What Is Killing America's Bees and What Does It Mean for Us?

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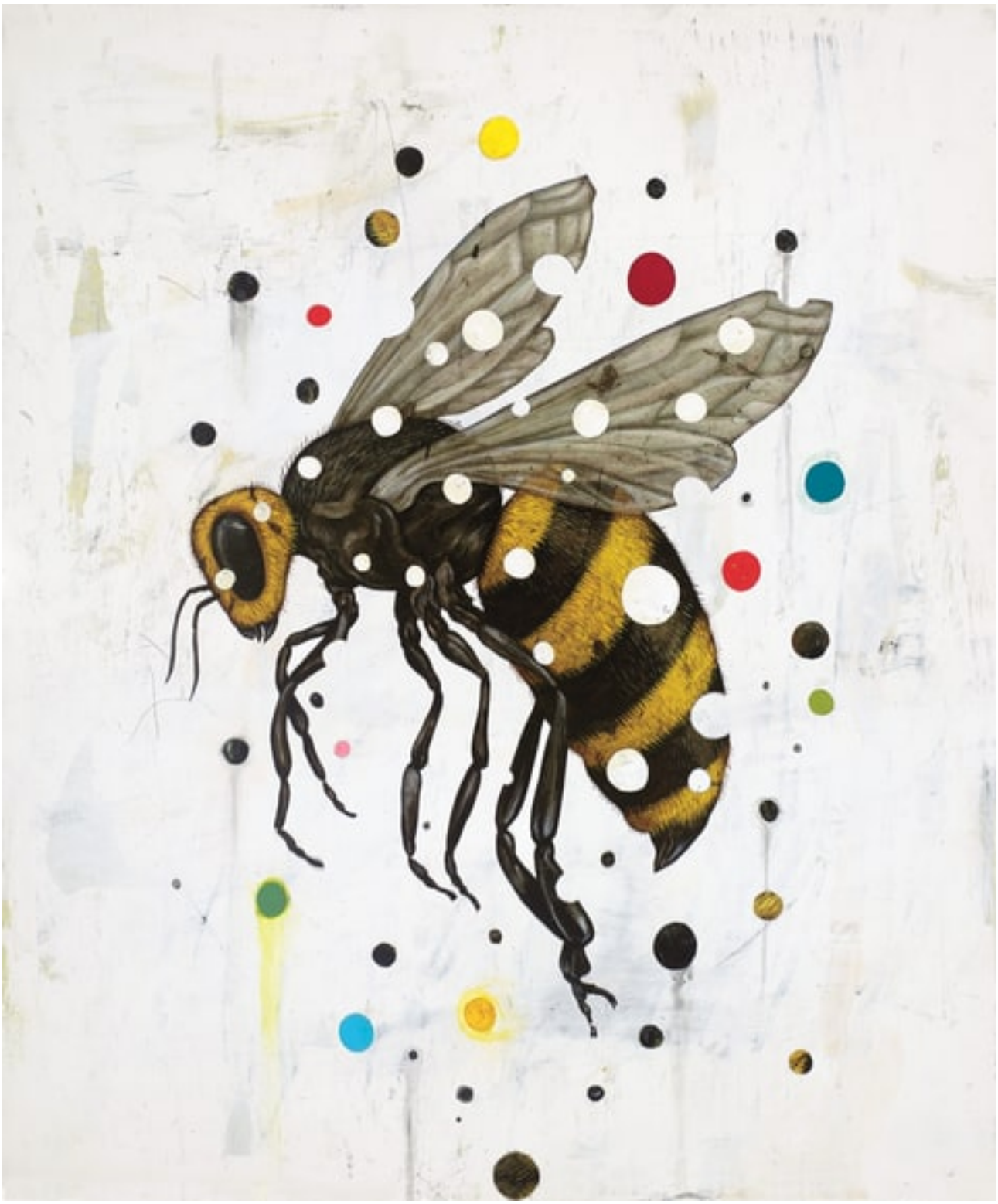


America's vanishing bees may be the "canary in the coal mine" signaling the degradation of the natural world at the hands of man. Illustration by Jason Holley

There was a moment last year when beekeeper Jim Doan was ready to concede defeat. He stood in the kitchen of his rural New York home, holding the phone to his ear. Through the window, he could see the frigid January evening settling on the 112-acre farm he'd just been forced to sell two weeks earlier. On the other end of the line, his wife's voice was matter-of-fact: "Jimmy, I just want to say I'm sorry, but the bees are dead."

By then, Doan was used to taking in bad news. After all, this was long after the summer of 2006, when he had first started noticing that his bees were acting oddly: not laying eggs or going queenless or inexplicably trying to make multiple queens. It was long after the day when he'd gone out to check his bee yard and discovered that of the 5,600 hives he kept at the time, all but 600 were empty. And it was long after he'd learned back in 2007 that he was not alone, that beekeepers all around the country, and even the world, were finding that their bees had not just died but had actually vanished, a phenomenon that was eventually named colony collapse disorder and heralded as proof of the fast-approaching End of Days by evangelicals and environmentalists alike. Theories abounded about what was causing CCD. Were bees, the most hardworking and selfless of creatures, being called up to heaven before the rest of us? Were they victims of a Russian plot? Of cellphone interference? Of UV light? Were they the "canary in the coal mine," as the Obama administration suggested, signaling the degradation of the natural world at the hands of man? Possibly. Probably. No one knew.

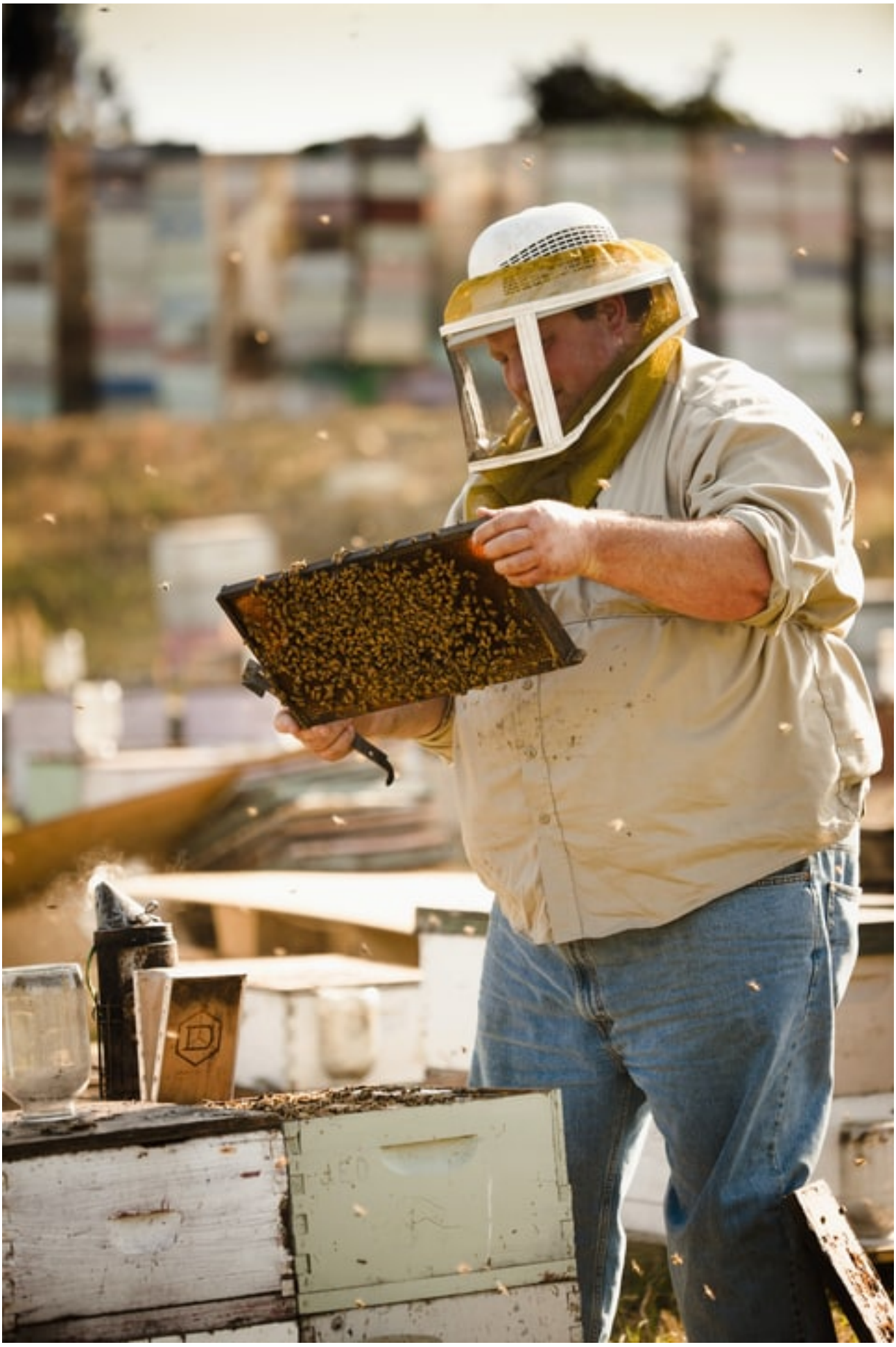
Even to Doan, at the epicenter of the crisis, none of it had made a lick of sense. As a third-generation beekeeper, he and his family had been running bees since the 1950s, and it had been good money; in the 1980s, a thousand hives could earn a beekeeper between $65,000 and $70,000 a year in honey sales alone, not to mention the cash coming in from leasing hives out to farmers to help pollinate their fields. But more than that, it was a way of life that suited Doan. He'd gotten his first hive in 1968, at the age of five, with $15 he'd borrowed from his parents. He paid his way through college with the 150 hives he owned by then, coming home to tend them on the weekends. He was fascinated by the industrious insects. "It's just that they are such interesting creatures to watch on a daily basis," he says. "If you spend any time with bees, you develop a passion for them."

In fact, humans have felt this way about honeybees for millennia. In ancient times, they were thought to be prophetic. Honey gathering is depicted in cave paintings that date back to the Paleolithic Age. The ancient Egyptians floated bees on rafts down the Nile to get them from one crop to another. While honeybees are not native to North America, they were deemed important enough to be packed up by the Pilgrims, and crossed the Atlantic around 1622 (according to Thomas Jefferson, the Native Americans referred to them as "white man's flies"). Today, bees are responsible for one out of every three bites of food you eat and are an agricultural commodity that's been valued at $15 billion annually in the U.S. alone. They are a major workforce with a dogged work ethic — bees from one hive can collect pollen from up to 100,000 flowering plants in a single day, pollinating many of them in the process. Americans wouldn't necessarily starve without them, but our diets would be a lot more bland and a lot less nutritious.

By the time Doan got that call from his wife in January 2014, his hives had dwindled from 5,600 in 2006 to 2,300 in 2008 to a mere 275, most of which he now feared were dead. Even the hives that did survive had to be coaxed and coddled. Rather than finding their own food,

they needed to be fed. Instead of averaging 124 pounds of honey per hive, they averaged nine.

At first, Doan blamed himself. "Before 2006, basically you couldn't do anything wrong," he says. "Very seldom did you lose bees unless you were a really bad beekeeper. If you lost one hive a yard, that was a lot." He racked his brain, trying to figure out what mistakes he might be making. He worried that he was letting his father and grandfather down, that he was letting his son down — even though he knew that other beekeepers were struggling too. Every time a major die-off happened, he tried to regroup, taking the remaining healthy hives, dividing them in two and buying new queens to stock them, but the constant splitting meant that the new colonies were weaker and less established than the ones before. Doan grew more and more depressed. "I was just mentally exhausted," he tells me. "I mean, you have to have bees to be a beekeeper. At that point, I truly thought, 'What's the point of living?' "



A third-generation beekeeper, Jim Doan has seen his hives dwindle from 5,600 to a mere 275. Rob Howard/Corbis

Doan never really considered the possibility that the fault might not be his own until scientists at Penn State who had been testing his bees told him of news coming out of France that pointed the finger at a relatively new class of insecticides called neonicotinoids, or neonics. The first commercially successful neonicotinoid compound was synthesized by agrochemical giant Bayer CropScience in 1985, but it wasn't until the early 2000s that they began to be used extensively. Compared to older, more toxic insecticides, neonics certainly seemed to be a win-win: Though neurotoxins, they mess with insect brains far more than those of mammals, and their application is a breeze. All a farmer need do is sow a seed coated in neonics and the water-soluble chemicals get drawn back up into the plant as it grows. Referred to as systemic insecticides, they spread through the plant, making it resistant to predators. Neonics don't require repeated applications in a hazmat suit. Rain can't wash them away — but then again, neither can your kitchen faucet (unless you're eating strictly organic, you're eating neonicotinoids all the time).

Doan knew his hives had tested positive for the neonicotinoid clothianidin, but the results had seemed dubious because clothianidin wasn't even registered for use in New York state. That's when he learned that neonic-coated seeds weren't subject to the same regulations as sprayed pesticides, meaning that seeds couldn't be treated in New York, but they could be purchased elsewhere and then planted there, with no one the wiser. Furthermore, studies demonstrated that bees exposed to sublethal amounts of these neonicotinoids showed a loss in cognitive functions, including their ability to navigate home.

To Doan, this seemed like a breakthrough — a perfect explanation for why his bees hadn't just been dying, but disappearing altogether. He testified at the Environmental Protection Agency. He testified in front of Congress. He was interviewed for a *Time* magazine article on neonics in 2013, the very same year a report by the European Food Safety Authority showed "high acute risks" to bees from neonics and the European Union issued a ban on the three that are most widely used. Meanwhile, the Saving America's Pollinators Act, a congressional bill introduced in 2013 by Reps. John Conyers and Earl Blumenauer that would have taken neonics off the market until their safety was more definitively proven, never made it out of committee. (The bill was reintroduced this spring, but its fate remains uncertain.)

Doan waited expectantly for the EPA to step in and address the situation: "When I first started learning about this, I'm like, 'Well, the EPA's there to protect us. We don't have to worry about this, because the EPA's here to help.'"But as the years passed and the use of neonics spread, it started to seem that maybe the EPA wasn't there to help beekeepers after all. To Doan, the mystery of colony collapse disorder deepened. He no longer wondered what was killing his bees; he wondered why steps weren't being taken to save them.

In the past decade, neonicotinoid insecticides have gone from little-known chemical compounds to the most commonly used insecticides in the world. Virtually every genetically modified corn seed and at least a third of soybeans that are planted in this country are coated in these toxins. According to conservative estimates, neonics are used on 100 million acres of American farmland, though the real number is probably much higher. More than 90

percent of corn and soybeans grown in the U.S. are genetically modified; they cover an estimated 89 million and 85 million acres, respectively. A 2012 U.S. Department of Agriculture survey found neonics in 30 percent of cauliflower, 22 percent of cherry tomatoes and in more than a fourth of bell peppers. In 2011, the Food and Drug Administration found them in 29 percent of baby food.

Neonics may have come on the scene rapidly, but their adoption is due to forces that have been at play for decades, starting with the Dust Bowl, which cleared the Midwest of many small family farms and left massive tracts of land available to be bought up cheaply. For large farms and corporations, it made the most economic sense to plant huge expanses of only one crop and to maximize the space by clearing the land of any other vegetation, a system known as monoculture. While good for business, monoculture is disastrous for biodiversity, wiping out beneficial species that need more varied habitats and diets, and also creating a smorgasbord for pests that prey on a single crop. (If every plant for miles blooms only two weeks a year, bees have nothing to eat for the other 50.)

Some of these monocultural crops rely on migratory beekeeping, a system in which hives are trucked in to pollinate a crop as it blooms and then hauled over to the next crop when the blooms are gone. Of the roughly 2,000 American beekeepers who own 300 hives or more, about two-thirds are migratory. ("Everybody knows everybody, because there aren't a whole lot of us," Doan says.) It's not a perfect system — an 18-wheeler isn't exactly a bee's natural habitat, after all, and beekeepers expect to lose a handful of their hives due to the stress of all that travel — but it's a system that's been in place in this country for decades, long before colony collapse disorder struck. Up until recently, the bees were all right.

What weren't all right were the crops. Monoculture not only provides a feast for pests, necessitating the use of a whole lot of insecticide, but it is also a perfect petri dish for insects to grow resistance. Genetically modified crops were meant to be less harmful than chemical applications, changing the plant itself to ward off predators. But altering genes can only protect a plant so much. Where modifications were found to be inadequate, neonics were adopted to pick up the slack.

In the face of mass die-offs, Doan waited for the EPA to step in and address the situation. When it didn't, he sued. Ropi/Zuma

Chemical companies have always faced a conundrum: How do you kill the plants you don't want without killing the ones you do, and how do you kill harmful insects without killing beneficial ones? That neonic insecticides can kill honeybees is not up for debate. If an unlucky bee flies into a cloud of dust kicked up when coated seeds are planted, she'll die on the spot. What is contested, however, is the severity of the effects that might arise from tiny, sublethal exposures to neonics over the course of a worker bee's six-week lifespan as she gathers pollen and nectar that is laced with trace amounts — and what happens when she brings this pollen and nectar back to the hive. A 2014 study in the *Journal of Agricultural and Food Chemistry* found that 90 percent of honey tested positive for at least one neonic, and 50 percent contained at least two. It's true that honeybees can metabolize these toxins quickly, but that also makes them difficult to detect. According to a report released in April by the European Academies Science Advisory Council, the effects are cumulative. Like an allergy, the response could get worse with repeated exposure. "It's the perfect crime," says Jeff Anderson, a beekeeper who is on the board of directors of the Pollinator Stewardship Council. "Neonics don't necessarily kill on first exposure — they can kill many months later."

Which has been a hard concept for many beekeepers to wrap their heads around. Doan says that only about 30 percent agree with him that neonics are specifically to blame. "These beekeepers grew up with pesticides where you'd see the damage right away, and they still expect that sort of cause-and-effect relationship," Doan tells me. "People don't look at what happened two months ago as affecting them today."

And the truth of the matter is that the world right now isn't the friendliest place for bees, even with pesticides out of the picture. Since the 1980s, honeybees have been preyed on by a nasty little blood-sucking, disease-spreading mite known as the varroa destructor, and thus have to contend with the miticides beekeepers apply to hives (miticides, mind you, that have the tricky task of killing one bug that literally lives on another). Meanwhile, there's a plethora of new bee pathogens emerging at warp speed, plus ever-shrinking habitats and the aforementioned stresses of a migratory lifestyle. All of which is why entomologists like Dennis vanEngelsdorp, who was part of the group that gave colony collapse disorder its name, caution against assigning just one cause to what is no doubt a complex problem. Certainly, each of these issues exacerbates the others: A hungry, stressed-out bee will be more susceptible to toxins, and eating neonics has been shown to cause bees to eat less. (In fact, a recent study published in *Nature* showed that rather than avoiding neonics, as had been hypothesized, bees actually prefer them — they are related to nicotine, after all.)

> "Bees are tanking, and this has all kinds of consequences for the ecosystem," says one advocate. "And we're doing more studies?"

Despite all these factors, Doan and many others feel strongly that neonicotinoids were the final stressor in a cascade of them, and the one that tipped the scales — and that discussion of other potential causes deflects attention away from neonics, which chemical companies are at pains to do. At the very least, the industry — particularly Bayer and Syngenta, the major manufacturers of neonics — doesn't dispel the confusion. They argue that there are more hives in America now than there were five years ago (which is true, but only because beekeepers constantly have to divide their colonies to make up for losses); that bees are thriving in a sea of neonic-infused canola in Canada ("If someone's pointing you to a study and saying, 'Look, it shows no harm,' you might want to see if it's a canola field," says Lori Ann Burd, the environmental health director at the Center for Biological Diversity. "For whatever reason, honeybees seem to experience significantly less harm in canola fields than in other fields"); and that any study that sees significant harm to bees after neonic dosing had methodological errors or used too high a dose. "The basic principle of toxicology and risk assessment is 'the dose makes the poison,'"says David Fischer, the chief bee researcher at Bayer CropScience. "Or to put it another way, all substances are toxic, but what differentiates a poison from a remedy is the dose."

Industry scientists emphasize that no one cause can explain the bee die-offs. "I don't think that we can deny that if a bee is exposed to a pesticide, there's not stress there," says Jay Overmyer, technical lead of Syngenta's Ecological Risk Assessment. "But it all goes back to the fact that there are multiple stressors, and they all have to be taken into consideration."

To assess how, or how much, neonics affect bees, many look to Europe, where the neonic ban has been in place for almost two years; yet the ban's outcome is still inconclusive, in part because of the persistence of the chemicals. Studies have shown that neonics can persist in the ground for years and that some neonic compounds break down into substances even more toxic than the parent product.

This past January, a task force of 29 independent scientists reported that they had reviewed more than 800 recent, peer-reviewed studies on systemic insecticides and determined that sublethal effects of neonics are very, very bad for bees indeed. But Fischer, the scientist at Bayer — which reportedly made $262 million in sales of the neonic clothianidin in 2009 alone — says that he doesn't see the study as being objective and that Bayer's research shows the opposite."This is an inherent problem because it's very easy to spin these things in a million directions," says Greg Loarie, a staff attorney for Earthjustice. "There are ways in which you can downplay the negative and prejudice the outcome." In fact, the greatest indication of what a study will find is often who is conducting or financing it. (A press contact at Syngenta sent me studies that ostensibly showed that neonics were not harming bees: The first was conducted by Syngenta employees; the second was funded by Bayer.)

Through it all, the loss of honeybees has continued apace, with an average of 30 percent of hives dying every year. Classic cases of CCD — in which the bees literally vanish — are now relatively uncommon. These days, beekeepers often find dead bees in or near the hive, implying that whatever is killing them is doing so acutely — or the colonies slowly dwindle until there is nothing left.

Scientists studying the bee deaths point to a number of factors, but many agree that the rise of neonicotinoid-coated seeds, like the corn kernels above, has contributed to the steep decline in bee populations. Courtesy of Syngenta

Supposedly standing guard between the tiny pollinators and the agrochemical giants is the EPA. It's the EPA's job to parse all this, and if not to fully protect the environment, per se, then at least to make sure that one particular industry doesn't ruin nature to such an extent

that it too drastically hurts the bottom line of others. In 1972, revisions to the Federal Insecticide, Fungicide and Rodenticide Act placed the responsibility on manufacturers to provide the safety data for the products they make, the idea being that American taxpayers should not cover the bill for tests done to products that financially benefit private companies. In practice, what this means is that the studies provided to the EPA when a product is up for approval are, by law, generated and submitted by the manufacturer of that product. Jim Jones, the assistant administrator for the Office of Chemical Safety and Pollution Prevention at the EPA, maintains that compliance monitoring is designed to keep companies honest: "They have to generate the data according to good laboratory practices, and our scientists review this." Loarie, the attorney for Earthjustice, isn't so sure. "I think there are many, many opportunities for the data to be played with," he says.

Also of concern then is the fact that agrochemical companies are not only responsible for reporting how much environmental exposure a pesticide might have, they're likewise responsible for submitting to the EPA's review the lethal dose for non-target organisms — what amount it would take to kill 50 percent of a population. "It's the fox guarding the henhouse," says Ramon Seidler, a former senior research scientist in charge of the GMO Biosafety Research Program at the EPA. "And the fox is the one collecting the eggs and bringing them to the regulators."

Even if the EPA wanted to test a product itself, the agency isn't set up that way. EPA scientists are meant to review studies conducted by others (including independent research), not to conduct studies themselves. It can take the agency two to three years to do a full review of a commercial product. "And with 80,000-some-odd of these chemicals to do?" says Seidler. "My God, it's an impossible task."

For this reason, regulators mainly consider a compound's active ingredient, which, as the entomologist vanEngelsdorp explains, can be problematic. "There is data that the inert ingredients may be having a negative effect on colonies on their own," he says. "Or that in combination with the active ingredient, they're much more toxic than they were before." Nor are regulators generally considering the combinations of multiple insecticides and herbicides sometimes coated on a single seed or how any of this might interact with the other agrochemicals applied to crops, a chemical bath that the program director for the Pollinator Stewardship Council, Michele Colopy, calls "meth in the field."

> "It's the fox guarding the henhouse," says a former EPA research scientist. "It's corporate greed over environmental safety."

"We do look for some obvious interactions, but you can't test for every possible combination of chemicals that might occur out in the real world," says Fischer. Yet it's unclear what the agrochemical companies are testing: Because they contain "proprietary information," the insecticides' nonactive ingredients are not publicly disclosed.

Despite these limitations, many feel that the body of evidence against neonics is strong enough that the EPA should be taking a stand. Which raises certain questions. "Why did the Europeans put a hold on the use of neonicotinoids?" Seidler asks. "And why did the EPA look

at that and stare it right in the face and say, 'No'?" Why is the EPA not restricting neonics when another government agency, the Fish and Wildlife Service, announced that it would phase them out on national wildlife refuges by 2016?

In fact, just three days after the European ban was announced, the USDA/EPA National Stakeholders Conference on Honey Bee Health issued its report in which the potential harm posed by neonics was not mentioned at all in the executive summary. "That really got to me," says Dr. Eric Chivian, founder and former director of the Center for Health and the Global Environment at Harvard Medical School. "There was huge international press attention that the EU banned the most widely used insecticides in the world because of concern about honeybees, and the part of the report most people read doesn't even mention them?" At the EPA/USDA Pollinator Summit in March 2013, less than two months after the EU issued its initial neonic warnings, "Half the speakers were from industry," says Chivian. "It would be as if the Surgeon General held a conference on the dangers of smoking and half the speakers were from Big Tobacco."

No one is saying that what the EPA is tasked with comes easy. "Go after Congress," Seidler says. "They are the ones who are not providing a sufficient budget for the EPA and other regulatory scientists to stay up with industry discoveries." Indeed, the number of laboratories serving the office of the pesticide program at the EPA has dropped from a reported dozen in 1971 to two today, which means it's very difficult for the EPA to keep pace with industry. "It's always a challenge," says the EPA's Jones, who maintains that despite the difficulties, the agency is resourced and operating adequately. But according to Loarie, "They're using 20th-century methodologies to test 21st-century pesticides. The EPA still doesn't appreciate the extent to which systemic pesticides are different."

With their livelihoods in the balance, beekeepers have grown frustrated with the EPA's lack of action. "I've been going to Washington for years working on these issues, basically asking them to do their job, and my experience has been that generally the agencies don't understand, and their approach doesn't get to the heart of the problem," says Zac Browning, a fourth-generation Idaho beekeeper who lost 50 percent of his hives in 2009. "On the ground, we're not seeing results."

What beekeepers are seeing, however, is that chemical companies — and their lobbyists — seem effective at fighting off tougher standards. "The problem is that industry knocks on the door and walks in," says Doan. "Beekeepers knock on the door, and it's like, 'Hold on, we'll see you in a while.' Industry has an open door into the EPA and beekeepers do not."

There has been some effort to address bee mortality. This past May, President Obama unveiled a strategy to promote honeybee health that did not call for a restriction on insecticides, but did request that pollinator habitat be improved by restoring 7 million acres of land and water. "The president is ordering specific action on a bug, you know? This is the first time anything like this has happened," says Burd of the Center for Biological Diversity.

An Oregon State University bee researcher extracts hemolymph, or "bee blood," from a bee at a laboratory in Corvallis, Oregon, on August 5th, 2014. Natalie Behring/Getty

And in April, the EPA announced that it would not approve new outdoor uses of neonicotinoids "until the data on pollinator health have been received and appropriate risk assessments completed." This data involves not just looking at how neonic exposure affects individual bees, but how it affects the whole hive. "To evaluate this, we had to create a completely new test," says Jones. "It just did not exist when these chemicals were first put on the market." But beekeepers and activists question why the agency would continue to allow any use at all if the data they have is, by their own admission, incomplete. "We wouldn't be doing the work if I knew what the answer was," Jones says of the new hive studies.

Then again, the EPA doesn't have to have all the answers. Through its process of "conditional registration," new chemicals can in certain circumstances enter the market before a company has submitted all the tests requested by the EPA. Jones maintains that a conditional approval would never be granted without "reasonable certainty of no harm." Unlike in Europe — which operates under the precautionary principle — chemicals in America are often given the benefit of the doubt. While Seidler is quick to say that the EPA scientists he worked with were "good people, hardworking, rigorous," he did not feel like the work they passed on to the regulatory arm of the agency was appropriately heeded. "They supported our research, they supported us within the agency, they made it very clear that we were doing the right kinds of things that would help the regulators," he says. "But although we provided a lot of documentation, I never became aware that our regulators ever required industry to do any of the things we thought would be relevant for them to do." As to why the industry seems to be running roughshod over regulators, he's more blunt: "It's corporate greed over environmental safety — and I have to live with this knowledge every day."

As Jim Doan delved deeper into the mystery of why his bees were dying, he wasn't surprised to learn of the lengths big conglomerates might go to protect their bottom line and manipulate the system; he was surprised to learn how easily it seemed that the system could be manipulated. After all, bees themselves are an important commodity. It takes 60 percent of all the commercial honeybees in this country just to pollinate the almond crop in California. Pesticides may cut down on losses, but it's pollination that increases yields. And without bees, crops would be devastated — in one province of China where wild bees were eradicated, farmers have been forced to hand-pollinate their apple orchards, a painstaking, highly labor-intensive process. The USDA reports that 10 million beehives have been lost since 2006, at a $2 billion cost to beekeepers (by contrast, in 2009 alone, the sale of neonics brought in $2.6 billion globally). In the past year's tally, hive losses were up to 42 percent, and for the first time ever, more losses were reported in the summer, when bees typically thrive, than the winter. No one knows exactly why.

What is known is that the prophylactic use of pesticides is leading to more insect resistance. Instead of applying insecticides periodically, systemics are present from the moment the plant starts to grow to the moment it's harvested. "It's no different than the repeated use of antibiotics," says Seidler, the former biosafety researcher at the EPA. "If you use the same antibiotic every time you sneeze, you are going to select for a population of antibiotic-resistant bacteria." GMO supporters may claim that fewer insecticides are being used, but

seed coatings aren't included in that tally. "When you count that in, along with other pesticides sprayed at the time of planting, the industry is not using less insecticide," Seidler says. "It's using more. Industry is trying to make the point that our farmers would be in a crisis without using those neonic-coated seeds" — or that they would have to resort to using more toxic chemicals — but the EPA's own recent study showed that growing soybeans without neonics had little or no effect on yields. "Our farmers are paying for something that's not of any benefit," says Seidler.

It's not in the interest of agrochemical companies to modify crops so that they don't require insecticides: These companies make the GM seeds, and they make the chemicals to treat the GM plants once bugs and weeds develop resistance. "These are not purveyors of seeds, per se," says
Seidler. "They are chemical companies, and chemical companies get profits by selling chemicals. So they have an internal conflict of interest. Don't expect them to be using less and less chemicals — that does not fit their business plan."

Of course, any ideology, whether it's capitalism or environmentalism, has the potential to be biased, and when it comes to the plight of the bees, it's tempting to have someone or something to blame. It's possible that in time, neonics could prove to be a limited factor in bee die-offs, a single leak in a sinking ship, as entomologist May Berenbaum has put it. But right now, the best that can be said of these chemicals is that we are pumping toxins into our environment without understanding exactly what implications they have. "If you take your car to 10 mechanics, and eight tell you that you urgently need to replace your brakes, are you really going to wait for two more to call you back?" asks Burd. "Our pollinators are tanking, and this has all kinds of consequences for humans and the ecosystem. And we're going to do more studies?"

Indeed, bees are not the only stakeholders in determining the non-target effects of neonics. They are what's referred to as an "indicator species": They provide a glimpse into broader environmental impacts, and because commercial honeybees are economic commodities, we pay attention to them in a way we don't to other insects. Yet if honeybees are suffering, native pollinators are suffering too. In a study published in *Nature* this past April, honeybee populations exposed to field-realistic doses of neonics were not harmed in the short term, but wild-bee density was reduced by half, indicating that they are especially vulnerable. Other studies show that neonics are affecting earthworms, amphibians and a plethora of species at the bottom of the food chain. The chemicals have also shown up in water sources throughout the Midwest, and at levels known to be toxic to aquatic organisms if exposed over an extended time. A 2013 report done by the American Bird Conservancy found that a single neonic corn kernel can kill a songbird.

What harm, if any, they may pose to humans in the long term is unknown. "We don't have data on neonicotinoids in our bodies because they're not included in the panel of pesticides that the CDC's biomonitoring program evaluates," says Melissa Perry, president of the American College of Epidemiology and chair of the Department of Environmental and Occupational Health at the Milken Institute School of Public Health at George Washington University. "These compounds have come on the market so rapidly that they've outstripped scientific readiness."

Perry's research team recently completed a review of all the studies published in English globally on the health effects of neonics on humans and found, to its surprise, that there were only seven. Four looked at acute effects — poisonings — and only three at chronic exposure. Of those three, all of them found adverse effects on children. "There were cases of congenital abnormality, associations with suggestion of autism, associations with suggestion of heart defects, birth defects," says Perry. Nevertheless, she counsels against using three studies to draw any major conclusions. "The status of the literature is so deficient that we know practically nothing," she says. What we do know is that some neonics have been shown in rodents to cross the placenta, which has raised concerns that if a pregnant woman ingests the toxins, the developing fetus' brain could be exposed. "I certainly have spent well over 20 years of my career having to play catch-up on the next chemical," says Perry. "Do we have to allow decades to elapse before we come to the conclusion that this is the wrong decision?" And if it is, will it be too late to repair the damage? Destroy the bottom of the food chain, and what eventually happens at the top?

When Jim Doan got down to Florida, where his wife had taken their 275 hives to wait out the cold New York winter, he surveyed the colonies she had given up for dead and found that some of them could be salvaged. Sure, they were ailing, but there was enough life left in them that he thought he'd give beekeeping one last shot. He made a pact with himself that from that moment, his bees would never return home, that he'd keep them away from neonicotinoid pesticides no matter what. He researched places where he could put them, places away from corn and other major GM crops, places where his bees could roam freely and mainly encounter crops that were neonic-free or organic. He leased some land in Amish country, found some safe havens in Florida. "We're never going to get 100 percent away from chemicals, because they're out here. They're in the water," Doan says. "But we can at least reduce the amount of susceptibility." Since making this plan, he says, he has been able to grow his hives up to 1,100 and has not yet experienced a serious die-off.

In 2013, he joined a collection of beekeepers who are suing the EPA, not for money, but for regulation. "When you go to the EPA and talk to them, they say, 'Well, if you don't like our decisions, then sue us.' So you have to sue them," he says. In questioning the EPA's conditional registration of the neonic clothianidin, the suit not only alleges that the agency has not met its own criteria for granting approval, but also challenges its approval process overall. Two years in, it's still in its initial stages of litigation and may not be decided for years.

Meanwhile, plans are being made for a time when perhaps bees won't be around. Scientists at Harvard have tried to make a robotic bee, while agrochemical companies are trying to develop a GM one, resistant to pesticides in the same way GM crops are meant to be resistant to herbicides. They are also touting the benefits of flupyradifurone, a new systemic pesticide that's supposed to be safer for bees because it's even more toxic, the idea being that if it kills a bee on the spot, then that bee won't transport the toxin back to the hive. But, as Doan sees it, it's not bees that will go extinct first, it's commercial beekeepers.

"I didn't want to be the person that failed three generations of Doans keeping bees. I didn't want it to end with me," Doan says. But he knows that he may not have a choice in the matter. "I mean, we want something to pass on, but I'm not sure there's going to be anything to pass on in another year or two. Just empty boxes."