JANUARY 2020
R: 19-12-A

REPORT

BIGGER THAN BEES:

HOW NEONICS CONTAMINATE WATER, THREATEN ECOSYSTEMS, AND CAUSE HUMAN HEALTH CONCERNS IN NEW YORK

AUTHORS
Daniel Raichel and Dr. Jennifer Sass

ACKNOWLEDGMENTS

The authors would like to thank Dr. Pierre Mineau and Dr. Christy Morrissey for their valuable peer review on this report, as well as NRDC's Science Center for their generous financial support.

NRDC Chief Communications Officer: Michelle Egan
NRDC Managing Directors of Communications: Lisa Goffredi and Jenny Powers
NRDC Publications Director: Mary Annaïse Heglar
NRDC Policy Publications Editor: Leah Stecher

Design and Production: www.suerossi.com

Table of Contents

What Are Neonics? 4

Neonics Are Toxic, Persistent, and Everywhere 5

Neonics' Use in New York Has Soared Despite DEC Concerns 6

Neonics Kill Bees 6

Bigger Than Bees: Neonics Harm Birds, Butterflies, and Other Wildlife 7

Neonics Contaminate New York Water and Destroy Aquatic Ecosystems 8

Neonics Get Into Food and Drinking Water and May Harm Human Health 9

Dollars and Cents: Most Uses of Neonics Don't Add Up 10

A Better Way: Alternatives to Neonics 11

While the World Acts, the United States Waits 11

Solutions: What New York Can Do 12

You've heard the buzz—bees are dying in record numbers in New York State and around the globe. Scientists increasingly identify the widespread use of bee-toxic neonicotinoid insecticides, or "neonics," as a leading culprit.[1]

But these findings fail to paint the full picture of how a new class of pesticides went from unknown to ubiquitous in a generation, contaminating New York's soil and water on an unprecedented scale and hollowing out ecosystems from the bottom up. Today, neonics contaminate not only New York's environment, but also New Yorkers themselves. Half of the U.S. population are exposed every day, and scientific studies continue to link neonic exposure with potential human health harms.[2] Moreover, the vast majority of neonics used in agriculture are designed to tackle pest problems that simply don't exist, wasting farmers' money and sometimes even reducing crop yields by damaging soil health and beneficial insects.

This report looks at that bigger picture—at the true costs neonics impose for little or no benefit to farmers and residents. It also looks at steps the state can take right now to curb the use of these dangerous pesticides.

WHAT ARE NEONICS?

Neonics are neurotoxic insecticides—pesticides that kill insects by permanently binding to, overstimulating, and ultimately destroying their nerve cells.[3] Insects poisoned with neonics often exhibit twitching, followed by paralysis and then death.[4] Even at minute doses, neonics weaken critical functions, such as an insect's immune system, navigational ability, stamina, memory, and fertility—making it harder or impossible for them to survive.[5]

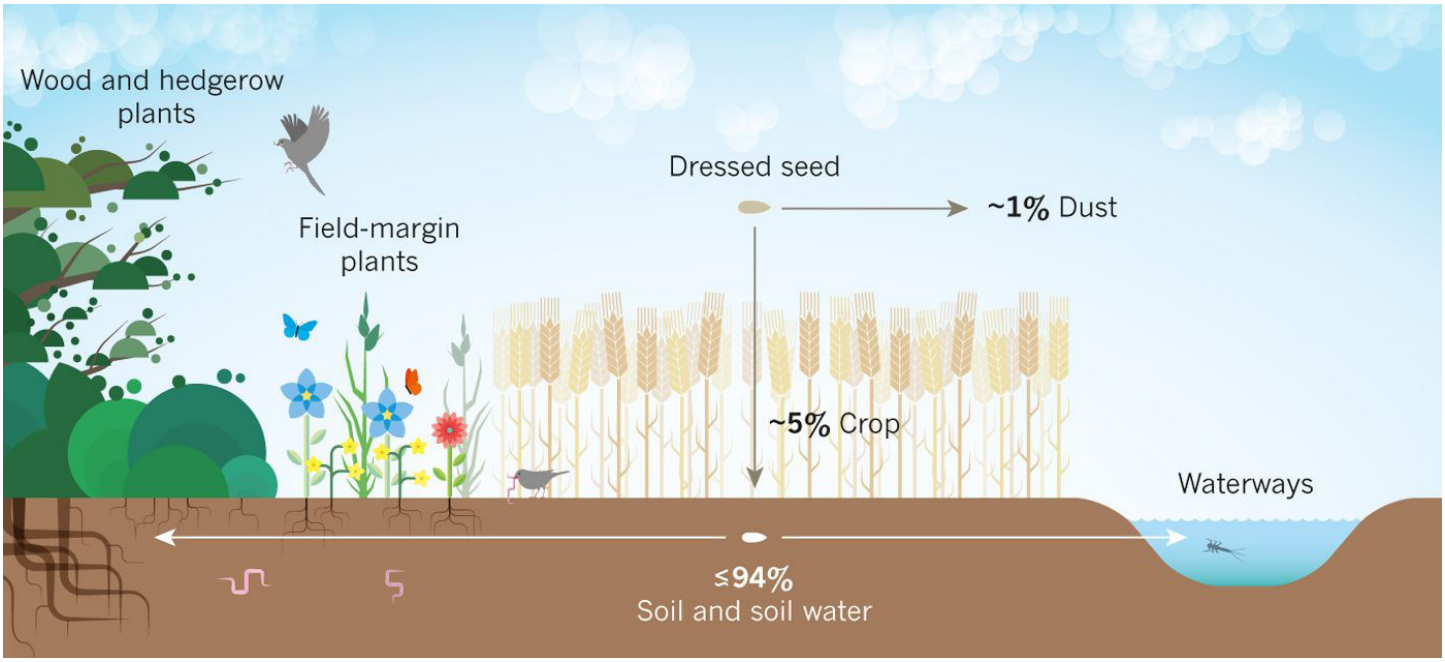
Unlike older, conventional insecticides, neonics are "systemic," designed to be absorbed by plant tissues in order to make the plant itself—including its nectar, pollen, and fruit—toxic. This allows neonics to be applied in new ways in addition to spraying. For example, they are commonly applied as a coating on a plant's seed that gets absorbed by the plant as it grows. Similarly, neonics can be injected into a plant or applied as a "drench" to its roots. Often the levels applied are high enough to make some plants toxic to insects for years.[6]

There are six major neonic chemicals approved for outdoor use in the United States—acetamiprid, clothianidin, dinotefuran, imidacloprid, sulfoxaflor, and thiamethoxam—and they appear in thousands of products.

NEONICS ARE TOXIC, PERSISTENT, AND EVERYWHERE

Neonics have been around only since the mid 1990s but have already caused considerable ecological damage, most noticeably as a leading contributor to plummeting bee and other insect populations across the globe.[7] There are three reasons why neonics are particularly destructive.

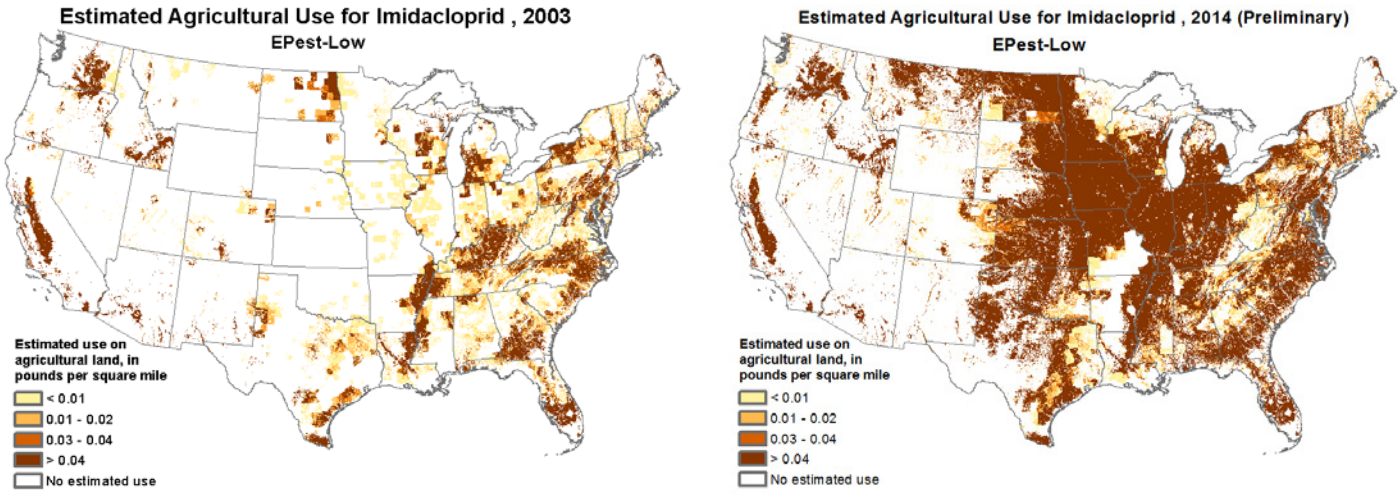
First, neonics are extremely toxic to insects. The typical neonic coating on just one corn seed can contain enough active ingredient to kill a quarter-million bees or more.[8] Since neonics were first introduced, U.S. agriculture has become 48 times more harmful to bees and other insects, with an estimated 92 percent of the total toxic load attributable to neonics alone.[9]



Reprinted by permission from Springer Nature: Dave Goulson, "Pesticides Linked to Bird Declines," *Nature* 511, no. 7509 (July 2014): 295-96, https://go.nature.com/2rNOZcK.

Second, neonics can stay in the soil for long periods of time and are easily carried by rain or irrigation water. In fact, they can travel considerable distances, contaminating water and soil as they move and making nontarget plants, which absorb the neonics through their roots, toxic to insects too.[10] Once the common neonic imidacloprid has contaminated water, says the U.S. Environmental Protection Agency (EPA), long-term exposure to only 10 parts per trillion—like 10 grains of sand in an Olympic-size swimming pool—is enough to harm aquatic insects and other invertebrate species.[11]

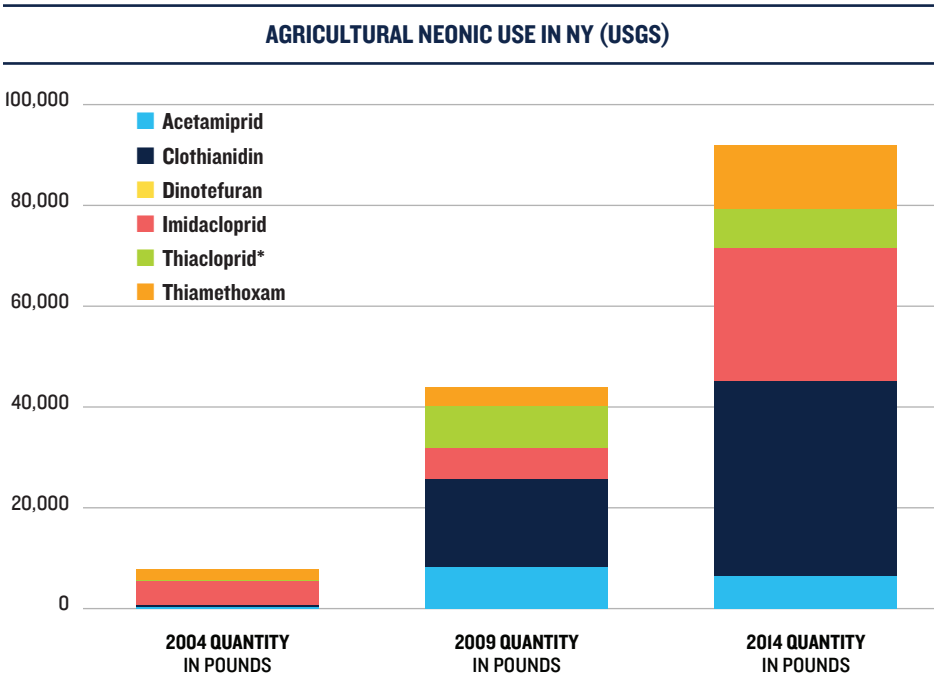
Third, neonics are wildly popular—appearing in lawn and garden bug sprays, fertilizers, flea and tick treatments for pets and livestock, and agricultural pesticides. Today neonics are the most widely used insecticides in the United States, contaminating soil and water across the country and building up in areas of year-after-year use.[12]



U.S. Geological Survey (USGS), *Estimated Agricultural Use for Imidacloprid, 2003, 2014*, https://on.doi.gov/2M7L1Dd, https://on.doi.gov/2ScRosN.

NEONICS' USE IN NEW YORK HAS SOARED DESPITE DEC CONCERNS

Since the New York Department of Environmental Conservation (DEC) first registered the neonic imidacloprid in 1995, neonic use in New York has grown dramatically, matching increases seen other states.[13] In 2014, the last year for which reliable data are available, state-certified pesticide applicators and farmers used an estimated 141,000 to 152,000 pounds of neonics, almost certainly making them the most popular insecticides in the state.[14] And because these numbers fail to account for use of the hundreds of state-approved neonic consumer products—such as home and garden treatments, insecticide-laced fertilizers, and bug sprays—they very likely underestimate the full neonic load entering New York's soil, water, and plants.



* Thiacloprid is no longer approved for use by EPA. EPA recently approved the neonic sulfoxaflor, but so far, New York has not approved any sulfoxaflor use in the state.

Data from Pierre Mineau, *Impacts of Neonics in New York Water: Their Use and Threat to the State's Aquatic Ecosystems* (2019).

Neonics are almost certainly the most popular insecticides in New York State.

Recognizing their risks, DEC has attempted to limit the use of neonics in the state, but to little effect. From 2005 to 2007 the agency refused to approve outdoor pesticides containing the neonics dinotefuran or clothianidin, citing concerns that they could harm bees and contaminate water.[15] However, DEC broadly approved products containing the neonics imidacloprid and thiamethoxam, even though they are similarly toxic and similarly likely to pollute water.[16] Both chemicals have been used in ever-increasing quantities since.[17]

Even DEC's attempted prohibition on outdoor clothianidin products has proved ineffective. In 2014 an estimated 38,000 pounds of clothianidin reached New York farm fields, making it the dominant neonic used in agriculture.[18] This is because clothianidin is most commonly used as a coating on crop seeds—which, due to a loophole in federal and state laws, is treated as exempt from DEC's normal regulation of pesticides.[19]

NEONICS KILL BEES

While this report does not focus on the impacts of neonics on bees, it should be mentioned that a large and growing body of scientific evidence links neonic use to the massive bee losses seen both here and around the globe. This includes findings from two comprehensive, worldwide academic assessments of neonic impacts on pollinators, Cornell University research, and even a major pesticide-industry-funded field study—the largest to date.[20]

In New York, beekeepers have lost more than 40 percent of their bee colonies nearly every year for the past decade, suggesting the possibility of similar catastrophic losses for the state's 400-plus species of wild bees.[21] Future bee losses could jeopardize the state's pollination-dependent crops, which contribute an estimated $1.2 billion annually to the state's agricultural economy.[22] Off the farm, 87.5 percent of flowering plants need pollination by bees and other pollinators to reproduce, so the loss of bees could lead not only to the destruction of the food system as we know it, but also to the collapse of whole ecosystems.[23]

© Tom Koerner/USFWS

A recent study in Japan found that fish populations collapsed shortly after the introduction of neonic treatments in nearby rice fields. Neonic levels later measured near those fields match those commonly seen in New York water.

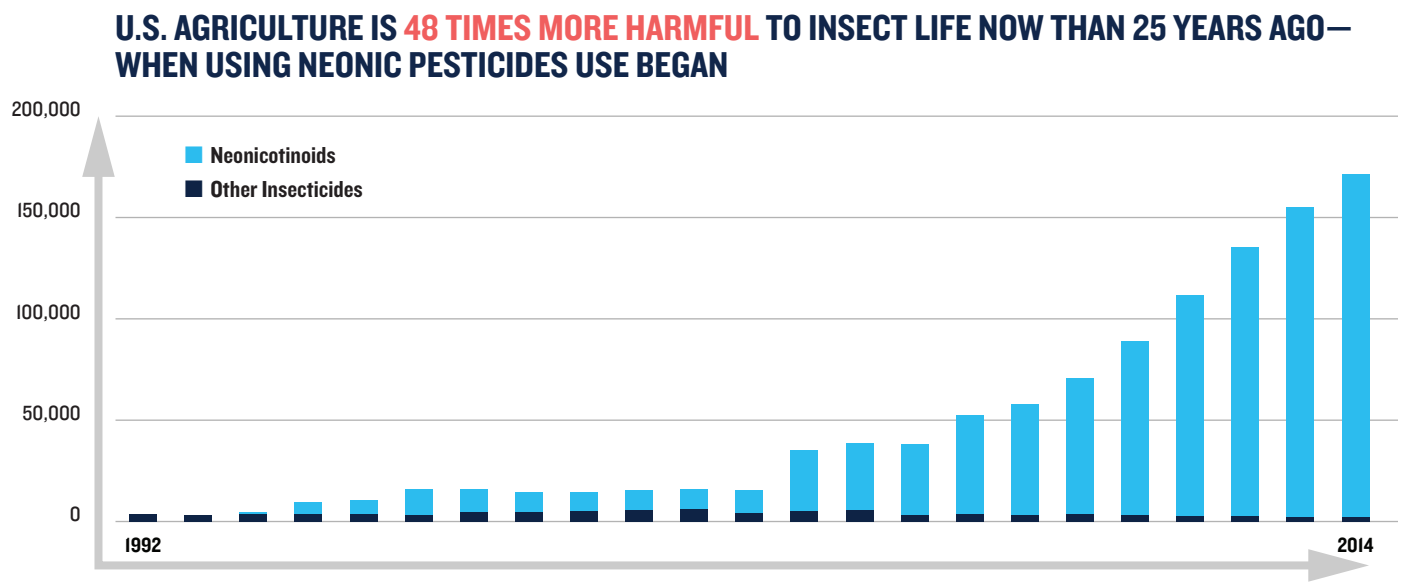
In light of the overwhelming scientific evidence, regulatory agencies around the world, including the EPA, the European Food Safety Agency, and Canada's Pest Management Regulatory Agency, have recognized the numerous risks that neonic use poses to bees.[24]

BIGGER THAN BEES: NEONICS HARM BIRDS, BUTTERFLIES, AND OTHER WILDLIFE

While plummeting bee populations have attracted national attention, growing evidence now illuminates neonics' harms to wildlife on a broader scale.

Like bees, populations of other beneficial insects across the globe have rapidly declined in the time since neonics were first introduced—a trend sometimes called the "insect apocalypse"—and new research is increasingly identifying neonics as a leading cause.[25] For example, recent studies have connected neonic use with significant declines in butterflies, which can encounter harmful or deadly neonic levels in farm fields or nearby wild plants that can absorb neonics and stay toxic for years.[26] Contaminated soil itself may also pose a hazard to populations of ground-dwelling insects and organisms.[27] And, as discussed below, neonics devastate aquatic insect populations.

TOTAL ACUTE ORAL INSECT-TOXICITY LOAD OF INSECTICIDES IN U.S. AGRICULTURE BY YEAR (IN LD_{50}-DAYS)



Data from Michael DiBartolomeis et al., "An Assessment of Acute Insecticide Toxicity Loading (AITL) of Chemical Pesticides Used on Agricultural Land in the United States," *PLoS One* (August 6, 2019).

© Andy Reago & Chrissy McClarren via Flickr

Eating just one neonic-treated seed is enough to kill some songbirds.

As losses of insects multiply, insect-eating animals suffer too. Birds appear particularly vulnerable. Ninety-six percent of land-based birds feed insects to their young, and many species also rely, in whole or in part, on insect food sources as adults.[28] In the Netherlands, researchers have linked declining populations of insect-eating birds to the introduction of neonics—even in areas with exceptionally low neonic levels in water (only 20 parts per trillion).[29] Additionally, France has seen steep declines in farmland birds over the past 17 years, and North America has lost an estimated 29 percent of its bird population—roughly three billion birds—in the past 50 years.[30] Neonics are suspected to play a key role in both of these declines as well.[31] One thing most of the declining species have in common is a dietary dependence on insects.

Neonics also harm birds directly. Eating just one neonic-treated seed is enough to kill some songbirds.[32] At nonlethal doses, neonics can damage birds' immune and reproductive systems, cause rapid weight loss, and impair navigation and migration ability—all reducing the likelihood of their surviving and reproducing in the wild.[33] With hundreds of millions of acres of U.S. farmland sown with neonic-treated seeds every year, birds are constantly at risk—particularly when, as commonly occurs, piles of seed are left out in the open or planted shallowly enough for birds to eat.[34] At least one assessment has made the case that bats can also be harmed directly or indirectly.[35]

Neonics may even harm large mammals exposed through contaminated water or otherwise. A new study has reported a link between neonics and birth defects in white-tailed deer—including decreased body and organ weight and decreased jawbone length—and higher death rates for fawns.[36] Surprisingly, some of the "control" group—deer purposely not exposed to neonics in the study—were found to have neonics in their organs anyway, demonstrating just how difficult it can be to avoid neonic exposure in the real world.[37]

NEONICS CONTAMINATE NEW YORK WATER AND DESTROY AQUATIC ECOSYSTEMS

Neonics contaminate water supplies across the United States, and New York water is no exception.[38] Federal and state water testing over the past 15 years has shown that the neonic imidacloprid frequently appears in surface waters throughout the state.[39] And recent testing of Long Island groundwater found imidacloprid in roughly 30 percent of samples, making it one of the most commonly detected pesticides on the island.[40]

The results not only reveal widespread neonic contamination but also suggest its likely devastating impact on the state's rivers, lakes, and coastal areas. More than 90 percent of the previously mentioned imidacloprid detections exceeded the EPA's long-term exposure benchmark for harm to aquatic invertebrates, and more than 37 percent of detections exceeded the benchmark by 10 times or more.[41] Overall, New York's water testing results indicate a very high probability that neonics are causing ecosystem-wide damage.[42]

New York's water testing results indicate a very high probability that neonics are causing ecosystem-wide damage.

Ecosystem damage often starts in the small streams and waterways that support diverse aquatic life and provide rich feeding grounds for other species. Aquatic insects and other invertebrates awash in neonic-contaminated water can succumb to daily low-level exposures over time or be wiped out suddenly by large influxes of neonics after a rainfall or following planting or pesticide applications. Those losses, in turn, can starve populations of birds, fish, and amphibians, eventually affecting predator species like hawks and mammals.[43] For instance, a recent study in Japan found that fish populations collapsed shortly after the introduction of neonic treatments in nearby rice fields.[44] Neonic levels later measured near those fields match those commonly seen in New York water.[45] In addition to the ecological impacts, diminishing trout, salmon, and wild bird populations are certain to harm New York's multibillion-dollar tourism and recreation industries.[46]

While the existing test results alone lead us to expect these ripple effects, neonic water contamination in New York is almost certainly worse than the data suggest. Much of the state's past water testing has not been sensitive or frequent enough to detect harmful neonic levels.[47] Further, almost all state water monitoring programs test only for imidacloprid, despite the fact that other EPA-registered neonic chemicals share similar toxicity profiles and have properties that make them even more likely to end up in water supplies.[48] Imidacloprid accounts for about half of the recorded neonic use in New York.[49] This means total neonic water contamination may be double that or worse.

NEONICS GET INTO FOOD AND DRINKING WATER AND MAY HARM HUMAN HEALTH

The use of neonics has grown exponentially, in large part because they are thought to be safer for humans than the older, acutely toxic insecticides they replaced. However, emerging research now links neonic exposures to elevated risk of developmental and neurological damage in humans, particularly in infants and young children.[50] These include malformations of the developing heart and brain, and a cluster of symptoms including memory loss and tremors.[51]

These results raise concerns for all New Yorkers because, as new monitoring results demonstrate, state residents are exposed to neonics every day. In 2019 the U.S. Centers for Disease Control and Prevention published the updated results of its national biomonitoring program, which measures pesticides in the urine of thousands of Americans age three and older.[52] The new update was the first to include neonics, and the results show that half of the U.S. general population is exposed to neonics on a regular basis, with children having higher levels than adults.[53] Japanese researchers also recently identified neonics in the urine of newborn babies, indicating that they can pass from a pregnant mother to her developing fetus.[54] This is especially alarming given the emerging data linking prenatal neonic exposures to adverse developmental effects.

Emerging research now links neonic exposures to elevated risk of developmental and neurological damage in humans, particularly in infants and young children.

People are commonly exposed to neonics through food and water. Fruits, vegetables, and processed foods frequently contain neonics; a recent national survey detected the pesticides in 80 percent of spinach and 73 percent of applesauce samples tested.[55] And because neonics are absorbed into treated foods, washing does not remove them, making it virtually impossible for consumers to avoid exposure.

Worse yet, neonics can break down in water, forming chemicals that are several hundred times more toxic to people than the original neonic chemical.[56] And since conventional drinking water treatment generally fails to remove neonics or these break down products, researchers frequently find neonics in tap water in places like Iowa City and southern Ontario, where neonics have entered the drinking water supply.[57] While more testing needs to be conducted in New York, results suggest that the risk of contaminated drinking water may be highest on Long Island (where imidacloprid alone showed up in nearly a third of recent samples) and in areas that get their drinking water from surface water, such as New York City.

Half of the U.S. general population is exposed to neonics on a regular basis.

DOLLARS AND CENTS: MOST USES OF NEONICS DON'T ADD UP

In both New York and around the country, most of the neonics now contaminating the environment provided little to no economic benefits to the people who used them.

For example, 73 percent of all agricultural neonic use in New York by weight is used on corn and soybean seeds.[58] Nationwide, up to half of soybean seeds and virtually all conventional corn seeds are treated with a neonic coating.[59] However, these coatings target early-season pests—such as wireworms, white grubs, and seedcorn maggots—that seldom reach economically damaging levels in northern climates. At the same time, they provide little to no protection against greater threats like corn rootworm and soybean aphid.[60] Independent research has shown soybean and corn seed treatments rarely or marginally benefit yields and, in some cases, may actually decrease yields by killing predators of insect pests (i.e., the "good bugs").[61] Seed treatments are wasteful too—even under ideal conditions, typically no more than 2-5 percent of the active neonic chemical enters the growing plant as intended, leaving the other 95-98 percent to accumulate, persist, and migrate in soil and water or be released as airborne "seed dust."[62]

Other preventive neonic applications—i.e., use of neonics regardless of whether a pest problem exists or will materialize—are also widely used in agriculture, even as emerging research suggests they may actually hamper crop production. For example, ongoing research at Purdue University finds that melon crops preventatively treated with neonics and other insecticides generally had decreased yields compared to crops treated with non-neonics only "as needed," likely because of the associated loss in bee and other insect populations needed to pollinate the crop.[63]

New research likewise indicates that conventional use of insecticides, including neonics, may hurt farmers' bottom lines. On canola crops, for example, a survey of nearly 300 farm fields found that increasing insecticide use decreased bee populations, failed to increase yields, and ultimately reduced farmer profits by increasing costs.[64] And a study of northern Great Plains farms found that fields using neonics and other conventional insecticide treatments had 10 times the insect pressure and fewer profits compared with those employing regenerative farming methods, likely due to lower input costs, more "good bugs" that keep pest populations under control, and better crop marketability.[65] In other words, farmers using neonics may be paying more money, seeing more pests, and enjoying fewer profits as a result.

Neonics are also overused off the farm, driven in part by the way in which neonic products are packaged and approved. Manufacturers often add neonics to fertilizers and other home and garden products.[66] The EPA also allows use of many consumer neonic products at much higher concentrations than those approved for agricultural products, in some cases up to 120 times higher.[67] That means that, even when used as directed, neonic applications in a backyard or on a golf course can put dozens of times more neonics into the environment than those on a typical farm field.

A BETTER WAY: ALTERNATIVES TO NEONICS

For nearly all uses, neonics are replaceable—with the best and most cost-effective alternative often being nothing.

For example, neonic corn and soybean seed treatments could be eliminated with no real effect on production because they target pest problems that largely don't exist in northern growing regions like New York State.[68] Eliminating preventative neonic uses for some of the state's top fruit and vegetable crops could also save farmers money by reducing input costs and preserving the pollinators that increase crop yields.[69]

Where pests do pose a significant problem, replacements exist. A recent comprehensive review of nearly 3,000 case studies by French government researchers concluded that, in 96 percent of cases, neonics can be replaced with effective alternatives, and, in 78 percent of cases, at least one effective non-chemical alternative was available.[70] Nonchemical alternatives to neonics include time-honored agroecological practices like diverse crop rotations, cover cropping, and introducing natural enemies of crop pests (again, those "good bugs"). Even where insecticides are used, non-synthetic or less-harmful synthetic substitutes exist, such as organic and minimum-risk pesticides.[71]

Like farmers, homeowners have better choices too. Many organic and less ecologically harmful alternatives—such as neem oil concentrate, diatomaceous earth powder, or beneficial nematodes and insects—are easily purchased at garden retailers or on the internet.[72] Even conventional lawn-care brands now increasingly offer neonic-free alternatives.[73]

WHILE THE WORLD ACTS, THE UNITED STATES WAITS

In response to recent science, countries across the globe have acted. In 2018 Europe approved a ban on all outdoor uses of three major neonic chemicals to protect bees and other pollinators.[74] And after discovering widespread neonic water contamination similar to that found in New York, Canada's Pest Management Regulatory Agency proposed banning outdoor uses of the same three neonics, citing unacceptable risks to aquatic ecosystems.[75] France, meanwhile, has banned all outdoor neonic use.[76]

In contrast, neonic protections in the United States have stalled. In 2013 the EPA added a "bee hazard" warning to many neonic product labels and placed some limits on using the products during plant blooming times.[77] But these measures fail to address the broader environmental harms caused by neonics migrating through soil, water, and plants or the risks of neonics entering food or drinking water. Even bees, it appears, have yet to see tangible benefits from EPA's efforts, with colony losses remaining at historic highs.[78]

Even obvious money-wasting neonic uses remain commonplace, often because of the near-monopoly power exercised by modern agrochemical giants. Just four companies now control roughly 70 percent of global seed and chemical markets, often giving farmers no choice but to buy a neonic-treated seed.[79] For example, as mentioned earlier, nearly all conventional corn seeds are neonic-treated before they reach the soil.[80] Even where farmers have options, they are commonly advised to purchase neonic-treated seeds by seed dealers or representatives with a financial interest in promoting products made by

the large agrochemical companies.[81]

SOLUTIONS: WHAT NEW YORK CAN DO

With market failures and a lack of federal leadership, it is up to New Yorkers—particularly, the state's elected leaders and agency officials—to take on neonic contamination and its harms. Fortunately, there are several steps that New York can take without further delay:

- **Banning Needless Neonic Uses**—Most neonics used in New York provide little to no benefit to users, and these and many others are easily replaced with safer alternatives. New York should ban harmful and unnecessary outdoor uses—which include neonic treatments on corn and soybean seeds as well as nonagricultural or "cosmetic" uses.
- **Hitting "Pause" on Other Harmful Neonic Uses**—Across the state, neonics contaminate water, harm wildlife, and enter New Yorkers' bodies. While more information on neonics' full range of environmental impacts continues to come in, New York should act to protect its residents against these known harms by imposing a moratorium on other outdoor neonic uses.
- **Addressing Systemic Insecticides**—Neonics are relatively recent arrivals on the pesticide market, but new chemicals that may cause similar harms are being developed all the time. New York lawmakers should establish a framework for addressing and regulating these "systemic insecticides" that would empower DEC to take swift protective action if they are found to have the same harmful qualities as neonics.
- **Investing in Better Agricultural Practices, Not Just Replacement Chemicals**—Neonic contamination and its impacts are the result of an agricultural system dominated by large agrochemical corporations that use the full weight of their influence to ensure farming depends on chemical inputs rather than more sustainable methods. While agroecological practices can help break this harmful and expensive chemical dependency, farmers are often at a loss for unbiased pest-control information or may be unable to reduce chemical use because of manufacturers' near-monopoly control of seed markets. New York should invest in researching, publicizing, and incentivizing agroecological best practices that reduce environmental and human health harms while increasing farm profitability. Legislators and regulators should also remove barriers caused by the monopolistic practices of large seed and chemical manufacturers.

ENDNOTES

1 Selina Bruckner et al., *Honey Bee Colony Losses 2018–2019: Preliminary Results*, Bee Informed Partnership, June 19, 2019, https://bit.ly/345qV3b. Lennard Pisa et al., "An Update of the Worldwide Integrated Assessment (WIA) on Systemic Insecticides Part 2: Impacts on Organisms and Ecosystems," *Environmental Science and Pollution Research International* (November 9, 2017), https://bit.ly/2HqqHwB. Simon G. Potts, Vera Imperatriz-Fonseca, and Hien T. Ngo (eds.), *The Assessment Report on Pollinators, Pollination and Food Production*, Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), 2016, https://bit.ly/2MVQJZE.

2 Maria Ospina et al., "Exposure to Neonicotinoid Insecticides in the U.S. General Population: Data From the 2015–2016 National Health and Nutrition Examination Survey," *Environmental Research* 176 (September 2019), https://bit.ly/2YKLjmX. Andria Cimino et al., "Effects of Neonicotinoid Pesticide Exposure on Human Health: A Systematic Review," *Environmental Health Perspectives* 125, no. 2 (February 2017): 155-162, https://bit.ly/2NVA1LR.

3 National Pesticide Information Center, "Imidacloprid: Technical Fact Sheet," https://bit.ly/2QEblaW (accessed December 2, 2019).

4 Larry P. Sheets, "Imidacloprid: A Neonicotinoid Insecticide," in *Hayes' Handbook of Pesticide Toxicology*, 3rd ed. (Cambridge, MA: Academic Press, 2010), 2055-2064, https://bit.ly/2lBYN6o.

5 Pisa, "Update of the WIA Part 2." Daniel Kenna et al., "Pesticide Exposure Affects Flight Dynamics and Reduces Flight Endurance in Bumblebees," *Ecology and Evolution* 9, no. 10 (May 2019): 5637-5650, https://bit.ly/2XAQpDm.

6 *See* J. M. Bonmatin et al., "Environmental Fate and Exposure; Neonicotinoids and Fipronil," *Environmental Science and Pollution Research International* 22, no. 1 (2015): 35-67, https://bit.ly/2OAwrCK.

7 Pisa, "Update of the WIA Part 2." Michael DiBartolomeis et al., "An Assessment of Acute Insecticide Toxicity Loading (AITL) of Chemical Pesticides Used on Agricultural Land in the United States," *PLoS One* (August 6, 2019), https://bit.ly/2Yr4Xc7. Alex Morris, "What Is Killing America's Bees and What Does It Mean for Us?" *Rolling Stone*, August 18, 2015, https://bit.ly/2HbC4bE.

8 *See, e.g.*, European Food Safety Authority, *Conclusion on the Peer Review of the Pesticide Risk Assessment for Bees for the Active Substance Thiamethoxam*, March 14, 2013, p. 9, https://bit.ly/2lR7Xfo (listing the acute oral honeybee "LD50"—the dose of imidacloprid expected to kill half a population of exposed honeybees when ingested—as 0.005 µg per bee). U.S. Environmental Protection Agency (hereinafter EPA), "Amended Label to Increase Soybean Rates + Supplemental Label for Soybean Cruiser® Insecticide," amended and approved February 23, 2009, https://bit.ly/2kGCgW3 (allowing up to 1.25 mg of thiamethoxam per corn seed). EPA, "Registration for Imidacloprid (NTN 33893)," March 10, 1994, p. 7, https://bit.ly/2K36Bbl (listing the honeybee LD50 as 0.0039 µg per bee). EPA, pesticide label for Gaucho 600 Flowable, p. 5, https://bit.ly/34FL8x2 (allowing up to 1.34 mg of imidacloprid per corn seed).

9 DiBartolomeis, "Assessment of Acute Insecticide Toxicity Loading."

10 *See* Giorio, "An Update of the Worldwide Integrated Assessment (WIA) on Systemic Insecticides Part 1: New Molecules, Metabolism, Fate, and Transport," *Environmental Science and Pollution Research International* (July 15, 2017), https://bit.ly/2qVqciQ.

11 EPA, "Aquatic Life Benchmarks and Ecological Risk Assessments for Registered Pesticides," https://bit.ly/2zY0SxV (accessed December 2, 2019). European Chemical Industry Council (Cefic), "Measuring Low Concentrations," https://bit.ly/2BYj239 (accessed December 2, 2019).

12 Margaret R. Douglas and John F. Tooker, "Large-Scale Deployment of Seed Treatments Has Driven Rapid Increase in Use of Neonicotinoid Insecticides and Preemptive Pest Management in U.S. Field Crops," *Environmental Science Technology* 49, no. 8 (March 20, 2015): 5088-5097, https://bit.ly/35i3Z14. Michelle Hladik and Dana Kolpin, "First National-Scale Reconnaissance of Neonicotinoid Insecticides in Streams Across the USA," *Environmental Chemistry* 13, no. 1 (August 18, 2015): 12-20, https://bit.ly/31Mse6o. Thomas Wood and Dave Goulson, "The Environmental Risks of Neonicotinoid Pesticides: A Review of the Evidence Post 2013," *Environmental Science and Pollution Research International* 24, no. 21 (June 2017): 17285–17325, https://bit.ly/2Hpn8T5.

13 New York State Department of Environmental Conservation, "Registration of Five New Pesticide Products Containing the New Active Ingredient Imidacloprid," March 24, 1995, https://bit.ly/2lE5ZyQ.

14 Pierre Mineau, *Impacts of Neonics in New York Water: Their Use and Threats to the State's Aquatic Ecosystems,* Pierre Mineau Consulting, 2019, p. 9, https://on.nrdc.org/2lXsO0O. *See also* Pierre Mineau, *An Assessment of Neonicotinoid Insecticides With Emphasis on New York: Use, Contamination, Impacts on Aquatic Systems, and Agronomic Aspects*, Pierre Mineau Consulting, 2019, p. 49, https://on.nrdc.org/2kVTgI3.

15 New York State Department of Environmental Conservation (hereinafter NY DEC), "Denial of Applications to Register the New Active Ingredient Dinotefuran Contained in the Pesticide Products Safari 20 SG Insecticide (EPA Reg. No. 33657-16-59639), Venom 20 SG Insecticide (EPA Reg. No. 33657-17-59639) and Venom Insecticide (EPA Reg. No. 59639-135)," January 7, 2008, https://bit.ly/2qWrYAk. NY DEC, "Denial of Application for Registration of Four New Pesticide Products, ARENA 50 WDG Insecticide (EPA Reg. No. 66330-40), CLUTCH 50 WDG Insecticide (EPA Reg. No. 66330-40), CELERO 16 WSG Insecticide (EPA Reg. No. 66330-52), and ARENA 0.5 G Insecticide (EPA Reg. No. 66330-53), Which Contain the New Active Ingredient Clothianidin," July 17, 2007, https://bit.ly/2Ipnfkt.

16 NY DEC, Imidacloprid Registration, 1995; NY DEC, "Registration of Actara (EPA Reg. No. 100-938), Platinum (EPA Reg. No. 100- 939), Flagship 25 WG (EPA Reg. No. 100-955), Flagship 0.22G (EPA Reg. No. 100-960), Endigo ZC (EPA Reg. No. 100-1276) and Platinum 75 SG (EPA Reg. No. 100-1291) Which Represent a Major Change in Labeling for the Active Ingredient Thiamethoxam," March 16, 2010.

17 Mineau, *Impacts of Neonics*.

18 Ibid.

19 The EPA excludes neonic-treated plant seeds from federal pesticide regulation under its "treated article" exemption. *See* Bret Adee et al., "Citizen Petition to the U.S. Environmental Protection Agency Seeking Rulemaking or a Formal Agency Interpretation for Plant Seeds Coated With Systemic Insecticides," April 26, 2017, https://bit.ly/2lYNyVZ. 40 C.F.R. § 152.25. While no similar exemption exists in New York law, DEC, in practice, treats neonic-treated seeds as exempt from normal state pesticide regulation.

20 Giorio, "Update of the Worldwide Assessment 1." Pisa, "Update of the WIA Part 2." Wood and Goulson, "The Environmental Risks." Scott H. McArt et al., "High Pesticide Risk to Honey Bees Despite Low Focal Crop Pollen Collection During Pollination of a Mass Blooming Crop," *Scientific Reports* 7 (April 19, 2017): 46554, https://go.nature.com/2Ir0o9Y. Daniel Cressey, "Largest-Ever Study of Controversial Pesticides Finds Harm to Bees," *Nature,* June 29, 2017, https://go.nature.com/2sgJjDk. B. A. Woodcock et al., "Country-Specific Effects of Neonicotinoid Pesticides on Honey Bees and Wild Bees," *Science* 356, no. 6345 (June 2017): 1393-1395, https://bit.ly/2lFOAG0. ("These field results confirm that neonicotinoids negatively affect pollinator health under realistic agricultural conditions.")

21 See Bee Informed Partnership, "Colony Loss Map," https://bit.ly/2HpheoW, and select "Annual" under the "Season" menu (accessed December 2, 2019). U.S. Fish and Wildlife Service, "Rusty Patched Bumble Bee *(Bombus affinis)*" https://bit.ly/2Y9Zrax (accessed December 2, 2019).

22 New York State Department of Environmental Conservation and New York Department of Agriculture and Markets, "New York State Pollinator Protection Plan Update," June 2018, p. 8.

23 Jeff Ollerton et al., "How Many Flowering Plants Are Pollinated by Animals?" *Oikos* 120, no. 3 (March 2011): 321-326, https://bit.ly/2qPVSts.

24 EPA, *Preliminary Bee Risk Assessment to Support the Registration Review of Clothianidin and Thiamethoxam*, January 5, 2017, pp. 14-23, https://bit.ly/2jfMFon (finding risks to bees likely for thiamethoxam used on berries, stone fruits [e.g., peaches], cucurbit vegetables [e.g., cucumbers], cotton, and citrus fruits, with screening level risks for numerous other crops identified). EPA, *Preliminary Pollinator Assessment to Support the Registration Review of Imidacloprid*, January 6, 2016, pp. 20-22, https://bit.ly/2kj3tbO (finding risks to pollinators indicated for imidacloprid uses on cotton and citrus fruits, with screening level risks for numerous other crops identified). European Food Safety Agency, "Q&A: Conclusions on Neonicotinoids 2018," February 28, 2018, https://bit.ly/2jsXsdN. Pest Management Regulatory Agency, "Re-evaluation Decision RVD2019-06, Imidacloprid and Its Associated End-use Products: Pollinator Re-evaluation," April 11, 2019, https://bit.ly/32nRboB.

25 Brooke Jarvis, "The Insect Apocalypse Is Here," *New York Times Magazine*, November 27, 2018, https://nyti.ms/2Aq0jMX. DiBartolomeis, "Assessment of Acute Insecticide Toxicity Loading." Stephen Leahy, "Insect 'Apocalypse' in U.S. Driven by 50x Increase in Toxic Pesticides," *National Geographic*, August 6, 2019, https://on.natgeo.com/32WNuXv. Pisa, "Update of the WIA Part 2."

26 Matthew L. Forister et al., "Increasing Neonicotinoid Use and the Declining Butterfly Fauna of Lowland California," *Biology Letters* 12, no. 8 (August 1, 2016), https://bit.ly/2XrSVM9. Andre Gillburn et al., "Are Neonicotinoid Insecticides Driving Declines of Widespread Butterflies?" *PeerJ* 3, e1402 (November 24, 2015), https://bit.ly/1lGvH0y. Penelope R. Whitehorn et al., "Larval Exposure to the Neonicotinoid Imidacloprid Impacts Adult Size in the Farmland Butterfly Pieris Brassicae," *PeerJ* 6, e4772 (May 18, 2018), https://bit.ly/2raBzY8. Jacob Pecenka and Jonathan Lundgren, "Non-target Effects of Clothianidin on Monarch Butterflies," *The Science of Nature* 102, no. 3-4 (April 2015), https://bit.ly/2O043g4. Kate Basley and Dave Goulson, "Effects of Field-Relevant Concentrations of Clothianidin on Larval Development of the Butterfly *Polyommatus icarus* (Lepidoptera, Lycaenidae)," *Environmental Science and Technology* 52, no. 7 (April 3, 2018): 3990-3996, https://bit.ly/2OpIgxq.

27 Pisa, "Update of the Worldwide Assessment Part 2." D. Susan Willis Chan et al., "Assessment of Risk to Hoary Squash Bees (Peponapis Pruinosa) and Other Ground-Nesting Bees from Systemic Insecticides in Agricultural Soil," *Scientific Reports* 9, no. 11870 (August 14, 2019), https://go.nature.com/2RSxvGW.

28 Anne Raver, "To Feed the Birds, First Feed the Bugs," *New York Times,* March 6, 2008, https://nyti.ms/2WnMKbj. Douglas W. Tallamy, *Bringing Nature Home: How Native Plants Sustain Wildlife in Our Gardens* (Portland, OR: Timber Press, 2007). "Insect-Eating Birds Consume 400–500 Million Metric Tons of Prey Annually," *Science News*, July 10, 2018, https://bit.ly/2khHYO5.

29 Caspar A. Hallmann et al., "Declines in Insectivorous Birds Are Associated With High Neonicotinoid Concentrations," *Nature*, July 17, 2014, https://go.nature.com/2pBJayo. David Gibbons et al., "A Review of the Direct and Indirect Effects of Neonicotinoids and Fipronil on Vertebrate Wildlife," *Environmental Science and Pollution Research* 22, no. 1 (January 2015): 103-118, https://bit.ly/2OpI6rK. Jason Bittel, "Second Silent Spring? Bird Declines Linked to Popular Pesticides," *National Geographic*, July 9, 2014, https://on.natgeo.com/2QCbPhV.

30 Laurianne Geffroy, "Where Have all the Farmland Birds Gone?" *CNRS News*, March 21, 2018, https://bit.ly/2GcNCL4. Kenneth V. Rosenberg et al., "Decline of the North American Avifauna," *Science*, September 19, 2019, https://bit.ly/2kvsV3o. *See also* R. L. Stanton, C. A. Morrissey, and R. G. Clark, "Analysis of Trends and Agricultural Drivers of Farmland Bird Declines in North America: A Review," *Agriculture, Ecosystems and Environment* 254 (February 2018): 244-254, https://bit.ly/2ko5JE0.

31 Ibid.

32 Pierre Mineau and Cynthia Palmer, *The Impact of the Nation's Most Widely Used Insecticides on Birds*, American Bird Conservancy, March 2013, p. 3, https://bit.ly/1jmQ7u0.

33 Ana Lopez-Antia et al., "Imidacloprid-Treated Seed Ingestion Has Lethal Effect on Adult Partridges and Reduces Both Breeding Investment and Offspring Immunity," *Environmental Research* 136 (January 2015): 97-107, https://bit.ly/2kwUdWS. Margaret L. Eng et al., "A Neonicotinoid Insecticide Reduces Fueling and Delays Migration in Songbirds," *Science* 365, no. 6458 (September 2019): 1177-1180, https://bit.ly/2kGS1MA. Margaret L. Eng, Bridget J. M. Stutchbury, and Christy A. Morrissey, "Imidacloprid and Chlorpyrifos Insecticides Impair Migratory Ability in a Seed-Eating Songbird," *Scientific Reports* 7, (November 2017), https://go.nature.com/2QEWHA6.

34 U.S. Department of Agriculture, "Corn Acres: United States," https://bit.ly/2kwMecn (accessed December 2, 2019). USDA, "Soybean Acres: United States," https://bit.ly/2lynS2m (accessed December 2, 2019). Charlotte Roy et al., "Neonicotinoids on the Landscape: Evaluating Avian Exposure to Treated Seeds in Agricultural Landscapes," Minnesota Department of Natural Resources & Wildlife Restoration, https://bit.ly/337ENZK (accessed December 2, 2019) (documenting exposed neonic-treated seed in 25 percent of 48 fields sampled, and reporting that ring-necked pheasants, Canada geese, American crows, various species of sparrows, and blackbirds, as well as white-tailed deer, rodents, rabbits, and raccoons, were all observed eating the seeds). Ana Lopez-Antia et al., "Risk Assessment of Pesticide Seed Treatment for Farmland Birds Using Refined Field Data," *Journal of Applied Ecology* 53, no. 5 (October 2016): 1373-1381, https://bit.ly/2m0Z5Ef.

35 Pierre Mineau and Carolyn Callaghan, *Neonicotinoid Insecticides and Bats: An Assessment of the Direct and Indirect Risks*, Canadian Wildlife Federation, 2018, https://bit.ly/2kSfs5K.

36 E. H. Berheim et al., "Effects of Neonicotinoid Insecticides on Physiology and Reproductive Characteristics of Captive Female and Fawn White-Tailed Deer," *Scientific Reports* 9, no. 1 (March 14, 2019): 4534, https://go.nature.com/2Q1I9Zf.

37 Ibid. Jim Daley, "As Pesticide Turns Up in More Places, Safety Concerns Mount," *Scientific American*, April 30, 2019, https://bit.ly/2CVTQL5.

38 Hladik and Kolpin, "First National-Scale Reconnaissance."

39 Mineau, *Impacts of Neonics*, at p. 1.

40 Ibid.

41 Ibid., p. 11, Table 7.

42 Ibid., p. 15. Anne Secord and Kathleen Patnode, *Pilot Study to Evaluate Neonicotinoid Pesticides in New York and Pennsylvania Streams*, U.S. Fish and Wildlife Service, November 2018, p. 16, https://bit.ly/2Gc2CYl (finding neonics "in streams in New York and Pennsylvania in excess of toxicity and regulatory thresholds," which "may bioaccumulate in aquatic organisms").

43 Ibid.

44 Masumi Yamamuro et al., "Neonicotinoids Disrupt Aquatic Food Webs and Decrease Fishery Yields," *Science* 366, no. 6465 (November 1, 2019): 620-623, https://bit.ly/34rKCSG.

45 *See* Mineau, *Impacts of Neonics*, at p. 10-12.

46 *See* Office of the New York State Comptroller, "Fishing, Hunting, and Trapping in New York State," December 2015, p. 1, https://bit.ly/2Qz3Kus. Audubon, "Ecotourism: Bird Watching Is Big Business in New York!" https://bit.ly/35dQOOD (accessed December 2, 2019).

47 Mineau, *Impacts of Neonics*, at p. 10-12.

48 Ibid., p. 1-2, 11. Christy A. Morrissey et al., "Neonicotinoid Contamination of Global Surface Waters and Associated Risk to Aquatic Invertebrates: A Review," *Environment International* 74 (January 2015): 291-303, https://bit.ly/2GGLTch.

49 Mineau, *Impacts of Neonics*, at p. 9.

50 Cimino et al., "Effects of Neonicotinoid Pesticide Exposure."

51 Ibid.

52 Ospina et al., "Exposure to Neonicotinoid Insecticides."

53 Ibid.

54 Go Ichikawa et al., "LC-ESI/MS/MS Analysis of Neonicotinoids in Urine of Very Low Birth Weight Infants at Birth," *PLoS One* 14, no. 7 (July 1, 2019), https://bit.ly/32XvmvP.

55 Olga Naidenko, "Neonic Pesticides: Banned in Europe, Common on U.S. Produce, Lethal to Bees," Environmental Working Group, July 26, 2018, https://bit.ly/2EejbSx. Friends of the Earth, "Toxic Secret: Pesticides Uncovered in Store Brand Cereal, Beans, Produce," http://bit.ly/2llE26V (accessed May 31, 2019).

56 Kathryn L. Klarich Wong et al., "Chlorinated Byproducts of Neonicotinoids and Their Metabolites: An Unrecognized Human Exposure Potential?" *Environmental Science and Technology Letters* 6, no. 2 (January 2019): 98-105, https://bit.ly/2sZnydm.

57 Kathryn L. Klarich et al., "Occurrence of Neonicotinoid Insecticides in Finished Drinking Water and Fate During Drinking Water Treatment," *Environmental Science and Technology Letters* 4 (April 2017): 168-173, https://bit.ly/2PMRunk. Tamanna Sultana et al., "Neonicotinoid Pesticides in Drinking Water in Agricultural Regions in Southern Ontario, Canada," *Chemosphere* 202 (July 2018): 506-513, http://bit.ly/2JZawXI.

58 Mineau, *An Assessement of Neonicotinoid Insecticides,* at p. 49.

59 John F. Tooker, "Why It's Time to Curb Widespread Use of Neonicotinoid Pesticides," *The Conversation*, June 26, 2018, https://bit.ly/2tthWc4.

60 Purdue University Extension et al., "The Effectiveness of Neonicotinoid Seed Treatments in Soybean," December 2015, https://bit.ly/2Nmq4Em. Adam Alford and Christian Krupke, "Translocation of the Neonicotinoid Seed Treatment Clothianidin in Maize," *PLoS ONE* 12, no. 3 (March 10, 2017): e0186527, https://bit.ly/2xZtEgS.

61 Spyridon Mourtzinis et al., "Neonicotinoid Seed Treatments of Soybean Provide Negligible Benefits to US Farmers," *Scientific Reports* 9 (September 9, 2019), https://go.nature.com/2kylh8v. Christian Krupke et al., "Planting of Neonicotinoid-Treated Maize Poses Risks for Honey Bees and Other Non-Target Organisms Over a Wide Area Without Consistent Crop Yield Benefit," *Journal of Applied Ecology* 54, no. 5 (May 22, 2017), https://bit.ly/2D4pVRg. Purdue, The Effectiveness of Neonicotinoid Seed Treatments." Sara LaJeunesse, "Insecticides Foster 'Toxic' Slugs, Reduce Crop Yields," *Penn State News*, December 4, 2014, https://bit.ly/2lTbkT5. Margaret Douglas et al., "Neonicotinoid Insecticide Travels Through a Soil Food Chain, Disrupting Biological Control of Non-Target Pests and Decreasing Soya Bean Yield," *Journal of Applied Ecology* 52, no. 1 (February 2015): 250-260, https://bit.ly/2IRr4MF.

62 Christian Krupke, "Written Testimony Regarding N.J. Senate Bill 2288," June 6, 2019, p. 3, https://on.nrdc.org/2kJYmqT. Dave Goulson, "Pesticides Linked to Bird Declines," *Nature* 511, no. 7509 (July 2014): 295-296, https://go.nature.com/2rNOZcK.

63 Purdue University, "Don't Just Spray—Survey," https://on.nrdc.org/2m0a9Bt (accessed December 2, 2019).

64 Rui Catarino et al., "Bee Pollination Outperforms Pesticides for Oilseed Crop Production and Profitability," *Proceedings of the Royal Society B* 286, no. 1912 (October 2019), https://bit.ly/2OUw0Xu. Dara A. Stanley et al., "Neonicotinoid Pesticide Exposure Impairs Crop Pollination Services Provided by Bumblebees," *Nature* 528, no. 7583 (November 2015): 548-550, https://bit.ly/2qnhWLW.

65 Claire LaCanne and Jonathan Lundgren, "Regenerative Agriculture: Merging Farming and Natural Resource Conservation Profitably," *PeerJ* 6, e4428 (February 2018), https://bit.ly/2YNxiop.

66 *See, e.g.,* BioAdvanced, *All-In-One Rose & Flower Care Granules,* https://bit.ly/2lyKOys (accessed November 20, 2019).

67 *See* Jennifer Hopwood et al., *How Neonicotinoids Can Kill Bees (2nd ed.)*, Xerces Society for Invertebrate Conservation, 2016, pp. 49, 53, https://bit.ly/36fqOn7.

68 *See* Mourtzinis et al., "Neonicotinoid Seed Treatments." Krupke, "Written Testimony," at 6-7 ("[The] available data suggest that in most cases, no replacement would be necessary to ensure production of corn and soybean crops if [neonic seed treatments] were eliminated").

69 *See, e.g.*, Purdue University, "Don't Just Spray."

70 Hervé Jactel et al., "Alternatives to Neonicotinoids," *Environment International* 129 (August 2019): 423-429, https://bit.ly/2D01vrN.

71 *See* 7 C.F.R. § 205.601 et seq. (listing pesticides allowed for use in organic crop production); 40 C.F.R. § 152.25(f).

72 *See, e.g.,* Strategist Editors, "The Best (Nontoxic) Pesticides and Insecticides, According to Gardeners," Slate.com, May 28, 2019, https://bit.ly/2Z9GlAx.

73 *See, e.g.,* Tess Stynes, "Scotts Miracle-Gro to Remove Certain Insecticides From Ortho Products," *Wall Street Journal,* April 12, 2016, https://on.wsj.com/2wzIvxl.

74 European Commission, "Protecting Bees: EU Set to Completely Ban Outdoor Use of Pesticides Harmful to Bees," *Daily News*, April 27, 2018, https://bit.ly/2HwtNee.

75 CBC Radio, *"Canada Bans Neonic Pesticides Implicated in Bee Declines,"* August 17, 2018, https://bit.ly/2nPgU6S.

76 Henry Samuel, "France Becomes First Country in Europe to Ban All Five Pesticides Killing Bees," *The Telegraph*, August 31, 2018, https://bit.ly/2OBMqCu.

77 Steven Bradbury, "Letter to Registrants of Nitroguanidine Neonicotinoid Products: Pollinator Protection Labeling for Nitroguanidine Neonicotinoid Products," EPA Office of Pesticide Programs, August 15, 2013, https://bit.ly/37kUn7n.

78 Bruckner et al., *Honey Bee Colony Losses.*

79 Pat Mooney, *Blocking the Chain: Industrial Food Chain Concentration, Big Data Platforms, and Food Sovereignty Solutions*, ETC Group, October 2018, p. 4, https://bit.ly/2DVGDVl.

80 Tooker, "Why It's Time."

81 Major seed and chemical producers like Monsanto (now owned by Bayer) and Pioneer (now owned by Corteva Agriscience, formerly a unit of DowDuPont) have sales representatives, advisers, and licensed seed dealers located across the country. *See, e.g.,* Monsanto US Ag Products, "Rep & Dealer Locator," https://bit.ly/2klBlPD (accessed November 20, 2019). Pioneer, "Find Your Local Pioneer Team," https://bit.ly/2m20A56 (accessed November 20, 2019).