The Insect Apocalypse: Legal Solutions for Protecting Life on Earth

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This Article fills a void in the legal scholarly literature by evaluating and proposing attainable legal strategies to address the current substantial declines in beneficial insect populations. Despite perceptions of insects as odious pests, the reality is that insects, the most abundant and diverse animals on earth, provide ecosystems services that are crucial to human welfare and the existence of life. Insects, including thousands of species of bees, wasps, butterflies, moths, beetles, and flies, are indispensable pollinators of agricultural crops. Beyond pollination, insects carry out natural pest control, decomposition, and nutrient cycling vital to both agricultural and natural ecosystems. In recent years, a number of scientific studies have raised the alarm over serious declines in populations of insects that provide these essential services. Drivers of insect population declines include loss of habitat, pesticide use, and climate change. Complex synergies among these drivers exacerbate the problem.

In this Article, we analyze three federal statutes to determine what, if any, utility they may have in addressing the problem of declines of beneficial insect populations: the federal Endangered Species Act, the Farm Bill, and the Federal Insecticide, Fungicide, and Rodenticide Act. An in-depth evaluation of these statutes reveals that the Endangered Species Act and Farm Bill have a limited role to play in protecting beneficial insect populations. The Federal Insecticide, Fungicide, and Rodenticide Act, on the other hand, has the potential to dramatically reduce insect population declines resulting from habitat loss and pesticide use. After taking a deep dive into this federal law, we propose solutions that can be implemented by the U.S. Environmental Protection Agency without the need for additional congressional action.

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Specifically, we offer five distinct recommendations that the Environmental Protection Agency could implement with its existing regulatory authority that would substantially reduce the decline in beneficial insect populations and the ecosystem services they provide, which are essential to protect life on earth.

INTRODUCTION

Creepy. Crawly. Stinging. Biting. Disease-spreading. Crop-destroying. Infesting. Pesky. Despite its repugnant reputation, the much-maligned insect is critical to life on Earth. In recent years, insect populations have suffered significant declines. Headlines announcing the "insect apocalypse" have drawn public attention to the pollinator crisis and colony collapse disorder in honey bee populations. However, the looming crisis of insect population decline reaches far beyond pollinator bees and is vastly complex and not well understood by science. With more than one million species of insects on earth already named, and millions yet to be named, the six-legged cousins to the lobster and spider are the most abundant and diverse class of animals on earth.[1] Due to their sheer numbers and diversity, not to mention their small size and general lack of attractiveness to humans, insects do not garner great public support or scientific attention. As a result, robust data on the complex roles insects play in the natural world and the multifaceted contributors to their declines are lacking.

Although when thinking of insects, what may come first to mind is the annoying mosquito or the odious cockroach, the reality is that many thousands, if not millions, of insect species carry out important ecosystem services that are necessary for life, including human life, to thrive. Such ecosystem services include pollination of crops and wild plants, natural pest control, and decomposition and recycling of nutrients and organic materials. Many of these services provide substantial economic benefits by supporting agriculture. Unfortunately, beneficial insect populations are in serious decline, and consequently, many of these critical ecosystem services are in peril. Drivers of this decline include habitat loss, pesticide use, and climate change. Existing federal laws designed to protect habitats of imperiled species or address environmental harms from pesticide use are not well suited to addressing insect population decline, nor the concomitant ecosystem services loss. Even where legal authority exists, federal agencies have failed to implement environmental law in ways that adequately address these losses.

In this Article, we explore the problem of beneficial insect population decline and evaluate the utility of existing federal law to reverse the trend. We offer solutions that can be implemented by the U.S. Environmental Protection Agency (EPA) under existing federal laws without the need for additional congressional action. In Part I of this Article, we explore some of the characteristics of insects that make them unique and more challenging to protect with traditional environmental laws than are many other animals. In Part II, we outline the current scientific understanding of the role insects play in carrying out ecosystem services and describe the gaps in current knowledge. In Part III, we review recent data on insect population declines and outline the

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[1] TIMOTHY D. SCHOWALTER, INSECT ECOLOGY: AN ECOSYSTEM APPROACH 1 (4th ed. 2016).

environmental drivers that are contributing to those declines. Then in Part IV, we examine existing and proposed approaches to addressing the problem and identify the limitations of these approaches. In Part V, we take a deep dive into evaluating how U.S. pesticide law could be used to reduce insects' exposure to harmful pesticides and to provide important habitats for these species on and around agricultural lands. Finally, we conclude with specific legal proposals to reverse the declines of beneficial insect species and to prevent the loss of critical ecosystems services necessary to protect life on earth.

I. UNIQUE CHARACTERISTICS OF INSECTS

Insects are very different in many regards from most species that environmental laws seek to protect.[2] Unlike mammals, birds, reptiles, and fish, insects are extremely small and occur in very large numbers.[3] Many insects live elusive lives, hidden in leaf litter or under the bark of trees, sequestered in underground cavities, or even burrowed within the tissues of plants or other animals.[4] Insects that crawl over the ground typically do so without catching the attention of humans. Even insects that fly around people are frequently viewed as no more than a generic buzzing nuisance. Very few people can even identify the general category of a given insect, let alone the species.[5] Thus, it is unrealistic to expect most people to be able to distinguish an insect species that is imperiled from one that is abundant or an insect species that is a pest from one that is beneficial to humans.

Insects also differ in several respects from other animal species, making it more challenging to understand and protect them. Unlike mammals, birds, and reptiles that maintain their same basic form and physiology throughout the course of their lifecycles, insects undergo metamorphosis.[6] Accordingly, young insects are not merely small versions of their adult selves. Some insect species, such as dragonflies, cockroaches, and grasshoppers, undergo incomplete metamorphosis, while others, including beetles, butterflies, ants, and bees, undergo a complete transformation.[7] In either case, but particularly in the case of species that undergo complete metamorphosis, young insects are very different from their adult versions in form, behavior, and physiology.[8] Many adult insects fly relatively long distances and visit different types of habitats

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[2] For a detailed description of the ecology of individual insects and what makes them unique among most animal species*, see id*. at 19–20.

[3] CEDRIC GILLOTT, ENTOMOLOGY 48 (3d ed., Springer 2005).

[4] *See generally id.* (describing throughout the numerous categories of insects that live in leaf litter, underground, under bark, and in the tissues of plants).

[5] For a discussion of humans' emotional response to insects, *see generally* JEFFREY A. LOCKWOOD, THE INFESTED MIND: WHY HUMANS FEAR, LOATHE, AND LOVE INSECTS (2013).

[6] *See generally* GILLOTT, *supra* note 3.

[7] *See* HOWELL V. DALY ET AL., INTRODUCTION TO INSECT BIOLOGY AND DIVERSITY 54–56 (1978).

[8] *Id.* at 54–55.

over the course of hours, days, or weeks.[9] Many, but not all, adult insect species are winged and can fly relatively long distances, sometimes engaging in long-distance migration.[10] Immature insects, however, never have wings and thus do not fly. Immature insects, limited by their ability to crawl, typically do not travel long distances, and stay close to where they hatched, among suitable food sources.[11] Immature insects are also eating machines,[12] while many adult insects do not eat at all or rely on very different food sources than do their young.[13] For example, honey bee larvae are fed protein-rich pollen to fuel their growth whereas honey bee adults rely on sugar-rich nectar as a source of energy.[14] Many young insects, such as larvae of butterflies, flies, beetles, ants, and bees, are soft-bodied caterpillars, maggots, or grubs, whereas once they emerge from pupae as adults, their bodies are better protected by hard exoskeletons.[15] Consequently, young insects have different vulnerabilities to environmental drivers than do adult insects.

Certain types of insects are much more vulnerable to environmental threats than are other species. Many species of insects are considered "generalists" in that they can survive and thrive in a wide range of conditions and with a wide range of food sources.[16] For example, cockroaches can survive in virtually any environment and will eat almost anything (including your college diploma).[17] Generalists typically tend not to undergo population declines in response to environmental impacts. Certain other insect species, known as specialists, can only exist under a narrow range of conditions and will only eat very specific food sources.[18] Monarch butterfly larvae, for instance, will only eat milkweed.[19] Specialist species, therefore, are more likely than

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[9] GILLOTT, *supra* note 3, at 679–88.

[10] DALY ET AL., *supra* note 7, at 179, 460.

[11] *See generally* David W. Hagstrum & Bhadriraju Subramanyam, *Immature Insects Ecological Roles of Mobility*, 56 AM. ENTOMOLOGIST 230 (2010).

[12] GILLOTT, *supra* note 3, at 49.

[13] DALY ET AL., *supra* note 7, at 71.

[14] *See* Zachary Huang, *Honey Bee Nutrition*, BEE HEALTH (Aug. 20, 2019), https://bee-health.extension.org/honey-bee-nutrition.

[15] *See generally* Amritpal Singh Kaleka et al., *Larval Development and Molting*, *in* EDIBLE INSECTS (Heimo Mikkola ed., 2019).

[16] *See* ROBERT W. MATTHEWS & JANICE R. MATTHEWS, INSECT BEHAVIOR 132–33 (2d ed., Springer 2010). For a detailed discussion of insect generalists and specialists, *see generally* Jared G. Ali & Anurag A. Agrawal, *Specialists Versus Generalist Insect Herbivores and Plant Defense*, 17 TRENDS PLANT SCI. 293, 293–302 (2012).

[17] *See What are Cockroaches Attracted to Inside?*, ORKIN, https://www.orkin.com/pests/cockroaches/cockroach-food (last visited Nov. 8, 2021).

[18] MATTHEWS & MATTHEWS, *supra* note 16, at 132–33.

[19] *See, e.g., https //www.fs.fed.us/wildflowers/pollinators/Monarch_Butterfly/habitat/* (last visited, July 14, 2021). *See, e.g.*, *Monarch Butterfly Habitat Needs*, U.S. FOREST SERV., *https //www.fs.fed.us/wildflowers/pollinators/Monarch_Butterfly/habitat/* (last visited July 14, 2021).

generalists to be imperiled by changes in temperature, environmental contaminants, degradation of habitat, and loss of specific food sources.[20]

To complicate matters more, some beneficial insects live in colonies with complex social structures where roles vary between individuals. For example, in honey bee colonies, the vast majority of bees are sterile female worker bees, with only the queen bee being capable of reproduction.[21] Male bees, known as drones, exist only for a limited time in order to fertilize the queen's eggs.[22] In these societies, while worker bees as a whole are critical for colony survival, individual worker bees have limited value, and in fact, are willing to sacrifice their own lives to protect the colony. [23]

All of these differences are important when considering risk data or conducting risk assessments for insects. However, as discussed in the following Parts of this Article, decision making under federal environmental statutes rarely considers these differences, or even the importance of insects at all.

II. THE IMPORTANCE OF INSECTS

Often overlooked, insects provide important benefits and fundamental services to humans and ecosystems as important distributors of matter and energy.[24] Comprising 80 percent of the world's biodiversity, insects are the most diverse group of organisms on the planet and compose the largest biomass of all terrestrial animals.[25] The ecosystem services[26] they provide to humans are commonly divided into four categories: provisioning (food, water, and other resources), supporting (soil formation, decomposition, and carbon sequestration), regulating (biological control and the stabilization of systems), and cultural services (recreation, aesthetic, and spiritual).[27] Together, these ecosystem services are annually valued at more than $57 billion in the United

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[20] *See, e.g.*, J.C. Biesmeijer et al., *Parallel Declines in Pollinators and Insect-Pollinated Plants in Britain and the Netherlands*, 313 SCIENCE 351, 353 (2006).

[21] Division of Agriculture, *About Honey Bees–Types, Races, and Anatomy*, UNIV. ARK., https://www.uaex.edu/farm-ranch/special-programs/beekeeping/about-honey-bees.aspx (last visited Mar. 28, 2021).

[22] *Id.*

[23] *See id.; see generally* Emma K. Mullen & Graham J. Thompson, *Chapter Ten–Understanding Honey Bee Worker Self-Sacrifice A Conceptual–Empirical Framework*, 48 ADVANCES IN INSECT PHYSIOLOGY 325 (2015).

[24] *See* Jorge Ari Noriega et al., *Research Trends in Ecosystem Services Provided by Insects*, 26 BASIC & APPLIED ECOLOGY 8 (2018).

[25] *Id.* at 8–9; Department of Systematic Biology, Entomology Section, National Museum of Natural History, *Numbers of Insects (Species & Individuals)*, SMITHSONIAN INST., https://www.si.edu/spotlight/buginfo/bugnos (last visited Nov. 22, 2020) [hereinafter SMITHSONIAN INST.]; *see also* SCHOWALTER, *supra* note 1, at 1–2.

[26] Ecosystem services may be defined as, "the beneficial functions and goods that humans obtain from ecosystems, that support directly or indirectly their quality of life." Noriega et al., *supra* note 24, at 8.

[27] *See generally* WALTER V. REID ET AL., MILLENNIUM ECOSYSTEM ASSESSMENT, ECOSYSTEMS AND HUMAN WELL-BEING (2005).

States[28] and $235–577 billion worldwide[29] for their ability to provide the benefits of crop and wild plant pollination, nutrient cycling, biological control, and food provisioning.[30] The sheer diversity of insects and their ability to fill virtually any ecological niche on earth makes them critical components of overall biodiversity and the ecological resilience that high biodiversity provides.[31]

But as insect diversity and populations continue to decline, the ability to provide these benefits declines as well, which can cause economic harm and human health impacts.[32] Scientists predict that less than half of living insect species have been recorded.[33] As a result, understanding the various benefits that insects provide—the pollination of crops and wild plants, recycling of nutrients and organic material, pest and disease control, and food provisioning[34]—illuminates the importance of urgently addressing the increasing declines in insect population and diversity before the sustainability of our ecosystems becomes disrupted beyond repair.

A. Pollination of Crops and Wild Plants

Of the benefits provided by insects, the most widely recognized and monetized is pollination. In fact, insects play a critical role in pollinating food crops and wild plants.[35] Pollination, which involves a system of complex ecological interactions, ensures the sustainability of natural plant communities by supporting seed production, genetic diversity within a population, and proper seed dispersion for reproduction.[36] Nearly 90 percent of flowering plants depend on animal pollinators.[37] More than half of the produce in typical

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[28] John E. Losey & Mace Vaughan, *The Economic Value of Ecological Services Provided by Insects*, 56 BIOSCIENCE 311, 312 (2006).

[29] Noriega et al., *supra* note 24, at 8–9.

[30] Oliver Dangles & Jérôme Casas, *Ecosystem Services Provided by Insects for Achieving Sustainable Development Goals*, 35 ECOSYSTEM SERVS. 109, 110 (2019).

[31] For a discussion of the role species diversity plays in ecological resilience, *see* Mary Jane Angelo, *Stumbling Toward Success A Story of Adaptive Law and Ecological Resilience*, 87 NEB. L. REV. 950, 960–62 (2009).

[32] SCHOWALTER, *supra* note 1, at 4–5.

[33] SMITHSONIAN INST., *supra* note 25.

[34] Beyond these four generally recognized categories of benefits, insects also provide us with medicine, industrial products, and cultural services. SCHOWALTER, *supra* note 1, at 561. Insects are also indicators of environmental change because they have short life cycles, rapid reproduction rates, and sensitivity to temporal variations. *Id.* at 547–49.

[35] *See generally* SIMON G. POTTS ET AL., SUMMARY FOR POLICYMAKERS OF THE ASSESSMENT REPORT OF THE INTERGOVERNMENTAL SCIENCE-POLICY PLATFORM ON BIODIVERSITY AND ECOSYSTEM SERVICES ON POLLINATORS, POLLINATION, AND FOOD PRODUCTION 22–28 (2016); Alexandra-Maria Klein et al., *Importance of Pollinators in Changing Landscapes for World Crops*, PROC. R. SOC. B 274, 303–313 (2006).

[36] U.S. Dep't of Agric., *Why is Pollination Important*, U.S. FOREST SERV., https://www.fs.usda.gov/wildflowers/pollinators/importance.shtml (last visited Feb. 5, 2021).

[37] Geoffrey G. E. Scudder, *The Importance of Insects*, *in* INSECT BIODIVERSITY: SCIENCE AND SOCIETY 10 (Robert G. Foottit & Peter H. Adler eds., 2018).

U.S. grocery stores depends on animal pollination, and this does not account for other foods like milk, butter, and cheese that indirectly depend on pollination.[38] Insects comprise the largest group of animal pollinators.[39] Globally, over 1,500 food crops, comprising an estimated 35 percent of the world's agricultural lands,[40] rely on insects for pollination.[41] Pollination increases crop production for 87 of the leading 115 food crops consumed across the globe, including many nuts, fruits, and vegetables.[42] Human reliance on pollinators for food production must not be overlooked, as in the past fifty years the volume of pollinator-dependent crops has increased by nearly 300 percent.[43]

Although a wide variety of insects—bees, butterflies, moths, beetles, and flies—are important pollinators, the role bees play in the pollination of crops and wild plants often garners the spotlight. In the United States, commercialized honey bees are widely used for crop pollination[44] and valued for the pollination of specific, high-value crops like almonds and many common non-citrus fruits.[45] The total annual economic value of ecosystem services and products provided by honey bees is estimated at $177 million to $16 billion in the United States and $117 billion globally.[46] Although honey bees are often the most well-known and studied bee pollinator, there are over 4,000 native and non-native bee species in the United States alone that pollinate both crops and wild plants.[47] These native and non-native species, such as the horn-faced, blue orchard, and alfalfa leafcutting bee, provide essential pollination services beyond agricultural contexts, valued at nearly $3 billion annually.[48] Unlike the United States, many developing countries rely more heavily on wild bees than honey bees for crop production, a fact which is often unaccounted for in current economic estimates.[49]

Our global reliance on wild bees demonstrates the importance of species diversity among bees and the many roles they play in feeding our planet.

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[38] Pollinator animals include insects, birds, and bats. *See* Nick Visser, *This Is What Your Grocery Store Looks Like Without Bees*, HUFFINGTON POST (June 6, 2014, 11:08 AM), https://www.huffpost.com/entry/store-without-bees_n_5500380.

[39] Scudder, *supra* note 37.

[40] U.N. FAO, WHY BEES MATTER 6 (2016), http://www.fao.org/documents/card/en/c/i9527en.

[41] Nick Hanley et al., *Measuring the Economic Value of Pollination Services Principles, Evidence and Knowledge Gaps*, 14 ECOSYSTEM SERVS. 124, 124–25 (2015).

[42] *FAO's Global Action on Pollination Services for Sustainable Agriculture Pollination & Human Livelihoods*, U.N. FAO, http://www.fao.org/pollination/background/en/ (last visited Dec. 1, 2020); *see also* Klein et al., *supra* note 35.

[43] U.N. FAO, *supra* note 40, at 6.

[44] POLLINATOR FACT SHEET, U.S. DEP'T OF AGRIC. (2020), https://www.usda.gov/sites/default/files/documents/pollinator-week-factsheet-06.25.2020.pdf.

[45] Virginia H. Dalea & Stephen Polasky, *Measures of the Effects of Agricultural Practices on Ecosystem Services*, 64 ECOLOGICAL ECONS. 286, 292 (2007).

[46] SCHOWALTER, *supra* note 1, at 558; POLLINATOR FACT SHEET, *supra* note 44.

[47] POLLINATOR FACT SHEET, *supra* note 44.

[48] SCHOWALTER, *supra* note 1, at 558; Dalea & Polasky, *supra* note 45, at 292.

[49] *See, e.g.*, SCHOWALTER, *supra* note 1, at 558–60.

Understanding the diversity of bee species and their contributions to our ecosystems is essential to species preservation. For example, honey bees live in large socially complex colonies, while most native bee species live solitary lives.[50] Native bees that do live in colonies, such as bumble bees, live in substantially smaller colonies than do honey bees.[51] Yet, the majority of native bees live in ground cavity nests or in the stems of plants.[52] Each distinct characteristic is key to supporting a specific ecosystem and careful attention must be paid to individual characteristics to adequately address declining populations.

Beyond bees, non-bee insects like wasps, moths, butterflies, flies, and beetles provide vital pollination services for agricultural systems and the broader ecosystem. In fact, the greater the diversity of non-bee pollinators within an ecosystem, the greater the quality and quantity of pollination services.[53] This increase in overall quality and quantity is attributed to non-bee insects' ability to provide pollination services in wider weather and temporal conditions and the ability to transfer pollen over greater areas than the bee counterpart.[54] Recent research suggests that non-bee pollinators exhibit less vulnerability to land use changes than bees[55] and support a wide variety of livestock and other vertebrates by pollinating non-consumption crops, such as alfalfa.[56] A diversity of pollinators is especially important in the Tropics where butterflies and moths are the sole providers of pollination services for specific crops.[57] For example, fig wasps exclusively pollinate figs, while crops such as cocoa and jackfruit benefit greatly from small, non-bee pollinators.[58] Thus, the discussion around pollination services must continue to be broadened beyond bees, because a decline in various insect populations will disrupt pollination services and eventually devastate the agricultural systems and natural systems on which human life depends.

B. The Recycling of Nutrients and Organic Materials

Insects support the sustainability of ecosystems by assisting in decomposition, soil formation, carbon sequestration, and water filtration.[59] Insects control and regulate the decomposition of waste and the reintegration of

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[50] GILLOTT, *supra* note 3, at 347–49.

[51] *Id.*

[52] *Id.*

[53] Romina Rader et al., *Insects are Important Contributors to Global Crop Pollination*, 113 PROCS. NAT'L ACAD. SCIS. 146, 147 (2016).

[54] *Id.*

[55] *Id.* at 149.

[56] SCHOWALTER, *supra* note 1, at 553.

[57] Hanley et al., *supra* note 41, at 124.

[58] Romina Rader et al., *Non-Bee Insects as Visitors and Pollinators of Crops Biology, Ecology, and Management*, 65 ANN. REV. ENTOMOLOGY 391, 401 (2020).

[59] *See* Charlotte L. R. Payne & Joost Van Itterbeeck, *Ecosystem Services from Edible Insects in Agricultural Systems A Review*, 8 INSECTS 24, 32–33 (2017).

nutrients into soil. Without detritivorous insects, decayed material accumulates on the surface leaving the soil void of nutrients. Dung beetles, which rarely receive the credit they deserve, play a vital role in recycling nitrogen and carbon by decomposing manure, making them vital actors in moderating climate change.[60] Beyond returning excess nitrogen back into the soil for safe storage, the decomposition of manure further reduces pest habitats and enhances the forgeability of other animals.[61] In the United States alone, the estimated value of the dung beetle's decomposition services is $380 million each year and reportedly saves the United Kingdom's cattle industry £367 million annually.[62] Moreover, flies, ants, termites, and other larvae break down organic material to a certain degree that allows soil microorganisms to begin their work of further decomposing the material and returning nutrients to the soil.[63] Termites and soil-dwelling ants particularly strengthen water filtration, which has been linked to increased crop yields in arid climates.[64] Moreover, normal and consistent rates of herbivory are essential aspects of primary plant production, similar to a predator-prey relationship, in which inefficient and weak plants are eliminated to stimulate more beneficial plant growth.[65]

C. Pest and Disease Control

Unfortunately, the fear of an unwanted insect infestation regularly overshadows the crucial and natural biological control services that beneficial insects provide by controlling invasive plant species, disease, and nuisance insect populations. As vital regulating components of agricultural ecosystems, predatory and parasitic insects provide an estimated $5.4 billion annually in biological control services by eliminating crop pests in the United States.[66] Countless beneficial predatory or parasitic insect species exist in both crop and natural systems. Even agricultural fields, which are often monocultural and contain relatively low species diversity, are not sterile laboratories.[67] Rather, they are complex assemblages of living organisms with relationships with each

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[60] Goutam Roy Chowdhury et al., *Ecosystem Services of Insects*, 1 BIOMEDICAL J. SCI. & TECH. RSCH. 491, 491-93 (2017) (The decomposition of manure helps aid in the sequestration of carbon and mitigation of greenhouse gases by returning carbon and other elements back into the soil.).

[61] Losey & Vaughan, *supra* note 28, at 312–15.

[62] Sarah A. Beynon et al., *The Application of an Ecosystem Services Framework to Estimate the Economic Value of Dung Beetles to the U.K. Cattle Industry*, 40 ECOLOGICAL ENTOMOLOGY 124, 124–25 (2015).

[63] *See* Luciana Elizalde et al., *The Ecosystem Services Provided by Social Insects Traits, Management Tools, and Knowledge Gaps*, 95 BIOLOGICAL REVS. 1418, 1420 (2020).

[64] *See* Theodore A. Evans et al., *Ants and Termites Increase Crop Yield in a Dry Climate*, 2 NATURE COMMC'NS 262, 262 (2011).

[65] SCHOWALTER, *supra* note 1, at 552.

[66] *Id.* at 559.

[67] Mary Jane Angelo & Joanna Reilly Brown, *Whole System Agricultural Certification Building a Resilient Agricultural System to Adapt to Climate Change,* 85 U. COLO. L. REV. 689, 718 (2014).

other.[68] Agricultural fields with high species diversity will generally have higher ecological resilience and be less likely to experience pest outbreaks.[69] A diverse functioning ecosystem will contain a large variety of species that utilize other species as a food source, and a robust community of predators and parasites will generally keep their prey and host species populations in check, preventing population outbreaks. In farm fields where pesticide use has not killed off insects that prey on or parasitize pest species, pest species populations are more likely to be kept in check.[70] The same is true in natural ecosystems. If predator and parasite species are removed from the system, whether by excessive pesticide use or other means, the natural checks on pest species will not exist and pest outbreaks become more likely.[71] Examples of beneficial predator or parasitic species abound: The Weaver Ant, a generalist predator, controls pests of valuable citrus, mango, and cashew crops throughout the Tropics,[72] while the Vespula Wasp controls pests within grain and vegetable crops throughout North America and Europe.[73]

Beyond benefiting agricultural systems, insects ensure the regulation of species that carry diseases known as vector species, and of harmful pathogens.[74] The conversion of rainforest and the disruption of ecosystems at the hands of development contribute to the transmission of diseases, leaving humans increasingly vulnerable to infection and outbreak.[75] Yet, insects like the dung beetle mitigate these vulnerabilities by removing manure, which in turn helps eliminate harmful microscopic parasites in drinking water.[76] Without these various forms of biological and pest control, human health and the health of ecosystems will suffer in foreseen and unforeseen ways.

D. Food Provisioning

Insects further stabilize ecosystems by transferring energy and nutrients throughout the food web. A loss in insect biodiversity and population reduces the availability of food for birds, amphibians, mammals, reptiles, arachnids,

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[68] Mary Jane Angelo, *The Killing Fields Reducing the Casualties in the Battle Between U.S. Endangered Species and Pesticide Law,* 32 HARV. ENV'T L. REV. 96, 152 (2008) [hereinafter Angelo, *The Killing Fields*].

[69] MARY JANE ANGELO, THE LAW AND ECOLOGY OF PESTICIDES AND PEST MANAGEMENT 30 (2013).

[70] *Id*. at 13–14.

[71] Francisco Sánchez-Bayo, *Indirect Effects of Pesticides on Insects and Other Arthropods*, 9 TOXICS 1, 4 (2021); *See* Peter J. Hudson et al., *Is a Healthy Ecosystem One That is Rich in Parasites?*, 21 TRENDS ECOLOGY & EVOLUTION 382 (2006).

[72] *See* Ross H. Crozier et al., *A Masterpiece of Evolution–Oecophylla Weaver Ants (Hymenoptera Formicidae)* 13 MYRMECOLIGAL NEWS 57 (2009).

[73] *See* Barry J. Donovan, *Potential Manageable Exploitation of Social Wasps*, *Vespula Spp. (Hymenoptera Vespidae)*, *as Generalist Predators of Insect Pests*, 49 INT'L J. PEST MGMT. 281, 281 (2003).

[74] SCHOWALTER, *supra* note 1, at 555.

[75] *Id.*

[76] *Id.*

and other insects, which can destabilize ecosystems. Birds alone consume an estimated four hundred to five hundred and fifty million tons of insects each year—the equivalent of approximately twenty quadrillion individual bugs.[77] And as essential food for various species of fish and wild game, insects indirectly support recreational fishing and hunting, which are industries valued at over $60 billion annually.[78]

III. DECLINES IN INSECT POPULATIONS

Amid signs of declining insect biomass, population, and species diversity, a number of recent scientific studies have raised the specter of an insect crisis—indeed, an "insect apocalypse."[79] While the precise causes are difficult to pin down and warrant more investigation, most studies point to three environmental stressors that most significantly contribute to the crisis: habitat loss and degradation, pesticide use, and climate change. And synergies among these stressors likely exacerbate the problem.

A. Habitat Loss and Degradation

Worldwide, the loss of natural habitat is a central driver in insects' declining populations, biomass, and diversity. Many insect species need consistent, stable, and high-quality habitats that include travel corridors for foraging, migration, and reproduction.[80] Human development activities that reduce habitable spaces and degrade habitat quality push insect populations to fragmented and isolated sections of land.[81] Specifically, industrial agriculture, urbanization, and deforestation all convert natural environments into

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[77] *See* Martin Nyffeler et al., *Insectivorous Birds Consume an Estimated 400–500 Million Tons of Prey Annually*, 105 Sci. Nature 1, 6 (2018); Doyle Rice, *Yum! Birds Eat Up to 550 Million Tons of Insects Each Year*, USA Today (July 9, 2018, 3:10 pm), https://www.usatoday.com/story/news/2018/07/09/birds-and-bugs-birds-eat-up-550-million-tons-insects-each-year/768342002/; John Capinera, Insects and Wildlife: Arthropods and Their Relationships with Wild Vertebrate Animals, 387–92 (Wiley-Blackwell, 2010).

[78] Losey & Vaughan, *supra* note 28, at 319.

[79] *See generally, e.g.*, I-Ching Chen et al., *Asymmetric Boundary Shifts of Tropical Montane Lepidoptera Over Four Decades of Climate Warming*, 20 Glob. Ecology Biogeography 34, 34–45 (2011); Matthew L. Forister et al., *Declines in Insect Abundance and Diversity We Know Enough to Act Now*, 1 Conservation Sci. & Prac. 1 (2019); David Goulson, *The Insect Apocalypse, and Why it Matters* Current Biology Mag., Oct. 7, 2019, at R967; Claudia Hitaj et al., *Sowing Uncertainty What We Do and Don't Know About the Planting of Pesticide-Treated Seed*, 70 BioScience 390, 390 (2020); William E. Kunin, *Robust Evidence of Insect Declines*, 574 Nature 641, 641–42 (2019); Gretchen Lebuh et al., *Detecting Insect Pollinator Declines on Regional and Global Scales*, 27 Conservation Biology 113 (2012); Noriega et al., *supra* note 24; Francisco Sanchez-Bayo & Kris A.G. Wyckhuys, *Worldwide Decline of the Entomofauna A Review of its Drivers*, 232 Biological Conservation 8, 8 (2019); David L. Wagner, *Insect Declines in the Anthropocene*, 65 Ann. Rev. Entomology 457, 457–80 (2020); Anne-Christine Mupepele et al., *Insect Decline and its Drivers Unsupported Conclusions in a Poorly Performed Meta-Analysis on Trends–A Critique of Sanchez-Bayo and Wyckhuys (2019)*, 37 Basic & Applied Ecology 20, 20–23 (2019).

[80] Forister et al., *supra* note 79, at 3.

[81] Goulson, *supra* note 79, at 969.

uninhabitable spaces for insects—by the end of the twentieth century, these anthropogenic activities encroached on 30 to 50 percent of natural ecosystems, and the rate of conversion is rapidly accelerating.[82] Forcing insect populations onto small habitat islands increases their vulnerability and susceptibility to decline, even to the point of extinction.[83] Indeed, habitat fragmentation and changes in land use are considered the leading causes of decline for *Coleoptera* (beetles), *Hymenoptera* (bees, ants, and wasps), and *Lepidoptera* (butterflies and moths) species.[84]

Moreover, although linked to declines in both specialist and generalist insect species,[85] habitat loss particularly harms specialists. Specialist pollinators, like bumble bees and wild bees, are highly vulnerable to land-use changes that result in the loss of floral resources for foraging and the elimination of hibernation and nesting sites.[86] Other changes that convert or remove native forest and hedgerow habitat also threaten specialist beetles and other beneficial species.[87] For instance, moth populations, which are highly dependent upon host flora for overwintering, have declined with the removal of vegetation for agricultural use.[88] Even aquatic insect populations are affected by land use changes. For example, surface water modifications made to facilitate industrial and intensive agricultural practices disrupt aquatic ecosystems enough to cause declines in insect population and biomass.[89]

1. *Industrial Agriculture*

In the second half of the twentieth century, farmers began relying on new technologies to increase crop yields, ushering in the industrialization and intensification of agriculture.[90] This shift from traditional, low-impact methods of farming to modern industrial agriculture has contributed to the decline of insect populations.[91] Currently, 50 percent of global land is used for agriculture.[92] Agricultural crops occupy approximately 12 percent of Earth's surface area, and in developing nations the conversion of land for agricultural

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[82] Sanchez-Bayo & Wyckhuys, *supra* note 79, at 8.

[83] Goulson, *supra* note 79, at 969.

[84] Sánchez-Bayo & Wyckhuys, *supra* note 79, at 19.

[85] *See* Matthew L. Forister et al., *Declines in Insect Abundance and Diversity We Know enough to act now*, CONSERVATION SCIENCE AND PRACTICE, June 22, 2019, at 1, 3.

[86] Sánchez-Bayo & Wyckhuys, *supra* note 79, at 19; *see also*, Paul H. Williams & Juliet L. Osborne, *Bumblebee Vulnerability and Conservation World-wide*, 40 APIDOLOGIE 367, 367 (2009).

[87] Sánchez-Bayo & Wyckhuys, *supra* note 79, at 13; *see, e.g.*, David R. Brooks et al., *Large Carabid Beetle Declines in a United Kingdom Monitoring Network Increases Evidence for a Widespread Loss in Insect Biodiversity*, 49 J. APPLIED ECOLOGY 1009, 1009 (2012).

[88] Sánchez-Bayo & Wyckhuys, *supra* note 79, at 19.

[89] *Id.*

[90] Martin Dallimer et al., *100 Years of Change Examining Agricultural Trends, Habitat Change and Stakeholder Perceptions Through the 20th Century*, 46, J. APPLIED ECOLOGY 334, 334 (2009).

[91] *Id.*

[92] *See* Hannah Ritchie & Max Roser, *Land Use*, OUR WORLD IN DATA (Sept. 2019), https://ourworldindata.org/land-use#breakdown-of-global-land-use-today).

use is accelerating.[93] Conversion of this natural insect habitat for industrial agriculture directly impacts countless insect species across the globe, driving biodiversity loss.[94]

Monocultures, a characteristic of industrial agriculture in which a single species of a genetically uniform crop is planted in a field, increase the land's susceptibility to soil damage and pest infestations, thus requiring increased application of pesticides and fertilizers.[95] The planting of monocultures not only exacerbates the presence of pests, but in turn requires the routine application of synthetic pesticides and fertilizers in increasingly high doses to eliminate pests in an attempt to maintain crop production levels.[96] This incremental synthetic response further contributes to the degradation of nearby habitat and leaves large portions of industrial farmland effectively impassable for insects, thus eliminating essential wildlife habitat corridors and contributing to population declines.[97]

Another characteristic of industrial agriculture is the large-scale modification of surface water. The draining of wetlands, altering natural stream flows, and channelization for irrigation negatively impact the specialized habitat of aquatic insects. These modifications increase sedimentation, siltation, and eutrophication[98] for the aquatic system, negatively impacting specialized species.[99] These ecosystems become inhospitable for aquatic species resulting in the decline of insect populations and diversity.[100] The accelerated removal of shrubs, trees, and hedges for the expansion of crop fields further eliminates essential microhabitats for insects.[101]

Finally, the intensification of agriculture would not be possible without the use of synthetic fertilizers, which represents an overlooked source of habitat degradation, and consequently, declining insect populations. Synthetic fertilizers increase the soil input of nitrogen and phosphorus, which can lead to eutrophic conditions downstream that are inhospitable for many aquatic insect

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[93] *Crop Production and Natural Resource Use*, U.N. FAO, http://www.fao.org/3/y4252e/y4252e06.htm (last visited Sept. 14, 2020).

[94] *See generally* Nigel Dudley & Sasha Alexander, *Agriculture and Biodiversity A Review*, 18 BIODIVERSITY 45 (2017).

[95] *EnviroAtlas Benefit Category Food, Fuel, and Materials*, EPA, https://www.epa.gov/enviroatlas/enviroatlas-benefit-category-food-fuel-and-materials (last visited Oct. 10, 2020).

[96] Goulson, *supra* note 79, at 969; Sánchez-Bayo & Wyckhuys, *supra* note 79, at 10; Julia Anderson et al., *Monocultures in America A System That Needs More Diversit*y, DEBATING SCIENCE: U. MASS. AMHERST BLOG (Dec. 5, 2017), https://blogs.umass.edu/natsci397a-eross/monocultures-in-america-a-system-that-needs-more-diversity/.

[97] Goulson, *supra* note 79, at 969.

[98] Eutrophication is the "process by which a body of water becomes enriched in dissolved nutrients (such as phosphates) that stimulate the growth of aquatic plant life usually resulting in the depletion of dissolved oxygen." *Eutrophication*, MERRIAM-WEBSTER, https://www.merriam-webster.com/dictionary/eutrophication (last visited Nov. 19, 2021).

[99] *See* Sánchez-Bayo & Wyckhuys, *supra* note 79, at 19.

[100] *See id.* at 19–20.

[101] Paul Eggleton, *The State of the World's Insect*, 45 ANN. REV. ENV'T. RES. 61, 70 (2020).

species.[102] The use of inorganic fertilizers can also contribute to habitat degradation more directly by displacing native plant species.[103] This displacement occurs because plants benefiting from high levels of nitrogen in the soil outcompete native species on which native insects rely.[104] The displacement is particularly alarming in bogs, heathlands, and semi-natural grasslands with traditionally low levels of nitrogen.[105]And as the quality of these habitats degrade because native flowering species supplying nectar are displaced by heavy nitrogen-feeding plants, insect pollinators are starved of their food supply.[106] Additionally, increased nitrogen and phosphorous from synthetic fertilizers increase habitat degradation because of eutrophication and inhospitable conditions for many aquatic species.[107]

2. *Deforestation*

Urbanization and deforestation comprise another category of land conversion driving the loss of insect habitat. Scientists often cite urbanization as a central concern for developed nations, and deforestation (though closely linked to urbanization) as a central concern for developing nations.[108] The broad-reaching term urbanization encompasses the conversion of habitat, in this case insect habitat, for a wide variety of human activities ranging from constructing housing developments to transportation routes and manufacturing centers for economic development. From 1970 to 2000, urban areas grew an estimated 58,000 square meters across the globe, and these land use changes have resulted in habitat fragmentation and the homogenization and simplification of insect communities.[109] Light pollution—the abundance of artificial light at night—additionally contributes to the decline of insect diversity and biomass for diurnal and nocturnal species alike.[110] Light pollution is often considered a subset of urbanization, and a growing number of scientists see light pollution as a central and independent driver to insect decline, since insects rely on natural light for navigation.[111] Artificial light pollution negatively affects navigation by impairing movement and foraging, altering life

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[102] *What is Eutrophication? Causes, Effects and Control*, ENISCUOLA: ENERGY & ENV'T (Nov. 3, 2016), http://www.eniscuola.net/en/2016/11/03/what-is-eutrophication-causes-effects-and-control/.

[103] Jan Christian Habel et al., *Mitigating the Precipitous Decline of Terrestrial European Insects Requirements for a New Strategy*, 28 BIODIVERSITY & CONSERVATION 1043, 1047 (2019).

[104] *Id.*

[105] *Id.*

[106] *Id.*

[107] *What is Eutrophication? Causes, Effects and Control*, *supra* note 102.

[108] Sánchez-Bayo & Wyckhuys, *supra* note 79, at 20; *see* Carrasco et al., *Global Economic Trade-offs Between Wild Nature and Tropical Agriculture*, 15 PLOS BIOLOGY 1 (2017).

[109] Eggleton, *supra* note 101, at 70.

[110] Avalon C.S. Owens et al., *Light Pollution is a Driver of Insect Declines*, 268 BIOLOGICAL CONSERVATION 1, 2–3 (2020).

[111] Eggleton, *supra* note 101, at 69–71; *see, e.g.*, Owens et al., *supra* note 110.

cycles, and making insects more susceptible to predators.[112] Concerns beyond the delineation of urban areas grow as transportation corridors further interfere with insects' ability to utilize natural light.[113] With human population on the rise, light pollution is predicted to increase.[114]

Deforestation refers to the clearing of natural forest for a wide variety of uses. Since 1990, over eighty million hectares of earth's primary forest,[115] essential insect habitat, have been destroyed.[116] And from 2015 to 2020 alone, scientists estimate that nearly ten million hectares disappeared each year.[117] In the tropics, deforestation is the single largest driver of insect declines and biodiversity loss.[118] Deforestation is particularly harmful to specialist insects that depend on dead and decaying wood for microhabitats.[119] And even reforestation, which takes generations to produce mature trees, fails to replace and compensate for the essential microhabitats lost through deforestation.[120]

B. Pesticides

1. A Brief Overview

Pesticides, used to control, eliminate, or repel unwanted plant and animal pests, encompass three main groups: insecticides, herbicides, and fungicides. Pesticides are widely applied in agricultural contexts to protect crops from harmful diseases and infestations, to control weeds, and for public health concerns to control the spread of viruses and disease, such as Zika and the Avian Flu.[121] However, scientists and those concerned with human and environmental health continue raising well-documented concerns about the negative effects of pesticides on human and environmental health.

To meet the needs of a growing population, twentieth-century farmers have increasingly turned to synthetic pesticides as a means to increase crop production and efficiency. Farmers began using herbicides to destroy unwanted vegetation, fungicides to control the growth of mildew and mold, and

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[112] Owens et al., *supra* note 110, at 3.

[113] *Id.* at 6.

[114] Eggleton, *supra* note 101, at 71.

[115] "Primary forest" refers to an old-growth forest ecosystem that has experienced no significant human disruption. *See* Sarah Ruiz, *What are Primary Forests and Why Should We Protect Them?*, GLOB. FOREST WATCH, https://www.globalforestwatch.org/blog/data-and-research/primary-forests-definition-and-protection/ (last visited Mar. 1, 2022).

[116] U.N. FAO & UNEP, THE STATE OF THE WORLD'S FORESTS: FORESTS, BIODIVERSITY AND PEOPLE (2020), http://www.fao.org/state-of-forests/en/.

[117] *Id.*

[118] Sánchez-Bayo & Wyckhuys, *supra* note 79, at 20.

[119] *See generally* Michael J. Samways et al., *Solutions for Humanity on How to Conserve Insects*, 242 BIOLOGICAL CONSERVATION 1 (2020).

[120] *See* Shaun C. Cunningham, *Perspectives in Plant Ecology*, 17 EVOLUTION & SYSTEMATICS 301, 301 (2015); Sanchez-Bayo & Wyckhuys, *supra* note 79, at 19–20.

[121] *See Why We Use Pesticides*, EPA, https://www.epa.gov/safepestcontrol/why-we-use-pesticides (last visited Oct. 15, 2020).

insecticides to eliminate unwanted insect pests. Despite the environmental movement of the 1960s (largely in response to public concern over the environmental effects of dichlorodiphenyltrichloroethane, commonly known as DDT), pesticide overuse continues, as large-scale agricultural producers view synthetic pesticides as an essential tool to maintaining levels of production.[122] Annually, approximately two million tons of pesticides are applied throughout the globe, with herbicides comprising 47.5 percent of those applied, insecticides at 29.5 percent, and fungicides at 17.5 percent. [123]

In the United States, agricultural pesticide use is a leading driver of environmental contamination. When considering the risks a pesticide poses to any nontarget organisms, it is necessary to consider both the toxicity of the pesticide and the likelihood and extent of nontarget organisms being exposed to the pesticide. Pesticides are, by definition, intended to kill or disrupt "pests," which are living organisms. Insecticides, specifically targeted at killing insect pests, are also toxic to non-pest insect species, including beneficial insect pollinators, predators, and parasites.[124] Many nontarget species, including beneficial insects, are exposed to these pesticides. This combination of toxicity and exposure translate into high risk for many beneficial insects. The magnitude and type of toxicity of different types of pesticides varies based on the pesticide's physiological mode of action, and the extent and mode of exposure to nontarget organisms varies depending on the method of application of the pesticide.[125]

Although the use of pesticides dates back hundreds, if not thousands, of years, it was not until the middle of the twentieth century that lab-produced synthetic pesticides began to be used in vast quantities in both agricultural and urban settings.[126] Over the ensuing years, several categories of synthetic pesticides have gained popularity and widespread use, only to be phased out once significant risks to humans or wildlife were revealed, seemingly lower risk alternatives became available, or as pest insect populations developed resistance to those pesticides.[127] Unfortunately, as each category of synthetic pesticides replaced the next, it became apparent that the new pesticides were not necessarily reducing overall risk, but instead merely replacing one type of risk for another.[128]

The first category of synthetic pesticides in widespread use, the organochlorines (which included the infamous pesticide DDT), were phased out starting in the early 1970s due to their persistence and bioaccumulation in

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[122] *See* ANGELO, *supra* note 69, at 67–72.

[123] ARNAB DE ET AL., TARGETED DELIVERY OF PESTICIDES USING BIODEGRADABLE POLYMERIC NANOPARTICLES 56 (2014).

[124] ANGELO, *supra* note 69, at 87.

[125] *Id.* at 89.

[126] *Id.* at 67.

[127] *See id.* at 68–72.

[128] *See* Angelo, *The Killing Fields*, *supra* note 68, at 142.

the environment.[129] These pesticides were largely replaced by organophosphates and carbamates, which while not as persistent in the environment, were highly toxic to a broad range of nontarget organisms, including humans.[130] Certain organophosphates, and specific uses of others, have been phased out largely due to the risks posed to humans. However, many of these pesticides are still in use. Another group of widely used pesticides, synthetic pyrethroids, have the benefit of relatively low toxicity to humans and other wildlife. But because their mechanism of action is to target insect nervous systems, they are highly toxic to insects.[131] These pesticides continue to be used widely in agricultural and urban settings and are very commonly used for mosquito control.[132]

One of the most recent groups of pesticides to gain widespread use is neonicotinoids. These pesticides were first commercialized in the mid-1990s as an alternative to organophosphates and carbamates. Neonicotinoids have lower human and mammalian toxicity but are highly toxic to bees and other insects.[133] They also persist for long periods of time in the environment.[134] During the 2000s, neonicotinoid use increased exponentially, and today these pesticides are used on almost all corn and soy, two of the major crops grown in the United States.[135]

Neonicotinoids are unique in that they are applied seed treatments, rather than being sprayed on the leaves of crops. Additionally, neonicotinoids are "systemic" pesticides, meaning that the substance coated on the seed is taken up by the plant system and distributed throughout all tissues and products of the plant, including the pollen.[136] Unlike pesticides that are sprayed onto the leaves of crop plants, systemic pesticides do not get broken down by sunlight.

Currently, most industrial agricultural producers rely on either prophylactic calendar-based chemical pesticide application, pesticide-treated seed, or a combination of the two.[137] In calendar-based application, producers spray pesticides at scheduled times, regardless of whether there is a

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[129] ANGELO, *supra* note 69, at 68–70.

[130] *Id.* at 70–71.

[131] *Id.* at 71–72.

[132] *See Permethrin, Resmethrin, d-Phenothrin (Sumithrin®) Synthetic Pyrethroids For Mosquito Control*, EPA, https://www.epa.gov/mosquitocontrol/permethrin-resmethrin-d-phenothrin-sumithrinr-synthetic-pyrethroids-mosquito (last visited Feb. 25, 2021).

[133] *See* JENNIFER HOPWOOD ET AL., XERXES SOCIETY, HOW NEONICOTINOIDS CAN KILL BEES: THE SCIENCE BEHIND THE ROLE THESE INSECTICIDES PLAY IN HARMING BEES 12 (2d ed. 2016).

[134] *Id.* at 17.

[135] DOUG GURIAN-SHERMAN, CTR. FOR FOOD SAFETY, HIDDEN COSTS OF TOXIC SEED COATINGS 2 (2015), https://www.centerforfoodsafety.org/files/neonic-factsheet_75083.pdf

[136] Raymond A. Cloyd, *Water Solubility and Systemic Insecticides*, GREENHOUSE PROD. NEWS (July 2018), https://gpnmag.com/article/water-solubility-and-systemic-insecticides/; N. Simon-Delso et al., *Systemic Insecticides (Neonicotinoids and Fipronil) Trends, Uses, Mode of Action and Metabolites*, 22 ENV'T. SCI. & POLLUTION RSCH. 5, 6 (2015).

[137] HELMUT F. VAN EMDEN & DAVID B. PEAKALL, BEYOND SILENT SPRING: INTEGRATED PEST MANAGEMENT AND CHEMICAL SAFETY 168 (1996).

demonstrated need for the pesticides. Consequently, large quantities of potentially unnecessary and potentially harmful pesticides are released into the environment simply to comply with predetermined application schedules. This overuse of pesticides has resulted in and will continue to cause pests to become resistant to pesticides.[138] The phenomenon of pesticide-resistant pests is in essence the same as antibiotic-resistant bacteria, such as MRSA (methicillin resistant *Staphylococcus Aureus*) resulting from the overuse of antibiotics, including when prescribed to patients who have illness caused by viruses that are not affected by antibiotics.[139] Similarly, overuse and unnecessary use of pesticides causes the more susceptible individuals in a population of pests or bacteria to be killed off, with ever more resistant individuals surviving. These more resistant individuals then reproduce, resulting in subsequent generations of the pest or bacteria being comprised of larger numbers of resistant individuals. Ultimately, after many generations, the population of resistant individuals is so large that the particular pest or bacteria will no longer respond to treatment by that pesticide or antibiotic. This creates a treadmill effect in which larger and larger quantities of ever more toxic pesticides are needed to control the pesticide-resistant pest population.[140]

2. *The Current Neonicotinoid Problem*

Since neonicotinoids were first commercially introduced in 1991, their use has rapidly increased; by 2014, they made up more than 25 percent of the global pesticide market.[141] This new class of pesticides was initially commended for its versatile application, systemic uptake by plants, and perceived minimal impacts on vertebrates.[142] Neonicotinoids have over 140 different uses and are applied in 120 countries.[143] In the United States alone, neonicotinoids comprise a growing $1.9 billion industry.[144]

Systemic pesticides like neonicotinoids raise complex new concerns surrounding their impact on insect populations and the greater environment. The high water solubility of neonicotinoids allows easy absorption of the

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[138] Helmut F. van Emden & M.W. Service, Pest and Vector Control 115 (2004).

[139] *Id.*; *see also* Maggie Hardy, *Resistance Shapes the Discovery of New Insecticides*, The Conversation, *https //theconversation.com/resistance-shapes-the-discovery-of-new-insecticides-22537* (last visited Nov. 8, 2021).

[140] Van Emden & Service, *supra* note 138, at 115–16. For further discussion of pest resistance, see generally Mary Jane Angelo, *Breaking our Pesticide Addiction A 12-Step Program for Ecologically-Based Pest Management*, *in* From Farm-to-Fork: Perspectives on Growing Sustainable Food Systems for the Twenty-First Century (Sarah J. Morath ed., 2016) [hereinafter Angelo, *12-Step*].

[141] Chris Bass et al., *The Global Status of Insect Resistance to Neonicotinoid Insecticides*, 121 Pesticide Biochemistry & Physiology 78 (2015).

[142] *See* Simon-Delso et al., *supra* note 136.

[143] Ola Lundin et al., *Neonicotinoid Insecticides and Their Impacts on Bees A Systematic Review of Research Approaches and Identification of Knowledge Gaps*, 10 PLOS One 1, 2 (2015).

[144] Michelle L. Hladik et al., *Environmental Risks and Challenges Associated with Neonicotinoid Insecticides*, 52 Env't Sci. & Tech. 3329, 3329–30 (2018).

pesticide through the plant's roots, before translocating throughout the tissue of the organism and impacting the entire plant.[145] The insecticide is then present in the plant's roots, leaves, pollen, and nectar.[146] Experts estimate that on average a crop absorbs a mere 5 percent of the neonicotinoid coating a seed, leaving the remaining 95 percent of the pesticide unabsorbed and free to roam to other parts of the environment.[147] Wildflowers in areas adjacent to crops treated with neonicotinoids exhibit the insecticide in their roots, leaves, pollen, and nectar.[148]

In the United States, studies demonstrate the prevalence of neonicotinoids in water bodies around agricultural areas throughout the Midwest and that the pesticide group is present at higher concentrations and frequency than other previously-used agricultural pesticides.[149] Globally, studies from the United States, Netherlands, and Vietnam surveying surface water have detected at least one neonicotinoid in 89 to 100 percent of water samples.[150] The neonicotinoids primarily used in seed treatment, clothianidin, imidacloprid, and thiamethoxam are frequently found in water bodies near high intensity agricultural areas, while other neonicotinoids commonly used in different application methods, such as spraying, are frequently found in urban-area water bodies.[151]

Neonicotinoids have been found in rivers,[152] wetlands,[153] and groundwater.[154] One reason neonicotinoids are widely detected throughout our environment is that they are used in the large-scale commercial crops, such as

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[145] Cloyd, *supra* note 136; Simon-Delso et al., *supra* note 136.

[146] *See id.*

[147] Hladik et al., *supra* note 144, at 3330.

[148] *Id.*; *see, e.g.*, M. Greatti et al., *Presence of the A.I. Imidacloprid on Vegetation Near Corn Fields Sown with Gaucho® Dressed Seeds*, 59 BULL. INSECTOLOGY 99 (2006); Lundin et al., *supra* note 143.

[149] Michelle L. Hladik et al., *Widespread Occurrence of Neonicotinoid Insecticides in Streams in a High Corn and Soybean Producing Region, USA*, 193 ENV'T POLLUTION 189, 192-93.

[150] Hladik et al., *supra* note 144, at 3330; Francisco Sánchez-Bayo & Ross V. Hyne, *Detection and Analysis of Neonicotinoids in River Waters–Development of a Passive Sampler for Three Commonly Used Insecticides*, 99 CHEMOSPHERE 144 (2014).

[151] Hladik et al., *supra* note 144, at 3330.

[152] *See e.g.*, Sánchez-Bayo & Hyne, *supra* note 150, at 143; Hladik et al., *supra* note 149, at 192 (2014); Keith Starner & Kean S. Goh, *Detections of the Neonicotinoid Insecticide Imidacloprid in Surface Waters of Three Agricultural Regions of California, USA, 2010–2011*, 88 BULL. ENV'T CONTAMINATION & TOXICOLOGY 316 (2012).

[153] *See, e.g.*, Todd A. Anderson et al., *Effects of Land Use and Precipitation on Pesticides and Water Quality in Playa Lakes of the Southern High Plains*, 92 CHEMOSPHERE 84 (2013); Anson R. Main et al., *Widespread Use and Frequent Detection of Neonicotinoid Insecticides in Wetlands of Canada's Prairie Pothole Region*, 9 PLOS ONE 1 (2014).

[154] *See, e.g.*, Marc Lamers et al., *Pesticide Pollution in Surface- and Groundwater by Paddy Rice Cultivation A Case Study From Northern Vietnam*, 39 CLEAN: SOIL, AIR, WATER 356 (2011); Anders Huseth & Russell L. Groves, *Environmental Fate of Soil Applied Neonicotinoid Insecticides in an Irrigated Potato Agroecosystem*, 9 PLOS ONE 1 (2014); Chloé de Perre et al., *Fate and Effects of Clothianidin in Fields Using Conservation Practices*, 34 ENV'T TOXICOLOGY & CHEMISTRY 258 (2015).

cotton, corn, potato, and tobacco.[155] However, because of their unique chemical composition, neonicotinoids are not limited to these common crops—their application extends to a wide variety of non-commercial settings. Neonicotinoids are applied in some home gardens and lawns, for instance. And because they are highly effective against sucking pests,[156] neonicotinoids are applied domestically to home gardens and lawns and prescribed by veterinarians for flea and tick management.[157] Specifically, the insecticide group is highly effective against sucking insects and some chewing species, including aphids, whiteflies, leafhoppers and planthoppers, and potato beetles.[158] As a result, neonicotinoids are widely used by a variety of people, professional and non-professional, in diverse settings.

Beyond their wide variety of uses, neonicotinoids may be broadly applied by means of seed treatment, soil application, and through foliar sprays. More than 60 percent of application to crops is through seed and soil treatments, such as incorporation into drip irrigation or drench systems for fruits and vegetables.[159] Initially, the applicational development of neonicotinoids as a seed treatment—the application of the chemical prior to planting by means of film coatings, multilayer coatings, and pelleting—was understood as an environmentally effective means to deliver crop protection, particularly during a plant's infancy.[160] However, environmental health concerns have been raised resulting from the long-term and repeated use of seeding coatings by farmers.

Moreover, because neonicotinoids are primarily applied as seed coatings, crop producers disregard the basic practices of integrated pest management to the detriment of beneficial insects. As discussed in more detail in Part IV of this Article, the use of seed coatings is inconsistent with universally accepted approaches and best practices for integrated pest management.[161] By relying on the uniform delivery of pesticides administered by seed coatings, producers disregard basic practices of integrated pest management, such as evaluating harmful pest thresholds,[162] forecasting,[163] and pest trapping.[164] This uniform

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[155] Peter Jeschke et al., *Overview of the Status and Global Strategy for Neonicotinoids*, 59 J. AGRIC. & FOOD CHEMISTRY 2897, 2897, 2901 (2010). This list also includes vegetables, pome and stone fruits, citrus, rice, cotton, corn, potato, sugar beet, oilseed rape, soybean, tobacco, and various other commercial crops.

[156] *Id.* at 2897.

[157] *Id.* at 2901.

[158] *Id.* at 2897.

[159] *Id.* at 2900.

[160] *Id.*

[161] Hladik et al., *supra* note 144, at 3332.

[162] A pest *threshold* is "a scientifically determined level [of pest damage] that could cause economic damage[, and u]ntil that threshold is reached, the cost of yield and quality loss will be less than the cost for control." *What is Integrated Pest Management?*, INTEGRATED PEST MGMT. INST. N. AM., https://ipminstitute.org/what-is-integrated-pest-management/ (last visited Dec. 19, 2020).

[163] *Forecasting* is practiced when "[w]eather data are consulted to predict if and when pest outbreaks will occur. Treatments can then be properly timed, preventing crop damage and saving sprays." INTEGRATED PEST MGMT. INST. N. AM., *supra* note 162.

application method does not allow farmers to take targeted, holistic approaches, resulting in the over-application of pesticides and the elimination of beneficial insects. Though well-intentioned, neonicotinoid seed coverings indirectly harm crops and reduce yields through their reduction and elimination of beneficial insects.[165]

The global use of seed coatings continues to accelerate, and in the United States neonicotinoid-coated seeds comprise over 79 percent of corn seeds and 34 to 44 percent of soybean seeds used.[166] Neonicotinoids are commonly found in soil where treated seeds have been sowed, and repeated sowing likely increases the concentration of neonicotinoids within the soil.[167] These concentration levels of neonicotinoid are present in the soil for several years after farmers discontinue use of the treated seeds.[168]

The widespread use and variety of application methods of neonicotinoids, catalyzing their presence and duration in the environment by means of soil and water pollution, is particularly devastating to non-target beneficial insect populations. Insects may become exposed to neonicotinoids either directly by ingesting plants that contain the pesticide, or indirectly by exposure to residues remaining on plants, in soils, or in water after pesticide application. Insects may also become exposed by coming into contact with contaminated pollen, nectar, seed-coating dust,[169] or other previously exposed organisms.[170] Upon exposure, neonicotinoids directly target the central nervous system of the insect.[171] Due to the systemic nature of neonicotinoids and their prevalence of contaminating soil and water, an insect is susceptible to the pesticide even months after application.[172]

Additionally, research suggests that neonicotinoids, particularly clothianidin, imidacloprid and thiamethoxam,[173] present greater risks to bees

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[164] *Pest Trapping* is practiced when "[t]raps that are attractive to insects are used so that growers can pinpoint when the pest has arrived and decide whether control is justified." *Id.*

[165] GURIAN-SHERMAN, *supra* note 135, at 2.

[166] *Id.* at 1.

[167] Notably, the concentration levels of the neonicotinoids begin to level off between four and six years without substantial increase after this period. Dave Goulson, *An Overview of the Environmental Risks Posed by Neonicotinoid Insecticides*, 50 J. APPLIED ECOLOGY 977, 979–81 (2013); *see also* Hladik et al., *supra* note 144, at 3330.

[168] Hladik et al., *supra* note 144, at 3330. *See* Hladik et al., *Neonicotinoid Insecticide Removal by Prairie Strips in Row-Cropped Watersheds with Historical Seed Coating Use*, 241 AGRICULTURE, ECOSYSTEMS & ENV'T 160 (2017).

[169] J. Bonmatin et al., *Environmental Fate and Exposure; Neonicotinoids and Fipronil.* 22 ENV'T SCI. POLLUTION RSCH. 35 (2015), at 35–36.

[170] HOPWOOD ET AL., *supra* note 133, at 12.

[171] Hladik et al., *supra* note 144, at 3329.

[172] HOPWOOD ET AL., *supra* note 133, at 2.

[173] *Pollinator Network at Cornell*, CORNELL COLL. AGRIC. & LIFE SCIS., https://pollinator.cals.cornell.edu/threats-wild-and-managed-bees/pesticides/neonicotinoids/ (last visited Nov. 12, 2020)*; see generally* Francisco Sanchez-Bayo & Koichi Goka, *Pesticide Residues and Bees–A Risk Assessment*, 9 PLOS ONE 1 (2014).

than previously-used pesticide classes.[174] A global collection sampling of honey from the nests of honey bees and bumble bees found the presence of a single neonicotinoid in 75 percent of the samples and the presence of more than one neonicotinoid in 45 percent of the samples.[175] The reported presence of neonicotinoids in non-target wildflowers increases exposure for honey bees and wild bees.[176]

Because of the valuable pollination services that honey bees provide to farmers, and especially in light of alarming reports of bee declines in Europe and the United States,[177] a growing body of research has focused on how neonicotinoids negatively affect honey bees. Lab studies found that exposing honey bees to neonicotinoids increases mortality, impairs foraging, feeding, and locomotion, reduces immunity, and alters learning and memory.[178] Field studies confirm these lab studies, and further demonstrate the negative impacts of reduced colony growth, complications with a queen's function, and reduced honey production.[179] The cumulative impacts of neonicotinoids on honey bees suggests that the pesticide group is linked to Colony Collapse Disorder.[180] The cause of Colony Collapse Disorder is complex and is believed to be the result of various environmental stressors such as pollution from neonicotinoids.[181] However, more information is needed to better understand the link between neonicotinoids and Colony Collapse Disorder.

Additionally, studies demonstrate the negative effects of neonicotinoids on bumble bees and other wild bee species. Exposed bumble bees experience reduced colony growth, brood production, and nest construction, as well as impaired feeding and increased mortality.[182] Studies on other wild bee species show that exposure to neonicotinoids similarly increases mortality, impairs locomotion, and reduces brood production.[183] Scientists and experts agree that more research needs to be conducted to better understand the cumulative impacts of neonicotinoids at lethal and sublethal exposure levels. [184]

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[174] *Pollinator Network at Cornell*, *supra* note 173.

[175] Edward A. D. Mitchell et al., *A Worldwide Survey of Neonicotinoids in Honey*, 358 SCIENCE 109, 109–11 (2017).

[176] *See* Hladik et al., *supra* note 144.

[177] *See, e.g.*, Christian H. Krupke et al., *Multiple Routes of Pesticide Exposure for Honey Bees Living Near Agricultural Fields*, 7 PLoS ONE 1*PLoS ONE* (2012); Pilar de la Rúa et al., *Biodiversity, Conservation and Current Threats to European Honeybees*, 40 APIDOLOGIE 263 (2009).

[178] *Pollinator Network at Cornell*, *supra* note 173.

[179] *Id.*

[180] Dina Spector, *Scientists May Have Finally Pinpointed What's Killing All The Honeybees*, BUS. INSIDER (May 13, 2014, 4:10 PM),) https://www.businessinsider.com/harvard-study-links-pesticides-to-colony-collapse-disorder-2014-5.

[181] HOPWOOD ET AL., *supra* note 133, at 26.

[182] *Pollinator Network at Cornell*, *supra* note 173.

[183] *Id.*

[184] *See* Hladik et al., *supra* note 144; *see generally* HOPWOOD ET AL., *supra* note 133.

Nevertheless, it is understood that neonicotinoid exposure negatively impacts bees on a sub-individual and individual level.[185]

However, more information should be gathered to better understand long-term effects due to data gaps.[186] Although research has focused on pollinator species, specifically honey bees, new research is emerging to show a wider impact on aquatic insects and other beneficial insect populations. Studies demonstrate that aquatic insects exposed to neonicotinoids, even at sublethal levels, experience negative outcomes.[187] Aquatic insects experience exposure due to the high water solubility of the pesticide class.[188] Additional studies demonstrate the negative impacts of neonicotinoid exposure on the reproduction, locomotion, behavior, and feeding inhibition of aquatic insects and raise concerns over delayed, long-term effects.[189] On a larger scale, experts have observed changes to ecosystem processes, species interactions and functions, and impacts on multispecies communities.[190] Again, although studies show that aquatic insects are impacted by neonicotinoid exposure, more research needs to be conducted to better understand how all forms of neonicotinoids affect aquatic systems.[191]

Despite the growing popularity of neonicotinoids, recent studies suggest that neonicotinoids are driving the dramatic decline of insect populations across the globe. Undoubtably, there is a need for more comprehensive research on the effects of neonicotinoid exposure to insects. Questions remain regarding the effects of long-term exposure, pesticide combinations exposure, and sublethal exposure to a wide range of insects. Notwithstanding, there is little doubt that neonicotinoids are negatively affecting the health of ecosystems and placing insect communities in peril.

C. Climate Change

As more information becomes available about how climate change affects ecosystems, climate change emerges as a central driver to the decline of insect population, diversity, and biomass. The adverse impacts of climate change on insects are complex and further compounded by insects' short life cycles and temperature sensitivity.[192] Climate change's synergistic role in diversity loss and population declines is difficult to isolate from other influential drivers, such

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[185] *See Environmental Risks and Challenges Associated with Neonicotinoid Insecticides*, *supra* note 144; *Pollinator Network at Cornell*, *supra* note 173. Like bees, other pollinating insects including butterflies, beetles, and flies experience negative impacts from neonicotinoid exposure. Hladik et al., *supra* note 144, at 3331; HOPWOOD ET AL., *supra* note 133, at 12.

[186] Hladik et al., *supra* note 144, at 3333.

[187] *Id.* at 3331.

[188] Bonmatin et al., *supra* note 169, at 47.

[189] Hladik et al., *supra* note 144, at 3331.

[190] *Id.*

[191] *Id.* at 3333.

[192] Eggleton, *supra* note 101, at 72.

as pesticide use, habitat loss, and industrial agricultural practices.[193] Despite its complexity and synergistic nature, climate change results in range shifts, phenology changes, and decreased access to food for insects, making climate mitigation a vital component of halting the decline of insect diversity and abundance.[194]

The effects of climate change on insect diversity and abundance result from changes in temperature, extreme weather episodes, and variable weather patterns.[195] These episodes directly impact the habitats of insects and alter the insect phenology impacting reproduction, migration, and daily activities.[196] The effects of climate change may result in insect populations experiencing chronic drought, reduced cloud cover, and altered rainfall.[197] The environmental shifts modify food supply and lead to potentially devastating changes in insect reproduction and migration abilities by altering or eliminating areas of connectivity and habitat corridors essential for migration and reproduction.[198]

Changes in temperature and water supply dramatically impact flora, including crop plants. Drought or increased rainfall makes growing conditions difficult for important food supplies and creates stressors for plants, making them more susceptible to disease and harmful insect invasions.[199] Alterations in rainfall produce drought, increasing the likelihood of forest fires.[200] These changes further contribute to ecosystems becoming more susceptible to invasive species.[201]

As planetary temperatures increase, of particular concern are insect species with cold-adapted lineages.[202] Modeled distributions of taxa under climate change scenarios demonstrate that increasing global temperatures by 1.5° C above pre-industrial levels would result in 6 percent of invertebrates losing at least 50 percent of their habitat range.[203] If global temperatures warm 2° C, then 18 percent of invertebrates would experience a 50 percent loss of

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[193] *Id.*

[194] *See* Sánchez-Bayo & Wyckhuys, *supra* note 79; Pedro Cardoso, *Scientists Warn Humanity About Worldwide Insect Decline, and Suggest Ways to Recognize and Avert Its Consequences*, LIFE SCI. NEWS (Oct. 10, 2020), https://www2.helsinki.fi/en/news/life-science-news/scientists-warn-humanity-about-worldwide-insect-decline-and-suggest-ways-to-recognise-and-avert-its-consequences.

[195] *See* Wagner, *supra* note 79, at 465.

[196] Eggleton, *supra* note 101, at 72; Wagner, *supra* note 79, at 465–66.

[197] Wagner, *supra* note 79, at 465–66.

[198] Scott H. Black, *Insects and Climate Change Variable Responses Will Lead to Climate Winners and Losers*, *in* ENCYCLOPEDIA ANTHROPOCENE 95–101 (Dominick A. Dellasala & Michael I. Goldstein eds., 2018).

[199] Wagner, *supra* note 79, at 466.

[200] *Id.*

[201] Eggleton, *supra* note 101, at 72–73.

[202] *See* Jermey T. Kerr et al., *Climate Change Impacts on Bumblebees Converge Across Continents*, 349 SCIENCE 177, 178 (2015).

[203] Forister et al., *supra* note 85, at 3.

habitat, and 49 percent of invertebrates would share the loss if global temperatures increased 3.2° C.[204]

Similarly, the nexus between the effects of climate change, deforestation, and agricultural intensification plays a central role in the loss of species diversity, making tropical forests particularly vulnerable. The decline of insect abundance and diversity within tropical forests is becoming well-documented in the rainforests of the Caribbean, Central America, and South America.[205] As agricultural intensification and deforestation increase the speed of climate change, the local and regional climates of tropical forests are rapidly changing, thus altering insect habitats. Unable to adapt to these accelerated habitat changes, insect populations, diversity, and biomass are declining.

Therefore, the role climate change plays in driving insect decline must be seen through a synergistic lens. Climate change affects ecosystems in known and yet-to-be-understood ways. The rapid alterations of ecosystems exacerbated by climate change are further accelerating the reduction of insect habitat in both quality and quantity. Thus, climate change must be considered when developing a solution to address the decline in insect populations.

IV. LIMITATIONS OF EXISTING AND PROPOSED APPROACHES

In this Part, we explore the strengths and weaknesses of a number of federal laws and programs, as well as the manner in which they have been employed by their implementing agencies, in order to tackle the complex challenge of reversing insect population declines. The laws and programs described in this Part have the potential to contribute to reversing the troubling declines of beneficial insect species. However, each of these approaches has significant limitations and as such is not sufficient to address the complex and widespread challenges. To date, federal agencies have made very minor attempts to address pollinator insect population declines, but these efforts were of little avail. Legal scholars have yet to grapple with finding legal or policy solutions to the problem of insect population decline. What little exists in the legal academic literature focuses almost exclusively on pollinators, particularly honey bees (and, to a lesser extent, bumble bees), and whether neonicotinoid pesticides should be banned.[206]

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[204] *Id.*

[205] *See generally* David L. Wagner, *Insect Declines in the Anthropocene*, 65 ANN. REV. ENTOMOLOGY 458-59 (2020). *See also* Ilkka Hanski et al., *Deforestation and Tropical Insect Extinctions*, 5 BIOLOGY LETTERS 653, 653–55 (2009).

[206] *See generally* Ann N. Coenen-Davis, Note, *The Mystery of the Disappearing Honeybee Will Government Funding and Regulation Save This Important Pollinator*?, 14 DRAKE J. AGRIC. L. 175 (2009); Katherine Headley, Note, *Honey Bees & Neonicotinoids Why Pollinators Need More Protections*, 38 N. ILL. UNIV. L. REV. 134 (2017); Emily Helmick, Note, *The Blight of the Bumblebee How Federal Conservation Efforts and Pesticide Regulations Inadequately Protect Invertebrate Pollinators From Pesticide Toxicity*, 13 J. FOOD L. & POL'Y 325 (2018); Kristen Hilferty, Note, Pollinator Stewardship Council v. U.S. Environmental Protection Agency *The Ninth Circuit Reaffirms the Prioritization of Protecting the Environment Over Agency Action*, 29 TUL. ENV'T L. J. 87 (2015);

Just as there are multiple drivers that contribute together to the decline in insect populations, it will likely take a multifaceted approach under a variety of laws to sufficiently tackle this complex problem. Several existing federal statutes provide legal authority to address aspects of insect population declines. These include the Endangered Species Act (ESA), the Farm Bill, and the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). An evaluation of these laws reveals that the ESA and Farm Bill provide authority to play limited roles in addressing the problem. We discuss the potential utility and limitations of the ESA and the Farm Bill in this Part, as well as review some other limited efforts that have been attempted to date to tackle aspects of the problem. Then, in the following Part, we take a deep dive into FIFRA, the primary federal pesticide law, and demonstrate its significant potential to address the insect crisis.

A. *Protecting Insects and Their Habitats with the Endangered Species Act*

The ESA[207] is intended to conserve threatened and endangered plant and animal species and their habitats.[208] Although considered one of the most far-reaching wildlife protection statutes[209] to date, the ESA has had limited success in protecting insect species. At least part of the explanation for this limited success is that, despite similar rates of extinction for insects and other animals,[210] relatively few insect species are currently protected by the ESA. In fact, of the more than 1,600 species currently listed as endangered or threatened under the ESA, only ninety-two are insects.[211] Of those ninety-two insect species, forty-seven are pollinators, including eight species of bees. Listed

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Emily Knobbe, Note, *Honeybees and the Law Protecting Our Pollinators*, 30 J. ENV'T L. & LITIG. 219 (2015); Alexander Martone, *Can* Pollinator Stewardship Council v. EPA *Help Solve the Colony Collapse Disorder Crisis?* (pts. 1–3), GEO. ENV'T L. REV. ONLINE (2014); Savannah Pugh, Note, *This is Not the Bee's Knees A Critical View of the Government's Lack of Policy to Conserve Pollinators*, 18 SUSTAINABLE DEV. L. & POL'Y 27 (2017); Jonathan P. Scoll, *Vanishing Insects?*, 32 NAT. RESOURCES & ENV'T 64 (2018); Alex Trabolsi, Note, Pollinator Stewardship Council v. EPA *and the Duty to Research FIFRA Applications*, 43 ECOLOGY L. Q. 503 (2016); Camila Acchiardo Vallejo, Note, *Preventing a Risk/Risk Trade-off An Analysis of Measures Necessary to Increase U.S. Pollinator Numbers*, 34 PACE ENV'T L. REV. 489 (2017); Maria Vanegas, Note, *The Silent Beehive How the Decline of Honey Bee Populations Shifted the Environmental Protection Agency's Pesticide Policy Toward Pollinators*, 44 ECOLOGY L. Q. 311 (2017); Meena Miriam Yust, *Wings Without Borders The Case for a Migratory Insect Treaty to Aid Monarch Butterflies*, 46 CASE W. RES. J. INT'L L. 711 (2014).

[207] 16 U.S.C. § 1531-1599.

[208] 16 U.S.C. § 1531(b).

[209] *Babbitt v. Sweet Home Chapter of Cmtys. for a Greater Or.*, 515 U.S. 687, 698 (1995) (quoting Tenn. Valley Auth. v. Hill, 437 U.S. 153, 180 (1978)).

[210] Ezequiel Lugo, *Insect Conservation Under the Endangered Species Act*, 25 UCLA J. ENV'T L. & POL'Y 97 (2006-2007).

[211] Of the total listed threatened and endangered species, 1133 are animals, and the remainder are plants. *See FWS-Listed U.S. Species by Taxonomic Group*, U.S. FISH & WILDLIFE SERV., https://ecos.fws.gov/ecp/report/adhoc-creator?catalogId=species&reportId=listedSpecies&columns=%2Fboxscore@gpcode,group_text,kingdom,us_e_count,us_t_count,us_count_tot,for_e_count,for_t_count,for_count_tot,count_tot,sp_with_rec_plans (last visited July 25, 2022).

insect species include thirty-seven species of butterflies, moths, and skippers, one species of fly, and one species of beetle.[212] Other insect pollinators, including the monarch butterfly, have been determined to be candidates for listing under the ESA, yet little progress has been made in listing other affected species.[213] Another significant shortcoming is that the statute is geared more toward protecting individual species, or even individual animals of a particular species, rather than protecting the complex ecosystems in which insects inhabit are intricately emmeshed. As described below, this approach is not well suited to protect insect populations.

The ESA contains several provisions designed to protect species "listed" as either endangered or threatened. Endangered species are those in danger of extinction throughout all or a significant portion of their range.[214] Threatened species are those which are likely to become endangered within the foreseeable future throughout all or a significant portion of their range.[215] Although the ESA provides distinct categories of endangered and threatened species, similar protections are afforded both.[216] The agencies responsible for listing,[217] designating critical habitats,[218] and implementing the ESA are the U.S. Fish and Wildlife Service (for freshwater and terrestrial species) and the National Marine Fisheries Service (for marine and anadromous species). Together these two agencies are referred to as the "Services" in this Article.

Species listed as either threatened or endangered are protected under section 9 of the ESA, which prohibits the "taking" of listed species. The ESA defines the term "take" broadly to include to "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or attempt to engage in any such conduct."[219] The Services have further defined the term "harm" to include acts

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[212] *See Listed Animals,* U.S. FISH & WILDLIFE SERV., https://ecos.fws.gov/ecp0/reports/ad-hoc-species-report?kingdom=V&kingdom=I&status=E&status=T&status=EmE&status=EmT&status=EXPE&status=EXPN&status=SAE&status=SAT&mapstatus=3&fcrithab=on&fstatus=on&fspecrule=on&finvpop=on&fgroup=on&header=Listed+Animals (last visited December 18, 2020).

[213] Georgia Parham, *U.S. Fish and Wildlife Service Finds Endangered Species Act Listing for Monarch Butterfly Warranted but Precluded*, U.S. FISH & WILDLIFE SERV. (Dec. 15, 2020), https://www.fws.gov/news/ShowNews.cfm?ref=u.s.-fish-and-wildlife-service-finds-endangered-species-act-listing-for-&_ID=36817.

[214] 16 U.S.C. § 1532(6).

[215] 16 U.S.C. § 1532(20).

[216] Section 7 of the ESA applies equally to both threatened and endangered species. 16 U.S.C. § 1536. While section 9 protections do not automatically apply to threatened species, pursuant to authority in ESA section 4(d), in 1978, the U.S. Fish and Wildlife service issued a blanket rule extending section 9 protections to all threatened species under its jurisdiction unless a specific section 4(d) rule provided for a different set of protections for that individual species. In 2019, FWS repealed the blanket rule, providing that for all species listed as threatened going forward, it would promulgate specific rules to extend section 9 protections or other protections for each species at issue. 50 C.F.R. § 17.21.

[217] 16 U.S.C. § 1533.

[218] 16 U.S.C. § 1532(5) (defining critical habitat as the specific areas within the geographic area occupied by the species which are essential to the conservation of the species, and which may require special management considerations for protections).

[219] 16 U.S.C. § 1532(19).

that involve significant habitat modification or degradation which actually kills or injures wildlife by significantly impairing essential behavior patterns, including breeding, feeding, or sheltering.[220] Violations of the section 9 "taking" prohibition can result in both civil and criminal penalties.[221]

Section 7[222] of the ESA contains the other major regulatory program. This section imposes two mandates on federal agencies. First, it requires federal agencies to use their existing authorities to conserve endangered and threatened species.[223] Second, it requires federal agencies to consult with the Services to "insure that any action authorized, funded, or carried out by such agency is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of [critical habitat] of such species." [224]

The section 7 consultation process applies to any federal agency action that "may affect," in any manner, a listed species. There are two types of consultation, formal and informal. Formal consultation with the Services is required where a federal agency action is "likely to adversely affect" listed species.[225] A formal consultation results in the Services issuing a Biological Opinion ("BiOp"), which contains a determination of whether the federal agency action is likely to jeopardize listed species.[226] If an action is deemed likely to jeopardize the continued existence of listed species, the BiOp will include "reasonable and prudent alternatives" that if implemented would avoid jeopardy.[227]

Despite the protections afforded by the ESA, its ability to protect and conserve insect species is limited. A frequently-cited limitation of the ESA in general is that it takes a species-by-species approach.[228] Although the ESA has prevented the extinction of 99 percent of listed species, critics contend that the utilization of an ecosystem approach would make the ESA more effective and inclusive.[229] Our understanding of the complex and interdependent

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[220] This interpretation has been upheld by the U.S. Supreme Court. Babbitt v. Sweet Home Chapter of Cmtys. for a Greater Or., 515 U.S. 687, 707 (1995).

[221] 16 U.S.C. § 1540(a-b).

[222] 16 U.S.C. § 1536.

[223] 16 U.S.C. § 1536(a)(1).

[224] 16 U.S.C. § 1536(a)(2). An action is considered to "jeopardize the continued existence of any endangered species" if it can reasonably be expected, directly or indirectly, to appreciably reduce the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species. 50 C.F.R. § 402.02.

[225] 50 C.F.R. §§ 402.13 & 402.14.

[226] *Id.*

[227] 16 U.S.C. § 1536(b) (4).

[228] *See generally* Holly Doremus, *Patching the Ark Improving Legal Protection of Biological Diversity*, 18 ECOLOGY L. Q. 265 (1991).

[229] *See, e.g.*, Curtis Filaroski, *Single-Minded Determination The Problems with The Endangered Species Act and the Consensus on Fixing Species Conservation Law through a Focus on Ecosystems and Biodiversity*, 30 ENV'T L. & LITIG. 57, 70 (2015); Edward T. Laroe, *Implementation of an Ecosystem Approach to Endangered Species Conservation*, 10 ENDANGERED SPECIES UPDATE 4, (Jan/Feb 1993).

relationships of organisms has grown significantly since the ESA was passed nearly five decades ago. By utilizing a species-by-species listing approach, the ESA fails to recognize this gained understanding and fails to promote comprehensive ecosystem management practices that protect biodiversity, which is a foundational factor in species preservation.[230] Though proponents of the approach argue that critical habitat is subsequently protected under the species-by-species approach, such an approach relies on keystone species[231] for wider habitat protection.[232] However, relying on keystone species, which are not given special consideration in the listing process,[233] or on individual species to protect critical ecosystems, often leaves less well-known species overlooked and habitats inadequately supported for recovery.[234] Additionally, such an approach requires that the species already be at risk of extinction or that they likely will be at risk in the near future, which prevents early intervention, making it more costly than an ecosystem approach.[235] Further, critics argue that the species-by-species approach innately favors the listing of vertebrates over invertebrates because less scientific data is available for past and present insect populations as required by listing petitions.[236] Thus, critics see an opportunity to replace the ESA's species-by-species with a more scientifically sound, holistic ecosystem approach to protect individuals and ecological communities.

The ESA's species-by-species approach may be sufficient to protect certain species, particularly vertebrates, in situations where a particular species is in peril due to certain activities, such as poaching or loss of a specific piece of critical habitat, that specifically affect that species. In these situations, the species at issue can be listed, and takings of individuals of that species would then be prohibited. However, where entire ecosystems or groups of species are threatened due to more generic widespread impacts to the environment, such as with habitat degradation or climate change, the ESA is lacking. That said, the ESA is not well-suited for protecting large habitats and ecological communities from degradation either, particularly when the degradation is caused by a multitude of interacting drivers. For example, in some situations, a number of factors such as climate change, pollution, habitat fragmentation, and invasive species may all contribute to widespread degradation of a variety of habitats upon which numerous species rely. The ESA's prohibitions on takings of listed

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[230] Filaroski, *supra* note 229, at 71.

[231] A keystone species is "a species of plant or animal that produces a major impact (as by predation) on its ecosystem and is considered essential to maintaining optimum ecosystem function or structure." *Keystone*, MERRIAM-WEBSTER, https://www.merriam-webster.com/dictionary/keystone%20species (last visited March 4, 2022.).

[232] Laura Spitzberg, *The Reauthorization of The Endangered Species Act*, 13 TEMPLE ENV'T L. & TECH. J. 193, 206 (1994).

[233] *Id.* at 206–07.

[234] Filaroski, *supra* note 229, at 73–74.

[235] *See* Laroe, *supra* note 229, at 4.

[236] Lugo, *supra* note 210, at 110.

species and requirements for federal agencies to undergo consultation are not well-tailored to addressing these widespread, multifaceted, and multispecies problems.

Regarding the protection of insects specifically via the ESA, the limitations are even more problematic. Invertebrates are different in kind from the types of species the drafters of the ESA likely had in mind.[237] One of the primary factors limiting the utility of the ESA for protecting imperiled insect species is the relative dearth of ecological data on insects and the environmental risks they face.[238] The vast majority of research on insects conducted at universities, governmental agencies, and private institutions is limited to insect species that humans consider to be pests.[239] These pest species represent less than 1 percent of all insect species.[240] The remaining 99 percent of insect species receive relatively little research attention, particularly when one considers the enormous numbers of insect species in relation to other more conspicuous species, such as mammals and birds.[241]

Zoologist T. R. New has explored the limitations of using a species-by-species approach to protect invertebrates, as opposed to larger, more charismatic organisms.[242] New explains, "[N]ot surprisingly, in view of the general inconspicuousness of many invertebrates and the difficulties of detecting and evaluating changes in their numbers and distribution, most terrestrial invertebrates [identified as warranting protection] belong to the more conspicuous" and popular groups, such as butterflies.[243] New goes on to explain the shortcomings of using a species focus in conserving invertebrates. The lack of knowledge about most invertebrates makes it difficult to assess whether a particular species is in need of protection.[244] For similar reasons, the invertebrate species that have received attention likely represent only the tip of the iceberg of those species in need of attention.[245] Accordingly, New argues in favor of taking a wider focus to address insect conservation, emphasizing the conservation of the "communities in which invertebrates participate."[246] These concerns are salient when considering beneficial insect population declines, and highlight the limitations of relying on the ESA's species-by-species approach in this context.

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[237] Ryan P. Kelly, *Spineless Wonders How Listing Marine Invertebrates and Their Larvae Challenges the U.S. Endangered Species Act*, 19 PENN. ST. ENV'T L. REV. 1, 3 (2011).

[238] Lugo, *supra* note 210, at 102.

[239] *Id.* at 117.

[240] *Id.*

[241] *Id.* at 110.

[242] *See generally* T. R. NEW, INVERTEBRATE CONSERVATION AND AGRICULTURAL ECOSYSTEMS (Cambridge University Press, 2005).

[243] *Id.* at 67.

[244] *Id.* at 69.

[245] *Id.*

[246] *Id.* at 70.

The sheer number of individual insects on Earth, coupled with their small size and ability to fly long distances, means that practically any human activity has the potential to "take" an individual of a listed species. For larger, less abundant species of animals, such as mammals or reptiles, the ESA makes sense because it can protect against activities that kill or harm even a few individuals or that significantly degrade specific important habitats. Insects, on the other hand, occur in large numbers in wide ranges of habitat. They are not easily seen and virtually no one can identify the many thousands of species that might exist even in a very small area. An individual car driving on a road may crush individual ESA-listed insects under its tires and splatter individual insects on its windshield. An individual homeowner digging a garden in their yard may inadvertently kill hundreds or even thousands of insects, potentially including imperiled species. It is doubtful that the ESA was intended to create liability for these types of daily activities. Not to mention that it would be virtually impossible to monitor and enforce these types of takings.

Insect jeopardy under section 7 also presents an interesting challenge. Depending on the species, insects may have four different life stages—egg, larva, pupa, and adult—each of which has different morphology, physiology, and behavior and may depend on different habitats. As a result, assessing whether an activity or combination of activities may jeopardize the continued existence of a listed insect species is much more complex than it would be for species where juveniles and adults are more similar.

Unlike many other animals, insects typically produce very large numbers of offspring. While it may be tempting to assume that this means that losses of large numbers of insects may be better tolerated than are losses of other animals, this is not necessarily the case. For many species that produce very large numbers of offspring, only very small numbers actually survive into adulthood to reproduce. Enforcing section 9's taking prohibition for every egg, larva, pupa, and adult of a species would be unwieldy; strict enforcement would likely shut down virtually all human activity in areas where listed species are present.[247] While the ESA clearly covers all stages in a species life, as ecologist Ryan Kelly describes with regard to another type of invertebrate, coral, "harm to an individual larva will not appreciably affect the species' overall likelihood of survival and recovery, but the aggregate harm to larvae by many independent actions might well doom the species altogether."[248] In addition, the fact that immature insects are so different from mature insects means that activities that may be extremely harmful to one life stage may not be harmful to a different stage. While the ESA certainly could be used to protecting specific stages of an insect's life, in many cases there is simply insufficient data on various life stages to make these fine distinctions. Finally, for insect species that live in colonies with complex social structures, different

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[247] Kelly, *supra* note 237, at 4.

[248] *Id.* at 27–28.

castes may have different vulnerabilities to certain human activities and some castes, such as queen bees, may warrant greater protections than others. These complexities increase the challenges of using the ESA to protect insect populations.

B. Conserving Habitat through Farm Bill Programs

The Farm Bill, a massive collection of ad hoc policies and programs, has directed agricultural production practices for decades, largely through substantial economic incentive programs. The Farm Bill covers a wide range of federal food and farming programs, and in more recent years a significant number of conservation and energy programs, administered by the U.S. Department of Agriculture (USDA). Every five years or so, Congress passes a new omnibus Farm Bill, which typically amends, reauthorizes, or repeals provisions of previous Farm Bills.[249] The Farm Bill is incredibly broad, covering everything from school lunch programs to biofuel incentives programs. In contrast to most environmental laws, the Farm Bill is non-regulatory, and instead seeks to provide support to the agricultural industry and encourage certain practices through a complex web of financial and technical assistance incentive-based programs. There are several programs that most directly influence the manner in which farm production is carried out and the resulting environmental impacts. These include commodity subsidy programs, which tend to encourage environmentally harmful industrialized farming practices,[250] and conservation programs that provide financial incentives for farmers to employ certain environmentally friendly practices on both working and retired farmlands.[251] These programs can have profound influence on the crops farmers grow, the manner in which they grow them, and the environmental impacts that result.

Originally, Farm Bill programs sought to address economic crises farmers were facing during the Great Depression and Dust Bowl of the 1930s.[252] Over ensuing decades, some programs remained intact, albeit modified. While numerous programs were added, significant changes were made to ongoing programs, and the breadth of issues covered was extended to encompass more contemporary concerns such as conservation, organic production, and bioenergy.[253] Historically, many of the Farm Bill's programs provided

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[249] CONG. RSCH. SERV., WHAT IS THE FARM BILL? 1 (2019), https://fas.org/sgp/crs/misc/RS22131.pdf.

[250] Jennifer Hoffpauir, *The Environmental Impact of Commodity Subsidies NEPA and the Farm Bill*, 20 FORDHAM ENV'T L. J. 233, 245–46 (2009).

[251] *See* CONG. RSCH. SERV., *supra* note 249, at 8–9.

[252] For a detailed history of the Farm Bill, *see* William S. Eubanks, II, *A Brief History of U.S. Agricultural Policy and the Farm Bill*, *in* MARY JANE ANGELO, ET AL., FOOD, AGRICULTURE, AND ENVIRONMENTAL LAW (Environmental Law Institute, 2013).

[253] For a detailed discussion of recent iterations of the Farm Bill, see Mary Jane Angelo and Joanna Reilly-Brown, *An Overview of the Modern Farm Bill*, *in id.*

financial incentives that were linked to production levels.[254] These policies encouraged the adoption of large-scale industrialized farming practices that utilized monocultures and required significant inputs of energy and chemicals.[255] In more recent Farm Bills, some of these incentive programs have been decoupled from per-acre yield, thereby eliminating certain incentives for high production industrial agriculture.[256] Nevertheless, many of the programs continue to encourage, or at a minimum tolerate, this type of high yield large-scale production.

Starting in 1985, a number of conservation-related incentive programs were added to the Farm Bill. Early conservation programs targeted conserving certain lands such as highly erodible lands, wetlands, and other environmentally sensitive lands.[257] While these programs had the benefit of preserving certain sensitive lands by taking land out of production, they also had the unintended consequence of encouraging farmers to farm more intensively to attempt to further increase yield on lands that were not set aside for conservation. More recently, Farm Bill Conservation programs have shifted away from “land retirement” to “working lands” programs. Working lands programs offer financial incentives to producers who voluntarily employ conservation practices in their farming operations.[258]

The Farm Bill’s most significant working lands programs with the potential to encourage practices aimed at beneficial insect conservation include the Environmental Quality Incentives Program (EQIP), the Conservation Stewardship Program (CSP), and the Agricultural Management Assistance Program. EQIP is a voluntary incentive-based program that provides technical and financial assistance and cost sharing for conservation and environmental improvements and practices on eligible working agricultural land.[259] Although historically a large focus of EQIP was to encourage on-farm water, soil, and nutrient managements, in more recent years EQIP has been used to address a broader range of conservation concerns. For example, in the 2008 Farm Bill, EQIP was expanded to encourage activities that provide support for at-risk wildlife species.[260] The Agricultural Management Assistance Program assists producers in managing risk by encouraging diversification and resource conservation practices. The CSP provides payments to producers for adopting, installing, or maintaining conservation activities. Under the CSP, payments are predicated upon producers achieving the level of environmental and

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[254] *Id.*

[255] Hoffpauir, *supra* note 250, at 247.

[256] *See id.* at 245–46.

[257] Erodible Land and Wetland Conservation and Reserve Program, 16 U.S.C. §§ 3811, 3821, 3831, 3837 (2006).

[258] *See* Natural Resources Conservation Service, *Financial Assistance*, U.S. DEP’T OF AGRIC., https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/ (last visited Apr. 3, 2021).

[259] 16 U.S.C. § 3839aa-22.

[260] *Id.*

conservation management required to "improve and conserve the quality and condition of natural resources in a comprehensive manner."[261] CSP funds may be used to encourage farming practices that enhance crop resiliency, provide wildlife habitat, and improve cover, food, and water for wildlife species.[262] Each of these programs, while not specifically targeted at protecting beneficial insects or the ecosystem services they provide, can be used to some extent to encourage conservation practices that do so.

In addition to the general working lands conservation programs that may be used to benefit insect conservation, recent Farm Bills have included some programs specifically designed to protect or conserve certain insects, primarily pollinators. Starting in 2008 and continuing through 2014 and 2018 iterations, the Farm Bill has included provisions specifically targeted at protecting pollinators and other beneficial insects. The 2008 Farm Bill included language designating all pollinators as "a priority resource concern."[263] This provision encouraged USDA to work with farmers to fund and plan pollinator enhancements, such as "pollinator meadows," "hedgerows," "cover crops," and "field borders."[264] The 2008 Farm Bill also authorized USDA to give special consideration to pollinators under the EQIP program for payments to encourage practices that promote pollinator habitat, and established the Specialty Crop Research Initiative.[265] The 2014 Farm Bill retained and strengthened the 2008 pollinator conservation provisions. The 2018 Farm Bill expanded the Specialty Crop Research Initiative grant program to prioritize certain areas of research, including research on pollinators and research into how natural enemy complexes can help with pest management, which ultimately may lead to the development of pest management practices that reduce the use of chemical pesticides.[266] The 2018 Farm Bill also mandated USDA to appoint a pollinator research coordinator.[267]

USDA has used its various authorities and funding sources under the Farm Bill to implement a number of insect conservation initiatives pursuant to a complex web of Farm Bill programs. According to USDA Natural Resources Conservation Service (NRCS), more than thirty-six NRCS conservation practices provide benefits to pollinators.[268] One such program is the Pollinator

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[261] *Id.*

[262] *See* Natural Resources Conservation Service, *Conservation Stewardship Program*, U.S. DEP'T OF AGRIC., https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/csp/ (last visited April 3, 2021).

[263] Scott H. Black, *Pollinators and the 2018 Farm Bill*, XERCES SOC'Y (Jan. 10, 2019), https://xerces.org/blog/Pollinators-and-the-2018-Farm-Bill.

[264] *Id.*

[265] *Id.*

[266] *Id.*

[267] *Id.*

[268] *See* U.S. DEP'T OF AGRIC., BIOLOGY TECHNICAL NOTE NO. 78, USING 2014 FARM BILL PROGRAMS FOR POLLINATOR CONSERVATION 5–8 (3rd ed. 2015), https://directives.sc.egov.usda.gov/opennonwebcontent.aspx?content=38006.wba; USDA, TECHNICAL NOTE NO. 78, USING FARM BILL

Habitat Incentive under the Conserve Reserve Program. USDA has also established the "Monarch Butterfly Initiative" under the Conservation Stewardship Program, which incentivizes farmers and ranchers to plant milkweed and other monarch food plants.[269]

Although the Farm Bill authorizes and provides funding to encourage farmers to engage in certain activities that benefit pollinators, these programs are insufficient to adequately address declines in beneficial insect populations. First, these programs are largely targeted at pollinators, not other beneficial insect species such as parasites and predators of pest species. It is true that other beneficial insects may benefit from some of the conservation practices designed to protect pollinators, but more is needed to ensure that these species are adequately protected. Second, Farm Bill programs are voluntary. Although many farmers have taken advantage of various Farm Bill Conservation Programs and changed their practices accordingly, there is nothing requiring them to do so or to continue to do so in the future. Moreover, the money available to farmers under Farm Bill Conservation programs in general is limited, and there is no guarantee it will continue under future Farm Bills enacted by future Congresses. Of the total Farm Bill Conservation funding, funding for insect conservation represents an extremely small percentage.[270] Consequently, farmers that receive incentives for insect pollinator conservation are relatively few.

C. Other Initiatives and Proposed Solutions

1. Obama's Presidential Memorandum

Acknowledging the critical role that pollinators play in food security, environmental health, and the nation's economy, President Obama issued a Presidential Memorandum directing the creation of a *Strategy to Promote the Health of Honey Bees and Other Pollinators* in an attempt to reverse the increasing decline of pollinators.[271] Issued on June 20, 2014, the Presidential

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PROGRAMS FOR POLLINATOR CONSERVATION 5–8 (2008), https://efotg.sc.egov.usda.gov/references/public/UT/TechNote78FarmBillProgramsforPollinators.pdf.

[269] Justin Fritscher & Jocelyn Benjamin, *Updated USDA Program Enables Farmers and Ranchers to Help Monarch Butterflies*, U.S. DEP'T OF AGRIC. (Feb. 21, 2017), https://www.usda.gov/media/blog/2015/06/19/updated-usda-program-enables-farmers-and-ranchers-help-monarch-butterflies.

[270] The Congressional Budget Office projected that the total cost of the 2018 Farm Bill would be $428 billion over five years. Of that total, only about 7 percent would go to all Conservation Programs combined. *Agriculture Improvement Act of 2018 Highlights and Implications*, ECON. RSCH. SERV., U.S. DEP'T OF AGRIC., https://www.ers.usda.gov/agriculture-improvement-act-of-2018-highlights-and-implications/ (last visited Mar. 4, 2022.). Although specific numbers for insect conservation are not readily available, because insect conservation activities represent a very small portion of conservation activities that are fundable through Farm Bill Conservation programs such as EQIP and CSP, it is likely that the funds paid for insect conservation are relatively minor compared to the vast array of other conservation program -funded activities.

[271] THE WHITE HOUSE OFF. OF THE PRESS SEC'Y, PRESIDENTIAL MEMORANDUM—CREATING A FEDERAL STRATEGY TO PROMOTE THE HEALTH OF HONEY BEES AND OTHER POLLINATORS (June 20,

Memorandum calls on federal agencies to restore pollinator populations to healthy levels by expanding federal efforts through the creation of an interagency Task Force.[272] Primarily authored by EPA and USDA, the May 19, 2015 *National Strategy to Promote the Health of Honey Bees and Other Pollinators (National Strategy)* defines three goals: (1) "[r]educe honey bee colony losses during winter (overwintering mortality) to no more than 15% within 10 years"; (2) "[i]ncrease the Eastern population of the monarch butterfly to 225 million butterflies occupying an area of approximately 15 acres (6 hectares) in the overwintering grounds in Mexico"; and (3) "[r]estore or enhance 7 million acres of land for pollinators over the next 5 years through federal actions and public/private partnerships."[273]

Generally, the multifaceted approach of the *National Strategy* seeks to address the stressors of pollinator losses such as habitat reduction, insufficient nutritional resources, pesticide exposure, and harmful pathogens.[274] By building on the directives of the Presidential Memorandum, the *National Strategy* calls on the executive branch to expand research, public education, and outreach, increase habitat to support pollinator species, and cultivate public-private partnerships to support these efforts at a state, local, and citizen level.[275] A *Pollinator Research Action Plan (Action Plan)* further accompanies the *National Strategy* to guide and prioritize research efforts to suffice information gaps needed to combat pollinator losses. The *Action Plan* identifies five key action areas for research: setting a baseline, assessing environmental stressors, restoring habitat, understanding and supporting stakeholders, and curating and sharing knowledge.[276]

To further build on the directives of the Presidential Memorandum, USDA and the U.S. Department of the Interior published a guide for those with land stewardship responsibilities.[277] Then, about a year and a half after publishing the *Proposal to Mitigate Exposure to Bees from Acutely Toxic Pesticide Products* for comments, EPA announced the finalized policy in January

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2014), https://obamawhitehouse.archives.gov/the-press-office/2014/06/20/presidential-memorandum-creating-federal-strategy-promote-health-honey-b.

[272] The Pollinator Health Task Force includes the following: Department of State, Department of Defense, Department of the Interior, Department of Housing and Urban Development, Department of Transportation, Department of Energy, Department of Education, Council on Environmental Quality, Domestic Policy Council, General Services Administration, National Science Foundation, National Security Council Staff, Office of Management and Budget, and Office of Science and Technology Policy. *Id.*

[273] POLLINATOR HEALTH TASK FORCE, NATIONAL STRATEGY TO PROMOTE THE HEALTH OF HONEY BEES AND OTHER POLLINATORS (2015), https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/Pollinator%20Health%20Strategy%202015.pdf.

[274] *Id.*

[275] *Id.*

[276] *Id.* at 1–3.

[277] *See* U.S. DEP'T OF AGRIC. & U.S. DEP'T OF INTERIOR, POLLINATOR-FRIENDLY BEST MANAGEMENT PRACTICES FOR FEDERAL LANDS (2015), https://www.fs.fed.us/wildflowers/pollinators/BMPs/documents/PollinatorFriendlyBMPsFederalLands05152015.pdf.

2017.[278] Although the January 2017 *Policy Mitigating the Acute Risk to Bees from Pesticide Products* does not legally compel changes to the pesticide registration process, it provides labeling recommendations and methods for managing acute pesticide risks.[279] The policy specifically applies to bees under contract services and only addresses the foliar application of liquid or dust pesticides.[280] Under the policy, "the EPA will use its Tier 1 acute risk assessment to, in part, determine the products that trigger concerns about pollinator risk that the label restrictions are intended to address" with the goal of more accurately identifying acute risks.[281] Additionally, the finalized policy allows "greater flexibility" for products with shorter residual toxicity and provides exemptions for such products and for crops with extended bloom periods.[282]

2. *Banning Neonicotinoids*

As described above, the category of insecticides known as neonicotinoids poses significant risks to pollinators and other beneficial insects due to a number of documented factors, including their high toxicity, water solubility, application as seed coatings, and systemic nature. These concerns have led to calls for the banning of some or all neonicotinoid pesticides.[283] The European Union (EU) has completely banned the outdoor use of three neonicotinoids—imidacloprid, clothianidin and thiamethoxam—and restricts the use of other pesticides in the neonicotinoid class.[284] In recent years, many have raised the specter of similarly banning neonicotinoids in the United States.[285] Although neonicotinoids appear to be significant contributors to pollinator and beneficial insect population declines, any movement to outright ban theses pesticides should proceed with caution and must consider the complexities and nuances of what could result from such action.

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[278] FREDERICK M. FISHEL ET AL., PESTICIDE LABELING: PROT. OF POLLINATORS, UNIV. FLA. IFS EXTENSION 1–2 (2017), https://edis.ifas.ufl.edu/pi271.

[279] *Id.*

[280] EPA, POLICY MITIGATING THE ACUTE RISK TO BEES FROM PESTICIDE PRODUCTS 4–5 (2017), https://www.epa.gov/pollinator-protection/policy-mitigating-acute-risk-bees-pesticide-products.

[281] *Id.* at 4.

[282] *Id.*

[283] *See, e.g.*, *Time to Ban Neonicotinoids for Good*, BUTTERFLY CONSERVATION (Jan. 14, 2021), https://butterfly-conservation.org/news-and-blog/time-to-ban-neonicotinoids-for-good; *U.S. Should Follow European Union Lead to Ban Neonicotinoid Pesticides*, AM. BIRD CONSERVANCY (April 27, 2018), https://abcbirds.org/article/u-s-should-follow-european-union-lead-to-ban-neonicotinoid-pesticides/; *Sign Petition to the EPA to Ban Systemic Pesticides (Neonicotinoids) that Kill Bees*, AM. BEE PROJECT, https://www.americanbeeproject.com/single-post/2014/02/04/sign-petition-to-the-epa-to-ban-systemic-pesticides-neonicotinoids-that-kill-bees (last visited March 10, 20222).

[284] Matt McGrath, *EU Member States Support Near-Total Neonicotinoids Ban*, BBC (Apr. 27, 2018), https://www.bbc.com/news/science-environment-43910536 (discussing the EU's partial ban of three classes of neonicotinoids and the 2018 expansion of the ban).

[285] *See supra* note 283.

While, at first blush, the outright ban or severe restriction of neonicotinoids seems an obvious course given the chemical's role in beneficial insect declines, many believe such an action would be overly simplistic and would ignore the reality that neonicotinoids are not the only chemical pesticides in use that are highly toxic to insect pollinators and other species. Accordingly, it is possible that an outright ban may not result in any meaningful reductions in harm. As others have pointed out, a ban on neonicotinoids would likely result in growers simply switching to equally or even more toxic pesticides.

Currently, the policy outcomes of an outright ban are playing out in the EU. Based on a 2012 risk assessment conducted by the European Food Safety Authority (EFSA), the European Commission took its first step toward restricting the use of neonicotinoids within the EU in 2013.[286] The Commission partially banned the use of three neonicotinoids—clothianidin, imidacloprid and thiamethoxam—in an effort to protect honey bees and other pollinators.[287] The initial ban prevented the use of these three neonicotinoids in the form of seed coatings or applications to plants on bee-attractive crops.[288] However, exceptions were made for some use in greenhouses and after the plants flowered.[289] EFSA continued to collect data on the outdoor use of the three neonicotinoids, and in 2018 the authority published a conclusion determining outdoor use of these three neonicotinoids unsafe for bees.[290]

As a result, the Commission, with the support of member states, further restricted the use of neonicotinoids. The outdoor use of clothianidin, imidacloprid and thiamethoxam was subsequently banned in April 2018. However, EFSA determined that acetamiprid—a fourth type of neonicotinoid—to be low risk to bees, and as such, approved it for use until 2033.[291] A recent investigation into the impact of the total ban found a regularly exploited loophole that allows the banned neonicotinoids to be applied outdoors.[292] The investigation found that in the two years since the ban, EU countries issued sixty-seven emergency authorizations for the banned chemicals in often questionable or unsupported circumstances.[293] For example, an exception was granted for the use of an imidacloprid product to protect a

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[286] *Neonicotinoids*, EUROPEAN COMM'N, https://ec.europa.eu/food/plant/pesticides/approval_active_substances/approval_renewal/neonicotinoids_en (last visited Mar. 15, 2021).

[287] *See* Commission Regulation 485/2013 of May 24, 2013, 2013 O.J. (L 139) 12.

[288] *Neonicotinoids*, *supra* note 286.

[289] *Id.*

[290] *Id.*

[291] *Id.*

[292] Crispin Dowler & Joe S. Clarke, *Loophole Keeps Bee-killing Pesticides in Widespread Use, Two Years after EU Ban*, GREENPEACE (July 8, 2020), https://unearthed.greenpeace.org/2020/07/08/bees-neonicotinoids-bayer-syngenta-eu-ban-loophole/.

[293] *Id.*

golf course from a beetle infestation.[294] And in many of these cases, the granted applicants were the chemical manufacturers themselves.[295]

Recently, in the United States, the Protect America's Children from Toxic Pesticides Act of 2020 was introduced in Congress. In addition to requiring the immediate suspension and review of any pesticide banned in the EU or Canada, the proposed legislation sought to amend FIFRA, give EPA more oversight and enforcement powers, and permanently ban several toxic pesticides such as imidacloprid, a neonicotinoid that poisons pollinators.[296] The Bill died in the Senate before receiving a vote.[297]

A ban on neonicotinoids, while superficially appealing, is a complex issue that may not accomplish the goal of beneficial insect protection. First, banning these pesticides could have the unintended consequence of dramatically increasing the use of other existing or new synthetic chemical pesticides that pose significant risks of their own. Whenever we seek to reduce harm by banning a particular pesticide or group of pesticides, it is necessary to consider what pesticides will be used to replace the banned ones. Historically, as groups of pesticides were phased out due to the risks they posed to humans or the environment, other pesticides filled the gaps, and over time it was revealed that the new pesticides were frequently just as risky, albeit frequently different in type of risk, as those they replaced.[298]

Further, concern with neonicotinoids is not limited to the toxicity of these pesticides themselves. The widespread use of these toxic systemic pesticides as seed treatments is what allows high exposure to pollinators and other beneficial insects.[299] This problem is greatly compounded by the fact that the use of seeds treated with neonicotinoids has grown exponentially in recent years to the point where it is almost impossible for a farmer to purchase certain crop seeds that have not been treated with these pesticides.[300]

Rather than an outright ban of one group of pesticides, we believe that the more prudent course is a more science-based and nuanced approach to regulating pesticides under FIFRA, as set forth in Part V below. Specifically, we propose that neonicotinoids, and any other insecticides that are highly toxic to bees and other beneficial insects, only be registered under FIFRA if their use is restricted to part of an Integrated Pest Management Program, where they are used only if an economic threshold has been tripped on a particular farm field. We further propose a more robust unreasonable adverse effects analysis and a

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[294] *Id.*

[295] *Id.*

[296] *See* Protect America's Children from Toxic Pesticides Act, S. 4406, 116th Cong. (2020).

[297] *See S. 4406 (116th) Protect America's Children from Toxic Pesticides Act*, GOVTRACK.US, https://www.govtrack.us/congress/bills/116/s4406 (last visited June 4, 2022).

[298] *See* ANGELO, *supra* note 69, at 68–72.

[299] *See* Hladik et al., *supra* note 144, at 3329.

[300] Penn State, *Pesticide seed coatings are widespread but underreported*, SCIENCEDAILY (Mar. 17, 2020), www.sciencedaily.com/releases/2020/03/200317215632.htm.

shift away from exempting seeds treated with systemic pesticides, such as noenicitinoids, from the treated article exemption.

V. AN EXPLORATION OF POTENTIAL SOLUTIONS UNDER FEDERAL PESTICIDE LAW

As discussed above, a number of potential solutions to the insect apocalypse have been tried or proposed. While each of these has its merits, none, at least standing alone, sufficiently tackles this challenging problem. We believe a multifaceted approach is needed. Such an approach, while drawing on Farm Bill programs and ESA protections where they make sense, must also include a transformative approach to regulating pesticides that is science-based and takes into account the complex roles insects play in ecosystems, including agroecosystems. While Farm Bill programs may be used to encourage the conservation of habitat for beneficial insects or promote other environmentally friendly farming practices, they are completely voluntary and only cover a very small percentage of farmland. In contrast, FIFRA can achieve similar objectives on a widescale basis through mandatory regulatory approaches. Unlike the ESA, which only protects species that have been listed as endangered or threatened, FIFRA can be used to address risks to all non-target species, including beneficial insect species which, even if not imperiled to the point that they are listed under the ESA, carry out crucial ecosystem services that are at risk. FIFRA, as the primary federal regulatory statute governing pesticides, undoubtedly will play a role in reducing beneficial insect exposure to toxic pesticides. However, as outlined below, there also may be a role for FIFRA in promoting increased and improved habitats for beneficial insects.

As described in depth in Part III of this Article, the scientific consensus is that the primary drivers of insect population declines are habitat loss and conversion, exposure to pesticides, and climate change. To reverse the trend, it will be necessary to find ways to reduce habitat destruction and degradation, increase and improve the quality of habitat critical to beneficial insects, reduce exposure of beneficial insects to highly toxic pesticides, and mitigate climate change. Meaningful climate change mitigation will require substantial reductions in greenhouse gas emissions from the energy, transportation, food production, and other sectors of the economy. Mechanisms to reduce these emissions are beyond the scope of this Article. Instead, we will focus on potential solutions related to habitat and pesticide exposure. Specifically, we focus on potential solutions under the primary federal pesticide law FIFRA.

Habitat and pesticide exposure are closely connected. To provide habitat for beneficial predators and parasites as well as pollinators, it is necessary for the habitat to be located on or close to working agricultural lands so that beneficial insect populations will be available to carry out critical ecosystem services such as pest control and pollination on the farms. Many beneficial predators and parasites have similar habitat needs, as do insect pollinators. The type and location of habitat is important to ensure that it is suitable to beneficial insect populations. For example, pollinators must have access to high quality pollen and nectar to thrive. Habitat must also provide adequate shelter and overwintering resources to protect insect populations. Fortunately, unlike large mammals, insects typically require only small areas of habitat. Accordingly, preservation of small habitats in appropriate locations or small improvements to existing habitats can go a long way toward protecting beneficial insect populations.

Unfortunately, habitat on or adjacent to farms is likely to have pesticide contamination. Even if natural areas that could serve as habitat are preserved, areas that are contaminated with pesticides will harm insect populations rather than benefit them. Thus, it is necessary not only to have sufficient acreage of the appropriate type of habitat, but also that the habitat be of high quality and not contain harmful contaminants such as pesticides. The best way to address this problem, as well as other issues associated with pesticide use, is through changes to the implementation of U.S. pesticide law, specifically FIFRA.

A. The Basic Structure of FIFRA

FIFRA[301] is the primary federal statute addressing the environmental effects of pesticide use in the United States.[302] FIFRA requires all pesticides[303] that are sold or distributed in the United States be registered by EPA.[304] A pesticide may only be registered if it will not cause an "unreasonable adverse effect on the environment."[305] More specifically, section 3(a) of FIFRA provides that EPA shall register a pesticide if it determines that, when considered with any restrictions imposed, the following are met: 1) its composition is such as to warrant the proposed claims for it; 2) its labeling and other material required to be submitted comply with the requirements of FIFRA; 3) the pesticide will perform its intended function without unreasonable adverse effects on the environment; and 4) when used in accordance with widespread and commonly recognized practice it will not generally cause unreasonable adverse effects on the environment.[306] Pursuant to FIFRA, the term "unreasonable adverse effects on the environment" means any unreasonable risk to humans or the environment, taking into account the

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[301] 7 U.S.C. §§ 136-136(y).

[302] For a more comprehensive overview of FIFRA, *see* JAN G. LAITOS ET AL., THE LAW OF TOXIC SUBSTANCES AND HAZARDOUS WASTES (Foundation Press Treatise, 2020). *See also* ANGELO, *supra* note 69; MARY JANE ANGELO ET AL., FOOD, AGRICULTURE, AND ENVIRONMENTAL LAW (Environmental Law Institute 2013).

[303] 7 U.S.C. § 136(u) provides that the term "pesticide" means "any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest." 7 U.S.C. § 136(u).

[304] *Id.* § 136a(a).

[305] *Id.* § 136a(c)(5). Section 136(j) provides that the term "environment" includes water, air, land, and all plants and man and other animals living therein and the interrelationships which exist among them. *Id.* § 136(j).

[306] *Id.* §136a(c)(5).

economic, social, and environmental costs and benefits of the use of a pesticide.[307] In other words, when making a registration determination, EPA is directed to consider the risks posed by the pesticide, as well as the economic and social implications of using the pesticide.[308] Although FIFRA does not explicitly mandate that EPA conduct a strict cost-benefit balancing standard, EPA has consistently interpreted and applied the unreasonable adverse effects standard as a weighing of the costs or risks associated with the use of a pesticide against the economic and social benefits of the pesticide. Professor William Rodgers, in analyzing the legislative history of FIFRA, argues that adverse effects were not intended to be acceptable unless there are "overriding benefits" from the use of the pesticide.[309] Nevertheless, EPA has consistently interpreted FIFRA to require a cost-benefit balancing, and this interpretation has been upheld in administrative and judicial decisions.[310]

To evaluate the potential risks posed by a pesticide for which registration is being sought, FIFRA requires that certain risk-related data be submitted to EPA.[311] The majority of EPA's FIFRA registration data requirements are designed to evaluate potential risks to human health.[312] The data requirements aimed at evaluating potential risks to wildlife and ecological systems are

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[307] *Id.* § 136(bb).

[308] It should be noted that cost/benefit terminology is used differently under FIFRA than it is used in discussing most environmental regulation. Typically, in doing a cost/benefit analysis, the regulatory agency compares the costs of regulation (e.g., the cost of installing pollution controls) to the benefits of regulation (e.g., lives saved, or cancers avoided). Under FIFRA, however, the "costs" are considered as the costs of allowing the use of the pesticide (e.g., cancer deaths), whereas the benefits are considered as the benefits of allowing the use of the pesticide (e.g., reduction in crop loss from pest insect damage).

[309] *See* WILLIAM H. RODGERS, ENVIRONMENTAL LAW 407, 451–53 (West, 2d ed. 1994). Other legal scholars have noted that although Congress did direct EPA to consider economic factors, it did not explicitly mandate that EPA conduct a strict cost/benefit analysis. *See* SIDNEY A. SHAPIRO & ROBERT L. GLICKSMAN, RISK REGULATION AT RISK: RESTORING A PRAGMATIC APPROACH 29, 32 (2003); ANGELO, *supra* note 69, at 176–77, 182.

[310] *See, e.g.,* Env't Def. Fund, Inc. v. EPA (heptachlor-chlordane), 548 F.2d 998, 1005 (D.C. Cir. 1976) (stating that "to evaluate whether use of a pesticide poses an 'unreasonable risk to man or the environment,' [EPA] engages in a cost-benefit analysis"), *abrogated by* Dir., Off. of Workers' Comp. Programs, Dep't of Lab. v. Greenwich Collieries, 512 U.S. 267 (1994); Chapman Chemical Co., FIFRA Dockets No. 246 *et al.* 1976 EAB West *3 (stating that "before any pesticide can be cancelled under FIFRA [EPA] must be persuaded that the risks to man or the environment from continued use of the pesticide outweigh the benefits of its continued use."); Protexall Products, Inc., FIFRA Docket Nos. 625, *et al.* 1989 EPA CJO West *1 (stating that "the risk-benefit assessment involves a balancing of the risks . . . against the benefits.").

[311] 7 U.S.C. §136a(c)(2)(a). Data requirements are found at 40 C.F.R. § 158 and provide for the submission of health and environmental effects data.

[312] These data requirements include testing on residue chemistry to estimate human exposure to pesticides, acute human hazard, subchronic human hazard, chronic human hazard, mutagenicity, metabolism studies, reentry hazard, spray drift evaluation, as well as oncogenicity, teratogenicity, neurotoxicity, and reproductive effects in humans. *See* 40 C.F.R. §§ 158.130(a), (c), (d), (e), (f), and (g); *id.* §§ 158.240, 158.390, 158.440 and 158.340.

limited, and data requirements aimed at assessing risks to insects are extremely limited.[313]

Despite the fact that many pesticides are intended to kill insects, and therefore are likely to pose serious risk to any insects that may be exposed to them, EPA requires very limited testing on risks to insects prior to registering a pesticide. For the most part, the only data requirements for invertebrates are for aquatic invertebrates, but not aquatic insects and adult honey bees.[314] EPA's data requirements do not address risks to aquatic insects, non-honey bee pollinators, or other insects that provide benefits to farm fields or other terrestrial systems. EPA does require acute contact toxicity testing for honey bees, which addresses risk from honey bees that are sprayed or otherwise come into direct contact with pesticides.[315] EPA only requires honey bee toxicity of residues on foliage[316] and field testing for pollinators in certain circumstances.[317] EPA does not require testing on bees or other insect pollinators other than honey bees, and even for honey bees, EPA only requires testing of adult bees, not larval bees. Based on its evaluation of the data submitted, EPA must determine whether use restrictions are necessary to minimize risks sufficiently to meet the registration standard.

The tools available to EPA to regulate pesticide use to reduce risk are very limited. In contrast to most other environmental statutes, FIFRA does not establish a permitting system or other ex-ante use approval mechanisms.[318] Thus, pesticide users are not required to seek approval from EPA prior to releasing pesticides into the environment, even for very substantial environmental releases. Accordingly, use-specific geographical and temporal factors are not evaluated under FIFRA prior to each release of pesticides into the environment. Instead, EPA's regulation of pesticide "use" is achieved through restrictions placed on the pesticide label as part of the registration

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[313] *See generally* § 158.130(h)(1). EPA requires applicants submit certain limited data designed to evaluate particular impacts to wildlife and aquatic organisms. For example, EPA's data requirements include avian toxicity studies and freshwater fish and invertebrate acute toxicity studies for pesticides intended for outdoor use. More sophisticated studies are required only on a case-by-case basis. *See generally Series 850 - Ecological Effects Test Guidelines*, EPA, https://www.epa.gov/test-guidelines-pesticides-and-toxic-substances/series-850-ecological-effects-test-guidelines (last updated Feb. 19, 2021). For example, for most outdoor use pesticides, EPA will require data to be submitted on avian reproduction, simulated and actual field testing of mammals and birds, acute toxicity to estuarine and marine organisms, fish early life stage, aquatic invertebrate life cycle, fish life cycle and aquatic organisms accumulation, and simulated or actual field testing of aquatic organisms. *Id.; see also* Leslie W. Touart & Anthony F. Macriowski, *Information Needs for Pesticide Registration in the United States*, 7 ECOLOGICAL APPLICATIONS 1086 (1997) (describing and evaluating EPA's ecological risk data requirements for pesticide registration).

[314] *See Series 850 – Ecological Effects Test Guidelines*, EPA, *supra* note 313.

[315] 7 U.S.C. §158.630(d).

[316] *Id.*

[317] *Id.*

[318] *See* Mary Jane Angelo, *Embracing Uncertainty, Complexity and Change to Protect Ecological Integrity An Eco-Pragmatic Reinvention of a First Generation Environmental Law*, 33 ECOLOGY L.Q. 105, 197 (2006) [hereinafter, Angelo, *Embracing Uncertainty*].

process.[319] The registration applicant is responsible for proposing all labeling directions and restrictions with the registration application.[320] EPA then approves final language that must be contained on the label. Specified information including precautionary statements, warnings, directions for use of the product, and an ingredient statement are required to be on the label of all registered pesticide products.[321]

All registered pesticide product labels must also include a statement that it shall be unlawful for any person to use any pesticide in a manner inconsistent with its labeling.[322] This is the legal hook EPA uses to regulate pesticide use and accordingly is the only mechanism to regulate user behavior to accomplish risk reduction goals. This approach to regulating use is limited by the fact that not all pesticide users will even read a label, let alone understand or be willing to follow the complex labeling instructions. Equally troubling is that it would be impossible for EPA to know who, where, when, and how persons are using pesticides, and to monitor each and every pesticide user in the country to assure that the labeling instructions are followed.

Additionally, FIFRA authorizes EPA to classify higher risk pesticides as "restricted use pesticides," which may be used only by or under the supervision of a certified applicator.[323] Such a designation, however, is of limited value in reducing risks to non-target organisms. The restricted use designation is focused primarily on protecting the user, rather than on ecological or wildlife risk reduction. After it registers a pesticide under FIFRA, EPA retains the authority to either cancel or suspend the registration based upon certain risk-benefit findings. FIFRA section 6(b) authorizes EPA to cancel a pesticide registration if, when used in accordance with widespread and commonly recognized practice, the pesticide generally causes unreasonable adverse effects on the environment.[324] Prior to taking final action under section 6(b), EPA is required to consider whether any unreasonable adverse effects posed by the pesticide's use can be sufficiently reduced by regulatory measures short of cancellation, which may include additional labeling restrictions or the classification of the pesticide for restricted use. If EPA determines that sufficient risk reduction cannot be achieved by such risk reduction regulatory measures, it is required to cancel the registration of that pesticide.[325]

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[319] 7 U.S.C. § 136j(a)(2)(G) provides that it shall be unlawful for any person to use any registered pesticide in a manner inconsistent with its labeling.

[320] *Id.* § 136a(c)(1)(C).

[321] A product whose label or labeling does not contain the information required by EPA or which sets forth false or misleading information is misbranded. *Id.* §§ 136(q) and 136j(a)(1)(E).

[322] *Id.* § 136j(a)(2)(G).

[323] *Id.*

[324] *Id.* § 136d(b).

[325] *Id.* § 136d(b)(2).

B. Limitations and Opportunities Under FIFRA

FIFRA provides sufficient legal authority for EPA to shift to a more insect-friendly approach to pesticide regulation and agricultural practices. However, EPA's current interpretation and application of FIFRA is contributing to the growing decline of beneficial insects. A major shift in the protection of beneficial insects could be made by addressing the following: (1) conducting more robust unreasonable adverse effects determinations by imposing data requirements targeted at assessing risk to beneficial insects and by conducting more robust analysis of the benefits provided by pesticides; (2) eliminating the treated article exemption for systemic pesticide seed coatings including neonicotinoids; (3) encouraging the use of Integrated Pest Management; and (4) utilizing labeling use restriction to reduce the risks to beneficial insects. Together, these changes could make FIFRA an important tool in combating insect population declines.

1. Unreasonable Adverse Effects Data Requirements

To determine whether the use of a particular pesticide poses an unreasonable adverse effect on the environment, as required by FIFRA, it is necessary to have robust data on the risks posed by the pesticide and the benefits provided by the pesticide, and then to conduct a rigorous evaluation of those data. As things stand, EPA does not require submission of the full range of data necessary to conduct such a rigorous evaluation. EPA's current data requirements for risks to beneficial insects and the ecosystem services they provide is severely lacking. EPA has waived the requirement for the submission of pesticide efficacy data and does not have specific data requirements aimed at assessing the benefits afforded by a particular pesticide being considered for registration. Moreover, EPA's overall interpretation and approach to conducting an unreasonable adverse effects evaluation is overly simplistic and does not take into account the important ecosystem services that many insects provide.

As described above, EPA requires only very limited data related to the potential risks a pesticide poses to beneficial insects. EPA's only data requirements for non-insect invertebrates are for aquatic non-insect invertebrates, and its only data requirements for assessing the risk to insects is for adult honey bees.[326] EPA does not require testing on bees or other insect pollinators other than honey bees, and even for honey bees, EPA only requires testing of adult bees, not larval bees. Moreover, even for honey bees, test requirements are limited to assessing acute lethal endpoints and does not include requirements to assess subacute, chronic, or nonlethal effects.

Honey bees are not representative of most pollinator species, or even most bee species. The majority of native pollinator bee species are solitary, while

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[326] *Id.* §158.630(d).

honey bees live in large, socially complex colonies.[327] Nonlethal adverse effects, particularly behavioral effects, may be very different for a colonial species than they are for solitary species.[328] Routes of exposure are likely also very different. Even native bee species that live in colonies, such as bumble bees, are very different from honey bees. Bumble bee colonies typically are made up of 50-500 individuals,[329] whereas honey bee colonies have 30,000-50,000 individual bees, with different groups of bees carrying out different functions within the hive.[330] Additionally, many important insect pollinators are not bees at all. Many *Lepidoptera* (butterflies and moths) are important pollinators, as are some flies and other insects. EPA does not require testing at all on any species within these groups. This is particularly concerning because some pesticides are specifically designed to kill lepidopteran species, as many lepidopteran caterpillars are agricultural pests.[331] Some studies have shown that certain pesticides that are not highly toxic to honey bees are extremely toxic to certain lepidopterans, such as monarch butterflies.[332] Similarly, EPA does not require any testing at all that is designed to address risks to other beneficial insects, such as parasitic wasps, that play important pest management roles. Using only honey bees and the aquatic crustacean, *Daphnia*, as the sole invertebrate test species does not adequately capture risks to other beneficial invertebrate species.[333] Honey bees and *Daphnia* may not be as sensitive to pesticides as some other species. They have been chosen as the standard test species not due to their sensitivity or their suitability as a surrogate species for other beneficial species, but instead because they are relatively easy to maintain in the laboratory setting.[334]

Testing only adult bees is a significant shortcoming for a number of reasons. As described above, larval insects have different morphology, physiology, behavior, food sources, and habitats than do adult bees. Accordingly, pesticides affect adult and larval bees in very different ways, making adults inadequate surrogates for extrapolating to larvae. For example,

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[327] *See Bee Pollination*, U.S. DEP'T OF AGRIC., https://www.fs.fed.us/wildflowers/pollinators/animals/bees.shtml (last visited Mar. 14, 2022).

[328] *See* MACE VAUGHAN ET AL., FARMING FOR BEES 49 (2015), https://xerces.org/sites/default/files/2018-05/15-007_04_XercesSoc_Farming-for-Bees-Guidelines_web.pdf.

[329] *About Bumble Bees*, XERCES SOC'Y, https://www.xerces.org/bumblebees/about (last visited Mar. 14, 2022).

[330] David R. Tarpy, Draft, *Honey Bee Health and the NC State Apiculture Program* 1 (Apr. 2, 2016), http://www.ncagr.gov/pollinators/documents/Chapter6-Honey-Bee-Health.pdf.

[331] *See Insecticides*, EPA, https://www.epa.gov/caddis-vol2/insecticides (last visited Mar. 14, 2022).

[332] *See* Carl Redmond et al., *Strengths and Limitations of Bacillus Thuringiensis Galleriae for Managing Japanese Beetle (Popillia Japonica) Adults and Grubs with Caveats for Cross-order Activity to Monarch Butterfly (Danaus Plexippus) Larvae*, 76 PEST MGMT. SCI. 472, 476–77 (2019).

[333] *See* EPA FIFRA testing requirements at 40 C.F.R. § 158.

[334] For a discussion of the limitations of using honey bees as surrogate species for solitary bees, see generally Fabio Sgolastra et al., *Pesticide Exposure Paradigm for Solitary Bees*, 48 ENV'T ENTOMOLOGY 22 (2019).

certain pesticides, called insect growth regulators, work by keeping larval insects from developing into adult insects. Testing this type of pesticide on adult insects would completely miss these lethal effects.

EPA data requirements are designed only to detect lethal effects. Sublethal effects, such as neurological or other impairments that impact an insect's ability to grow, find food, or find mates, are not studied at all.[335] Pollinators depend on complex navigational skills that enable them to find nectar and honey sources, and in the case of colonial species, to communicate the location of those food sources to other members of the colony. Consequently, pesticides that cause sublethal effects that impair a pollinator's ability to navigate and communicate can result in substantial adverse effects on individual bees and colonies as a whole, even if the pesticide does not directly kill individual bees.[336]

Under the Obama Administration, EPA took some limited steps to assess pesticide risks to pollinators more rigorously. EPA established the Pollinator Risk Assessment Framework, which establishes a tiered testing framework to specifically assess the risks that pesticides pose to bees, wherein more refined testing in higher tiers takes place based on the results of lower tier testing.[337] The guidance addresses risks for bees from foliar spray application of pesticides, as well as for pesticides applied to soil or via seed treatment.[338] While the guidance does address testing of larvae under some circumstances, the tiered testing process relies on testing honey bees as surrogate species for all bee species and, as such, does not require testing to be conducted on wild bee species.[339] Although EPA developed this more robust testing protocol, its implementation of it was found to be lacking. In 2015, in *Pollinator Stewardship Council v. EPA*,[340] the Ninth Circuit determined that EPA had failed to properly follow its own standard for assessing risks to bees when it found that a particular pesticide, sulfoxaflor,[341] met the standard for unconditional regulation under FIFRA. Specifically, EPA based its decision on

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[335] *See* OFF. OF PESTICIDE PROGRAMS, GUIDANCE FOR ASSESSING PESTICIDE RISKS TO BEES 35 (June 19, 2014), https://www.epa.gov/sites/default/files/2014-06/documents/pollinator_risk_assessment_guidance_06_19_14.pdf.

[336] HOPWOOD ET AL., *supra* note 133, at vii, 21–22.

[337] In 2014, EPA developed the *Guidance for Assessing Pesticide Risks to Bees*, which describes the tiered testing process. OFF. OF PESTICIDE PROGRAMS, *supra* note 335. In 2016, EPA issued two additional guidance documents, *Guidance on Exposure and Effects Testing for Assessing Risks to Bees* and *Process for Requiring Exposure and Effects Testing for Assessing Risks to Bees during Registration and Registration Review. See* POLLINATOR RISK ASSESSMENT GUIDANCE, EPA, https://www.epa.gov/pollinator-protection/pollinator-risk-assessment-guidance (last updated March 15, 2021).

[338] OFF. OF PESTICIDE PROGRAMS, *supra* note 335, at 6.

[339] *Id.*

[340] Pollinator Stewardship Council v. EPA, 806 F.3d 520, 529–32 (9th Cir. 2015).

[341] EPA first registered sulfoxaflor in 2013 for use to eliminate pests that are increasingly becoming resistant to neonicotinoid, carbamate, and similar insecticides groups. *Decision to Register New Uses for the Insecticide Sulfoxaflor*, EPA, https://www.epa.gov/ingredients-used-pesticide-products/decision-register-new-uses-insecticide-sulfoxaflor (last updated June 8, 2021).

an assumption that certain risk reduction measures, including a lower application rate, would adequately reduce risk to bees rather than requiring Tier 1 and Tier 2 studies to be conducted based on the reduced application rate and other risk reduction measures. Finding that EPA had failed to follow its own process, the court vacated the unconditional registration and remanded the matter back to EPA for further analysis consistent with EPA guidance.[342]

Upon remand from the vacated 2013 registration of sulfoxaflor, EPA approved new registrations of sulfoxaflor in 2016 and 2019.[343] Noting additional uses would be considered at a later date, in 2016 EPA approved a more restrictive registration of sulfoxaflor with fewer crop use application methods.[344] With the 2016 registration, EPA sought to protect pollinators by limiting application to bee-attractive crops until post-bloom, as well as prescribing buffer zones, windspeed maximums, and notification requirements for foliage application.[345] However, these restrictions were substantially revoked in 2019, under the Trump Administration, when EPA approved a new registration of sulfoxaflor and expanded the chemical's use.[346] Citing sulfoxaflor's ability to more quickly disappear from the environment than alternative insecticides, and despite acknowledging the significant risk that this pesticide poses to honey bees and other pollinators, EPA restored previously banned crop applications from the 2013 registration, added new crops for use, and eliminated most of the 2016 registration restrictions that sought to protect pollinators.[347] As a result, the 2019 registration now includes use for new crops, such as alfalfa, grains, and pineapple, allows application during bloom if there is low or limited risk exposure to bees, and revokes buffer zone requirements for spray application.[348] Instead, EPA added labeling requirements for sulfoxaflor, which primarily address risks to commercial beekeeping through language warning that the pesticide is highly toxic to bees and instructions to notify beekeepers within one mile of the treatment area prior to applying the pesticide.[349]

In response to the expanded uses of sulfoxaflor, several groups are challenging the 2019 registration. The Center for Food Safety and the Center for Biological Diversity petitioned the Ninth Circuit to review EPA's registration of sulfoxaflor for new uses.[350] The filing asserts that EPA violated

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[342] Pollinator Stewardship Council, 806 F.3d at 533.

[343] *Decision to Register New Uses for the Insecticide Sulfoxaflor*, *supra* note 341.

[344] Press Release, EPA, EPA Issues Sulfoxaflor Registration for Some Uses (Oct. 14, 2016), https://www.epa.gov/pesticides/epa-issues-sulfoxaflor-registration-some-uses.

[345] *Decision to Register New Uses for the Insecticide Sulfoxaflor*, *supra* note 341.

[346] *See* 2019 Sulfoxaflor Registration, Decision Memorandum, EPA Docket ID No. EPA-HQ-OPP-2010-0889-0570 (July 12, 2019).

[347] *Decision to Register New Uses for the Insecticide Sulfoxaflor*, *supra* note 341.

[348] *Id.*

[349] *See id.*

[350] Brief for Petitioner at 1–2, Ctr. for Food Safety v. Wheeler, No. 19-72109 (9th Cir. Aug. 20, 2019).

its duties under FIFRA and ESA, because EPA failed to provide substantial evidence for the registration and failed to conduct a consultation on the impacts of sulfoxaflor as mandated by the ESA.[351] EPA responded by filing a motion asking the court not to vacate the 2019 registration and to remand the issue back to EPA so it can comply with the ESA, and in the remand EPA acknowledged the registration violated the ESA.[352] Since EPA's motion to the court, additional parties have filed motions and amicus briefs asking the court not to remand the issue and to immediately vacate the 2019 registration.[353]

To adequately address risks to beneficial insects, EPA must expand its testing requirements to include a wider range of tests on a wider range of insect species. Surrogate species that represent important groups of beneficial insects including predators, parasites, and pollinators must be included in testing requirements. A broader range of types of pollinator species beyond the commercialized honey bee must be included. Larval as well as adult individuals of a species must be tested. Finally, testing should not be limited to acute toxicity testing. Subacute effects such as reproductive effects and behavioral effects that influence an insect's ability to find food, mate, or migrate must also be included.

Existing data requirements apply only to pesticides going through the registration process, not pesticides that are already registered. However, if EPA were to amend its data requirements to make them more robust, FIFRA provides the authority and a mechanism for imposing new data requirements on previously registered pesticides. First, FIFRA section 3(c)(2)(b)[354] authorizes EPA to issue "data-call-ins," requiring registrants of existing FIFRA registrations to submit additional data if EPA determines such data are required to maintain in effect an existing registration. Further, as part of the 1996 Food Quality Protection Act,[355] Congress, recognizing that science and pesticide practices change over time, imposed a periodic review system, the Registration Review Program, to ensure that as changes occur, pesticide products can continue to meet FIFRA's standards for registration. FIFRA section 3(g) establishes a 15-year Registration Review cycle for existing pesticide registrations. FIFRA section 3(g)(2) further provides that EPA shall use its Data-Call-In authority in subsection 3(c)(2)(B) when such data are necessary to

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[351] *Id.* at 1–3.

[352] *States, Environmental Groups Challenge EPA Over Sulfoxaflor*, NAT'L AGRIC. L. CTR. (Feb. 4, 2021), https://nationalaglawcenter.org/states-environmental-groups-challenge-epa-over-sulfoxaflor/.

[353] *See, e.g.*, Amicus Brief of the States California, Hawaii, Maryland, Minnesota, New Jersey, New York, New Mexico, Oregon, Vermont, and Washington in Support of Petitioners, Ctr. For Food Safety v. Wheeler, No. 19-72109 (9th Cir. Sept. 3, 2020); Brief for Petitioner, Ctr. For Food Safety v. Wheeler, No. 19-72109 (9th Cir. Dec. 7, 2020) (asking the Court to deny EPA's request to not vacate the registration while it comes into compliance with the ESA).

[354] 7 U.S.C. § 136a(c)(2)(B).

[355] Food Quality Protection Act, Pub. L. No. 104-170, 110 Stat. 1489 (codified at 7 U.S.C. §§ 136-136(y) and 21 U.S.C. §§ 301–381.

carry out a Registration Review.[356] Thus, whether as part of the Registration Review cycle or whether based on new concerns that an existing registration may not meet the unreasonable adverse effects on the environment standard through Registration Review or Data-Call-In, EPA has the ability to require additional data on risks to beneficial insects to be submitted to support an existing registration.

While EPA's data requirements regarding the risks posed by pesticides are limited and need to be expanded, EPA's evaluation of the economic, social, and environmental benefits a pesticide provides are virtually non-existent. Although EPA has interpreted FIFRA's unreasonable adverse effects standard to be one of cost/benefit balancing, EPA generally does not require registration applicants to demonstrate any benefits of the pesticide for which they are seeking approval. While FIFRA requires EPA to determine that the pesticide "will perform its intended function" without unreasonable adverse effects on the environment,[357] it also expressly states that EPA shall not make any "lack of essentiality" a criterion for denying registration of any pesticide, and that where two pesticides both meet the standards for registration, one should not be registered in preference to the other.[358] In other words, FIFRA does not mandate a pesticide be deemed essential or better than other pesticides to obtain a registration.

In addition, FIFRA authorizes EPA to waive all data requirements pertaining to efficacy of pesticides for which registration is being sought and EPA has, by rule, waived such requirements, except in circumstances where there is a claim that the pesticide controls pests that pose a threat to human health.[359] Accordingly, despite the language of FIFRA, EPA does not actually require any demonstration of the economic or social benefits to be derived from most pesticides. Instead, EPA assumes that pesticides have benefits, or people would not purchase them.[360] The lack of a requirement for efficacy data is in contrast to other licensing statutes, such as the licensing provisions of the Federal Food Drug and Cosmetic Act governing the approval of new drugs, which explicitly requires a finding that a drug is "effective" as part of the

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[356] 7 U.S.C. 136a(g).

[357] *Id.* § 136a(c)(5)(B).

[358] *Id.* § 136a(c)(5) provides that:

> The Administrator shall not make any lack of essentiality a criterion for denying registration of any pesticide. Where two pesticides meet the requirements of this paragraph, one should not be registered in preference to the other. In considering an application for the registration of a pesticide, the Administrator may waive data requirements pertaining to efficacy, in which event the Administrator may register the pesticide without determining that the pesticide's composition is such as to warrant proposed claims of efficacy.

[359] *Id.*; *see also* 40 C.F.R. § 158(d).

[360] At the time EPA promulgated the regulation waiving the requirement to submit efficacy data for agricultural pesticides, EPA stated that efficacy of agricultural pesticides can be "effectively regulated by the marketplace." Regulation for the Enforcement of FIFRA, 44 Fed. Reg. 27932, 27938 (May 11, 1979).

premarket review process. A new drug is considered to be "effective" if there is a general recognition among experts, founded on substantial evidence, that the drug in fact produces the results claimed for it under prescribed conditions.[361]

Neonicotinoid insecticides provide a stark illustration of the consequences of EPA's failure to require pesticide registrants to provide data demonstrating the efficacy and benefits provided by the pesticide. As described in detail above, these insecticides pose significant risks to many pollinators, other beneficial insects, and other nontarget species, including ESA-listed threatened and endangered species. Under FIFRA's unreasonable adverse effects standard, one would assume that such high risks would only be justified if the benefits provided by the insecticide were equally high. Yet, numerous studies suggest that these insecticides actually provide little, if any, benefit. As set forth in the Center for Food Safety Petition, reviews of published studies on crop yields and neonicotinoid-treated seeds show no net crop yield benefit for the majority of crop-planting contexts.[362] The Petition also points out that subsequent to the EU prohibition of most neonicotinoid uses, there was no evidence of declines in crop production, despite dire warnings that such a decline would result from the ban.[363] Even EPA's own review of existing data calls into question whether these treated seeds provide any benefit in terms of crop yield for soybeans, one of the most ubiquitous crops for which these treated seeds are used.[364] Without robust data requirements on the efficacy of these pesticides and their actual benefit in terms of crop yields, it is impossible to conclude that they pose no unreasonable adverse effect on the environment.

In addition to waiving efficacy data, EPA does not require registration applicants to demonstrate that their pesticide provides greater benefits, either environmentally or economically, than other registered pesticides or other pest control methods. Likewise, EPA does not require applicants to show their pesticide fulfills an important pest control need. Instead, EPA assumes that pesticides for which registration is sought offer significant benefits because pesticide manufacturers would not incur the substantial costs of developing and seeking registration for the pesticide. In other words, pesticides are registered without any showing that they actually work for their intended purposes or that there is any genuine need for addressing the particular pests the pesticides are intended to target. Moreover, EPA does not require applicants to assess whether a similarly efficacious cost-effective existing chemical or non-chemical alternative means of pest control are available. Assuming a product is efficacious and beneficial based on a manufacturer's willingness to make it or a consumer's willingness to purchase it ignores the billions of dollars spent each year on ineffective unnecessary weight loss products, wrinkle creams, and

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[361] 21 U.S.C. § 111.

[362] Ctr. for Food Safety, Citizen Petition to the U.S. Environmental Protection Agency (Apr. 26, 2017) at 26–27.

[363] *Id.*

[364] *Id.* at 27.

baldness treatments. While many ineffective products may result in consumers wasting money or being disappointed with results, the effects of unnecessary pesticide products reach well beyond wasting money and can result in serious harm to the environment, including to insects that provide critical ecosystem services. Virtually every synthetic chemical pesticide poses at least some risk, and EPA's failure to require any demonstration of actual benefits is a dereliction of its duty to ensure that registered pesticides do not pose an unreasonable adverse effect on the environment.

When EPA conducts a registration review every fifteen years as required by FIFRA, it includes a "benefits" summary. However, a review of the registration review EPA conducted for a number of neonicotinoid pesticides reveals that EPA's benefits review at this stage was very cursory and primarily consisted of data showing the pesticide was sold and used. Presumably, EPA treats evidence of a market for a pesticide and use of the pesticide as evidence of its "benefits." However, the benefits analysis did not include an in-depth analysis of the efficacy of the pesticide, the actual economic or social benefits of the pesticide, or whether other lower risk or lower priced chemical or nonchemical methods of pest management were available.

Although EPA does not conduct any significant evaluation of benefits when it registers a pesticide, it does consider the benefits of a pesticide in determining whether to cancel an existing registration due to unreasonable adverse effects on the environment. However, even when evaluating benefits for the purpose of cancellation, EPA's analysis is somewhat limited. For example, EPA will only consider as alternatives pesticides that are already registered under FIFRA for the same use (which are assumed to be efficacious because they are registered).[365] It is not EPA's typical practice to comprehensively evaluate all alternative pest control strategies that may be available. EPA does not conduct an in-depth assessment of non-chemical alternative pest control techniques such as cultural control, biological control, Integrated Pest Management (IPM), or organic farming practices.

Even when evaluating existing chemical alternatives, EPA's analysis is limited in that it does not conduct a comparative assessment, comparing the risks and benefits of the pesticide proposed for cancellation with those of registered alternatives. This approach could lead to an unintended consequence where the order in which pesticides are proposed for cancellation determines which pesticides are cancelled and which remain registered, regardless of the relative risks of such pesticides.[366] For example, a series of moderately risky pesticides may be cancelled because other alternatives exist. However, as more pesticides are cancelled over time, the benefits of the remaining registered pesticides grow, even if those pesticides are higher risk than those already cancelled. Ultimately, the benefits of the "last pesticide standing" are perceived

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[365] Angelo, *The Killing Fields*, *supra* note 68, at 105, 142.

[366] *Id.*

as extremely high because alternative registered pesticides no longer exist. Consequently, a given "last pesticide standing" could retain its registration even though it has higher relative risks than previously cancelled pesticides, merely because it was the last pesticide that EPA considered for cancellation. While this example may not be a common occurrence, it illustrates one of the shortcomings of EPA's limited evaluation of benefits and limited consideration of what constitutes alternative pest control for purposes of a benefits analysis.

Although EPA does not typically consider the relative risks of alternative pesticides when making either registration or cancellation decisions, EPA has taken some modest steps to encourage the development and registration of lower-risk alternative pesticides. In 1997, EPA issued Pesticide Registration (PR) Notice 97-3, which provides for the expedited review of conventional pesticides and biological pesticides that EPA considers to have "reduced risk."[367] The purpose of PR Notice 97-3 is to provide an incentive of "expedited registration review" to manufacturers to develop lower-risk alternative pesticides "which would result in reduced risks to human health and the environment, when compared to existing alternatives."[368] Expedited review applies to pesticides that "may reasonably be expected to accomplish one or more of the following: (i) reduce the risks of pesticides to human health; (ii) reduce the risks of pesticides to nontarget organisms; (iii) reduce the potential for contamination of groundwater, surface water or other valued environmental resources; and (iv) broaden the adoption of integrated pest management strategies."[369] EPA has further interpreted these criteria to develop a list of factors that will most significantly contribute to EPA's decision to grant reduced risk status. These factors include, in descending order of importance: very low mammalian toxicity; toxicity generally lower than alternatives (10-100 times); displacement of chemicals that pose potential human health concerns; reduction of exposure to mixers, loaders, applicators, and reentry workers; very low toxicity to birds; very low toxicity to honey bees; significantly less toxicity or risk to birds than alternatives; not harmful to beneficial insects; highly selective pest impacts; very low toxicity to fish; less toxicity or risk to fish than alternatives; potential toxicity or risk to fish mitigatable, or similar toxicity to fish as alternatives but significantly less exposure; low potential for groundwater contamination; lower use rates than alternatives; fewer applications; low pest resistance potential (i.e., new mode of

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[367] Pesticide Registration Notice 97-3: Guidelines for Expedited Review of Conventional Pesticides under the Reduced-Risk Initiative, EPA, at I (Sept. 4, 1997). This policy was developed partially in response to the 1996 Food Quality Protection Act mandates to develop procedures and guidelines for expedited pesticide review. The policy supersedes EPA's prior reduced-risk criteria proposed in Incentives for Development and Registration of Reduced Risk Pesticides, 57 Fed. Reg. 32, 140 (July 20, 1992), discussed at 58 Fed. Reg. 5854 (Jan. 22, 1993), and published in Voluntary Reduced-Risk Pesticides Initiative, PR Notice 03-9 at V. (July 21, 1993).

[368] Pesticide Registration Notice 97-3: Guidelines for Expedited Review of Conventional Pesticides under the Reduced-Risk Initiative, EPA, at I (Sept. 4, 1997).

[369] These criteria are found in FIFRA § 3(c)(10), 7 U.S.C. § 136a(c)(10).

action); high compatibility with IPM; efficacy.[370] This is one of the very few instances where EPA explicitly acknowledges concerns related to toxicity to beneficial insects.

To adequately protect important ecosystem services provided by insects, EPA should repeal its regulation that waives efficacy data to ensure that pesticides are only registered where they have actual economic, social, or environmental benefits that outweigh the risks they pose. Without efficacy data, there is no way for EPA to determine the actual benefits of the pesticides. In addition to requiring efficacy data, EPA should require registration applicants to demonstrate the actual benefits of the pesticide. The importance of a particular pesticide to growing an important food crop could be part of the benefits consideration. Overriding benefits may be demonstrated where alternative pest control measures—whether they be other chemical pesticides, IPM, or non-chemical means of control—are not available, not effective, more costly, or infeasible. Availability of lower-risk alternatives should be part of the registration decision.

2. *Unreasonable Adverse Effects Determination*

Even if EPA were to expand its risk-related data requirements and begin to require the submission of information related to the potential economic, social, and environmental benefits a pesticide may provide, EPA still would have to modify the way it makes an unreasonable adverse effects determination to adequately evaluate whether a particular pesticide should be registered. As described above, although EPA has routinely applied FIFRA's unreasonable adverse effects standard as a cost/benefit balancing standard, this approach is not dictated by FIFRA.[371] FIFRA directs EPA to "take into account" economic and social as well as environmental considerations but does not specify how EPA is to do so or how to weigh the various considerations. EPA has, however, consistently employed a cost/benefit balancing approach, which has been upheld in administrative and judicial decisions.[372] However, there is nothing in FIFRA to suggest that this approach was what the drafters of the legislation had in mind; in fact, there is evidence in the legislative history that the drafters of the 1972 FIFRA intended that registration would be granted only where environmental or human health risks were outweighed by a pesticide's "overriding benefits."[373]

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[370] Pesticide Registration Notice 97-3, *supra* note 368, at V.

[371] For a more detailed discussion of FIFRA's unreasonable adverse effects standard and how it is applied, see generally Angelo, *Embracing Uncertainty*, *supra* note 318.

[372] Env't Def. Fund, Inc. v. EPA (heptachlor-chlordane), 548 F.2d 998, 1005 (D.C. Cir. 1976), *abrogated by* Dir., Off. of Workers' Comp. Programs, Dep't of Lab. v. Greenwich Collieries, 512 U.S. 267 (1994); Chapman Chem. Co., FIFRA Dockets No. 246 *et al.* 1976 EAB West *3; Protexall Products, Inc., FIFRA Docket Nos. 625, *et al.* 1989 EPA CJO West *1.

[373] For a detailed discussion of FIFRA's legislative history on overriding benefits, see Angelo, *Embracing Uncertainty, supra* note 318, at 176–77; RODGERS, *supra* note 309, at 451.

EPA's strict cost/benefit balancing approach is particularly problematic in the context of imperiled species because such an approach could permit the registration of a pesticide that poses a significant risk to a protected species, provided the economic benefits to be achieved from the use of the pesticide are very high. For decades, EPA has struggled with how to address risks to ESA-listed species when conducting a FIFRA cost-benefit balancing.[374] The difficulties of reconciling the strict prohibitions on "takes" and the consultation requirements under the ESA have resulted in a multitude of lawsuits that eventually led to EPA and the Services seeking out advice from the National Academies' National Research Council (NRC).[375] Pursuant to the recommendations of the NRC, EPA, and the Services developed an interim approach to reconcile the FIFRA and ESA ecological risk assessment process.[376] Nevertheless, EPA's reliance on a cost/benefit balancing approach inevitably creates conflict with the pure risk-based approach taken in both the ESA's prohibition on takes in section 9 and the consultation process of section 7 designed to prevent jeopardy to listed species. Moreover, for insects in particular, EPA has rarely employed the ESA section 7 consultation process for any pesticide registration decision. In fact, it appears that EPA has only conducted ESA "effects determinations" on pesticide registration decision for two listed insect species, the Federally Threatened Bay Checkerspot Butterfly (*Euphydryas editha bayensis*) and the Valley Elderberry Longhorn Beetle (*Desmocerus californicus dimorphus*).[377] Accordingly, it is not surprising the ESA plays a very limited role in protecting ecosystem services provided by insect species, particularly from risks posed by the use of pesticides.

Because FIFRA does not mandate that evaluating unreasonable adverse effects be a strict cost/benefit balancing, EPA has some discretion in how it interprets and applies the standard. EPA could take a different approach to "taking into account" social, economic, and environmental considerations. EPA could employ the overriding benefits standard that Congress seems to have intended. Similarly, EPA could afford different weights to different components of costs and benefits based on their relative value to society.

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[374] For a detailed discussion of the history of the challenges reconciling FIFRA and the ESA and potential solutions to the problem, see Angelo, *The Killing Fields*, *supra* note 68.

[375] *See* NAT'L RSCH. COUNCIL ET AL., ECOLOGICAL RISK ASSESSMENT UNDER FIFRA AND ESA 16 (2013).

[376] *See* EPA, INTERIM APPROACHES FOR NATIONAL-LEVEL PESTICIDE ENDANGERED SPECIES ACT ASSESSMENTS BASED ON THE RECOMMENDATIONS OF THE NATIONAL ACADEMY OF SCIENCES APRIL 2013 REPORT (2015), https://www.epa.gov/sites/production/files/2015-07/documents/interagency.pdf. In 2019, EPA published in the Federal Register a Draft Revised Method for National Level Endangered Species Risk Assessment Process of Biological Evaluations of Pesticides. *Draft Revised Method for National Level Endangered Species Risk Assessment Process for Biological Evaluations of Pesticides*, EPA, https://www.epa.gov/endangered-species/draft-revised-method-national-level-endangered-species-risk-assessment-process (last updated Apr. 5, 2022).

[377] *See* Off. of Pesticide Programs, *Endangered Species Effects Determinations, Consultations, and Biological Opinions*, EPA, https://iaspub.epa.gov/apex/pesticides/f?p=101:23 (last visited Mar. 15, 2022).

Nothing in FIFRA explicitly limits EPA's ability to afford different weights to different factors it must consider. In other words, FIFRA's direction to "take into account" economic, social, and environmental concerns would seem to provide ample leeway for EPA to determine that some of these considerations are of greater importance than are others. For example, on the risk side of the equation, EPA could determine that a pesticide that poses a high risk to an abundant nontarget species is not of as great a concern as is a pesticide that poses a risk to an imperiled nontarget species. Similarly, risks to nontarget species that carry out important ecosystem services could be afforded greater weight than are risks to species that do not carry out such services.

EPA could determine that certain benefits to society—e.g., preventing human disease, or protecting an important human food source for which other methods of pest control do not exist or are not feasible—should be afforded greater weight than purely economic benefits that only accrue to the manufactures of a pesticide. Similarly, EPA could determine that a pesticide that is a key tool in the pest control arsenal necessary to maintaining a supply of a critical human food source warrants greater weight than a pesticide that is only one of a large number of tools available. This would not violate FIFRA's prohibition on EPA requiring applicants to demonstrate essentiality because EPA would not be automatically denying registration for pesticides simply because other alternatives exist. Instead, EPA would merely be recognizing that a pesticide that is critical to maintaining a food source is of higher benefit than a pesticide that, for example, is only one of many available to combat a nuisance pest. In sum, the time has come for EPA to exercise its full authority under FIFRA to conduct more robust and sophisticated analysis consistent with the statute's legislative history and should take into account new scientific understandings to ensure it does not register pesticides that pose unreasonable adverse effects on beneficial insects that carry out critical ecosystem services.

3. *Treated Article Exemption*

FIFRA defines the term "pesticide" as "any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest."[378] An article treated with a pesticide, including a seed treated with insecticides, is a "mixture of substances intended for preventing, destroying, repelling, or mitigating" a pest, and is therefore considered to be a pesticide under FIFRA. However, since 1988, EPA has exempted these "treated articles" from FIFRA regulation.[379] Prior to EPA's adoption of the "treated article exemption," EPA considered treated articles to be "products that are not

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[378] 7 U.S.C. § 136(u).

[379] 40 C.F.R. § 152.25(a).

pesticides because they do not have a pesticidal effect."[380] In 1988, EPA acknowledged that treated articles could be considered to be pesticides, but that they are of a character not requiring regulation under FIFRA.[381] FIFRA section 25 authorizes EPA to exempt certain pesticides from some or all of FIFRA regulation if either the particular pesticide is adequately regulated by another federal agency, or if EPA determines that the pesticide is of a character for which regulation is not necessary. In 1988, relying on this authority, EPA promulgated the current treated article exemption, which exempts "from all provisions of FIFRA when intended for use, and used, only in the manner specified," "[a]n article or substance treated with, or containing, a pesticide to protect the article or substance itself . . .if the pesticide is registered for such use."[382] In other words, when a FIFRA-registered pesticide is properly used to treat a product or article to protect the product or article itself from pests, the subsequent treated article or product is exempt from "all provisions of FIFRA" including registration requirements, labeling requirements, and other use restrictions.[383] The regulation gives as examples paint treated with a pesticide to protect the paint costing or wood products treated to protect the wood against an insect or fungus infestation.

The treated article exemption makes sense in the context of pesticide treatment of paint or wood. The thinking behind the exemption is that as long as the pesticide used to treat the paint or wood is properly registered, there is no reason to also require the treated paint or wood product to undergo the registration process because the pesticide it is treated with has already undergone a complete FIFRA review. If a wood or paint product is properly treated with a pesticide consistent with the pesticide's FIFRA labeling restrictions, it is not necessary to register and further regulate the wood or paint itself as a pesticide product or impose additional regulatory risk reduction measures on those products. This exemption has been interpreted for years to apply to seeds that have been treated with pesticides to protect the seeds themselves from pests by dipping or otherwise coating the seeds with a registered pesticide. While this approach might make sense in the context of seeds dipped into some traditional chemical pesticides, the logic does not extend to seeds that have been treated with systemic pesticides, such as neonicotinoids.

Seeds treated with systemic pesticides differ in a number of respects from traditional "treated articles" warranting FIFRA exemption. For treated paint or treated wood, the pesticide is intended to protect the paint or wood itself. Even for traditional non-systemic pesticides used to treat seeds, the pesticide is

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[380] *See* FIFRA, 49 Fed. Reg. 37,935, 37,937 (Sept. 26, 1984). *See also* Lawrence S. Ebner & David A. Webb, *Scope and Application of the FIFRA Treated Articles Exemption*, 10 J. TRANSP. TECHS. 16, 17 (2020) (explaining the regulatory history of the treated article exemption).

[381] 53 Fed. Reg. 15,975, 15,977 (May 4, 1988).

[382] 40 C.F.R. § 152.25(a).

[383] *See generally* Ebner & Webb, *supra* note 380, for a further discussion of the exemption.

intended to protect the seed itself. As described above, neonicotinoid pesticides have become ubiquitous as seed treatment for many major crops such as soy and corn. However, unlike some seed treatment pesticides, these pesticides are not applied to protect the seeds from pests. Instead, the pesticides are "systemic" and are taken up throughout the seed coat into the seeds and end up throughout the crop plant once the seed germinates. Accordingly, pesticide exposure is not merely via exposure to the seed, but also extends to exposure to every part of the plant that grows from the seed.

With systemic seed treatments, the seeds themselves are not the sole target of the treatment. Rather, the crop plant that grows from the seed is the "article" that the pesticide is intended to protect from pests. Thus, the nature and extent of exposure to nontarget organisms, including beneficial insects, is very different than it would be with typical treated seed. Because the pesticide gets in all tissues of the plant, the exposure extends far beyond exposures to nontarget organisms that feed on or otherwise come into direct contact with the seed coat. Any organisms that feed on any part of the plant (including leaves, roots, flowers, nectar, and pollen) that grows from the seed will be exposed, and risk of exposure will continue as long as plant parts remain in the field. Interpreting the treated article exemption to apply to seeds treated with systemic pesticides enables plant parts that contain pesticide, and are very different from the article (e.g., the seed), to escape regulation even if pesticides in these plant parts cause greater insect exposure than would a non-systemic seed treatment.

Another consequence of the treated article exemption for these systemic insecticide-coated seeds is that there is a lack of information about how much and where this seed is planted. Neonicotinoid insecticides have become the most widely used insecticides throughout the globe, and the vast majority of them are applied as treated seed.[384] Understanding the risks posed to insects and other organisms by these pesticides demands robust data on the spatiotemporal patterns of their use.[385] Unfortunately, the publicly available data on pesticide usage in the United States does not identify pesticide-treated seed usage.[386] Part of the explanation for the lack of data is that farmers do not have knowledge of the pesticides coated on their seeds.[387] Farmers have much greater knowledge of pesticides they are using when they purchase and apply the pesticides themselves.[388] Farmers' limited knowledge of the pesticides coating their seeds may stem in part from the fact that the treated seeds themselves are not regulated as pesticides under FIFRA and thus do not have mandatory enforceable labeling that could provide farmers with more information about the risks associated with the pesticides and proper

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[384] Hitaj et al., *supra* note 79, at 390–91.

[385] *Id.*

[386] *See generally id.*

[387] *Id.* at 392.

[388] *Id.* at 398, 401–08.

procedures for safe use.[389] Not only could the elimination of the exemption provide farmers with better information to reduce risks, but it could also result in better data being collected from farmers on the use of the treated seeds that could lead to a better understanding of their spatiotemporal use, and ultimately a better understanding of the risks they pose.[390]

There has been some dispute over the years as to whether EPA should require labeling and some "downstream use" regulation of the treated articles under the treated article exemption. In fact, in 1984, as part of a proposed rulemaking on labeling, EPA requested public comment on the possibility of requiring "'downstream' labeling of consumer products treated with pesticides."[391] EPA stated that it believed that treated articles that have regular human contact should bear statements of potential hazards on the article.[392] EPA proposed a mechanism for requiring such labeling wherein the original pesticide label would require that manufacturers of the treated article label the product with a statement that the product had been treated with a pesticide.[393] Despite this proposal, it appears that EPA never adopted such a requirement for downstream labeling. Certainly, the rationale for warning the public about pesticides contained in the products they come into contact with has merit. However, there may be an even stronger argument for downstream labeling of treated seeds, for which the pesticidal effect is not limited to protecting the seed itself. Instead, there is in fact a downstream pesticidal effect. Specifically, the systemic pesticide is intended to protect all parts of the plant that ultimately grow from the seed from pests. Nevertheless, EPA continues to invoke the treated article exemption, without a specific regulation requiring downstream labeling, when faced with seeds treated with systemic pesticides. Interestingly, despite the seemingly clear language of the treated article exemption exempting covered products from "all FIFRA regulation," EPA has attempted to impose some downstream labeling requirements on treated products such as treated wood and treated seeds. Others have accused EPA of violating both the terms and purpose of the exemption.[394] If EPA believes that a treated article or product is of a character warranting FIFRA regulation, the obvious course of action would be to amend the treated article exemption to impose appropriate requirements designed to reduce risks posed by such products, rather than continuing the exemption while simultaneously attempting to shoehorn certain labeling requirements on the products.

Organizations concerned with the impacts of systemic neonicotinoid-treated seeds on beneficial pollinator insects have argued that the treated article exemption should not apply to these seeds. In 2017, a number of organizations,

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[389] *Id*. at 395–416.
[390] *Id*. at 401.
[391] 49 Fed. Reg. 37,960, 37,969 (Sept. 26, 1984).
[392] *Id.*
[393] *Id.*
[394] Ebner & Webb, *supra* note 380, at 18–19.

including the Center for Food Safety, the American Beekeeping Federation, and the Pollinator Stewardship Council, filed a Citizen Petition under FIFRA seeking to "end an existing regulatory loophole for seeds coated with systemic pesticides."[395] The petition, which seeks an amendment or reinterpretation of the treated article exemption, contends that seeds treated with systemic pesticides fit the definition of "pesticide" under FIFRA and have devastating impacts to the environment, and thus should not be exempt from FIFRA regulation. Specifically, the petition argues that because the coated seeds are not treated primarily to protect the seed itself, but are instead intended to protect the plant that ultimately grows from the seed, they should not fall within the scope of the treated article exemption. The petition goes on to explain that unlike other more traditional exempt treated articles, such as treated paint or treated wood, these systemic pesticides continue to be spread throughout the tissue of the plant long after the plant emerges from the seed and become spread widely in the environment. The petition points out that more than 150 million acres of systemic pesticide-treated seeds are planted in the United States, representing the vast majority of systemic pesticide usage in the country. Petitioners describe the science of honey bee and wild bee mortality resulting from these pesticides and contend that these pesticides should be required to comply with FIFRA's mandatory environmental standards, including enforceable labeling requirements. The petition also notes that when EPA promulgated the exemption in 1988, it did not even mention treated seeds, and that in subsequent statements, EPA actually indicated that systemic neonicotinoid seeds should be excluded from the exemption because the pesticidal protection extends beyond the seed itself.[396] The petition describes a number of these products for which, the petitioners contend, "EPA has failed to fully assess the adverse effects . . . of the systemic insecticide beyond the seed coating process."[397] The petition explains that the language of the treated article exemption does not mention treated seed, and systemic pesticide treated seeds do not clearly fit within the exemption because they are not primarily intended to protect the seed itself. Therefore, the petition asserts that EPA has not made an interpretation that it considers these seeds to be exempt. Nevertheless, EPA's practice has been to "neither requir[e] registration of the seeds nor impos[e] enforceable labeling on their bags or tags."[398] Petitioners conclude that because these treated seeds cause unreasonable adverse effects on the environment, FIFRA does not authorize their exemption, and therefore,

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[395] Ctr. for Food Safety, Citizen Petition to the U.S. Environmental Protection Agency (Apr. 26, 2017). In a prior lawsuit seeking to have EPA register neonicotinoid insecticide-coated seeds registered as pesticides under FIFRA, EPA was granted summary judgment based on the U.S. District Court for the Northern District of California's lack of subject matter jurisdiction because EPA had not taken final agency action.

[396] *Id.* at 11.

[397] *Id.* at 12.

[398] *Id.* at 34.

EPA's interpretation of the treated article exemption is unlawful.[399] Finally, the petition argues that EPA's interpretation of this exemption is also in violation of the ESA due to the listed species that may be affected by the use of these seeds, and the fact that EPA has never undergone an ESA consultation to determine whether the use of these treated seeds is likely to jeopardize a listed species.[400] As of the time of this writing, more than four years after the petition, EPA has yet to take any action.

A significant benefit of repealing the treated article exemption for seeds treated with systemic insecticides, such as neonicotinoids, is that treated seeds would then be considered a regulated pesticide. As such, the systemic pesticide-treated seed itself would be required to be registered under FIFRA and labeled as a pesticide. Regulating treated seeds as a pesticide under FIFRA would facilitate a full evaluation of risks due to all exposures to all parts of the plant. Moreover, a repeal of the exemption for seeds treated with systemic pesticides would mean that bags of seed could not be sold without FIFRA labeling, including detailed directions for proper use and detailed hazard and warning information. With the exemption still in place, only the pesticide used to treat the seed must be labeled, and thus, farmers may not have full information about what is in the seed, the risks it poses, or the proper directions for use of the seed in a way that minimizes risks to nontarget organisms such as beneficial insects. Repealing the exemption would ensure that all information required on FIFRA labels is readily available to farmers purchasing and using the seed, and the appropriate risk reduction restrictions could be imposed. In this way, risk reduction measures such as those outlined below could be imposed on the use of systemic insecticides used to treat seed.

4. *Integrated Pest Management*

EPA has the authority under FIFRA to encourage more environmentally friendly and beneficial insect-friendly methods of pest management. As described above, reversal of the declines of beneficial insect populations requires, at minimum, a significant reduction in the use of certain chemical pesticides and conservation of important habitat. Integrated Pest Management (IPM) is a way to achieve both. The past fifty-plus years of relentless and mindless use of synthetic chemical pesticides, whether needed or not, has caused significant environmental damage and has also resulted in the

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[399] *Id.* at 34–35.

[400] *Id.* at 37. On January 15, 2021, EPA entered into a settlement agreement with the Natural Resources Defense Council in which EPA agreed that by June 30, 2022, it would complete an "effects determination" and request initiation of any necessary ESA regarding the potential effects of the neonicotinoid pesticide active ingredient imidacloprid on any and all listed species and designated critical habitat that are potentially affected. *See* Unopposed, Joint Motion to Approved the Proposed Stipulated Settlement Agreement, Nat. Res. Def. Council v. Wheeler, No. 1:17-CV-02034 (D.D.C. Jan. 15, 2021).

development of pesticide resistance in many pest species.[401] The premise of IPM is that although we can never completely control pests, we can effectively manage them if we understand the ecology of agricultural systems. IPM, which relies on a comprehensive science-based approach to pest management and has been used in a limited fashion for decades,[402] could be part of the solution to the insect apocalypse if employed widely. Pest management decisions that are informed by science and based on an intimate understanding of what is actually happening in a farm field at a particular time can lead to more targeted and less frequent pesticide application and improved habitat conservation.

IPM, as its name suggests, relies on an integration of a variety of pest management approaches, including cultural controls, biological controls, and chemical controls,[403] with a goal of maximizing non-chemical techniques to reduce the risks posed by chemical pesticides.[404] IPM does not seek to achieve total control over pests. Instead, it pursues the more modest and realistic goal of managing pests.[405] IPM strives to combat many of the problems created by over reliance on toxic chemical pest control, including the development of pest resistance,[406] loss of biological controls, loss of biodiversity, and the abandonment of historically used cultural controls, such as crop rotation, cover crops, and intercropping.[407]

A basic tenet of IPM is to "prevent, or at least delay, counter-adaptation by pests to control measures by diversifying the latter."[408] To accomplish this diversification objective, growers using IPM rely heavily, but not exclusively, on a wide range of non-chemical pesticide pest management tools.[409] Chemical pesticides are employed in more of a "gap filling" role only where necessary. Critical tools of IPM include the use of economic thresholds, the use of pesticides in a manner that minimizes harm to beneficial insects that provide natural biological control, the use of host-plant resistance to pests, and the use of cultural controls. IPM minimizes the use of chemical pesticides by utilizing sophisticated scientific knowledge of a farm's particular pest problems and available pest management strategies to establish an "economic threshold" at which a site's pest problems causes unacceptable harm. The term "economic threshold" is defined as the pest density at which "control measures should be

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[401] *See* Fred Gould, *The Evolutionary Potential of Crop Pests*, 79 AM. SCI. 496, 500–02 (1991).

[402] VAN EMDEN & PEAKALL, *supra* note 137, at 70.

[403] VAN EMDEN & SERVICE, *supra* note 138, at 304.

[404] VAN EMDEN & PEAKALL, *supra* note 137, at 70.

[405] NAT'L RSCH. COUNCIL, ECOLOGICALLY BASED PEST MANAGEMENT vii (1996). For an in-depth discussion of ecologically-based pest management, *see* Angelo & Brown, *supra* note 67, at 723–26; Mary Jane Angelo, *Corn, Carbon and Conservation Rethinking U.S. Agricultural Policy in a Changing Global Environment*, 17 GEO. MASON L. REV. 593 (2010).

[406] For a detailed discussion of how pests develop resistance to pesticides, forcing growers onto a "pesticide treadmill," *see* Angelo, *12-Step*, *supra* note 140.

[407] VAN EMDEN & PEAKALL, *supra* note 137, at 70.

[408] *Id.*

[409] *Id.*

determined to prevent an increasing pest population from reaching an economic injury level."[410] Thus, an "economic threshold" will always be lower than the "economic injury level,"[411] providing a level of insurance against risk for growers. Waiting until an economic threshold is triggered before applying chemical pesticides provides time for the pesticide to take effect and reduce pest populations before economic injury occurs.[412]

A fundamental principle of IPM is that chemical pesticide intervention should only be used when the economic threshold has been met. In other words, growers would wait to use chemical pesticides until their use is necessary to avoid unacceptable economic harm.[413] Common practice among non-IPM growers is to spray pesticides prophylactically on a regular predetermined schedule, regardless of what is actually happening with pest populations in the field. A grower using IPM, however, will only apply chemical pesticides at specific times and locations and at only those levels that are determined to be appropriate based on pest populations in the field. IPM is a way to limit the use of chemical pesticides to only being one component of a comprehensive pest management program to be used only when economic thresholds are triggered based on a science-based understanding of the population dynamics of pest species and beneficial parasites and predators in the field, rather than automatically spraying pesticides whether they are needed or not.

Simply by switching from a predetermined spraying schedule to only spraying when an economic threshold is triggered can reduce chemical pesticide use by up to 30 percent.[414] To determine when an economic threshold for a particular farm is met requires ongoing monitoring of numbers of pests in the farm field.[415] At its most basic, IPM monitoring is simply counting the number of individuals of each pest species within a sample area of the planted crop. An approach that is more ecologically sophisticated, and thus provides more useful data, is to count not only the numbers of pest species in the field, but also the numbers of predators and parasites of those pests. This information enables the ratio of certain pests to their predators and parasites to be established, which provides a more robust indicator of when pest levels are likely to become economically injurious.[416] Of course, this more sophisticated approach to monitoring is also more complex, requires a high level of knowledge about predator and parasites of pest species, and is more resource intensive for farmers.[417] Computer models are used to analyze gathered

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[410] *Id.* at 71 (citing V.M. Stern et al., *The Integrated Control Concept,* 29 HILGARDIA 81 (1959)).

[411] VAN EMDEN & PEAKALL, *supra* note 137, at 71.

[412] *See generally id.*

[413] *See generally id.*

[414] *Id.* at 71.

[415] *Id.* at 73.

[416] *Id.*

[417] *Id.*

monitoring data. These models take into account variables such as soil conditions and climatic conditions to predict likely pest damage, which informs farmers of the best times to apply chemical pesticides.[418]

In IPM, even when an economic threshold calling for the use of chemical pesticides is tripped, the pesticides are used very selectively to minimize non-target organism exposure, which can be accomplished in a number of ways. Although most chemical pesticides are considered "broad spectrum," in that they are toxic to a broad range of organisms, some chemical pesticides and many biological pesticides, known as "selective pesticides," exert their toxic effects primarily on a limited group of organisms. A well-known example of this is the biological pesticide, *Bacillus thuringiensis israelensis* (Bti), which targets mosquitos and other flies, rather than broadly affecting all insects.[419] In some situations, farmers can use these "selective pesticides" that are more toxic to the target pest species than they are to beneficial or other non-target species. In addition, selective pesticide application can be achieved even with broad spectrum pesticides by timing their application, or by using formulations of the pesticide that limit exposure to certain types of organisms.[420] For example, very small quantities of insecticides may be encapsulated into a sticky polymer that adheres to plants, thereby limiting exposure to organisms that actually feed on the plant and avoiding organisms that may simply be present in the area of spraying.[421] Moreover, selective spatial and temporal application of pesticides can target the pest species while avoiding exposure to beneficial species. Typically, natural predators and parasites of pests do not arrive or emerge in a crop field until after pest populations have reached a certain level. Accordingly, early application of short-lived pesticides can target the pest species and limit exposure to beneficial predators and parasites.[422]

Similarly, pesticide application can be limited to times when insect-pollinated crop plants are not in bloom, thereby limiting exposure to bees and other pollinator species who visit flowers to gather pollen and nectar. In certain cases, short-lived pesticides can be applied during times when beneficial insects are protected from exposure, such as when parasitic wasps are in the pupal stage.[423] Risk to beneficial insects can also be avoided by being selective in the spatial application of the pesticide.[424] Insecticides can be enclosed in traps baited with chemical attractants, such as pheromones, that are only attractive to specific pest species, but are of little interest to other species.[425] Because many predator and parasite species are more mobile than are many

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[418] *Id.* at 74.
[419] *Id.* at 96.
[420] *Id.* at 77.
[421] *Id.*
[422] *Id.* at 79.
[423] *See generally id.*
[424] *Id.* at 80.
[425] *Id.*

pest species, an approach called "band spraying" can be implemented to leave certain crop areas to be pesticide-free refuges for beneficial species that can more readily move into untreated areas to avoid exposure.[426]

One of the most important tools of IPM is the use of biological controls in an integrated pest management strategy. This can be accomplished by encouraging the presence of naturally-occurring predators and parasites of the pest species[427] or by introducing additional biological control agents into the crop field.[428] These natural enemies can be insect predators (such as ladybugs), insect parasites (such as parasitic wasps), or microbial pathogens.[429]

In addition to biological organisms, IPM also relies on certain biochemical pesticides derived from plants, such as rotenone and pyrethrum. Although these natural plant-derived pesticides can be highly toxic, their toxicity may be more selective to certain taxa of pests than many synthetic chemical pesticides. IPM also utilizes other less toxic biochemicals, such as semiochemicals.[430] IPM also encourages the use of pest-resistant crop varieties, developed through traditional plant breeding or through genetic modification techniques, to minimize the need for chemical pesticide inputs.[431]

In addition to reducing pesticide use, IPM can also result in improved habitat for beneficial species on the farm. One of the hallmarks of IPM is the integration of cultural controls with other pest management techniques. Cultural control is the manipulation of agricultural practices designed to reduce pest outbreaks.[432] Historically, cultural controls were the primary tools available to farmers to control pests. Cultural controls include practices such as cultivation, mulching, sanitation, destroying standing crop material, pruning, intercropping, trap crops, and crop rotation.[433] Cultural controls do not require the purchase of expensive chemical inputs, but can be very labor intensive.[434] Many of these cultural control practices, such as intercropping and crop rotation, actually provide habitats for a diversity of insects, including beneficial insects. When the same crop is grown on the same field year after year, populations of pest species continue to increase in the field. For example, if a monoculture of corn is planted in the same field every year, populations of pests that feed on corn will continue to grow year after year. Larvae or pupae of corn pests may continue to live in soils or in plant material left behind after harvesting, waiting for the next season's crop, which becomes an all-you-can-eat buffet for them. Crop rotation and the use of cover crops, on the other hand,

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[426] *Id.*

[427] *Id.* at 85.

[428] *Id.*

[429] *Id.* at 86.

[430] *Id.* at 123.

[431] *Id.* at 134.

[432] *Id.* at 113.

[433] *Id.* at 115–21.

[434] *Id.* at 123.

can break this cycle, reducing populations of pest species and enabling a diversity of insect species to thrive. If corn is planted one season and another crop the next year with a different cover crop grown in between planting seasons, the corn pest populations will not have the opportunity to grow. There will not be corn for them to feed on during the time other crops are being grown. If corn pest populations do not reach economic threshold levels, chemical pesticide application will not be necessary. If chemical pesticides are not applied, beneficial insect species will not be killed off, enabling them to achieve a level of natural pest control.

Despite the great benefits of IPM, it has not been employed widely. Large-scale industrialized agriculture operates more like a factory than an ecosystem. Crops are grown in vast monocultures with little or no opportunity for beneficial natural pest control insects such as predators or parasites to thrive. With no natural pest control, and a total lack of diversity in the field, toxic chemical pesticides are a must. More complicated decisions about using cultural or biological controls are rejected in favor of more simplistic chemical controls. Sophisticated science-informed decisions about whether or when to apply chemicals are tossed aside in favor of easy regular spraying regimens. All of this leads to a system of agriculture that negatively impacts beneficial insects and self-perpetuates the ongoing need for evermore toxic chemicals.[435] This problem is exacerbated when, as is the case with widespread neonicotinoid seed treatment, farmers are encouraged to purchase seed that might be treated with a variety of different chemical pesticides with no regard for whether the pesticides will be needed, or even whether the pests they are intended to control exist in the location where the seed will be used. Pesticide-treated seed is antithetical to principles of IPM, which seek to limit the use of chemical pesticides to only when needed, instead of every time a seed is planted.

The underutilization of IPM may be attributed, at least in part, to FIFRA not providing EPA with any direct authority to require IPM, and in fact limiting EPA's ability to require IPM. For example, FIFRA explicitly states that certified applicators are not required to receive instruction on IPM and are not required to be shown to be competent in IPM practices.[436] Thus, EPA does not have the authority to require certified applicators to consider IPM practices when making decisions regarding which options to choose in order to control a particular pest. Pursuant to FIFRA, a certified applicator's job is merely to ensure that once a particular chemical pesticide is chosen, it is applied properly in accordance with label instructions.

The only provision in FIFRA that encourages the use of IPM is section 11's mandate that both the states and EPA make instructional materials on IPM available to certified applicators at their request. Nevertheless, the opportunity

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[435] Angelo, *12-Step*, *supra* note 140.

[436] 7 U.S.C. § 136i(c).

exists for EPA to implement its other FIFRA regulatory authorities in ways that encourage IPM and other lower-risk pest control alternatives.

Although FIFRA does not provide EPA with authority to require certified applicators to employ IPM techniques, it does provide EPA with the ability to consider IPM in its unreasonable adverse effects determination and to encourage the use of IPM techniques through pesticide use labeling restrictions as part of making a registration determination. As described above, EPA does not typically consider the availability of alternative pest management approaches when determining the benefits offered by a pesticide being considered for registration. This is a significant weakness in EPA's unreasonable adverse effects analysis. If there are many alternative pest management approaches available to combat a particular pest on a particular crop, including lower-risk nonchemical alternatives, the benefits of the pesticide under consideration will be reduced. To truly evaluate a pesticide's benefits, EPA should do a comprehensive review of alternative pest management approaches, chemical and nonchemical. Part of this analysis should consider the availability of IPM approaches to combat the targeted pests on the crop of concern. The availability of established proven IPM approaches can greatly reduce the benefits of systemic chemical pesticides, thereby altering EPA's risk/benefit balancing. Moreover, when determining whether "use" restrictions should be imposed on a pesticide in order for it to meet the registration standard, EPA should consider whether it is appropriate to limit the use of the pesticide to part of an IPM program. Some pesticides may not meet the unreasonable adverse effects standard when applied automatically at predetermined intervals but may meet the standard when applied only as part of a comprehensive IPM program when an economic threshold is triggered.

Certain neonicotinoid insecticides, as well as any other insecticide that is highly toxic to bees and other beneficial insects, may only meet FIFRA's unreasonable adverse effects standard if they are used as a part of an IPM program. To allow insecticides that are highly toxic to pollinators and other beneficial insects to be applied without regard for whether the insecticide's targeted pests are even present in the field does not seem to meet FIFRA's unreasonable adverse effects standard. Prophylactic spraying of highly toxic insecticides into farm fields without first monitoring the fields to determine pest levels and beneficial insect levels would seem to violate FIFRA's registration standard and requirement that EPA impose use restrictions to minimize risk. Some specific insecticides that have very high toxicity to beneficial insects and relatively low benefits, including some systemic insecticides, may not meet the standard for registration at all. Others may warrant registration only if used sparingly and when needed, as informed by monitoring what is happening in the field and by applying science and economics to make a fully informed decision, which is the case in an IPM program. The challenge of this approach would be monitoring on-farm activities to ensure compliance. However, this is a challenge with all FIFRA use requirements and is not limited to requirements to use pesticides only as part of an IPM program.

Seed treatment, by design, cannot be part of an IPM program. Seeds treated with pesticide means the pesticide will be applied whether or not it is needed, with no opportunity to monitor the field to determine whether an economic threshold has been met or whether conditions on the ground otherwise warrant the use of the pesticide. Thus, treated seeds, particularly if treated with a systemic pesticide, would never have the benefit of being part of an IPM program and could never have the risks of its use reduced by requiring that it only be used as part of such a program. Much of today's treated seeds are actually treated with multiple pesticides. Seeds with multiple pesticide treatments may be the only quality seeds available to farmers. Thus, farmers needing seeds treated with one pesticide may be forced to purchase seeds treated with unnecessary pesticides. When purchasing seeds, farmers may have no opportunity to determine which, if any, of those pesticides are truly necessary. Seeds may be treated with pesticides that target pests that are not of concern in a particular geographic area or for a particular purpose. For example, some pesticides target pests that cause only cosmetic damage to a crop.[437] If a farmer is growing a crop for a purpose for which cosmetics are not relevant (for example, growing fruit for juice production only), the farmer may not need or want pesticides, but may end up using them because the seeds come treated with them. Seeds treated with highly toxic pesticides should only be permitted where benefits are overriding and where appropriate risk reduction measures are mandated through labeling.

5. *Labeling "Use" Restrictions*

In addition to considering requiring a pesticide to be used only as part of an IPM program when making a registration decision, EPA should also consider imposing other IPM-type restrictions on the use of pesticides through labeling requirements to reduce the risk to nontarget beneficial insects. For example, for certain pesticides on specific crops, it may be appropriate to require that refuges of native habitat be set aside on the farm field to provide habitats for predators, parasites, and pollinators to thrive. Similarly, through label restrictions, EPA could require pesticide-free buffer zones surrounding treated crops to enable beneficial insects to escape treated areas and survive. As described above, EPA initially attempted to mandate buffer zones for the use of Sulfoxaflor but later abandoned the mandate under the Trump administration.[438] These approaches can not only reduce pesticide exposure to beneficial species but also decrease the development of pesticide resistance in pest species by enabling pesticide-susceptible individuals to survive and

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[437] ANGELO, *supra* note 69, at 62–63.

[438] *See* EPA Issues Sulfoxaflor Registration for Some Uses, EPA, https://www.epa.gov/pesticides/epa-issues-sulfoxaflor-registration-some-uses (last updated Sept. 21, 2021).

reproduce. Moreover, buffers have the added benefit of capturing rain run-off that contains water-soluble pesticide, preventing it from traveling to nearby farm fields or natural areas.

EPA already requires the use of pesticide-free farm areas in a slightly different context to achieve a different objective. Due to concerns with certain genetically modified crops accelerating pesticide resistance in certain pest species, EPA developed an Insect Resistance Management (IRM) program for crop plants that have been genetically modified to produce proteins that are harmful to certain insects.[439] Specifically, this program addresses crop plants that had been genetically altered to contain genetic material from the bacterium *Bacillus thuringiensis* (Bt), which produces a protein that is toxic to certain insects. EPA's rationale for such a policy is that these genetically modified crops increase selection pressure for pest resistance. Similar to what happens with a systemic pesticide seed treatment, the Bt toxin is found at high levels in most or all of the plant tissues of these genetically modified plants and are produced by the plant continually during the growing season. Moreover, many of the major target pests of these crops feed almost exclusively on specific crop types subject to the policy. Consequently, the continuously high levels of exposure to the Bt toxin will cause insects susceptible to these toxins to die, leaving only less susceptible individuals to survive and reproduce. Subsequent generations of insects will, therefore, be resistant to the Bt toxin, rendering it ineffective as a pest control substance. To combat this problem, EPA's IRM program requires, among other things, the use of refuges, which are intended to provide Bt-free habitat to enable large numbers of Bt-susceptible insects to survive.[440]

EPA requires the refuges to be a specified percentage of the size of the total field planted in the Bt crop, and further requires that the refuges be close enough to the Bt-treated fields to ensure that susceptible insects mate with resistant ones.[441] EPA has been requiring these refuges for many years and reports that the IRM refuge strategy has been largely successful.[442] Much of the rationale for the IRM also applies to systemic pesticides, including when they are used to treat seed. Specifically, systemic pesticides, such as the neonicotinoids frequently used to treat seed, can be found on most plant tissue continuously throughout the growing season. Thus, these pesticides are more likely to result in the development of pest resistance than are pesticides that are applied to a field and breakdown quickly via sunlight or water. In addition, the fact that these pesticides are present in most plant tissue for extended periods of time means that nontarget organisms, including beneficial insects, are also

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[439] Insect Resistance Management for Bt Plant–Incorporated Protectants, EPA, https://www.epa.gov/regulation-biotechnology-under-tsca-and-fifra/insect-resistance-management-bt-plant-incorporated (last updated Dec. 1, 2021).

[440] *Id.*

[441] *Id.*

[442] *Id.*

likely to have exposure to them. Requiring refuges similar to those in EPA's IRM program for genetically modified crops would provide pesticide-free habitats for susceptible pest species, as well as for beneficial insects such as pollinators. In this situation, rather than a Bt-crop-free refuge, EPA would require a treated-seed-free or other pesticide-free refuge for pesticides that pose significant risks to beneficial insects. Because of EPA's longstanding IRM program, there is already precedence for this type of approach under FIFRA, and EPA has considerable experience implementing such a program. Accordingly, it should be feasible for EPA to develop a similar program for certain pesticides that warrant such an approach.

6. EPA's Most Recent Proposals on Neonicotinoids

On February 3, 2020, EPA published a notice in the Federal Register announcing the availability of "Proposed Interim Decisions for Several Neonicotinoid Pesticides" and seeking public comment on the proposal.[443] The Proposed Interim proposal was part of EPA's registration review, required to be carried out every 15 years by FIFRA section 3(g).[444] Each of the Interim Decision documents provides scientific assessments of the risks associated with a particular neonicotinoid pesticide and proposes interim risk mitigation measures.[445] Many of the risks outlined in the documents are risks to humans, and many of the proposed risk reduction measures relate to protecting human workers who handle these pesticides. Nevertheless, the documents also contain ecological risk assessments and proposed risk reduction measures, including those relating to nontarget wildlife impacts.

In each of these documents, EPA makes clear that it has not yet developed an approach for assessing risk to any species listed under the ESA. Instead, EPA states that it is currently working with its federal partners and other stakeholders on an interim approach for assessing potential risk to listed species and their designated critical habitats. EPA provides information on risk assessment on non-listed species, including mammals, birds, reptiles, and amphibians. Regarding invertebrates, EPA's risk assessment appears to be limited to honey bees and aquatic invertebrates, which most likely results from the fact that EPA only requires risk data to be submitted on these organisms. However, EPA does acknowledge potential concerns with other pollinator species, stating that "although the focus of the pollinator risk assessments is on

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[443] Pesticide Registration Review; Proposed Interim Decisions for Several Neonicotinoid Pesticides; Notice of Availability, 85 Fed. Reg. 5953 (Feb. 3, 2020)

[444] 7 U.S.C. § 136a(g).

[445] *See* Proposed Interim Registration Review Decision for Acetamiprid, Case No. 7617 (Jan. 2020); Proposed Interim Registration Review Decision for Clothianidin and Thiamethoxam, Case Nos. 762 and 7614 (Jan. 2020); Proposed Interim Registration Review Decision for Imidacloprid, Case No. 7605 (Jan. 2020); and Proposed Interim Registration Review Decision for Dinotefuran, Case No. 7441 (Jan. 2020), https://www.epa.gov/sites/production/files/2020-01/documents/dinotefuran_pid_signed_1.22.2020.pdf (last visited Jan. 18, 2021).

honey bees, the agency recognizes that numerous other species of bees occur in North America and that these non-Apis bees have ecological importance in addition to commercial importance in some cases."[446]

In these documents, EPA recognizes potential risks to honey bees, including colony-level risk, which varies from "weakest evidence of risk" to "strongest evidence of risk," depending on the particular application method and crop for each of the neonicotinoid pesticides. EPA concludes in these documents that there are ecological "risks of concern" for pollinators and aquatic invertebrates.[447] To address these concerns, EPA is proposing a number of risk mitigation measures, which include:

- Cancelling use on bulb vegetables;
- Reducing maximum application rates or restricting applications during pre-bloom and/or bloom, targeting certain uses with potentially higher pollinator risks and lower benefits;
- Preserving the current restrictions for application at-bloom;
- Requiring advisory language for residential ornamental uses;
- Applying targeted application rate reductions for higher risk uses;
- Requiring additional spray drift and runoff reduction label language; and,
- Promoting voluntary stewardship efforts to encourage employment of best management practices, education, and outreach to applicators and beekeepers.

While many of these proposed risk reduction measures may help to reduce risk to some extent, they do not go nearly far enough. Most significantly, these risk reduction strategies are simply impossible to apply to treated seeds, which is one of the most highly used and highest risk forms of pesticide use. It is impossible to restrict pesticide use to "at-bloom," apply targeted application rate reductions, or utilize spray drift and runoff reduction language for treated seeds. Once a treated seed is planted, the systemic insecticide will make its way into the tissue, nectar, and pollen of the plant and will be present when the plant is in bloom. Similarly, it is not possible to reduce the rate of pesticide usage for treated seed, because the seed comes with the pesticide pre-applied. Insecticides from treated seeds get into water and are present in runoff. Thus, it is not possible to reduce pesticide runoff through label language for treated seeds. Further, as described above, because EPA only requires risk data to be submitted on adult honey bees and certain aquatic invertebrates, its risk assessment simply does not address potential risks to larval honey bees, other species of bees, other non-bee pollinators, or other beneficial insects. Beyond that, some of the proposed risk reduction measures are voluntary, vague, and

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[446] Proposed Interim Registration Review Decision for Dinotefuran, *supra* note 445.

[447] *Id.*

unenforceable. For example, "promoting voluntary stewardship efforts to encourage employment of best management practices, education, and outreach to applicators and beekeepers" is unlikely to yield the risk reductions that are necessary to address the serious risks posed by certain pesticides to beneficial insect species that carry out critical ecosystem services. While EPA describes promoting additional pollinator habitat, promoting IPM, and encouraging growers to "take care" when planting treated seed, EPA does not provide details on how it will promote these activities. Likewise, it does not describe how much or what type of habitat is necessary, how growers are to implement IPM to reduce risks from pesticides that are permitted to be used prophylactically and outside of an IPM program, or what it means by encouraging growers to "take care" when planting treated seed. These proposed measures may represent a step in the right direction, but they are unlikely to go far enough to result in any significant risk reduction to beneficial insects.

CONCLUSION

The worldwide decline in insect populations is a significant threat. Beneficial insects play crucial roles in maintaining agricultural and natural systems vital to life on earth. The ecosystem services provided by these insects include natural pest control, pollination, nutrient cycling, and decomposition, which are necessary components of global food supply. Drivers of insect population decline include pesticide use, habitat loss, and climate change.

A number of existing programs and proposals exist that attempt to tackle some aspects of beneficial insect loss. However, these programs have severe limitations and only address the problems at the margins. The ESA provides authority to protect insect species that have been listed as endangered or threatened. However, most likely due to the limited data available on most insect species, coupled with the general public's lack of interest, fear, or disgust of insects, relatively few insects ever receive such protection. Moreover, the ESA is not well suited for protecting insect species. In contrast to other types of animals where a relatively small number of individuals of a species can play an important role in ecosystem function, the value of insects often stems from large numbers of them that carry out similar ecosystem services. Certain U.S. Farm Bill programs have the potential to encourage environmentally sensitive farming practices and habitat conservation that can benefit beneficial insect species. However, these programs are completely voluntary incentive-based programs, and historically, relatively limited resources have been devoted to such programs, especially when compared to the vast resources devoted to Farm Bill programs that may actually encourage high-crop-yield farming practices that have the opposite effect.

The key to solving the problem at hand is a reevaluation of the manner in which U.S. pesticide law, namely FIFRA, is employed. In this Article, we have engaged in an in-depth evaluation of FIFRA and the manner in which EPA has interpreted and applied it in the context of conserving beneficial insect species. What emerged from this reevaluation is that EPA's current approach to implementing pesticide law is a major contributor to beneficial insect declines. However, upon deeper analysis, it is clear that changes in EPA's interpretation and application of FIFRA could be an important factor in conserving beneficial insects such as predators, parasites, and pollinators.

FIFRA provides sufficient legal authority for EPA to shift to a more beneficial, insect-friendly approach to pesticides regulation. A critical step in this shift is for EPA to develop robust data requirements that evaluate the full range of risks to beneficial insects posed by the pesticides it evaluates for registration under FIFRA. EPA should extend its current data requirements beyond merely testing adult honey bees to include surrogate test species that represent a full range of beneficial insects, including predators and parasites of pests, wild bee species, and other insect pollinator species. Similarly, EPA should require testing of both larvae and adults of each surrogate species. EPA also should require test data related to subacute impacts, such as reproductive effects and behavioral effects that diminish an insect's ability to find food, find mates, and migrate.

In addition to requiring expanded testing on the risks that pesticides pose, EPA should revise its current waiver of efficacy data for most pesticides so that it has information available to consider the actual economic and social benefits a pesticide provides. Without such efficacy data, there is no way to know whether a pesticide actually performs its intended purpose. Beyond efficacy data, EPA should require registration applicants to provide additional benefits data, such as the availability of alternative chemical and nonchemical pest control substances and techniques, and data to support an evaluation of the importance of the pesticide under consideration to important crops or to public health. Without such data, EPA cannot fully carry out its statutory mandate to factor in environmental, economic, and social considerations in determining whether a pesticide meets the standard for registration under FIFRA.

With a more robust set of data on both the risks and benefits of a particular pesticide, EPA will have the tools to make a more informed decision about whether a pesticide poses unreasonable adverse effects on the environment, as required by FIFRA. In making such a determination, EPA should ensure that it assigns appropriate weight to each factor it considers, rather than simply adding up dollars and cents on each side of the equation. In this analysis, EPA should exercise its discretion to ensure imperiled species or imperiled ecosystem services are afforded the weight they deserve and are fully considered. EPA should also include a consideration of IPM techniques as alternatives in the benefits portions of the unreasonable adverse effects determination.

Another crucial change to the manner in which EPA implements FIFRA would be for EPA to eliminate the treated article exemption for seeds treated with systemic insecticides. Currently, EPA considers these pesticides—which present high risk to beneficial insects—as exempt. By eliminating the exemption, EPA could require every bag of treated seed sold in the United States to contain legally enforceable warnings and risk reduction language. Such labels would inform farmers that they are purchasing seeds that have been treated with systemic pesticides, which would better inform farmers of not only of what they may be inadvertently and potentially unnecessarily purchasing, but could also provide risk reduction directions for use, such as prohibiting the use of such seed in geographic locations where there is particular beneficial insect vulnerability. Such labels would also serve to inform farmers that these pesticides, by design, are not suitable for use in an IPM program. Finally, EPA should include label restrictions on FIFRA-registered pesticides that require insecticide-free on-farm habitats to be maintained. These labels and pesticide-free zones could be modeled on EPA's existing IRM Program for Bt GMO crops.

None of the changes proposed in this Article require congressional action. EPA could accomplish all of these proposed actions by either exercising its rulemaking authority under FIFRA or simply modifying the way it implements its existing rules. These changes could dramatically improve protection of beneficial insect populations that carry out crucial ecosystem functions, including pollination and natural pest control. Without these changes, beneficial insect populations—along with the important ecosystem services they provide—will continue to decline, to the detriment of both the global economy and life on Earth.

We welcome responses to this Article. If you are interested in submitting a response for our online journal, Ecology Law Currents, please contact cse.elq@law.berkeley.edu. Responses to articles may be viewed at our website, http://www.ecologylawquarterly.org.