all support for chemical-intensive agriculture immediately. It means that the Department of Interior (DOI) must manage all public lands with organic practices that ensure soil health and all that means for a livable future.

SOURCE: Rodale Institute, *Farming Systems Trial: 40-Year Report*, 2022.

AGRICULTURE | FEBRUARY 24, 2023

Perennial Crops Identified as Tools To Fight Biodiversity Collapse

Among the solutions to the dire state of global biodiversity is, *Civil Eats* reports, perennial agriculture, which improves biodiversity both on- and off-farm. Increased adoption of perennial cropping provides critical on-farm habitat for many kinds of pollinators, insects, birds, and myriad additional creatures. Below ground, where plant roots remain active year-round, perennials create far-richer ecosystems for microbial communities and fungal networks. Planting annual crops—and often, the same ones year after year across huge swaths of acreage, as conventional agriculture generally does—leads to multiple bad outcomes: intensive synthetic pesticide and fertilizer use and the harms that flow from them; poor soils; erosion; inefficient holding and use of water; depleted carbon capacity; and a denuded above-soil landscape and diminished microbial, fungal, and nutrient environment

below. Thus, perennial cropping boosts on-farm biodiversity as noted, and benefits off-farm biodiversity by reducing the unsavory impacts, on the broader environment, of traditional, chemically intensive, monoculture farming.

Biodiversity loss has emerged in the past decade as yet another crisis humanity faces—one that continues to go unaddressed at the level the loss requires. Beyond Pesticides has written extensively about the crisis and the central solution of ending the use of toxic, synthetic pesticides as soon as possible, and certainly within the next decade. Doing so would eliminate one of the chief contributors to the diminution of biodiverse populations, and of pollinators, in particular.

Speaking to the capacity of perennials to impact species, a chief scientist at the Kansas-based The Land Institute (TLI)—which has conducted extensive and foundational work on perennial agriculture—Tim Crews, PhD cuts to the chase: "A vegetated landscape is going to accommodate species that a tilled, denuded landscape as far as the eye can see does not. There are going to be a lot of species that take advantage of it."

The Land Institute website notes, "Many fruit, forage, and some vegetable crops, including fruit trees, alfalfa, grapes, asparagus, and olive trees, are perennials that have been grown for thousands of years. The Land Institute is working to add perennial grains, legumes, and oilseed crops to the list." Among the perennial crops the institute is investigating and promoting are: Kernza®, a wheatgrass whose seeds provide grain, and whose foliage, post-harvest, can be forage for livestock.

Research in 2022 in *Frontiers in Plant Science* concludes that, "Perennial grain crops could make a valuable addition to sustainable agriculture, potentially even as an alternative to their annual counterparts. . . . Presently, perennial grain crops are not grown at large scale, mainly due to their early stages of domestication and current low yields." Yet TLI has made significant headway, especially with Kernza, which has successfully moved into small, niche markets as a viable grain crop. The TLI researchers note that the roots of this plant can extend as much as 10 feet into the soil, "delivering atmospheric carbon to the soil and efficiently taking up nutrients and water." They also say that its slender, long seed heads can, under good growing conditions, actually contain more seeds than a typical annual wheat head. The researchers are working, with each breeding cycle, to increase Kernza's seed size, which achievement would enhance its marketability.

Agricultural perennials can include orchards (fruit and nut trees), row crops, agroforestry, and integrated pasture lands (silvopasture). In addition to the biodiversity benefits, perennials yield multiple soil, food security, and climate benefits. For the agricultural producer, they also, compared with annual crops:

- Do not have to be reseeded or replanted every year.
- Do not require annual plowing/tilling.
- Do not need pesticides to help get them established.
- Protect soil from erosion.
- Improve soil structure.
- Increase ecosystem nutrient retention, carbon sequestration, and water infiltration.
- Reduce farmers' costs via lowered need for pricey inputs (e.g., synthetic fertilizers and pesticides, and laborious tilling and planting.

The Land Institute website asserts that increased use of perennials "stands to catalyze a rich culture around food production and supply chain development. Research is emerging to understand the social and economic strategies needed to support these new agricultural systems. . . . Given that grains make up over 70% of our global caloric consumption and over 70% of our global croplands, transitioning from an extractive annual model to a perennial model is the best chance we have to create a truly regenerative food future."

A primary ethos in perennial agriculture is learning from Nature and using approaches that mimic or reproduce what works in the natural world. For instance, "monocrops" are not generally found growing naturally; rather, diverse plant species grow together and in relationship. (The dominant use of monocropping in conventional agriculture, in fact, contributes to pollinator decline and biodiversity loss.) TLI conducts ecological intensification research that seeks to find optimal combinations of perennial species—polycultures that mimic the benefits found in native and natural ecosystems.

A chief TLI scientist, Ebony Murrell, PhD explains: "The idea with perennial crops is that you want them to stay in the ground for many years, which means you're not rotating anymore. So how do you take that diversity in time and move it to diversity in space?" One important answer: planting together different perennial plant crops that will benefit one another. Examples of such a strategy might include:

- Planting silflower (a perennial sunflower) with a perennial groundcover as a natural weed barrier.
- Alternating rows or areas of Kernza and alfalfa; the alfalfa provides nitrogen, and prevents Kernza from clumping together, which can result in lowered production; without its companion, Kernza will tend to produce less after a few years.
- Supporting pollinators by growing together two flowering species that bloom at slightly different times.
- Incorporating into a farm system trees or shrubs that generate fruits and/or nuts, edible leaves, and/or mushrooms that help support growth of other species.

Polycultures have a lot to offer re: restoring biodiversity. The title of 2022 research published in *Environmental Entomology* reveals its conclusions: "Native Flowering Border Crops Attract High Pollinator Abundance and Diversity, Providing Growers the Opportunity to Enhance Pollination Services." The research finds that non-crop plantings, as borders, hedgerows, buffer strips, or crop strips, diversify landscapes and offer more habitat in heavy production areas. The research finds that such plantings, with various combinations of natives—silflower, cup plant, sanfoin (a forage legume), Kernza, white alfalfa,

and a mix of "prairie" species (including liatris, helianthus, mints, native grasses, and asters)—yielded "a significant, positive relationship between pollinator abundance and floral resource amount and bloom duration."

The title of another bit of research from 2022, published in *Ecosphere*, is similarly revealing of its findings: "Woody Perennial Polycultures in the U.S. Midwest Enhance Biodiversity and Ecosystem Functions." The paper points to the potential, saying, "Concepts from ecology and complex adaptive systems suggest that persistent structural heterogeneity and functional diversity are key for supporting biodiversity, ecosystem services, and resilience, but these concepts have not been extensively applied in agriculture, which is still dominated by annual monocropping systems. Perennial agriculture seems to embody these ecological concepts."

The paper continues, "We found that perennial fields had (1) more diverse soil fungal, invertebrate, plant, and bird communities . . .; (2) less compacted soil; (3) denser ground cover; (4) more active carbon, organic carbon, and nitrogen and the same available phosphorus in the top layer of soil; and (5) more species of predatory, detritivorous, and herbivorous insects, and approximately fourfold higher abundance of herbivorous insects. . . . [T]hese findings indicate that woody perennial polyculture fields in the U.S. Midwest are characterized by higher biodiversity and ecosystem functions than adjacent conventional fields."

Research published early in 2023 in Frontiers in *Sustainable Food Systems* emphasizes not only the many benefits of perennial agriculture, but also, the need for changes in federal policy and "a range of support structures. Federal policymakers should support perennial agriculture by establishing safety nets like those available for annual crops, centering perennial practices in cost-sharing conservation programs, facilitating market opportunities, and investing in perennial agriculture research and development."

There has been some increasing governmental support to advance aspects of the perennial agriculture movement. In 2020, the U.S. Department of Agriculture (USDA) awarded "$10 million to a coalition of farmers, scientists, educators, policymakers, and food industry players to help scale up Kernza production. The five-year Kernza CAP initiative, spearheaded by The Land Institute and the University of Minnesota, recently released its year-two annual report." *Civil Eats* identifies the Savanna Institute as a nonprofit that works on advancing agroforestry and perennial agriculture in the Midwest. The organization will use some of the $60 million allocated by USDA in 2022 to ramp up its work to "catalyze the development and adoption of resilient, scalable agroforestry."

To the argument for the transition off of synthetic chemical inputs should be added those for the transformation of what and how farmers grow. The biodiversity benefits of using more perennial crops, as noted above, are one part of the story, but expanding the profoundly narrow range of food crop varieties currently grown is another biodiversity issue. The International Development Research Centre (IDRC) asserts that most agriculture across the world is focused on a very small number of varieties designed for intensive production. Indeed, IDRC notes that the food supply depends on roughly 150 plant species. Of those, a mere 12 provide three-fourths of the world's food, and more than half of the world's caloric food energy comes from rice, wheat, and maize. This reduced diversity, coupled with increased industrialization, leads to dramatically reduced genetic diversity, a.k.a. genetic erosion, which can spell trouble for the future of successful and sustainable food production.

In the 2022 research paper *Perennials as Future Grain Crops: Opportunities and Challenges*, researchers highlight some of the risks of our current agricultural *modus operandi*. "For millennia, the repeated selection and breeding of plants has led to the development of multiple, high-yielding annual grain crops finely tuned for growth under specific environmental regimes. In the twentieth century, cropping systems were developed that took advantage of readily available resources and agrichemical development, with the focus primarily on grain yield. However, considering the current range of complex challenges that agriculture faces, including climate change, pandemics, [biodiversity loss], and war, the focus must now be on ensuring food security in a more environmentally friendly and socially robust way. Continued climate change is rendering our existing cultivars increasingly vulnerable to stress, and ultimately unfit for many regions of the world, serving as another impetus for reinventing agriculture."

Research published in 2020 by the U.S. National Institutes of Health/National Library of Medicine reenvisions the role of perennials in a revisioned agricultural landscape, saying "Greater adoption of a wider array of perennial vegetables could help to address some of the central, interlocking issues of the 21st century: climate change, biodiversity, and nutrition. The great diversity of PVs [perennial vegetables] is a powerful tool to address the loss of crop biodiversity. As perennials, PVs sequester carbon, particularly the woody species. Many PVs are high in the key nutrients needed to remedy nutrient deficiencies that impact billions of people."

The Savanna Institute's Fred Iutzi sees, in perennial agriculture, powerful potential for solving multiple problems, including biodiversity loss. *Civil Eats* cites his conviction that, "[W]e need to think of agricultural productivity in a more holistic way that includes factors like biodiversity. 'One of the biggest challenges in front of humanity is how we get both ample food while providing a stable climate, healthy soil, clean water, and biodiversity. . . . We have to expect both from our agricultural landscapes."

SOURCES: Emma Scott, et al., Policy pathways for perennial agriculture, *Frontiers in Sustainable Food Systems*, Volume 6, 2022, https://doi.org/10.3389/fsufs.2022.983398

Christina Cooke, Perennial Crops Boost Biodiversity Both On and Off Farms. Researchers Explain How. *Civil Eats*, February 16, 2023, https://civileats.com/2023/02/16/perennial-crops-boost-biodiversity-farms-habitat-science-kernza/.

AGRICULTURE | APRIL 18, 2023

Crop Diversification with Intercropping Effective at Reducing Pest Pressures, Study Finds

Crop diversification is effective at reducing pest abundance in growing climates across the globe, according to a meta-analysis published this month in the *Journal of Applied Ecology*. The meta-analysis, which includes a review 44 field studies from six continents, provides greater weight to approaches that work with natural processes, rather than those focused on human-made chemical sprays for pest management.

Within the studies reviewed, researchers aim to understand the associational effects that result in either associational resistance (a decrease) or associational susceptibility (an increase) in insect herbivores on the primary crop being grown. Researchers reviewed a range of variables, comparing pest numbers in monocultures versus bicultures, evaluating whether the pest is a generalist or specialist, how it feeds (checking or piercing/sucking), its origin (native/non-native), as well as climate, crop type (only onions, brassicas, cotton, and cucurbits were evaluated), plot size, and the experimental design within each particular study.

In sum, the review represents one of the most comprehensive evaluations of intercropping to date. And the results confirm the benefits many farmers and gardeners across the world have found anecdotally in their own plots. "Overall, intercropping proved to be very effective against pests, but it did vary based on the pest and their feed preferences," said study coauthor Philip Hahn, PhD of University of Florida. "It also depended on crop type, with cabbage and squashes showing the strongest resistance, while resistance was less strong for onions and cotton."

Bicultures provide a significant reduction in pest pressure. But this approach is most effective in protecting crops from generalist predators. "In the studies we examined, we found intercropping was more effective for generalist pests that feed on a variety of crops," Dr. Hahn said. "Specialist pests that target one type of crop were less affected." This makes sense, as pest predators that evolved a close relationship with a crop are much less likely to be enticed to feed on a crop it did not specialize in consuming.

The effect of intercropping did appear to wane as latitudes increased, but only for certain crops and certain insect pests—specifically specialist, piercing, and native pests. "We did find a stronger benefit for pest suppression at lower latitudes—so, in tropical systems versus northern temperate systems," Dr. Hahn said. "There are lots of reasons we could have found that pattern, of course; the tropics are places where there tend to be more species of insects year-round. It was surprising that the pattern was not as strong as I would have expected."

The meta-analysis and studies previously reported on by Beyond Pesticides

show the benefits of increasing crop diversity on farms. A 2020 study finds that crop diversity in agriculture is just as important as plant diversity in non-commercial landscapes, and that less diversity leads to more pesticide use. A 2021 study finds that multi-crop farmlands produce higher biomass and seed yields than single crop monocultures. While intercropping and multi-cropping provide numerous benefits, monocropping contributes to the loss of biodiversity, including pollinator populations, according to a 2019 study.

It is incredibly important to continue research like the present study, so scientists can aid farmers in determining the best natural strategies to take as part of their production practices. But it is apparent from the data collected that one generally cannot go too wrong with such an approach. "There are a few combinations that seem to be particularly effective at reducing pest abundance," Dr. Hahn indicates. "Overall, for growers interested in organic methods, intercropping seems to be a very effective tool."

SOURCE: Philip Hahn and Joseph Cammarano, Environmental context and herbivore traits medicate the strength of association effects in a meta-analysis of crop diversity, *Journal of Applied Ecology*, 60(5)2023, pp875-885.

AGRICULTURE | JULY 12, 2023

Cultivating with Natural Predators Gets Farmers Off the Pesticide Treadmill, According to Study

A study by University of Delaware entomologist Thabu Mugala and colleagues finds that modifications to their farming methods can reduce slug damage when those changes also encourage natural slug predators, allowing farmers to avoid the endless cycle of pesticide dependency, pest resistance, genetically engineered crops, and synthetic fertilizers. With insects as the target for tens of millions of pounds of agricultural pesticide use, growers of the highest-production crops in the U.S., corn and soybeans, continue to find slugs to be a serious problem. Corn and soybean growers who have adopted no-till or conservation tillage and cover crops often think these practices worsen the problem by increasing moisture and decaying plant material in fields, which slugs love. But the cause-and-effect picture is more nuanced and requires strategies that nurture ecological balance.

Slugs are the most damaging non-arthropod pest in no-till corn production in the U.S., and truly effective chemical deterrents do not exist at agricultural scale, as Beyond Pesticides noted here, although biological methods may be on the horizon, such as a parasitic nematode already used in Europe that shows promise. The most voracious natural slug hunters are ground beetles, but harvestmen (daddy longlegs), and wolf spiders also eat them.

The Mugala study, "Ground beetles suppress slugs in corn and soybean under conservation agriculture," investigates 41 fields in Mid-Atlantic states through two growing seasons. The researchers looked at the interactions among cover cropping, tillage, preplant insecticide applications, weather, and natural enemies on slug populations and activity.

Slugs are mollusks and generalists, making use of both living and decaying plants, and cool, wet weather often triggers a slug outbreak. Farmers dealing with slugs know that tillage disrupts the soil microclimates that slugs like, and are tempted to use it, especially because, once started, a slug outbreak is difficult to suppress by chemical means. The available chemicals are expensive, do not work well in damp environments, and kill wildlife, according to Mugala et al., who also observe that while "there is no commercially available biological control agent for slugs in North America, there is an array of native and exotic predatory and parasitic natural enemies of slugs present." Many of the pesticides used against insects, including neonicotinoid seed treatments, also kill these other beneficial arthropods, as well as other soil invertebrates important to cycling nutrients naturally.

Some slug baits are also problematic. Many contain metaldehyde, which as Beyond Pesticides reported in March, hampers the growth of vegetables and is quite toxic to many animals. Other anti-slug weapons may be difficult to use on field scales, such as bread-dough or beer bait. One Lithuanian study found that invasive Spanish slugs would not eat a lethal dose of either metaldehyde or iron phosphate pellets, and about 17 percent of the pellets were removed nightly from the study area by earthworms.

Less toxic regenerative methods may help to manage slugs, but they have the added advantage of helping their predators, and some tweaks to tillage and cover cropping may discourage slugs while encouraging their enemies. Mugala et al. report that the timing of cover crop removal affects slugs' depredations—doing it too soon before planting gives slugs a leg up, so to speak. While a 2022 study of chemical-intensive corn production found reduced need for slug bait with the use of row cleaners to remove plant debris in seed rows and the application of nitrogen fertilizers at night, this approach ignores the value of natural predators and ecosystem services (see more).

The pesticide industry has long tried to monkey-wrench agricultural independence; Monsanto introduced Roundup-Ready soybeans in 1996 and claimed genetically modified seeds would enable sustainable (and now regenerative) agriculture by eliminating the need for tillage. Unfortunately (but inevitably) the target weeds became resistant to Roundup, and many farmers returned to tillage and even stronger chemicals.

Adding to the uncertainty about the best way to deal with slugs, some of the research data can appear contradictory; a 2013 survey of Shenandoah Valley farmers found that 13 percent of no-till fields planted with corn and soybeans showed slug damage, while only one percent was reported for conventionally-farmed fields. But another study found that farmers who always used insecticide at planting report the most slug damage, independent of their tilling practices. This may be because their arthropod predators suffer sharp declines in fields applied with pesticides and where seeds have been treated with neonicotinoids. Farmers may be blaming regenerative methods for damage that is actually caused by pesticides.

The pesticide industry has long tried to monkey-wrench agricultural independence; Monsanto introduced Roundup-Ready soybeans in 1996 and claimed genetically modified seeds would enable sustainable (and now regenerative) agriculture by eliminating the need for tillage. Unfortunately (but inevitably) the target weeds became resistant to Roundup, and many farmers returned to tillage and even stronger chemicals. The first insect resistance to a pesticide (sulfur-lime) was noted in 1914. With each iteration of this Darwinian process, the industry's response is to develop a variant of the failed pesticide rather than developing ecologically-based pest management and abandoning chemical-intensive agricultural practices that ignore the ecosystem in which they operate.

Where once the industry touted the Green Revolution and the utter dependence of agriculture on its products to feed the world, now it is trying to convince people that it is on the sustainability bandwagon, all the while continuing to market its non-regenerative products. In Syngenta's words, "Although the green revolution has been successful in feeding a rapidly growing human population, it has also depleted the Earth's soil and its biodiversity and contributed to climate change. These extractive practices are not sustainable. We must move quickly to transform agriculture by employing a suite of practices known as regenerative agriculture." The company manufactures the herbicide atrazine, a notorious endocrine disrupter.

Even as it claims progressive goals, the industry also continues its old-school scaremongering. CropLife America, the agricultural chemical industry's powerful lobby group, claims that "Without pesticides, farmers would need twice as much land to grow the same amount of food due to reduced yields." This is not true. Many farmers have reduced or eliminated pesticides without significant loss of yields or profits.

Despite the industry's use of the right buzzwords and its attempts to clothe itself in the virtues of regenerative practices, pesticide use has not decreased. Just the opposite. In the U.S., about 196 million pounds of pesticides were used

in agriculture in 1960; by 1981 it was 632 million pounds; by 2020 it was up to more than a million *tons*. The U.N. Food and Agricultural Organization put global usage in 2022 at just over four million tons, with the U.S. in the lead and Brazil second.

Farmers are already familiar with Integrated Pest Management (IPM), which looked like a step in the right direction when President Richard Nixon directed federal agencies to integrate it into agriculture in 1972. The U.S. Department of Agriculture (USDA) update in 2018 describes IPM as "a science-based, sustainable decision-making process that uses information on pest biology, environmental data, and technology to manage pest damage in a way that minimizes both economic costs and risks to people, property, and the environment." But it took two decades for USDA, the Environmental Protection Agency (EPA), and the Food and Drug Administration (FDA) to jointly agree to get IPM in place on 75 percent of U.S. acres by 2000. IPM has not been universally popular, and it has not weaned agriculture off pesticides. By 2001, some kind of IPM had been practiced on 70 percent of crop acreage, but pesticide use increased during the same interval, with little decline in the use of the most toxic pesticides.

More recently, organic and regenerative agriculture have been expanding. Between 2012 and 2017, U.S. cover crop usage increased by 50 percent. Still, cover crops are in use in less than five percent of croplands nationwide, reflecting a stubborn resistance to a core practice of regenerative agriculture. There remains among many farmers a fear, encouraged by the pesticide industry, that abandoning pesticides will result in pest apocalypse, yield reduction, and penury.

Agriculture will likely only survive and thrive if pesticide use declines rapidly. Nontarget effects of pesticides ranging from neonicotinoid insecticides to dicamba are wreaking havoc with the balance among plants, animals, and humans. It should not take yet another generation to make the transition to sustainable food production, whether you call it integrated pest management or regenerative agriculture. See Beyond Pesticides webpages on Organic Agriculture and Keeping Organic Strong.

SOURCE: Mugala T, Brichler K, Clark B, Powell GS, Taylor S, Crossley MS. Ground beetles suppress slugs in corn and soybean under conservation agriculture. *Environ Entomol.* 2023 May 26:nvad047, https://pubmed.ncbi.nlm.nih.gov/37235638/.

MORE ON THIS SUBJECT

Growing Sunflowers Near Honey Bee Colonies Helps Reduce Mite Problems—January 18, 2023

Strawberries Lose Their Sweetness, Aroma, and Taste after Being Sprayed with Chemical Fungicides, Study Finds—March 1, 2023

Corporations Are Asked to Stand Up for Health and the Environment; Sell Organic Compatible Products—March 27, 2023

Research Highlights Best Plants to Attract Important Pest Predators—May 3, 2023

Scientists Develop Nontoxic Method To Deter Rodents from Eating Planted Seeds in Crop Production—May 23, 2023

Hawaii Officials Prepare to Release Wasp as Biocontrol to Protect Coffee Crops—June 6, 2023

Soil Amended with Insect Exoskeleton Is Effective Alternative to Harmful Chemical Fertilizers—June 14, 2023

ORGANIC SYSTEMS | SEPTEMBER 7, 2023

Of Note During Organic Month, Study Finds Organic Diet and Location Affect Pesticide Residues in the Body

During Organic Month, the importance of organic practices is brought into sharp focus by a study published in July in *Environmental Health Perspectives*, which emphasizes the importance of an organic diet and location to residues of pesticides in the body. The study finds urinary levels of the weed killer glyphosate significantly decrease through an organic diet for pregnant individuals living further than 0.5km (~1640 ft) from an agricultural field. However, the study finds that adopting an organic diet among pregnant individuals living closer than 0.5km to an agricultural area does not significantly decrease glyphosate levels, indicating alternative sources of contamination outside of diet. Although past studies prove time and time again that an organic diet can reduce the levels of pesticides in the body, far too few studies investigate how the intervention of the organic diet can alter glyphosate levels among pregnant individuals living near or far from agricultural fields on which the herbicide is used. Furthermore, pesticides' presence in the body affects human health, especially during vulnerable life stages like childhood, puberty, pregnancy, and old age.

The study raises the complexity of fully tracking multiple exposures to glyphosate and other pesticides and the need for a more holistic or systemic solution, as embraced by those transitioning to organic management practices and/or the need for regulatory decisions that eliminate the use of toxic chemicals based on the availability of nontoxic alternative practices and products.

Pesticide exposure during pregnancy is of specific concern as health effects for all life stages can be long-lasting. This study highlights the importance of where you live and the associated

exposure patterns. In the study population, the primary source of chemical exposure appears to differ among vulnerable populations depending on rural-urban location. Suppose rural communities' primary exposure source comes from agricultural uses, while urban communities mainly encounter glyphosate through diet. Or, suppose that residential and urban populations get multiple glyphosate exposures from diet, landscaping, park and playing field use, and roadside or rights-of-way management. In these cases, as this study notes, "[I]t is necessary to understand sources of exposure in diverse populations to develop effective exposure-reduction recommendations."

Conducted in Idaho, the researchers evaluate the urinary glyphosate concentrations of 39 pregnant individuals living near (0.5km or less; rural) and from (more than 0.5km; urban) agricultural fields routinely treated with pesticides. Randomly, participants receive a supply of organic or conventional (non-organic) groceries (grown with chemical-intensive practices) over two weeks to determine the glyphosate concentration in urine samples. The study compares the difference in urine sample glyphosate concentration between the organic and conventional grocery weeks, stratifying by proximity to agricultural fields. The results find urinary glyphosate levels among individuals furthest from agricultural fields (urban) are moderately lower than those of individuals living near agricultural fields (rural), with the concentrations decreasing when switching from a conventional to an organic diet. Thus, the study suggests that "diet is an important contributor to glyphosate exposure in people living >0:5 km from agricultural fields; for people living near crops, agriculture may be a dominant exposure source during the pesticide spray season."

Glyphosate is the most commonly used active ingredient in the U.S. and worldwide, appearing in many herbicide formulations and readily contaminating soil, water, food, and other resources. As the active ingredient in the popular weed killer Roundup™, with use growing especially during the last few decades, extensive glyphosate use has put human, animal, and environmental health at risk. Four out of five U.S. individuals over six years have detectable levels of glyphosate in their bodies. Exposure to glyphosate has implications for the development of various health anomalies, including cancer, Parkinson's disease, developmental and birth disorders, and autism. Although the U.S. Environmental Protection Agency (EPA) classifies glyphosate herbicides as "not likely to be carcinogenic to humans," stark evidence demonstrates links to various cancers, including non-Hodgkin lymphoma. EPA's classification perpetuates adverse impacts, especially among vulnerable individuals, like pregnant women, infants, children, and the elderly. Glyphosate's ubiquity threatens 93 percent of all U.S. endangered species, resulting in biodiversity loss and ecosystem disruption (e.g., soil erosion, loss of services, and trophic cascades). Moreover, chemical use has been increasing since the inception of crops genetically modified to tolerate glyphosate.

Not only do health officials warn that continuous use of glyphosate will perpetuate adverse health and ecological effects, but that use also highlights recent concerns over antibiotic resistance. It is commonly used on crops grown from genetically engineered (GE) companion seeds for various staple crops (e.g., soybeans, cotton, and corn).

These GE seeds are glyphosate-tolerant, whose attribute has allowed growers to apply the herbicide and expect that it will kill weeds and not harm the crop. This calculation is changing, however, as weeds develop resistance to glyphosate, causing the industry to double down on its chemical solutions.

This study is one of the first "to examine the effect of an organic diet intervention on glyphosate among people living near and far from agricultural fields." Most notably, this study is the first to investigate the impact of an organic diet mediation on glyphosate exposure during pregnancy. Pregnancy is a critical window of susceptibility for exposure to glyphosate and other environmental chemicals, as prenatal exposure has associations with adverse birth outcomes that can impact subsequent generations.

Previous studies demonstrate a significant reduction (up to 70 percent for glyphosate) in urinary pesticide metabolites (breakdown products from parent compounds) achieved by a dietary shift from consuming conventionally grown food to organically grown foods in as little as a week. This subject research furthers the investigation of the impacts of an organic diet on pesticide exposure. Like this article, the paper, *Organic Diet Intervention Significantly Reduces Urinary Glyphosate Levels in U.S. Children and Adults*, reports on the second phase of a two-part study evaluating the same set of urine samples.

Although the results of this study and others suggest an organic diet effectively reduces exposure to pesticides for most of the general population, rural areas have difficulty avoiding glyphosate exposure because of its use on farms. Thus, sources of glyphosate exposure in rural areas are far beyond diet. Organic agriculture is not magically "free" of all chemicals, given the reality of pesticide drift and background levels in the environment. However, the National List of Allowed and Prohibited Substances, overseen by the National Organic Standards Board and subject to public review and comment, establishes the prohibition of toxic pesticides in certified organic production under the USDA organic seal.

This September, celebrate National Organic Month to improve and sustain human, animal, and environmental health. Emissions from fossil-fuel-based synthetic pesticides and nitrogen fertilizers continue to threaten the ecosystem, fueling the climate crisis. A complete switch from chemical-intensive agriculture to regenerative organic agriculture can significantly reduce the threat of the climate crisis by eliminating petrochemical, synthetic fertilizers and toxic pesticide use. Furthermore, supporting the use of alternative practices such as polyculture rather than monoculture, mulching systems instead of herbicides for weed management, animal integration, and other organic practices assist in eliminating the need for pesticides and their movement through air (pesticide drift) and into waterways (runoff).

As for glyphosate, Beyond Pesticides has challenged the registration of this chemical in court due to its impacts on soil, air, water, and health. While legal battles press on, the agricultural system can eliminate the use of toxic synthetic herbicides to avoid the myriad of problems they cause. Instead, the main focus can be the conversion to regenerative-organic systems and using least-toxic pest control to mitigate harmful pesticide exposure, restore soil health, and reduce carbon emissions. Public policy must advance this shift, rather than allow unnecessary reliance on pesticides. Purchasing organic food whenever possible—which never allows glyphosate use—can help curb exposure and adverse health effects. Beyond Pesticides provides tools, information, and support to take local action: check out our factsheet on glyphosate/Roundup and the report, Monsanto's Roundup (Glyphosate) Exposed.

SOURCE: Carly Hyland, et al., Urinary Glyphosate Concentration among Pregnant Participants in a Randomized, Crossover Trial of Organic and Conventional Diets, *Environmental Health Perspectives,* 131(7) 2023, https://doi.org/10.1289/EHP12155.

MORE ON THIS SUBJECT

(Reflection) This Organic Month, Transition Your Park to Organic Land Management—September 14, 2023

Standards Now Open to Public Comments To Protect the Integrity of USDA Organic!—September 18, 2023

PARKS & PLAYING FIELDS | JUNE 1, 2023

New York City Parks Dept. and Advocates Announce Organic Demonstration Sites Following Passage of Law

Eco-Friendly Parks for All (EFPA),[1] a partnership of environmental, public health and advocacy organizations, has teamed up with Beyond Pesticides, New York City Parks and Recreation Department, and Stonyfield Organic Yogurt to celebrate the success of pilot organic land management programs at eight sites across the five boroughs. The demonstration programs,[2] directed by Beyond Pesticides board member and nationally recognized natural turf expert Chip Osborne, were initiated by the coalition after the city council adopted new legislation on Earth Day in 2021 prohibiting the use of chemical pesticides on all New York City parks.

"We are excited to be working with the City of New York on organic land management practices that protect community health and the environment, and support efforts to mitigate climate change and biodiversity decline," said Jay Feldman, executive director of Beyond Pesticides, "Organic practices, such as those being used on these demonstration sites, eliminate fossil fuel petroleum-based products and sequester atmospheric carbon in the soil, combating the climate crisis. It's a win for the city, the public, and the environment."

The new law, Intro 1524, required to be fully implemented by the fall of 2022, restricts pest management products to those compatible with organic systems, which eliminates synthetic weed killers like glyphosate (Roundup), tied to cancer by the World Health Organization, and bee-toxic insecticides like neonicotinoids, which have been prohibited by many communities and countries.

The demonstration sites are part of Beyond Pesticides' nationwide Parks for a Sustainable Future program, with the long-term goal of adopt organic practices that rely on methods and products that support soil biology and soil health, while beautifying parks and playing fields by strengthening the grass plants to be better able to stand up to the stress associated with use. In New York City, the program also features the use of compost from the city's Sanitation Department, which can provide valuable nutrients to park grounds and reduce the cost of fertilizer.

The press conference was held on June 1, 2023 on the baseball field at Morningside Park in Harlem at 11 AM EDT (Manhattan Ave. and W 112 Street).

A few words from EFPA members and stakeholders:

- "We are proud of the significant reduction in pesticide use at Parks, and our collaboration on this pilot with Eco-friendly Parks for All will further demonstrate what can be achieved through our continued and expanded use of sustainable landscaping practices," said NYC Parks Deputy Commissioner for Environment and Planning Jennifer Greenfeld.
- "The Mount Sinai Children's Environmental Health Center applauds the implementation of this legislation as a major victory for children's health. Outdoor play and access to green spaces is essential to health and well-being—all families have a right to safe, pesticide-free parks," said Sarah Evans, PhD, Assistant Professor of Environmental Medicine and Public Health at the Icahn School of Medicine at Mount Sinai.
- "It's critical that municipal governments take these positive steps forward to make our parks safer for people and our cities more sustainable," said Patti Wood, Executive Director of Grassroots Environmental Education, one of the Coalition's founding members. "We're hoping this will help convince other cities across the country that they can do it too!"
- Bertha Lewis, Founder and President of The Black Institute, said, "This initiative not only benefits the environment, but it also addresses environmental justice by ensuring that our Black and Brown communities have access to safe, healthy, and sustainable parks. We're working together to create a better future for all New Yorkers, regardless of their background, by promoting organic land management practices that protect our people."
- Paula Rogovin, NYC public school teacher for 44 years (now retired)

said, "It is a joy of a lifetime to see this law, introduced in 2015 on behalf of my kindergarten students from PS 290, coming to fruition. No one is too young or too old to advocate for a better world for all."

- "Stonyfield is pleased to collaborate and support the city's efforts as a leader in sustainability and now organic land management with demonstration sites that serve as an opportunity to adopt practices that meet the environmental and health challenges of our time," said Mairead Dunphy-Fabrycki, Public Relations Manager, Stonyfield Organic Yogurt, which helped underwrite the costs of the pilot program.
- "Eco-friendly lawn care takes a responsible approach to maintaining our green spaces, including parks like Pelham Bay Park. The use of pesticides can have harmful effects on our environment and the health of humans and animals. By adopting eco-friendly practices, we can promote the growth of healthy parks and green spaces without compromising the health of our community," said New York City Council Member Marjorie Velázquez. "These practices not only protect our environment but also contribute to the resilience and sustainability of our communities for generations to come."
- "By embracing sustainable practices, families can enjoy the beauty of our parks without it being a health hazard. We support Eco-Friendly Parks for All and The Black Institute in ensuring New York City parks are safe and sustainable," said New York City Council Member Darlene Mealy.
- "Parks are invaluable public resources that help us maintain the health of our communities," said New York City Council Speaker Adrienne E. Adams. "It's important that our parks and public spaces utilize eco-friendly practices so that New Yorkers can enjoy them for generations to come. These sustainable measures to ban chemical pesticides in our parks, as passed by the City Council in 2021, are important to ensuring that our city is accessible. I thank Eco-Friendly Parks for All for their work to protect our communities and our city's natural biodiversity."

What can people do?

It is critically important to educate people and our communities on not only the hazards associated with cosmetic lawn care pesticides, but the availability of alternative practices and products. Check out Beyond Pesticides' 40 Commonly Used Lawn Pesticides factsheet and infographic, as well as alternatives for safer lawn care, myths about organic playing field management, and stopping systemic environmental racism in New York City parks. Beyond Pesticides urges people to take this work to the next level and sign up to be a Parks Advocate!

People do not have to be an expert on landscaping management or the health effects of every pesticide used on playing fields. What communities do need to know is that children are being unnecessarily exposed to chemicals that can impair their health, and that a safer, proven way exists.

Steps to take: Determine whether a state, school or community has a law or policy governing pesticide usage in and around schools, or on public lands. Find out whether, and how well, it is being implemented. If you do not have a law, call for an organic land care policy in the community. Petition the school and the town parks department to convert the playing fields to organic care and require that the grounds maintenance director or contracted professional be trained in organic land care.

For more information, contact Beyond Pesticides at info@beyondpesticides.org

SOURCES:

Eco-Friendly Parks for All founding members include Beyond Pesticides, The Black Institute, Grassroots Environmental Education, Children's Environmental Health Center, at Mount Sinai Institute for Exposomic Research, (Icahn School of Medicine) and Voters for Animal Rights.

Demonstration sites include Bronx—Claremont Park, Mapes Playground (Jacobo Field); Brooklyn—Canarsie Park (cricket field) and Lincoln Terrace; Manhattan—Morningside Park; Queens—Rufus King Park; Staten Island—Rev. Dr. Maggie Howard Playground and Mahoney Playground.

SOIL MANAGEMENT | NOVEMBER 1, 2023

NFL Players Association Calls for Stadiums To End Synthetic Turf Use

As communities consider maintenance and renovation of their playing fields, it is not uncommon for synthetic (or artificial) turf to come up as an alternative to natural grass. Promoters of synthetic turf argue that it provides a solution to climate change, reduces water use and maintenance costs, and allows for year-round play. But is this true? Is synthetic turf an environmentally responsible alternative to its organic grass counterpart? An established and growing body of scientific evidence is demonstrating environmental and health risks with synthetic turf. In addition, there is growing concern for the safety of those playing on artificial grass, which has led to a call from the National Football League's (NFL) Players Association to utilize natural grass on all 30 NFL stadiums after New York Jets quarterback, Aaron Rodgers, suffered a season-ending Achilles tear in September and Kansas City Chiefs tight end Travis Kelce suffered a mid-game ankle injury.

Synthetic turf playing fields are reliant on polluting plastic (can contain perfluoroalkyl and polyfluoroalkyl substances-PFAS) and toxic pesticides for managing bacteria, mold, and fungus, create contaminated water runoff, and cover over the natural environment,

which is critical to preserving health and biodiversity, and averting climate disasters. Artificial fields can cost over $1 million for the field installation, drainage system, and any additional costs for water treatment for an approximately 10-year lifespan, not including the game-day and ongoing maintenance costs. Manufacturers also recommend watering the synthetic field during the hottest time period because of the heat generated by the artificial material. The National Recreation and Park Association (NRPA) writes on synthetic turf: "[T]he high surface-level temperatures recorded on these fields compared to natural turf have been well-documented. Since grass leaves release water vapor (or transpire) and the evaporation of that water vapor leads to cooling, grass fields rarely get above 100° F. [Synthetic] Turf fields, in comparison, regularly rise well above 100° F. Penn State University's Center for Sports Surface Research conducted studies comparing surface temperatures of synthetic turfs composed of various fiber and infill colors/materials and found that the maximum surface temperatures during hot, sunny conditions averaged from 140° F to 170° F. The high surface-level temperatures on synthetic fields can lead to dehydration, burns and blisters if exposed skin comes into contact with the hot surface, as well as heat stroke." Restricted play is advised when temperatures exceed 80° F.

Synthetic turf is widespread across the United States. According to a multi-federal-agency presentation, there were 12,000 to 13,000 synthetic turf fields in the U.S. in 2019, with 1,200 to 1,500 new installations each year. Based on estimates, the global artificial turf market was valued at $8.1 billion in 2021, and it is expected to reach over $12 billion by 2027. Many of these fields have recycled tire crumb rubber, and a small fraction use coconut-based alternatives. According to Dan Bond, the president and CEO of the Synthetic Turf Council, "Over 90 percent of those fields have crumb rubber infill, and the other infills—the coconut, the EPDM, the virgin rubber, thermoplastics—are 1 to 2 percent." Mr. Bond elaborated in an article by Athletic Business, "It's [coconut infill] a very small market share. It's growing, but it certainly is not going to overtake crumb rubber in five years." Typically produced from discarded tires, crumb rubber has been shown to contain carcinogens and heavy metals.

A groundbreaking study, The dark side of artificial greening: Plastic turfs as widespread pollutants of aquatic environments, has unearthed some disturbing revelations on the use of artificial turf, which has become a pervasive fixture on sports fields and playgrounds. This comprehensive study, prominently featured in the *Environmental Pollution* (June 2023) journal, has cast a spotlight on the dire consequences of plastic fibers from artificial turf, which are wreaking havoc on marine ecosystems.

The study has uncovered multiple entry points, such as river transport and stormwater runoff, where plastics and microplastics can enter watersheds. Once they make their way into the water, these fibers pose a menacing threat to marine life, leading to a host of health issues and, tragically, even mortality. These fibers also accumulate in sediments, compromising the overall health of aquatic ecosystems.

The authors of the study call for immediate intervention to tackle artificial turf pollution. The study authors indicate that plastic fields require enhanced waste management practices to staunch the plastic fibers from entering aquatic habitats. The results of this study serve as a call to policymakers,

sports organizations, and the general public.

Communities discussing synthetic versus natural turf are faced with a number of issues that go to safety, environmental health, and cost. The chemicals used to manage synthetic turf for bacteria, mold, and fungus raise serious health issues and represent a threat that does not exist in organic land management. A builder of sports facilities, American Athletic, states, "Beyond surface cleaning, the artificial turf should be sanitized weekly or monthly to protect the players' and coaches' health. This disinfection requires special solvents, cleansers, and antimicrobial products to remove invisible particles and bacterial growth. You should strive to sanitize the field after every game and throughout the school day if it's used for physical education classes."

When all the synthetic turf issues are considered, including chemical use, maintenance, heat effects, water contamination and treatment, playability and safety, organic turf offers an approach that checks all the critical boxes for protecting health and the environment at a competitive price. Organic management practices build soil health, cycle nutrients naturally, enhance turf resiliency, reduce water use, and do not use petrochemical pesticides or fertilizers. The organic alternative is central to a community's discussion about its residents' commitment to both the elimination of practices and products that are petrochemical-based and the ability of organically managed soils to draw down (sequester) atmospheric carbon, which contributes to mitigating global warming and erratic temperatures.

Learn more about how easy it is to create non-plastic and organic turf care. Prevent plastics from entering your local community with toxic and unsafe astroturf and artificial grass. Sign up to be a Parks Advocate today to encourage your community to transition to organic land management. Session 3 of the National Forum, *Transformative Community-Based Change from the Ground Up: Managing Parks and Playing Fields with Organic Practices and Policies*, is available here. This session is for all who want beautiful landscapes, parks, and playing fields without the reliance on petrochemical pesticides and fertilizers. The subject matter is crosscutting and will inform people concerned about their health and community health, elected officials (from town, city, county, regional, state to school boards) interested in effecting movement away from toxic chemical reliance, and land managers and landscapers who work in parks and on playing fields and other landscapes.

SOURCE: William P. de Haan, et al., The dark side of artificial greening: Plastic turfs as widespread pollutants of aquatic environments, *Environmental Pollution*, (334)122094, 2023; https://doi.org/10.1016/j.envpol.2023.122094.

MORE ON THIS SUBJECT

Sports World Rejects Synthetic Turf, Favors Natural Grass as Organic Offers Safe Alternative—November 6, 2023

Hear From the Grassroots at the Third Session of National Forum on Transformative Community-Based Change—November 29!
—November 24, 2023

Grassroots Power: Discover How Organic Local Action Can Transform Public Spaces on Nov 29—National Forum Series
—November 22, 2023

Viruses Shown to Be Effective Biological Control
—November 30, 2023

PROTECTING ORGANIC INTEGRITY | JANUARY 27, 2023

Enforcement Rules for Organic Standards Far Surpass Those in Chemical-Intensive Agriculture

The U.S. Department of Agriculture (USDA), through its Agricultural Marketing Service (AMS), announced on January 19 its final rulemaking, the Strengthening Organic Enforcement Rule (SOE). The new requirements aim to strengthen the integrity of the National Organic Program (NOP) through both enhanced oversight and enforcement of existing program regulations, and the introduction of new ones to address occurrences of fraud in organic supply chains. Beyond Pesticides welcomes this important step in increased rigor for the burgeoning organic sector; the organization has long advocated for strong enforcement of the provisions of the 1990 Organic Foods Production Act (OFPA), the statute that gave rise to the NOP.

It must also be noted that there is a significant difference between the (appropriate) attention being paid to oversight and enforcement in organic, and the long-standing lack of same in regard to the U.S. Environmental Protection Agency's (EPA's) pesticide regulations, weak as they are. Beyond Pesticides Executive Director Jay Feldman commented, "It is difficult to have a balanced conversation about any weaknesses in organic enforcement—which must be strengthened—without assessing the entire food system. NOP provides the structure and the requirements for compliance with the OFPA. Not only does this far surpass anything that exists in the chemical-intensive food production sector, but also, advocates, government, and members of the agricultural community work continually to improve it. We must work to ensure that people can trust the USDA organic label, and know

that the system is 'wired' to ensure its integrity." To this end, those working in organic, believing in continuous improvement, have indicated that there must be vigilance in oversight and enforcement, as captured by Beyond Pesticides' coverage of a 2010 USDA Office of the Inspector General (OIG) report.

To the point about lack of rigor in the regulation and enforcement of conventional (chemical) agriculture: the U.S. Government Accountability Office (GAO) has repeatedly identified flaws in federal oversight and enforcement related to pesticide restrictions, starting more than 40 years ago. See Beyond Pesticides' coverage of an EPA Office of the Inspector General's report on the agency's inefficacy. Other coverage has included this report by Harvard Law School's Environmental and Energy Law Program in 2020, and coverage of (1) a 2021 GAO report on poor protection of farmworkers from pesticides, (2) a GAO report on EPA's "conditional" registrations practice, and (3) another GAO report finding that EPA "does not have sufficient chemical assessment information to determine whether it should establish controls to limit public exposure to many chemicals that may pose substantial health risks."

The Federal Register publication of the SOE (which will be effective March 20, 2023) asserts that the rulemaking is designed to "strengthen oversight and enforcement of the production, handling, and sale of organic agricultural products. The amendments protect integrity in the organic supply chain and build consumer and industry trust in the USDA organic label by strengthening organic control systems, improving farm to market traceability, and providing robust enforcement of the USDA organic regulations." *The Washington Post* reporting notes, "Key updates to the rules include requiring certification of more of the businesses, such as brokers and traders, at critical links in organic supply chains. It also requires organic certificates for all organic imports and increases inspections and reporting requirements of certified operations."

Even deeper into the weeds, the AMS announcement includes a list of specific topics addressed: "applicability of the regulations and exemptions from organic certification; National Organic Program Import Certificates; recordkeeping and product traceability; certifying agent personnel qualifications and training; standardized certificates of organic operation; unannounced on-site inspections of certified operations; oversight of certification activities; foreign conformity assessment systems; certification of producer group operations; labeling of nonretail containers; annual update requirements for certified operations; compliance and appeals processes; and calculating organic content of multi-ingredient products."

This new rulemaking finalizes the draft version proposed by USDA in 2020. USDA has taken some small steps to improve enforcement of NOP requirements, including, for example, a memo to "put a stop to the practice of allowing organic certification for container systems produced on land managed with substances, such as the herbicide glyphosate, which are not permitted in organic production."

Chief Executive of the Organic Trade Association, Tom Chapman, remarked that the new rulemaking represents "the single largest revision to the organic standards since they were published in 1990," adding that it should help boost confidence in the organic label. According to *The Washington Post*, Mr. Chapman indicated that the move "raises the bar to prevent bad actors at any point in the supply chain."

Executive Director of the National

Organic Coalition, Abby Youngblood, commented that the organization "applauds the USDA for their sustained work to bring this rule to completion. Organic producers' livelihoods depend on strong and consistent enforcement of organic regulations. For more than a decade, operations have been undercut by fraudulent products that have no business carrying the organic seal. NOC strongly supports provisions in this rule that will give USDA and certification agencies more authority to crack down on bad actors."

Recent high-profile cases of "organic fraud" have brought increased attention to the issue of producers representing their products (e.g., non-organic grain, dairy, meat, or produce) as organic, and typically harvesting an undue premium price for the scheme. More recently, others in the organic supply chain have entered the fraudulent arena. And as the sector has grown, some "food manufacturers" source ingredients from abroad, which makes it more challenging to assure that such items are legitimately organic. Domestic producers recognize, and voice, that enabling such companies to market their products as organic—absent better oversight and enforcement—undermines trust in the label and makes a distinctly uneven playing field for "genuine Certified Organic" vs. "faux-organic."

Both *The Washington Post* in 2017 and *The New Yorker* in 2021 covered such incidents. (That first article covers a shipment of soybeans from Ukraine, via Turkey, to California, during which trip the beans were miraculously transformed from conventionally grown/treated with pesticides to "organic.") Beyond Pesticides wrote an article in response to the somewhat "organic skeptical" coverage in *The New Yorker* article, "The Great Organic Food Fraud," in which it was explained how NOP operates, and provided fuller context for thinking about fraud in the organic sector, given the state of conventional, chemical-intensive agriculture and the massive harms it inflicts on public health and the environment.

Last year, a Minnesota farmer was federally indicted for fraud because of his scheme to sell what he claimed were organically grown grains—but were not, according to the FBI—to buyers in Pennsylvania and elsewhere. He netted some $46 million from those sales. A co-conspirator farmer in the case has also been charged in the scheme. Another example is that of several individuals and entities (out of Dubai and Turkey) being charged by the U.S. Department of Justice in the District of Maryland for a 2015–2017 multimillion-dollar scheme to export non-organic grain into the U.S. to be sold as Certified Organic.

Some in the organic sector note that the increased demand for organically produced foods in recent years may be contributing to the increase in such cases. The *MinnPost* writes, "The booming organic produce market is worth at least $63 billion per year. Increasing demands for organic grains have raised their prices to double or even triple the cost of grains grown conventionally with synthetic fertilizers, pesticides and herbicides. But for those who purchase grain, it's difficult, if not impossible, to tell organic grain from non-organic grain, making fraud hard to detect and prosecute. And the temptation to sell crops at a much higher price is difficult for some to resist." USDA has indicated, according to *MinnPost*, that the growth of the organic industry, for example, "has attracted many businesses to the USDA organic label and increased the complexity of global organic supply chains," perhaps overwhelming the capacity of organic industry watchdogs.

USDA said in its press release on the new rule, "Complexity makes oversight and enforcement of the organic supply chains difficult because organic products are credence goods, which means that their organic attributes, or 'integrity,' cannot be easily verified by consumers or businesses who buy organic products for use or resale. The elements needed to guarantee organic integrity—transparent supply chains, trusted interactions between businesses, and mechanisms to verify product legitimacy—are more difficult to achieve in the increasingly complex modern organic industry." This reality explains the importance of "eternal vigilance" on the part of federal regulators, and evolution of NOP to respond to the dynamism of the organic sector.

U.S. Representative Chellie Pingree (D) of Maine welcomes the new SOE regulations, saying in a statement from her office, "When rule-breakers cheat the system, it sows seeds of doubt about the organic label's integrity and jeopardizes the future of the industry as a whole. As a longtime organic farmer, I know how expensive and time consuming it is to adhere to the required standards to earn a USDA [C]ertified [O]rganic label. It's been a long wait, but I am pleased that the USDA and the Biden Administration are publishing a final rule that works to help consumers trust that the food they're paying for was actually farmed in a way that supports soil health, minimizes synthetic material usage, and strengthens biodiversity, as the organic label suggests. Equally importantly, it is critical that farmers who comply with the rigorous certification standards are not losing sales to fraudulent growers, suppliers, or importers."

Beyond Pesticides is among the most ardent of voices for organic integrity, as evidenced by the organization's consistent urging of steps to protect it. (For more, see here, here, here, and the organization's webpage, Keeping Organic Strong.) Beyond Pesticides recognizes that protecting and improving the organic sector is an ongoing project, and is hopeful that the new rule will make meaningful differences in NOP oversight and enforcement—bolstering trust of the Certified Organic designation and label by the public and, indeed, by elements of the organic supply chain itself. Advocates for organic integrity look forward to the improvements this SOE is designed to launch, will pay attention to its impacts on the organic sector, and continue to encourage public engagement with keeping organic strong.

SOURCE: Laura Reiley, USDA moves to crack down on "organic" fraud, *The Washington Post,* January 19, 2023, https://www.washingtonpost.com/business/2023/01/19/usda-rule-organic-fraud/.

PROTECTING ORGANIC INTEGRITY | APRIL 3, 2023

A Livable Future Tied to Growth of Organic Land Management with Strong Standards

The National Organic Standards Board (NOSB) opened its public comment period, with comments on organic standards due by 11:59 pm EDT April 5. April 5 was also the deadline for registering for the public comment webinar on April 18 and 20, which precedes the online meeting April 25-27—in which the NOSB deliberates on issues concerning how organic food is produced. Written comments are submitted through Regulations.gov.

As always, there are many important issues on the NOSB agenda this Spring. For a complete discussion, see Keeping Organic Strong (KOS) and the Spring 2023 issues page, where Beyond Pesticides' comments are posted on all issues facing the NOSB at this meeting. In the spirit of "continuous improvement," Beyond Pesticides urges the public to submit comments (using comments on the KOS page) that contribute to an increasingly improved organic production system. In addition to the key issues suggested (below), Beyond Pesticides urges the public to visit its KOS page and pick additional issues to comment on. (The public is welcome to cut-and-paste from the Beyond Pesticides' comments posted on its KOS page.) Here are some high priority issues for Beyond Pesticides:

Prohibit the Routine Allowance of Ingredients Processed with Ion Exchange. Because the ion exchange process is a chemical process, all organic ingredients processed in this manner must be subject to review by the NOSB. Ion exchange creates synthetic ingredients through chemical change—removing some components and substituting other chemicals—that are used in processed food. It is not simply filtration. Chemicals in the ion exchange resins may leak into the food product. Yet, the Handling Subcommittee of the NOSB is proposing to allow any and all resins without review. To maintain the integrity of the organic label, resins must be subject to full National List (National List of Allowed and Prohibited Substances) review to determine whether these ingredients meet organic standards, rather than establishing a blanket allowance of ion exchange in organic processing.

Organic Agriculture is Climate-Smart Agriculture. In a draft letter to Secretary of Agriculture Tom Vilsack, the NOSB has written an excellent primer on how organic agriculture responds to the climate emergency. An important caveat is that NOP and certifiers must hold organic producers to the letter and spirit of the *Organic Foods Production Act*, which requires that organic production be soil-based, incorporate diversity, and protect the environment. Operations based on hydroponics or confined animal facilities, and those that replace native ecosystems with organic farms do not meet those requirements. The

NOSB has made its position clear on those issues and must insist that NOP and certifiers carry out NOSB recommendations and consistently enforce the law—for the sake of reducing climate change, biodiversity loss, and human health impacts, as well as fairness. The NOSB should also stress the need for USDA to dramatically increase support for converting chemical-intensive agriculture to organic. It is critical that the National Organic Program ask, "What more should USDA be doing to advance organic?" As the Board states, the resiliency of organic is established: "Organic is the solution to mitigating climate change *and* responding to it." However, despite the astronomical growth in organic consumption in the U.S., conversion to organic agriculture lags behind demand. USDA could and should require the adoption of organic/climate-smart practices a prerequisite for receiving the benefits of its programs and abandon its promotion of chemical-intensive agriculture supported by the biotech/chemical industry.

Plastic mulch is under consideration this year as a part of its five-year review cycle. This is part of the larger issue relating to the use of plastic in organic production and handling. Awareness is growing about the impacts of plastic—and the microplastic particles resulting from its use—on human health and the environment. Plastics manufacture requires transportation of hazardous chemicals, such as those involved in the recent train derailment in East Palestine, Ohio. Plastic mulch should not be relisted as allowable in organic production. Moreover, the NOSB should initiate action to eliminate all uses of plastic in organic processing and packaging.

The NOSB should use the review (or sunset) process to eliminate nonorganic ingredients in processed organic foods. Materials listed in §205.606 in the organic regulations are nonorganic agricultural ingredients that may comprise 5 percent of organic-labeled processed foods. The intent of the law is to allow restricted nonorganic ingredients (fully disclosed and limited) when their organic form is not available. However, materials should not remain on §205.606 if they can be supplied organically, and we can now grow virtually anything organically. The Handling Subcommittee needs to ask the question of potential suppliers, "Could you supply the need if the organic form is required?" The materials on §205.606 up for sunset review this year are made from agricultural products that can be supplied organically and thus should be taken off the National List of allowed materials.

MORE ON THIS SUBJECT

Strong Organic Standards Require Continuing Public Involvement; Comments Are Due 11:59pm EDT April 5—March 20, 2023

PROTECTING ORGANIC INTEGRITY | DECEMBER 11, 2023

USDA Supports Expansion of "Organic" Hydroponically-Grown Food, Threatening Real Organic

Update: This Daily News is updated to address the organic status of the company cited in the piece, Merchant's Garden. The article now indicates that the company is certified as organic under a different name (Merchant's Garden Agrotech) than the name used in the USDA press release. As a result, their name did not appear in USDA's Organic Integrity Database (OID) at the time of the original Daily News and Action of the Week posting. USDA updated OID on December 8, 2023, the same day that it received a complaint on this matter from former National Organic Standard Board chair Jim Riddle. The critical focus of the piece remains the same: It is not disclosed to consumers on food products labeled "organic" when that food or ingredients are grown hydroponically. Beyond Pesticides, as indicated in the article, views hydroponic as a non-organic growing practice that does not meet the spirit and intent of the organic system, as defined in the Organic Foods Production Act.

U.S. Department of Agriculture (USDA) Secretary Tom Vilsack announced on November 27, 2023 funding that appears to be supporting the expansion of "organic" hydroponic, an approach to food production that has been criticized by the vast majority of the organic community as a process that violates foundational organic principles. The funding, under USDA's Rural Business and Value-Added Producer Grants program, is intended to assist in financing an expansion of rural businesses, including 185 projects worth nearly $196 million. Organizations representing organic producers and consumers have told the USDA's National Organic Program that hydroponic food production, as a form of conventional chemical-intensive agriculture, does not meet the standards of soil-based food production required for USDA organic labeling. Currently, federal law does not require that hydroponically produced food be labeled, leaving consumers unable to distinguish production practices at the point of sale.

One of the projects highlighted in the USDA announcement states, "Merchant's Garden LLC is a hydroponic and aquaponic farm in Tucson, Arizona. The company will use a $250,000 Value-Added Producer Grant to expand

marketing and sales of prepackaged salad mixes to help them become a local supplier of organic leafy greens for southern Arizona." However, Merchant's Garden's website does not make any organic claims for its produce, so Beyond Pesticides' question why USDA is promoting this hydroponic/aquaponic producer as "organic."

Beyond Pesticides has said: "Taxpayer dollars should not used to finance a hydroponic/aquaponic operation that does not comply with the *Organic Foods Production Act* (OFPA). If products from this operation are to be sold as "organic," it will cause harm to producers who comply with OFPA. It will also deceive consumers who purchase organic products believing that such products are produced in healthy, fertile soil, as required by the organic law and regulations. To the extent that hydoponic operations supplant soil-based (real) organic operations, these subsidies negate the climate and biodiversity benefits of organic agriculture."

The *Organic Foods Production Act*, at 6513(b), requires that all organic crop production operations submit and follow organic plans that "shall contain provisions designed to foster soil fertility, primarily through the management of the organic content of the soil through proper tillage, crop rotation, and manuring." The same section of OFPA goes on to state, "An organic plan shall not include any production or handling practices that are inconsistent with this chapter."

It is widely understood that organic farms support soil health, help sequester carbon dioxide, and avoid the use of materials like soluble nitrogen fertilizers that contribute many times as much warming potential as carbon dioxide. Beyond Pesticides advocates that USDA's financial support should go to new and transitioning organic farms.

By a decisive vote in 2010, the USDA's National Organic Standards Board determined that hydroponic and aquaponic operations are inconsistent with OFPA and do not qualify for organic certification. Under the law, the National Organic Program (NOP) is required to determine whether Merchant's Garden LLC complies with section 6513(b) of OFPA and whether the operation intends to sell their hydroponically-grown products as "organic." If the operation does not comply, NOP is required to ensure that it is not certified organic.

Historically, perhaps the most important principle of organic production is the "Law of Return," which, together with the rule "Feed the soil, not the plant" and the promotion of biodiversity, provide the ecological basis for organic production.

Historically, perhaps the most important principle of organic production is the "Law of Return," which, together with the rule "Feed the soil, not the plant" and the promotion of biodiversity, provide the ecological basis for organic production. (Sir Albert Howard. *The Soil and Health: The Study of Organic Agriculture* (1940), and *An Agricultural Testament* (1947).) Together, these three principles describe a production system that mimics natural systems. The Law of Return says that what is taken from the soil must be returned to the soil. Non-crop organic matter is returned directly or through composting plant materials or manures. To the extent that the cash crop removes nutrients, they must be replaced by cover crops, crop rotation, or additions of off-site materials when necessary.

The dictum to "Feed the soil, not the plant" reinforces the fact that soil is a living superorganism that supports plant life as part of an ecological community. Soil organisms are not fed to plants in isolation to have them process nutrients for crop plants. The soil is fed to support a healthy soil ecology, which is the basis of terrestrial life.

Finally, biological diversity is important to the health of natural ecosystems and agroecosystems. Biodiversity promotes balance, which protects farms from outbreaks of damaging insects and disease. It supports the health of the soil through the progression of the seasons and stresses associated with weather and farming. It supports our health by offering a diversity of foods.

A 2010 National Organic Standards Board report embraces these foundational principles but also contrasts organic production and "conventional" chemical-intensive agriculture. At the time of the passage of OFPA, the organic community's characterization of soil as alive was viewed with amusement by the "conventional" agriculture experts, who saw soil as a structure for supporting plants, while farmers poured on synthetic nutrients—and the poisons that had become necessary to protect the plants growing without the protection of their ecological community. Interestingly, organic producers at that time compared conventional agriculture to hydroponics.

Conventional agriculture has now learned something about soil life—enough to promote some use of cover crops despite continued reliance on petrochemical nitrogen. On a parallel track, practitioners of hydroponics have learned the value of biology in their nutrient solutions. However, in both cases, the lessons have not been completely understood. This is made very clear from the hydroponics industry explanation that "bioponics" (non-sterile hydroponics) depends on biological activity.

It is the case that bioponics relies on biological activity in the nutrient solution to break down complex molecules and make them available to the plants. It is also true that the nutrient solution in bioponics has an ecology—as all biological systems do. However, the hydroponics industry repeatedly calls this a "soil ecology," although it is merely an artificial mimic of soil ecology and a reductionist approach to manipulating nature.

Conventional agriculture has now learned something about soil life—enough to promote some use of cover crops despite continued reliance on petrochemical nitrogen. On a parallel track, practitioners of hydroponics have learned the value of biology in their nutrient solutions. However, in both cases, the lessons have not been completely understood.

A quote from the *Omnivore's Dilemma* 2006) by Michael Pollan can provide some perspective on the importance of organic as envisioned by the early adopters of the practices and the drafters of OFPA:

"To reduce such a vast biological complexity to NPK [nitrogen-phosphorous-potassium] represented the scientific method at its reductionist worst. Complex qualities are reduced to simple quantities; biology gives way to chemistry. As [Sir Albert] Howard was not the first to point out, that method can only deal with one or two variables at a time. The problem is that once science has reduced a complex phenomenon to a couple of variables, however important they may be, the natural tendency is to overlook everything else, to assume that what you can measure is all there is, or at least all that really matters. When we mistake what we can know for all there is to know, a healthy appreciation of one's ignorance in the face of a mystery like soil fertility gives way to the hubris that we can treat nature as a machine."

The ecological system of a hydroponic nutrient system is described by the hydroponics industry to be more like a fermentation chamber—a means of processing plant nutrients—than the soil ecosystem of an organic farm. The three principles cited above are explained in further detail below:

The Law of Return. In a soil-based system, residues are returned to the soil by tillage, composting, or mulching. In a bioponics system, the residues may be composted; the residue is not returned to the bioponic system, closing the loop. The inputs that are typically identified in bioponics include many agricultural products—animal-based compost, soy protein, molasses, bone meal, alfalfa meal, plant-based compost, hydrolyzed plant and animal protein, composted poultry manure, dairy manure, blood meal, cottonseed meal, and neem seed meal—and these are produced off-site, with no return to their production system. While most organic growers depend on some off-site inputs, most of the fertility in a soil-based system comes from practices that recycle organic matter produced on-site. The cycling of organic matter and on-site production of nutrients—as from nitrogen-fixing bacteria and microorganisms that make nutrients in native mineral soil fractions available to plants—is essential to organic production. The Law of Return is not about feeding plants but about conserving the biodiversity of the soil-plant-animal ecological community.

Feed the soil, not the plant. The description of the bioponics system and case studies reveal how much bioponics relies on added plant nutrients. These nutrients may be made available through biological processes, but they are added to feed the plants, not the ecosystem. Here is an example of a case study of bioponic tomatoes:

After planting the seedlings in this growing media, it is necessary to add supplemental nutrition throughout the

growing cycle (approximately one year). About once per week, solid and liquid nutrients are added to the growing media. Some fertilizers can be applied through the irrigation lines because they are soluble enough and will not clog the lines. The use of soluble nitrogen fertilizers is limited because of their high costs, for instance, for plant-based amino acids. [S]odium nitrate . . . will be used as a lower cost nitrogen source. Soluble organic-compliant inorganic minerals, such as potassium and magnesium sulfate, are also added through the irrigation system.

Biodiversity. The definition of "organic production" in the organic regulations requires the conservation of biodiversity. As stated in the National Organic Program Guidance on Natural Resources and Biodiversity Conservation (NOP 5020), the preamble to the final rule establishing the NOP explains, "[t]he use of 'conserve' [in the definition of organic production] establishes that the producer must *initiate practices to support biodiversity and avoid, to the extent practicable, any activities that would diminish it.* Compliance with the requirement to conserve biodiversity requires that a producer incorporate practices in his or her organic system plan that are beneficial to biodiversity on his or her operation." (76 FR 80563) [Emphasis added.]

Under this guidance, while the hydroponics industry may say it is not diminishing soil and plant biodiversity, certified organic operations must take active steps to support biodiversity. On a soil-based organic farm, many practices support—from crop rotations to interplanting to devoting space to hedgerows and other nonproductive uses. These practices are also used by organic farmers producing food in greenhouses. However, bioponics is a monocultural environment that does not support biodiversity.

INTEGRATING ORGANIC ALTERNATIVE IN EVALUATING PESTICIDE REGISTRATION | AUGUST 21, 2023

Health Advocates Urge EPA Integration of Safer Chemicals and Organic Practices in Pesticide Assessments

As the U.S. Environmental Protection Agency's (EPA) Safer Choice program asks for public input into the expansion of its work to label green chemicals, the need to recognize the importance of holistic management systems in sync with nature looms large. Will simple chemical substitution ignore the value of natural processes that require nurturing for a sustainable future? EPA's Safer Choice program is a non-regulatory program that identifies alternative chemicals for a number of uses that meet expanded safety criteria.

For problems requiring a chemical solution—for example, laundry detergents—EPA's Safer Choice is a valuable resource, and consumers can look for products with the Safer Choice label, which requires that EPA review *all* chemical ingredients that must meet safety criteria for both human health and the environment, including

carcinogenicity, reproductive and developmental toxicity, toxicity to aquatic life, and persistence in the environment. While EPA's Safer Choice/Design for the Environment (DfE) program performs alternatives analyses on chemicals and identifies chemicals that are less hazardous, it stops short of identifying systems that make chemical inputs unnecessary. Substituting a less toxic pesticide, for example, is not the same as switching to available organic methods. [For pesticidal uses, the program is called Design for the Environment (DfE), which has so far been limited to disinfectants.]

Like Safer Choice, the National Organic Program (NOP) established by the *Organic Foods Production Act* (OFPA), is a label-centered program. Relying on consumer demand for food without pesticides or other chemical additives, produced in a way that benefits health, ecology, and biodiversity, NOP establishes standards for producers to use the organic label. OFPA does not require organic producers to use safer inputs. Rather, it requires them to adopt a system consistent with organic principles—building soil, increasing biodiversity, and producing healthy food—using only inputs that are natural (non-synthetic) or are approved for a specific use by the National Organic Standards Board and placed into regulations on the National List. The growth of organic food sales in the U.S.—exceeding $60 billion in 2022—is based on consumer recognition of the value of organic food.

The organic program could have a larger impact if EPA, in its pesticide registration program, recognized that pesticide uses are unreasonable if the goals of the use could be met by available organic methods.

Similarly, Safer Choice would have a larger impact if expanded and incorporated into regulatory programs, as part of a system. The heart of the Clean Water Act (CWA) program, for example, is the National Pollution Discharge Elimination System permit. EPA has largely ignored the elimination part of this program. Instead, EPA says, "An NPDES permit will generally specify an acceptable level of a pollutant or pollutant parameter in a discharge." There are two ways that the Safer Choice program could improve CWA implementation. First, the chemical and toxicological analyses required by Safer Choice could identify priorities for elimination. Second, the Safer Choice alternatives analyses could identify alternative processes that could eliminate those substances and create a list of substances for which NPDES permits might be allowed for specified uses—analogous to the National List in NOP.

In the arena of pesticide regulation, EPA could determine that the registration of a toxic substance is unreasonable in light of the availability of alternative practices and products identified by the Safe Choice program.

These applications are consistent with policies of EPA and the Biden administration. EPA characterizes Safer Choice as being part of the agency's pollution prevention (P2) program, which EPA defines as "any practice that reduces, eliminates, or prevents pollution at its source prior to recycling, treatment, or disposal." EPA says, "Pollution prevention approaches can be applied to all potential and actual pollution-generating activities, including those found in the energy, agriculture, federal, consumer and industrial sectors. Prevention practices are essential for preserving wetlands, groundwater sources and other critical ecosystems—areas in which we especially want to stop pollution before it begins." P2, in concert with President Biden's Executive Order 14057 on catalyzing American clean energy industries and jobs through federal sustainability and accompanying Federal Sustainability Plan, establishes a framework for applying Safer Choice to eliminate harmful practices and emissions by compelling a transition to practices that build a climate- and sustainability-focused economy.

Note: Beyond Pesticides will continue the discussion on Safer Choice in future postings, both in the context of suggesting an expansion of the program, as well as in the context of what is needed to meet the challenges of severe health threats, biodiversity collapse, and the climate emergency—systemic change in the way synthetic chemicals are regulated.

Note: Beyond Pesticides began its Safer Choice program prior to EPA's.

MORE ON THIS SUBJECT **Is "Safer Choice" Eliminating Hazardous Chemical Use through Management and Product Choice?**—August 10, 2023

GREENWASHING—MISLEADING ON THE SOLUTION | FEBRUARY 3, 2023

With Environmental Collapse on the Horizon, California's Sustainable Pest Management "Roadmap" Misses Mark

On January 26, California's Environmental Protection Agency (CalEPA), Department of Pesticide Regulation (CDPR), and Department of Food and Agriculture (CDFA) announced a new "roadmap" for sustainable pest management (SPM). The plan is promoted by the agencies as an accelerator of the state's commitment to transitioning away from "high-risk pesticides" and toward "adoption of safer, sustainable pest control practices," and to eliminating "priority [high-risk] pesticides" by 2050. Although *Sustainable Pest Management: A Roadmap for California* recognizes the state (and federal) failure of current pesticide policies and land management practices

to restrict pesticides sufficiently, environmental advocates say that even this plan does not "meet the moment." Its relative ambition (compared to what most states are doing), still does not, according to those advancing transformative change, adequately address the current existential health, biodiversity, and climate crises. With these crises being especially urgent, meaningful change is the adoption of approaches predicated on ensuring healthy soil biology. This calls for the deployment of a plan for the wholesale transition to organic systems that eliminate all materials/inputs that are harmful to soil health, ecosystems, natural resources, and the health of humans and all living organisms.

The California roadmap was developed by a team of 33 people—25 members of the Sustainable Pest Management Work Group and eight comprising the Urban Subgroup. The designation of the Urban Subgroup was a wise move, according to Beyond Pesticides, because although public perception is that "pesticides" are related to agriculture—and certainly agriculture is the central focus of much discussion about pesticides—the reality is that pesticide use in urban areas is real and not insignificant. In fact, studies have documented that the poundage of pesticide use per acre is often higher in non-agricultural areas, such as golf courses and lawns. These urban uses happen in residences, businesses, and institutions, and have been evidenced through studies that focus on wastewater, surface waters, and stormwater.

The plan defines SPM as an "evolution" of the IPM (Integrated Pest Management) concept—defined by the University of California Statewide Integrated Pest Management Program (UCIPM) as an ecosystem-based strategy that focuses on long-term prevention of pests or their damage, using strategies such as habitat manipulation, biological controls, resistant plant varieties, and modified horticultural practices. But UCIPM goes on to add, "Pesticides are used only after monitoring indicates they are needed according to established guidelines, and treatments are made with the goal of removing only the target organism. Pest control materials are selected and applied in a manner that minimizes risks to human health, beneficial and nontarget organisms, and the environment."

Beyond Pesticides has been critical of IPM as it has generally been executed in agriculture because IPM has largely failed to achieve the goals of its original conceit—significant reduction of synthetic pesticide use. Researchers on IPM have noted that over the decades since the inception of the IPM concept some 60 years ago, deployment of strategies has focused far more on reducing negative environmental impacts than on using ecological processes to replace chemical pesticides—an approach that would advance sustainability. Other factors mitigating against the original ideal have included: poor education of practitioners on the concept, multiple and competing definitions of IPM, lack of understanding of ecological concepts that were to underlie IPM, inadequate research and funding, and agrochemical industry lobbying against IPM programs.

The roadmap document describes SPM as a "a process of continual improvement that integrates an array of practices and products aimed at creating healthy, resilient ecosystems, farms, communities, cities, landscapes, homes, and gardens. SPM examines the interconnectedness of pest pressures, ecosystem health, and human wellbeing."

It identifies its goals as (1) eliminating the use of Priority Pesticides by transitioning to sustainable pest management practices, and (2) adopting SPM as the de facto pest management system in California, all by 2050. Beyond Pesticides considers 2050 far, far too late in the game for meaningful changes in the faces of the above-referenced crises.

Those Priority Pesticides are defined as "pesticide products, active ingredients, and groups of related products within the context of specific product uses or pest/location use combinations that have been deemed to be of greatest concern and warrant heightened attention, planning, and support to expedite their replacement and eventual elimination. The criteria for classifying pesticides as 'Priority Pesticides' includes . . . hazard and risk classifications, availability of effective alternative products or practices, and special consideration of pest management situations that potentially cause severe or widespread adverse impacts."

The keystone actions the plan sets out are these:

- prioritize prevention of pest problems: prevent the establishment of new invasive pest species, and proactively eliminate pest-conducive conditions both in agricultural and urban settings;
- coordinate state-level leadership: create an accountable and connected leadership structure to champion SPM in the field, effectively embed SPM principles across agencies, and improve coordination;
- invest in building SPM knowledge through research and outreach, for both agricultural and urban sectors: invest in SPM-focused research and outreach so that all pest management practitioners have equal and adequate access to the support and resources necessary to develop and implement their own SPM system;
- enhance health and environmental monitoring and data collection: expand and fully fund health and environmental monitoring infrastructure, data collection, and interpretation; and,
- improve the state's pesticide registration and continuous evaluation processes, and bring alternative products to market: create mechanisms to improve DPR's registration review process and to prioritize and expedite safer, more sustainable alternative products to high-risk pesticides, and improve processes for evaluating currently registered pesticides.

Those actions all sound great . . . until that last one, according to Beyond Pesticides. Improving a pesticide registration process is, in the view of Beyond Pesticides, somewhat akin to the storied rearrangement of the deck chairs on the *Titanic* as it sinks. As Executive Director Jay Feldman commented, "We are no longer in a period of environmental and health challenges, associated with chemical-intensive agriculture and land management, that permits us simply to 'minimize reliance on the use of toxic pesticides.' We must eliminate all petrochemical pesticides and fertilizers in the context of agricultural systems." He continued, "An example of good intentions gone awry is that the SPM document contains the word 'fertilizer' exactly once, and then only in reference to consolidation in the chemical input (synthetic pesticide and fertilizer) sector. And 'soil fertility' is mentioned just once—in a sidebar on expanding non-pesticidal methods. An SPM program that is a genuinely holistic response to multiple crises—health, climate, and biodiversity—must proscribe the currently ubiquitous use of synthetic fertilizers, as well as pesticides, in dominant, chemically intensive land management systems." Use of petrochemical pesticides and fertilizers represents the antithesis of sound efforts to build biologically healthy soil—the basis of any truly sustainable agricultural pest management system.

To its credit, the SPM plan includes important aspects of a truly sustainable approach. It asserts (p. 16), "In agricultural settings, SPM is rooted in an agroecological approach that considers the whole farm as well as the wider landscape in which it sits. . . . The practices and products together aim to build healthy, pest-resilient agroecosystems that reduce the need for external inputs. Agricultural SPM takes a systems approach to pest prevention and management, while considering environmental health, social equity, and economic viability each step of the way. Therefore, SPM facilitates, where possible, an enhancement of the following co-benefits:

- improving soil health, water quality, use efficiency, and supply; air quality; and biodiversity;
- advancing climate mitigation and adaptation;
- increasing nutrient density in crops while maintaining yields;
- improving land management practices;
- improving farmer and farmworker working conditions; and,
- increasing community health and well-being."

The roadmap also includes proposed robust efforts to bring alternative (presumably, non–synthetic chemical) pest control products to market. But the plan continues to rest on an underlying assumption that "pesticides are here to stay," at least in the short and medium term. The SPM document includes a section on "SPM and Pesticides" (see p. 79) that asserts, "There will no doubt be times when all other pest management options have been exhausted, and still a significant pest pressure remains. . . . In these cases, pesticides may still be employed, so long as the intention is to apply these products in a targeted way, as needed in order to eradicate the pest(s) and continue with a holistic, integrated pest management approach that aims to build overall system health. Pesticides and pesticide-related uses include but are not limited to a. fumigants, b. repellents, c. use of seeds that have been treated with pesticides, d. antibiotics, e. herbicides, f. fungicides, g. insecticides." That is a very large "escape hatch" to a pesticide path of least resistance for producers.

Additionally, the proposed SPM action, Improve California's Pesticide Registration and Continuous Evaluation

(p.19), begins with a focus on a transition to lower-risk chemicals—which presumably include perhaps less-risky, but nonetheless, synthetic compounds for which there is insufficient evaluation by the state or the U.S. Environmental Protection Agency (EPA). The roadmap asserts, "DPR must . . . improve its processes for evaluating currently registered pesticides."

But if the historical record offers any instruction, this would be, at best, a long-term process, and would be fought against aggressively by the agrochemical industry. A plan that would respond to the urgency of the moment would forward the principles of organic, regenerative, agroecological approaches, rather than the SPM approach of tweaking a broken pesticide regulatory system in which chemicals are not adequately evaluated for efficacy or essentiality. See Take Action: Sustainable "Roadmap" Falls Short of What Is Needed To Solve Existential Crises.

It should be noted that reform of California's pesticide registration system (as well as the national EPA registration system) would appropriately require an analysis of nontoxic alternatives. Yet, to address the current crises, reform must also—given the limitations of the current state of pesticide risk assessment, which fails to integrate the range of vulnerabilities in the human population, data gaps, untested health outcomes, exposures to pesticide mixtures and potential synergistic effects, and a range of other complexities that go unaddressed through testing protocols—require adoption of the Precautionary Principle, with its built-in protective ethos.

Beyond Pesticides asserts that there is an urgent imperative to recreate agricultural policy and practices on the scaffolding of organic systems, as defined in the 1990 U.S. Organic Foods Production Act (OFPA). Organic is a framework with a ban on synthetic fertilizers and a National List of Allowed and Prohibited Substances that is required to be established and updated on a five-year cycle with a cradle-to-grave analysis of allowed substances. Beyond Pesticides holds that this system should be continually improved, and expanded to become the dominant approach to agricultural and other land management in the U.S.

Mr. Feldman concludes, "Decades ago, I would have said that the SPM plan was a good start. But with today's realities, I would have to call this a false start that does not embrace the true changes that are required for our times and the crises we face. *Now* is the time to transform our approach to agricultural and nonagricultural land management. We *can* stop using synthetic pesticides and fertilizers; we need a plan—based on precautionary, organic, and regenerative principles—to move us forward to that goal, and we need it ASAP."

SOURCE: https://www.cdpr.ca.gov/docs/sustainable_pest_management_roadmap/spm_roadmap.pdf and https://www.cdpr.ca.gov/docs/sustainable_pest_management_roadmap/spm_executive_summary.

CHEMICAL FAILURE, EFFICACY, AND CLIMATE | FEBRUARY 15, 2023

Glyphosate Weed Killers Reduce Crop Yields and Hamper Climate Mitigation Efforts

Glyphosate use in grassland pastures reduces crop yield and impedes climate change mitigation, find two studies (1,2) published this month from the University of Turku, Finland. While massive public relations campaigns by the agrichemical industry have poured in millions of dollars to convince politicians and the public that pesticides are necessary to 'feed the world' and address the climate crisis, the data does not support these claims. "Only in recent years, we have started to realise that intensive agriculture and agrochemical pollution in fact contribute to a reversal of the intended purpose. Soils are polluted with pesticides and at the same time, extreme weather events erode soil nutrients," says study coauthor Benjamin Fuchs, PhD.

Researchers approached their investigation through two separate experiments on the grass *Festuca pratensis,* an important forage crop grown for grazing animals throughout the world. The first experiment was conducted in an enclosed greenhouse, while the second took place in a field setting. For both experiments, plots were separated between glyphosate-sprayed and unsprayed controls. All plots received three different approaches to cutting the grass: one group that was intensely cut to two inches (5cm), the second group cut to six inches (15cm), and the third group remained uncut. To determine effects, scientists measured total root biomass and total yield. For the greenhouse experiment, plant chlorophyll and shoot (above-ground plant material, not including roots) biomass was also recorded separately.

For all experiments and plot variables, none saw glyphosate use having a positive impact on yield or biomass. For the greenhouse experiment, shoot biomass was lowest in grasses cut intensively and those growing in glyphosate-sprayed soils. In general, the more frequently the grass was cut, the larger the reduction in root biomass. However, even among uncut grasses, those grown in glyphosate-sprayed soils showed the lowest root biomass. Chlorophyll content also followed this pattern, with

those in the most intensively cut grouping showing the lowest content if also grown in soils where glyphosate was applied.

The similarity of the greenhouse results to those of the field experiment adds considerable weight to the study's ultimate conclusions. Intensively cut grasses show the lowest root biomass, and roots grown in glyphosate-sprayed soils are found to be six grams lighter than those grown in soils that have not been sprayed with the chemical.

The primary finding of these studies is surprising to researchers—regardless of cutting intensity and other factors, glyphosate use reduces the root growth of the grasses.

"This demonstrates a tremendous limitation to the potential carbon binding and storage belowground when soils are polluted by pesticide. Considering the vast amount of pesticides applied to agricultural fields yearly, we can conclude that the impact on soil quality is a major driver of limited root growth, carbon sequestration, and consequently plant resilience and productivity," Dr. Fuchs says.

Fodder grasses are grown throughout the world for grazing, hay, or silage, and glyphosate is often used to treat these pasturelands. When these plants grow, they take in carbon from the atmosphere and bind it into soils through root growth. "[U]nderstanding how pesticide pollution in soil and intensive management limit plant productivity is the key to optimising intensive grassland-based agriculture in a sustainable and climate-friendly way," says Dr. Fuchs.

It is becoming increasingly clear that addressing climate change means reining in all fossil-fuel based products, including the use of hazardous pesticides. As the pesticide industry continues to push claims that their products are the only solution for a growing population on a warming planet, the science shows the opposite. Less intensive, more ecologically friendly organic agricultural practices are better at combating climate change, while the use of toxic chemicals undermines the ability to embrace this more beneficial approach.

For more information on the dangers ongoing pesticide use poses to our ability to combat climate change, see talks from Beyond Pesticides recent climate change webinar, featuring Rachel Bezner Kerr, PhD, Cornell University professor and coauthor of the definitive United Nations (UN) report on climate and food production and Andrew Smith, PhD, chief operating officer of the Rodale Institute and coauthor of several landmark reports on soil biology and carbon sequestration, including the just released *Farming Systems Trial—40-Year Report*.

Take the opportunity to express your concerns to USDA, EPA, and Congress by urging them to incorporate climate change considerations into all future policy decisions.

SOURCES:

Sanna Keronen, et al., Management practices and soil properties affect plant productivity and root biomass in endophyte-symbiotic and endophyte-free meadow fescue grass, *Journal of Sustainable Agriculture and Environment*, December 12, 2022, https://doi.org/10.1002/sae2.12035

Rainio Laihonen, et al., Root biomass and cumulative yield increase with mowing height in *Festuca pratensis* irrespective of *Epichloë* symbiosis. *Sci Rep* 12, 21556 (2022). https://doi.org/10.1038/s41598-022-25972-y.

CHEMICAL FAILURE, EFFICACY, AND CLIMATE | MARCH 2, 2023

Groups Challenge EPA on Allowing Toxic Pesticides that Do Not Even Work and Without Its Review

On February 22, a group of 65 nonprofit organizations (including Beyond Pesticides) filed a citizen petition with the U.S. Environmental Protection Agency (EPA) that asks the agency to close a gaping—and well exploited—regulatory loophole by revoking a 1984 regulation that waived efficacy data requirements in pesticide evaluations. This means that EPA has, for 39 years, registered pesticides without demonstrated proof of efficacy and benefits. The petition is aimed primarily at the widespread use of neonicotinoid insecticides (neonics), which are so harmful to hundreds of species—and to bees, other pollinators, and birds, in particular—that many advocates have insisted they should be banned altogether. Beyond Pesticides has advocated for a neonics ban because of their extensive harms to pollinators, multiple other organisms (including humans), ecosystems, and natural resources.

The Center for Food Safety, Pesticide Action Network North America, Center for Biological Diversity, Beyond Pesticides, and other advocates have filed lawsuits in recent years to get EPA to act protectively on neonics and other pesticides. The coalition of groups in the subject case seeks to rein in a plethora of harmful impacts of neonics, given EPA's overall lack of protective action. (For recent developments, see here and here.) Indeed, in the absence of effective neonic regulation, many localities and states (e.g., Maine, Maryland, New York, New Jersey, Massachusetts, Portland and Eugene, Oregon), as well as France and unitary state entities, such as the European Union and the United Kingdom, have taken steps to ban or curb significantly the use of these noxious compounds.

Led by PEER (Public Employees for Environmental Responsibility) and the American Bird Conservancy (ABC), the petition "asks EPA to amend its existing regulation for registrations of all neonicotinoid insecticides and other systemic insecticides so as to require all registration and reregistration applicants to provide performance (efficacy) data to ensure that the benefits of their products actually exceed their costs, including to society and to the environment." Beyond Pesticides Executive Director Jay Feldman asserts that EPA does not evaluate the efficacy of pesticides, except for those deemed to have public health benefits (such as those used in a public health emergency or for a "special local need"); even then, he says agency action on the latter has hardly been stellar.

According to the Environmental Health Newsletter (EHN), the current, ubiquitous use of neonics has arisen in large part from that 1984 EPA waiver, which said, "rather than require efficacy data, the Agency presumes that benefits exceed risks." EHN also notes that, "The petition specifically calls for the EPA to reinstate performance data re-

quirements and says if the companies failed to provide such information, the EPA should revoke their product registrations. The rule change would include products currently on the market."

Neonics are the most widely used class of insecticides globally; they impact roughly 100 million acres annually in the U.S. In a PEER press release subtitled "Neonicotinoid insecticides targeted for wreaking eco-havoc despite lack of economic benefits," Senior Counsel Peter Jenkins commented, "While EPA should hold all pesticides to a higher standard, for the neonics we have voluminous published evidence on their lack of efficacy, their prophylactic overuse, and the environmental harm they are causing. The threat they pose to long-term ecosystem integrity is especially insidious."

Launched to market two decades ago, use of neonics increased significantly when the treatment of crop seeds with the compounds took hold. This marked "an unprecedented shift toward large-scale, preemptive insecticide use," and has contributed to the insect apocalypse underway—as evidenced by a 75 percent decline in insect abundance.

The impacts on pollinators are of extreme concern, both generally and because these creatures are critical to food production. The U.S. Geological Survey (USGS) recently reported, for example, that the western bumble bee underwent a 57 percent decline from1998–2020. The use of neonics, and pesticides broadly, threatens not only global ecosystems, but also, food production that depends on pollinators. Neonic seed treatments are commonly used on cotton, soybean, wheat, canola, wheat, sunflower, potato, and many vegetables seeds.

A chief contributor to bee, other pollinator, and bird decline, neonics affect the central nervous systems of organisms. The chemicals impair, for example, bees' foraging, navigational, and learning behaviors, and immune responses, and often result in paralysis and death. As Beyond Pesticides has written, "These individual impacts are compounded at the level of social colonies, weakening collective resistance to common parasites, pathogens, and other pesticides . . . thus leading to colony losses and mass population declines. In 2018, more than two hundred scientists coauthored a 'call to restrict neonicotinoids' on the basis of the bulk of evidence implicating neonicotinoids in mass pollinator and beneficial insect declines."

Neonics are systemic compounds, meaning that they move throughout a plant's vascular system, and are present not only in plant tissues, but also, in pollen, nectar, and guttation droplets. Organisms that feed off of treated plants (and those that grow from treated seed) thus ingest the compounds and suffer the risks outlined above; this includes beneficial insects. Any plant remnants left in the field also harbor the compounds, polluting the soils on which they decompose. Neonics can persist for long periods in soil, and are highly water soluble; they can be transported by rain or irrigation systems to surface waters, waterways, and groundwater.

Yet another vector for exposures is the neonic dust that becomes airborne when treated seeds are planted. Together, these paths account for much of the contamination of drinking water by neonics. Neonic impacts on health, via compromise of the central nervous system, is not limited to the insect and bird world. Humans are also at risk, with established associations between neonic exposures and neurotoxicity, reproductive anomalies, hepatic and renal damage, and an increase in gene expression linked to hormone-dependent breast cancer.

Acting director of the pollinator initiative at the Natural Resources Defense Council, Daniel Raichel, commented: "The failure to regulate treated seeds creates a gigantic regulatory blind-spot —allowing one of the largest and most widespread uses of pesticides to go almost completely untracked and unregulated."

Research published in the *Proceedings of the National Academy of Sciences Journal* in 2020 adds to the arguments against this class of insecticides: "[N]eonicotinoid exposure is far higher than necessary to achieve plant protection and yield objectives. Neonicotinoid seed coatings rarely improve crop yield, and neonicotinoids are applied preventively to vast areas of turf, which cover more land in the United States than any other irrigated crop, even when pests are absent or below thresholds. . . . Risks to many terrestrial, aquatic, and detrital organisms and ecosystems have been documented. Considering these risks, advocacy groups have frequently promoted outright bans on all neonicotinoids in all circumstances, and this stance seems easy to justify."

Efficacy facts belie the intensive use of neonics as seed treatments. EPA itself (in 2014) reported that "seed treatments with neonicotinoid insecticides provide little or no overall benefit in controlling insects or improving yield or quality in soybean production." (See the detailed EPA letter on the underlying research here.) Research in 2019, as reported by Beyond Pesticides, found that neonic-treated soybeans provide negligible benefits to farmers in terms of yield and overall economic benefit. Environmental advocates maintain that EPA, in its neonic registrations and reregistrations, ought to be evaluating whether pesticide compounds—especially those with such demonstrated harms as neonics—are necessary and effective *before* introducing them into the environment or allowing their continued deployment.

It is instructive, in discussion of the petition's attention to efficacy, to note that under the Organic Foods Production Act (OFPA), the U.S. Department of Agriculture's (USDA's) National Organic Program (NOP) operates with attention to the *necessity* of a substance: "NOSB members use specific criteria when voting on substances, including the essentiality for the substance and its impacts on human health and the environment." If EPA were to operate like NOP, it would find that if a neonic does not work, it is entirely unnecessary.

Mr. Feldman comments, "The justification EPA has used for efficacy of

pesticides is that 'the marketplace determines efficacy,' and that 'farmers and consumers wouldn't buy them if didn't work.' When we're talking about toxic substances and acknowledged hazards and risks, it is inappropriate for an agency to allow harm, especially if the product doesn't work or perform as intended." In 2021, a coalition of groups, including PEER and Beyond Pesticides, issued a scathing critique of the performance of EPA's Office of Pesticide Programs—embedded in the groups' advocacy for a series of 25 reforms.

The subject petition is the most recent strategy used by advocates to pressure EPA to curb the use of neonics by altering its registration (and reregistration) process for them (and all pesticides) to take into account their efficacy. The petition tackles one specific aspect of EPA's process on one class of insecticides. The agency's track record, on so many pesticides, is to deal with one compound (under a narrow range of circumstances and/or narrow time frame and/or specific exposure levels) at a time. Beyond Pesticides has dubbed this the "whack-a-mole" struggle on pesticides.

Each regulatory baby step at EPA, each judicial settlement or knock-down of a particular pesticide, each bit of research demonstrating harms—these represent small, incremental advances on a pesticide problem that is vast in scope. But this approach is seen as wholly inadequate to the devastation that toxic pesticides are causing, and it continues the "collision course" we are on re: human health and well-being, biodiversity collapse, and the climate crisis. A precautionary approach—captured in organic, regenerative agriculture and land management protocols—is *far* more suited to the task of genuinely protecting public health and the environment than EPA's current, industry friendly, piecemeal approach.

The availability of alternative materials and practices that prevent (or vastly reduce) toxic hazards, as are used in organic management, makes the dependence on synthetic chemical pesticides even more reprehensible, according to environmental advocates. As consistent readers of *the Daily News* are aware, Beyond Pesticides pursues a vision of a genuinely protective approach to pests (floral or faunal) in agriculture and land management, via a transition from chemical dependency to organic land management in food production, and in parks, playing fields, and all recreational and public spaces. In the meantime, efforts to push EPA will continue to move the needle, however slowly and haltingly.

SOURCE: Citizen Petition to the Environmental Protection Agency, Petition for Rulemaking to Amend EPA's 1984 Pesticide Regulation that Waived Efficacy data Requirements, February 16, 2023.

MORE ON THIS SUBJECT

Slug Killer Chemical Found to Hamper Growth of Garden Veggies—March 29, 2023

Efficacy and Health Issues Stop Release of Genetically Engineered Mosquitoes in California; Florida Continues—May 17, 2023

CHEMICAL FAILURE, EFFICACY, AND CLIMATE | APRIL 21, 2023

More Data Shows Failure of Crops Genetically Engineered to Incorporate Insecticide

Into the annals of "entropic methods of agricultural pest control" arrives recent research showing that pests are, unsurprisingly, developing resis-tance to a genetically engineered (GE) biopesticide used for more than 90 percent of U.S. corn, cotton, and soybeans. Bt (*Bacillus thuringiensis*) is a naturally occurring bacterium; the versions deployed in conventional agriculture are engineered into Plant Incorporated Protectants (PIPs)—GE ingredients "inserted" into seeds for multiple kinds of crop plants. These PIPs target multiple crop-destructive insect species, including (in larval form) the corn rootworm and cotton bollworm, in particular. Beyond Pesticides continues to warn that "controls," whether synthetic chemical pesticides or GE "biological" agents (such as GE Bt) that target living things (e.g., pests and weeds) are not sustainable over time because—in addition to the harms they cause—the issue of resistance will ultimately thwart their efficacy.

There are two basic categories of genetic engineering employed in conventional agriculture. One technology transfers genetic material into seed to make plants tolerant of specific herbicide compounds that will be applied after planting (for example, the infamous "Roundup Ready," glyphosate-tolerant seeds and plants). The other comprises plant-incorporated protectants (PIPs), in which the genetic material introduced causes endogenous production of proteins harmful to particular insect pests. (See much more on Bt through the Beyond Pesticides Bt archive.)

As *U.S. Right to Know* (USRTK) explains in its coverage of a 2016 independent research study on the subject, "Crops engineered with Bt genes express specific proteins (known as Cry proteins) that make the crops toxic to specific insects—the plants effectively provide their own insecticide—[theoretically] reducing the need for chemical applications. . . . Th[is] research adds to evidence that after 20 years of use of crops engineered to tolerate herbicides and resist certain harmful insects, both technologies are losing effectiveness."

Corn seed engineered with Bt was developed in 2003 by Monsanto and deployed to deal with the Western corn rootworm. EPA stepped in early on to require that producers using Bt products create so-called "refuge" areas—fields

of specific size and proximity (to the Bt fields) that are planted without PIPs. These "refuge" areas aimed to ensure that breeding would occur between non-resistant rootworms from the untreated corn and resistant individuals that would emerge from the areas planted with Bt varieties. The theory is that such breeding would dilute the frequency of the genes that encode resistance and inhibit their inheritance in subsequent generations of rootworms.

This refuge tweak has largely failed, in part because of noncompliance. PIP manufacturers responded to that issue by creating a farmer-friendlier "refuge in a bag" system that allowed farmers to avoid setting aside some of their field areas as free of the Bt trait. How? By encouraging the spreading of uneven low doses of the Bt toxin to feeding insects throughout all their fields. Monsanto "'touted refuge-in-a-bag' as fast and convenient for farmers, allowing them to plant the specialized seed 'fence row to fence row.'" In reality, the tactic catalyzed resistance in the insects over time. *Progressive Farmer* warned of this in 2012.

In addition, critics of EPA's introduction of the "refuge" tactic noted that to be at all effective, the refuge areas needed to be much bigger than EPA required. In 2012, a study concluded that, "EPA should more than double the percentage of corn acres planted to mandated refuges to delay insect resistance." (One investigator and co-author of that study was the same Bruce Tabashnik, PhD who was lead author on the subject study cited above.)

The increasing recognition of developing resistance to GE-Bt-as-PIP underscores several problems:

1) all pesticides are ultimately doomed to fail because of the all-but-inevitable development of resistance in organisms (including weeds);
2) the response of industry and the U.S. Environmental Protection Agency (EPA) to resistance continues to be, respectively, doubling down on chemical approaches, and/or tweaking use parameters to try to rein in problematic impacts; and,
3) there are many Bt strains, some of which are permitted for pest management purposes in organic agriculture (in addition to the many GE insecticide versions); the increasing use of Bt in GE-plus-chemical agriculture —and the resulting uptick in resistance —represent a real threat to this useful tool for the organic sector.

EPA acknowledges the resistance issue: "Like [with] most pesticides, insects are capable of developing resistance to Bt proteins. In Bt PIPs, this risk may be heightened by the fact that:

- Bt proteins are expressed at high levels in most or all plant tissues;
- the proteins are produced by the plant continually during the growing season (i.e., throughout the lifespan of the plant); and,
- some of the major target pests, such as European corn borer, corn rootworm, and pink bollworm, feed almost exclusively on corn or cotton.

These factors can increase insect exposure to the controlling toxins (Bt protein) and hence, increase selection pressure for resistance. That means that if the toxin kills susceptible insects, those that survive and reproduce are more likely to be resistant to the toxin."

The issue of resistance to Bt began to be noticed in 2008 in cotton bollworms —a mere five years after initial deployment of Bt products. The industry claim that genetic manipulation of plants

would result in reduced pesticide use began to be exposed as false a decade ago. In 2013, *The Wall Street Journal* noted that, as resistance to Bt products began to ratchet up and corn rootworm damage surged, farmers returned with a vengeance to chemical insecticides—unraveling a central argument for the GE Bt strategy. (Beyond Pesticides wrote about typical industry response to resistance in 2019: "Manufacturer response is often either to find a new chemical, or to 'double down' with combined-ingredient products that may be effective until the next wave of resistance develops.")

A 2013 study published in *PNAS* (the *Proceedings of the National Academy of Sciences*) concluded that, "The widespread planting of crops genetically engineered to produce insecticidal toxins derived from the bacterium *Bacillus thuringiensis* (Bt) places intense selective pressure on pest populations to evolve resistance.... These [early] cases of resistance by western corn rootworm highlight the vulnerability of Bt maize to further evolution of resistance from this pest and, more broadly, point to the potential of insects to develop resistance rapidly."

In 2020, EPA issued a draft proposal for ways to "improve" the problem of pest resistance for Bt PIPs in corn and cotton crops. The agency's goal was to "prolong the durability of Bt PIPs from pests." Zeroing in on the lack of meaningful changes in the proposal, Beyond Pesticides, led a group of nine other advocate organizations, commented on it: "The agency is proposing changes to three aspects of ... insect resistance management that consist of new resistance definitions, increased resistance monitoring and mitigation efforts, and modified annual reporting to the agency. *These changes do not address or impact the biology of pest populations developing resistance, but only the recognition and identification of such resistance* [emphasis by Beyond Pesticides]. In addition to the above proposed framework changes, the agency is considering options to ... increase percent of refuge in seed blend products, and change ... refuge compliance measures. These options at best will only delay the development of more prevalent pest resistance to Bt toxins.... [W]e find that the proposed new resistance management framework ... will do little to curb the trajectory in the increasing resistance." (See comment here.)

In that same year, EPA also began considering a proposal to reduce, gradually, the use of some Bt corn and cotton products in an attempt to combat pest resistance. One tactic was a three-year "phasedown" to some unspecified "minimal acreage cap" of Bt products for corn. The agency also considered (again) increasing the ratio of non-Bt corn seeds in blends used in "refuge" areas, the aim being to slow resistance by allowing nonresistant insects to mate with resistant insects. The proposal received significant pushback from grower groups and the crop protection industry. The former is very accustomed to use of Bt PIPs and considers them still useful despite evidence that efficacy is time limited, given galloping resistance. The latter is looking to Hoover up profits from this technology for as long as it can.

The very human, and very unwise, tendency to think short term is on full display throughout the agrochemical and agro-biotech sectors, as well as at EPA. In 2020, Beyond Pesticides wrote: "Resistance to pesticides is nearly inevitable. Development of resistance is an entirely normal, adaptive phenomenon: organisms evolve, 'exploiting' beneficial genetic mutations that give them survival advantage. For nearly a century, human response to this has been primarily a chemical 'chasing' of such evolutionary changes—developing a compound that kills the offending organism (whether pest or weed or bacterium or fungus) for a while. Organisms nearly inevitably change to become resistant to that particular chemical assault, whereupon people—the chemical industry, researchers, applicators, farmers, public health workers, clinicians, et al.—have typically moved on to the next chemical 'solution.'" To the "chemical" critique, "biotechnical" approaches can now readily be added.

Last year, Beyond Pesticides coverage of a study on emerging Crispr technology quoted Ethan Bier, PhD on that new technology. His comment is equally relevant in this Bt context, and underscores Beyond Pesticides' perspective: "This is no silver bullet. You never win when you try to play the evolutionary game with insects." We would add, "or with other living organisms." Industry focus on, and EPA collusion with, the search for "silver bullets" without precautionary forethought to the issue of resistance is the Achilles heel of pesticide—and now biotech—dependence in conventional agriculture. These are eventually doomed to failure, and meanwhile, EPA continues to power the pesticide and GE treadmills.

Beyond Pesticides believes that consideration of (1) the incorporation into food crops of genes from a natural bacterium, such as Bt, (2) the development of herbicide-tolerant crops and their paired use with herbicides, such as Roundup Ready soybeans and glyphosate, and (3) the ongoing planetary assault by thousands of synthetic pesticide compounds leads to the conclusion that these GE and chemical approaches to agriculture and pest management are short sighted and dangerous, and as noted above, entropic by their very nature. At broad scale, they generate adverse environmental, human health, biodiversity, climate, and economic consequences; they also are undermining the use of Bt as a biological pest management tool in organic production. Regenerative organic approaches are the only genuinely sustainable practices, and are the linchpin of a thoughtful, future-conscious route forward for humankind.

SOURCE: Bruce Tabashnik, et al., Global Patterns of Insect Resistance to Transgenic Bt Crops: The First 25 Years, *Journal of Economic Entomology*, Volume 116, Issue 2, April 2023, Pages 297–309, https://doi.org/10.1093/jee/toac183. A correction has been published: *Journal of Economic Entomology*, Volume 116, Issue 2, April 2023, Page 648, https://doi.org/10.1093/jee/toad013.

Let's Leave a Legacy
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Volume 43, Numbers 2–4 & Volume 44, Numbers 1–2

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