

STUDY FAQ

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An assessment of acute insecticide toxicity loading (AITL) of chemical pesticides used on agricultural land in the United States

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AUTHORS

Michael J. DiBartolomeis^[1], Susan E. Kegley^[2], Pierre Mineau^[3], Rosemarie Radford^[2], Kendra Klein^[4]

1 Toxicology Research International, Haiku, Hawaii, United States of America

2 Pesticide Research Institute, Inc., Santa Rosa, California, United States of America

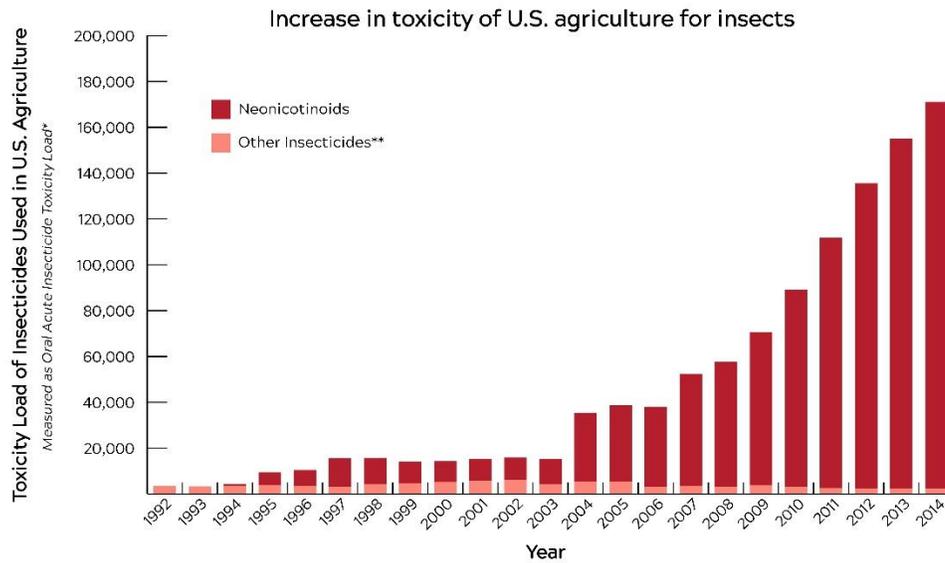
3 Carleton University, Ottawa, Ontario, Canada

4 Friends of the Earth U.S., Berkeley, California, United States of America

Q: What are the main findings of the study?

A:

- U.S. agriculture is 48 times more toxic to insect life than it was two decades ago.
- Neonicotinoids account for 92 percent of the increase in toxicity.
- This is the first study to quantify how toxic our agricultural lands have become for insect life by providing a way to compare changes in the toxicity of U.S. agriculture year-to-year.
- The persistence of neonicotinoids creates a cumulative toxic burden in the environment that is much higher than that experienced by insects 25 or more years ago. This is because neonicotinoids are considerably more toxic to insects and far more persistent in the environment than other commonly used insecticides. While others break down within hours or days, neonicotinoids can be effective at killing insects for months to years after application.
- The increase in toxicity measured by the study is consistent with the reduction in beneficial insect and insectivorous bird populations observed in recent years.
- Neonicotinoid use on corn and soybeans contributed the most to the increase in toxicity load.
- The three neonicotinoids that contributed most to the toxicity load are imidacloprid and clothianidin — which are manufactured by Bayer-Monsanto — and thiamethoxam, a product of Syngenta-ChemChina.
- Based on the study analysis, it is clear that existing regulations for the registration of pesticides in the U.S. are not adequate to prevent the introduction of chemicals that can cause catastrophic harm in the environment. The study presents a new method that could be used by the Environmental Protection Agency to assess future potential risks to biodiversity before introducing new pesticides into the environment.



*For method, see DiBartolomeis and Kegley et al., 2019. An assessment of acute insecticide toxicity loading of chemical pesticides used on agricultural land in the United States. PLOS One.
 **pyrethroids, organophosphates, pyrazoles, spinosyn, N-methyl carbamates, others

Q: What is unique about this study?

A: Other research has revealed important parts of this picture — how toxic neonicotinoids are for bees and other insects, how many pounds are used each year, and how long these chemicals persist in the environment. This study designed a way to combine all of this information to create a sort of time-lapse of impact. It reveals that the toxicity load of U.S. agriculture for insect life has surged dramatically since neonicotinoids were introduced in the 1990s. It also shows an increase in the toxicity load beginning in the mid-2000s, which is when the practice of using neonicotinoids to coat the seeds of commodity crops like corn and soy began.

Q: Why are neonicotinoids concerning for insect life?

A: A large and growing body of research shows that neonicotinoids have inflicted serious damage on pollinators and other beneficial insects and are a leading cause of massive declines in bee populations.¹ Neonicotinoids kill bees directly and also compromise their behavior, reproduction, health and immunity, leading to bee deaths from pathogens and parasites.^{2,3} In addition to commercial honey bees, many of the more than 4,000 species of native bees that live in the U.S. are even more vulnerable to neonicotinoid exposure.⁴

Although neonicotinoids are generally applied at lower rates per acre than other commonly used pesticides organophosphates, carbamates and pyrethroids, they are considerably more toxic to insects and persist in the environment. Neonicotinoids have half-lives ranging from 39 to more than 1,000 days in the environment, depending on the chemical and environmental conditions.⁵ For comparison, organophosphates — another commonly used class of pesticides — generally have environmental half-lives ranging from a few hours to less than 30 days, depending on environmental conditions and the chemical. Neonicotinoids have been found to be effective at killing insects for months up to a few years after application.^{6,7} Our study found that the persistence of neonicotinoids creates a compounding toxicity load in plants, soils and

surface waters that is substantially higher than that experienced by insects 20 or more years ago.

Q: Why should these findings be of interest to the public?

A: A growing body of research documents declining insect numbers around the world. A recent meta-analysis warns that 40 percent of insect species may be on the path to extinction and points to pesticides as a significant driver.⁸ This is a dire problem because insects make up the basis of the food webs that sustain all life on Earth. They are critical to ecosystem health and play a fundamental role in cycling nutrients and building healthy soil. Insects also contribute to the agricultural production of crops that feed humankind. Beneficial insects act as natural controls of pests that feed on crops important to human survival, and bees and other pollinators are responsible for 1 in 3 bites of food we eat. Without them, we would face shortages of some of our most nutritious foods, including nuts, fresh fruits and vegetables, meat and dairy, processed foods, juices and more.

The compounding toxicity of neonicotinoids in the environment is also of concern for other wildlife. These insecticides have been linked to dramatic negative effects on a range of bird species.^{9,10,11} Because neonicotinoids are highly water soluble, they are readily carried into waterways by rain or irrigation water. The U.S. Geological Survey has found that neonicotinoids contaminate lakes and rivers nationwide, often at levels that harm critical aquatic insects and other wildlife.^{12,13} Recent research has also found that they can harm white-tailed deer.¹⁴

Q: How was the study analysis conducted?

A: We developed the Acute Insecticide Toxicity Loading (AITL) method presented in this study as a screening tool to quantify historical trends and predict potential future harm of pesticide use in agriculture.

The AITL method uses honey bees as an indicator species to assess toxicity to a wide range of terrestrial insects. The honeybee (*Apis mellifera*) is relatively sensitive to insecticides when compared to other bee species, and has historically been used as a “proxy” or “indicator” for ecotoxicological testing.¹⁵

The AITL method incorporates: 1) the total mass of insecticides used in the U.S. based on pesticide use data obtained from the U.S. Geological Survey, 2) the environmental persistence of the insecticides and 3) the acute toxicity to insects of the insecticides using honeybee contact and oral LD₅₀ as reference values for arthropod toxicity. The study applies this method across the time span of 1992 to 2014. After 2014, the USGS stopped collecting data on pesticide seed treatments, creating a significant gap in data beyond that point.

The study accounts for the persistence of pesticides in the environment using a method akin to how a pharmacist determines how long a drug will be active in a person’s body. It takes the value of honeybee lethality (as LD₅₀) and modifies the value by the half-life of the chemical (in days), assuming exposure continues as long as the chemical is present, with degradation governed by the half-life of the chemical and the dose expressed as the area under the curve of concentration versus time.

The study evaluates the two primary ways that insects are exposed to insecticides in the environment, known as *oral* and *contact* exposure. Oral exposures to neonicotinoids are of

greater concern because they are more toxic and more likely to occur than contact exposures. Since neonicotinoids are systemic — meaning they dissolve in water and are absorbed by plants — they make the plant itself toxic, including its leaves, nectar, pollen, fruit and even water droplets that are exuded by plant leaves, known as guttation water. Consumption of any of these results in oral exposure.

The study found a 48-fold increase in oral toxicity loading from 1992 to 2014. Based on our analysis, neonicotinoids account for 92 percent of that increase. Chlorpyrifos, the fifth most widely used insecticide during this time, contributed just 1.4 percent of total oral toxicity loading. For contact toxicity loading, the study found a 4-fold increase from 1992 to 2014 and found that neonicotinoids account for nearly 30 percent of the total contact toxicity loading during that time.

Q: Why does the analysis stop at 2014?

A: The study applies the Acute Insecticide Toxicity Loading method across the time span of 1992 to 2014. After 2014, the US Geological Survey stopped collecting data on pesticide seed treatments, creating a significant gap in data beyond that point since seed treatments account for the vast majority of total neonicotinoid use in the U.S.¹⁶

Q: Are there limitations to your study?

A: This method provides an estimate of overall toxicity, it is not meant to be a risk analysis tool — it does not quantify the actual or estimated exposure dose after application of pesticides, nor does it identify peaks and ebbs in toxicity in a given year relative to the exact time and mode of application. It may or may not overestimate actual insecticide doses received by bees and other beneficial insects from insecticide applications, depending on the specific circumstances.

Our findings are likely a significant underestimate of the total toxicity experienced by insects from agricultural pesticides because the data needed to do a more in-depth analysis based on the factors listed below is largely unavailable.

First, the Acute Insecticide Toxicity Loading uses acute lethality (bee death) as the measure of harm, but death is a blunt measurement of toxicity. Nonlethal toxicity is usually measured in doses that are 10 to over 100 times less than the doses needed for causing death. The insecticides we analyzed can cause significant sublethal effects in honey bees, including impaired reproduction, altered immune function, inability to navigate effectively and behavioral changes in essential colony activities leading to decreased colony health and survival. While the AITL method could be modified to include sublethal effects, this data is not available for a large number of insecticides because the U.S. Environmental Protection Agency does not require sublethal toxicity studies in honey bees when registering new pesticides.

Second, we use data from the U.S. Geological Survey to estimate total use of insecticides on agricultural land, but the impact zone of pesticides extends beyond these boundaries. Persistent pesticides like neonicotinoids have a greater tendency to move offsite into surrounding fields, land, surface water and other waterways outside of the agricultural fields where they are directly applied, but our AITL analysis does not quantify those exposures.

Third, available research shows that neonicotinoids can have synergistic effects that make natural pathogens and parasites more harmful.¹⁷ Again, sufficient data and methodology do not exist to incorporate these factors into the AITL analysis.

Q: Does your study say anything about neonicotinoid seed coatings?

A: Our study accounted for total use of pesticides in a given year based on data collected by the U.S. Geological Survey. This data includes multiple types of pesticide use — foliar spray, soil drenches and seed coatings — but does not distinguish between these uses. However, our study found that corn and soybeans are the two crops most responsible for the increase in toxicity of U.S. agriculture over the past two decades. This is consistent with data showing that neonicotinoid use rose dramatically starting in the early 2000s when they began to be used as coatings on soybean and corn seeds.¹⁸ Seed coatings account for the vast majority of total neonicotinoid use in the U.S.¹⁹

Only about 5 percent of the neonicotinoid coating is absorbed by the plant — the other ~95 percent is left in the soil where it can harm wildlife and run off to contaminate rivers, lakes and drinking water sources.

Research shows that farmers could stop using neonic-coated seeds without harming their crop yields or their incomes. The Environmental Protection Agency determined that neonic-coated seeds provide “little or no overall benefits to soybean production,” yet nearly half of all soybean seeds in the U.S. are treated.²⁰ Similar analyses have found no economic benefit to farmers from neonic-coated corn, yet up to 100 percent of U.S. corn seeds are treated.²¹ However, U.S. farmers typically can’t find uncoated seeds (unless they purchase organic seeds) because they are not available on the market.

In 2008, Italy instituted a ban on the use of neonicotinoid seed coatings for corn. In an evaluation five years later, researchers found a “clear and dramatic improvement” in the number of bees and colonies in the region.²² They also found that the ban did not impact farmers’ yields of corn.

Q: Who funded the study?

A: The project is possible thanks to the generous members of Friends of the Earth U.S. and the Ceres Trust. You can read Friends of the Earth’s organizational policy on funding [here](#).

Q: Have any governments taken action to restrict use of neonicotinoids?

A: As mentioned above, in 2008, Italy instituted a ban on the use of neonicotinoid seed coatings for corn. In an evaluation five years later, researchers found a “clear and dramatic improvement” in the number of bees and colonies in the region.²³ They also found that the ban did not impact farmers’ yields of corn.

In 2018, the European Union banned the most dangerous neonicotinoids for field use based on their harm to pollinators.²⁴ In 2019, Canada also passed restrictions on the use of the most widely used neonicotinoids.²⁵

More leadership comes from the German state of Bavaria, which passed a law in April 2019 to transition 30 percent of the region’s farmland to organic by 2030 in order to protect bees and other beneficial insects.²⁶ Research shows that organic farms support up to 50 percent more

pollinating species than pesticide-intensive farms, and they help other beneficial insects flourish.²⁷ Organic farmers do not use an estimated 900 pesticide active ingredients allowed in non-organic farming, including neonicotinoids.²⁸

In the U.S., a number of states have passed restrictions on certain types of neonicotinoid use, including [Maryland](#), [Connecticut](#), [Vermont](#), [Minnesota](#), [Oregon](#), [New York](#) and [California](#). In addition, over 115 U.S. cities and universities have passed policies to restrict use.²⁹

In the research journal *Science*, over 240 scientists from around the world called for international action to restrict use of neonicotinoids based on their harm to pollinators and other beneficial insects.³⁰

Q: What is the U.S. government doing?

A: The U.S. Environmental Protection Agency continues to stall scientific review of neonicotinoids, and although the agency placed a moratorium on new uses in 2015, it has not taken action to restrict the vast majority of uses currently on the market. In 2018, the U.S. Fish and Wildlife Service reversed a ban on the use of neonicotinoids in national wildlife refuges.³¹ Environmental groups have turned to the courts in the face of government inaction. In a recent settlement linked to the Endangered Species Act, the EPA [cancelled](#) registrations of twelve neonicotinoid products. This decision sets an important precedent, but since there are still more than 45 approved formulations, does little to curtail the vast majority of neonicotinoid use.³²

Q: What comes next?

A: Friends of the Earth is calling on Congress to pass the [Saving America's Pollinators Act](#) introduced by Rep. Earl Blumenauer (D-OR) to immediately suspend use of neonicotinoids and other systemic insecticides. We are also advocating for a [bill](#) introduced by Rep. Nydia Velazquez (D-NY) to end the use of neonicotinoids in wildlife refuges.

While we work to end the use of neonicotinoids in the U.S., we are also working to rapidly transition U.S. agriculture to [organic](#), which is a solution to both the biodiversity crisis and the climate crisis. Organic farms, which do not use neonicotinoids nor some 900 other active pesticide ingredients allowed in conventional agriculture, support up to [50 percent more](#) pollinating species and help other beneficial insects flourish. Research shows that organic farming can help [reverse pollinator decline](#). Research also shows that organic agriculture dramatically [reduces pesticide exposure](#) for consumers, farmworkers and farmers. Expert consensus [asserts](#) that a rapid shift away from pesticide-intensive agriculture to agroecological farming methods like organic agriculture is necessary to protect the biodiversity, soil and water we need to feed ourselves now and into the future.

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