Pollinators, Biodiversity, and Scientific Integrity

Heal the soil to solve the bee problem and biodiversity crisis

by Jonathan Lundgren, Ph.D.

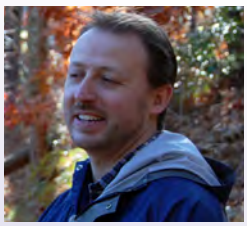
[Eds. note. The following are excerpts of a keynote talk that Jonathan Lundgren, Ph.D., the founder and director of Ecdysis Foundation (www.ecdysis.bio) and Blue Dasher Farm (www.bluedasher.farm) gave to the 34th National Pesticide Forum, Cultivating Community and Environmental Health*, in Portland, Maine, April 16, 2016. The complete talk can be found at http://bit.ly/Lundgren34NPF. The talk was introduced by Paula Dinerstein, Beyond Pesticides board member and senior counsel with Public Employees for Environmental Responsibility (PEER), which represented Dr. Lundgren in a whistleblower case in which he disclosed that the U.S. Department of Agriculture had suppressed his scientific work on pollinators and genetically engineered crops.]*

Introduction –Blowing the whistle with good science

by Paula Dinerstein, senior counsel, Public Employees for Environmental Responsibility (PEER), board member of Beyond Pesticides

I don't believe that Dr. Lundgren set out to be a whistleblower –he set out to do good science, his science came up with some results that upset certain interests in industrial agriculture. His employer, the U.S. Department of Agriculture (USDA), essentially turned against him. Until recently, Dr. Lundgren was a senior research entomologist and lab supervisor with the Agricultural Research Service of USDA in South Dakota. He worked there for 11 years with great success and his research received national and international recognition. However, in April of 2015, he published a study in *The Science of Nature*, which demonstrated that clothianidin, a neonicotinoid insecticide, killed the larvae of monarch butterflies in the laboratory.

Some months later in August, USDA imposed a 14-day punitive suspension on Dr. Lundgren. We believed it was for the trumped-up charges of submitting that study to the journal, and what they called "travel irregularities." There were minor discrepancies on his travel authorizations to address the National Academy of Sciences, and a USDA stakeholder group in Pennsylvania, the No-Till Alliance. Fairly recently, the Obama administration ordered all federal agencies to implement new scientific integrity policies. Dr. Lundgren filed a complaint under the scientific integrity process with USDA, but it was rejected, and we now have a lawsuit challenging certain aspects of that policy. The policy directs scientists not to say anything about their science that could impact policy, which is where Dr. Lundgren got in trouble. If you want to read more about him, there was a cover story in *The Washington Post* weekly magazine about him, entitled, "Was a USDA scientist muzzled because of his bee research?" Dr. Lundgren is no longer with the USDA. He left recently and has begun some very new and exciting endeavors, which he will tell you about. It is my great honor to introduce Dr. Jonathan Lundgren.



First, let me preface this presentation by saying that I frankly would not be here if it was not for PEER. So, I cannot say enough good things about PEER's work in supporting scientists behind the scenes. You don't see a lot of the help for scientists who need it, and, like me, never expected to be in a situation like this. One important aspect of my research program is trying to get at very complex ecological questions underlying how we assess risk reliably within a realistic context. The other aspect of what I do is the development of solutions that can replace the use of pesticides with ecological principles, which probably appeals to a lot of folks in the organic sector, but not exclusively the organic sector.

Pesticide Safety: Are we asking the right questions?

What a great meeting –the 34th National Pesticide Forum, *Cultivating Community and Environmental Health*. This is exactly the kind of meeting that we need to be having. It's not just focused on pesticides as bad for society, but also providing solutions. Because there is either a real or perceived need for these pesticides. Without filling that need with the use of alternative methods, then really we're having a discussion that's not going to lead to solutions.

In 1948, Paul Müller, Ph.D. received the Nobel Prize for Medicine. He discovered a chemical that was cheap to produce, very low in mammalian toxicity, and was blindingly effective at killing insects. This was a game-changer folks. It saved millions of lives. It tipped the balance in our favor because, prior to this, insects had really come to have serious deleterious effects on the human race. Insects had killed more soldiers than bullets or bombs. Until these early insecticides came along, diseases literally turned the tides of war. We started

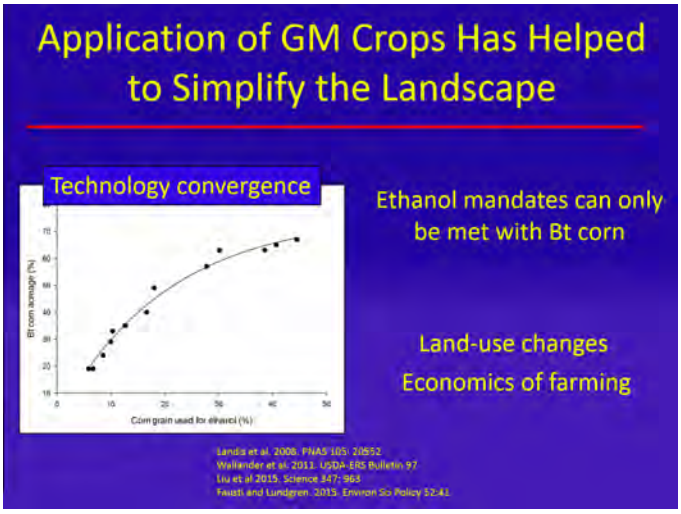
spraying it in our houses. We started spraying it in our wetlands. There was actually a World Health Organization (WHO) sanctioned mosquito eradication program for the entire planet, where we used DDT-like pesticides trying to eradicate mosquitoes from the face of the earth. It did not work by the way. Nevertheless, we used it without thoughts of consequences, because now we had a tool. Farmers no longer had to think about things as far as insect management was concerned. They could simply react as a pest became problematic.

Dr. Lundgren speaking at the 34th National Pesticide Forum in Portland, Maine in April 2016.

But, there *were* concerns. There were problems that started to arise, many of which we are still uncovering today. There are harmful environmental effects. We're still finding DDT and the other organochlorine pesticides in tissue, even within the human population. Our large apex predators were eliminated, some driven to near extinction. Some of these organochlorine pesticides weaken the eggshells of birds, and they bioaccumulate, so they are present at higher densities within some of these large predators. Incidentally, we're starting to see declines again in some of these large raptor populations.

Of course, there were a lot of human health problems, not just cancer, but also birth defects, diabetes, and brain damage –all linked to some of our pesticide uses. To add insult to injury, the pests themselves became resistant to the actual use of these pesticides. Insects are good at that. High reproductive rates, quick adaptability, strong selection pressures within the environment.

Are these chemicals inherently bad? Should Paul Müller have received the Nobel Prize for Medicine? I think it's easy to look back through history and say now we have information that says that there were some serious problems with the use of DDT. At the time, using the best technology of the day and the questions that we were asking suggested that this was a safe chemical. Does that mean that all of these chemicals are inherently bad, or should we presume that there are problems with them and use them as needed, with more of a precautionary approach? No matter what decision we make, there are costs and benefits to everything. Even doing nothing at all has a cost and a benefit. The question is how do we measure these costs and benefits effectively?



Slide: Bt technology has become an integral part of a corn-dominated food production system, which has had consequences on biodiversity, ecosystem functions, and the economics of farming throughout the country.

This is a very important issue because ecological risk assessment is really hard. We are trying to prove a negative, and all it requires is a single example. Switching the question around can reveal that our presumption of safety was erroneous all along. So, we rely on a preponderance of evidence, but the preponderance of evidence is only as strong as the questions that we are asking with our risk assessment. It is only as strong as our technology allows us to measure risks in the environment.

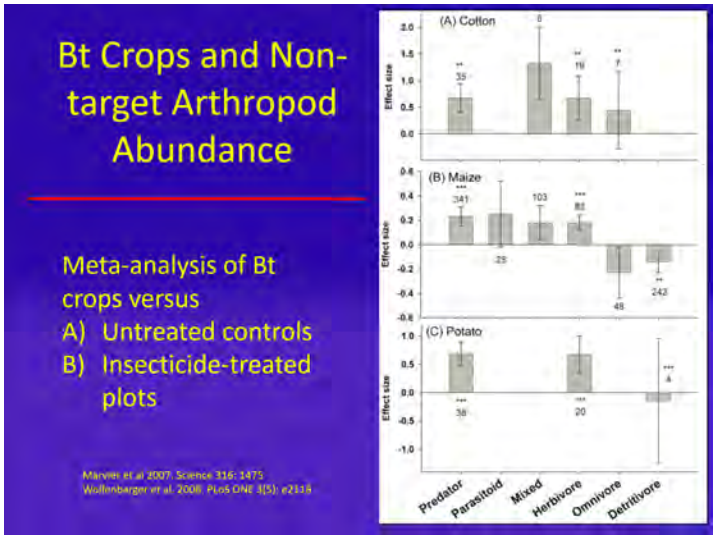
Genetically engineered Bt crops as insecticides

Bt crops raise a great question –do they pose an extraordinary risk to the environment? Bt crops are genetically modified to incorporate a gene from entomopathogen, which is an insect disease that expresses itself from root to pollen. It tends to be fairly specific for particular insect groups, especially key pests of the crop plant itself. This was really a game-changer, in terms of risk assessment and from the environmental standpoint. Whether you love them or hate them, genetically modified crops are here. There is a lot of public interest in ensuring their safety because there's a lot of fear that's associated with them. Should we be genetically manipulating and inserting foreign genes into our food production system?

There is a war being waged on genetic engineering in the public that was driven a lot by the monarch butterfly. Bt crops really represent a paradigm shift back to a prophylactic pest management strategy. For a number of years, after EPA was established, integrated pest management (IPM) emerged, as farmers started to go out into the fields and sample for pest problems, and only use pesticides when they had a problem. With Bt crops, by putting all of the insecticides right in the bag, the farmers no longer had to think about it anymore.

They were investing in a pest management strategy whether or not they needed it. We know that's a bad business decision. If you know you're going to have a pest problem annually, then maybe it's worth the investment. However, this was a slippery slope because it opened the door for a lot more prophylactic pest management.

Risk assessment is only as strong as the questions that we ask. Are pesticidal Bt crops toxic to non-target organisms (non-human)? Do Bt crops reduce the abundance of non-target organisms in the field? Abundance is a proxy for all kinds of different fitness effects. A reduction in abundance could be caused by a reduction in fecundity or reproductive rates, reduced longevity, outright mortality, or it could be biological dispersal. All of these things should be housed within this one proxy of abundance in the field, arguably.



Slide: The baseline is an untreated crop. In nearly all cases, Bt had little effect on non-target arthropod guilds.

We have hundreds of published studies in the system on this. I was actually part of a meta-analysis looking at effects of Bt crops on non-target arthropod abundance in the field. It was done on Bt cotton, Bt corn, and Bt potatoes. We examined different functional groups of insects –predators (lady beetles, parasitoids (largely wasps)), herbivores eating plants, omnivores eating plants and insects, and soil dwellers. Using an untreated control as the baseline year, we found a bunch of studies on the primary parasitoids (beneficial predators) of the European corn borer, which were eliminated with the Bt corn. There's a general borer reduction, but none of it is significant, except for predators in cotton. In potatoes, you can actually see an increase in some of these pressures.

We also studied the insecticides because there's a cost and a benefit to every decision. If Bt is not used, then it's possible that insecticides would be used to replace it. What we find is that, in this case, Bt crops are almost always better than the insecticides that they're supposed to be replacing, except for, oddly enough, omnivores and detritivores (such as earthworms, which eat decomposing plants and animals). *Collembola*, little springtails, which are jumping around in the soil, are actually reduced more in corn systems by the Bt than by insecticide use. [*Collembola* contribute to soil health, aid in plant update of soil nutrients, and control fungal diseases.]

Suppression of science on Bt effects

Based on the available data, Bt crops seem to have a minimal toxicological effect on non-target organisms in the laboratory as well. But, I qualify that by attaching the caveat 'based on the available data' because there are studies that have been suppressed that show an adverse effect. In fact, I wrote one of them. So, of the published literature, is there a file drawer of effects based on what these meta-analyses may not be capturing? It's very possible. Is toxicology the risk that we're worried about? There are some exceptions. Specialist natural enemies, such as parasitoid wasps –which are actually the most diverse group of animals on the planet Earth– instead of stinging people, use their stingers to lay eggs inside other insects.

The claim that Bt crops have reduced insecticide use has been debunked. This is true, not because Bt crops require additional insecticide use, but because the paradigm shift to prophylactic pest management led to an increase in marketing and sales of other insecticides that became necessary with this approach. We actually see that neonicotinoids are now used on the majority of cropland acres. In corn, soybean, and cotton plantings, we are seeing a rise in insecticide use. Data from the National Agricultural Statistics Service does not capture this because it is not including the seeds treated with insecticides as well as some other chemicals.

Bt crops have been associated with the simplification of our land use, of our food production system. The ethanol mandates that were put forward in 2007 necessitate a certain quantity of ethanol be produced by plants. Corn is the only realistic source of this ethanol, so it has artificially increased the value of corn and resulted in more farmers abandoning other crop management strategies to focus exclusively on corn, as well as increasing corn acreage and taking non-crop habitat and planting it with corn. That's only possible with Bt corn because you can only plant corn, after corn, after corn, otherwise the pests just overcome you.

So the question is, "Are Bt crops safe?" We're asking the question, "Are Bt crops toxic?" The answer is probably no. Should we be asking the question, "Has Bt crops changed the natural environment in which we're living and increased our exposure to other insecticides?" Perhaps, not directly, but they all have been associated with this major change.

A problem with our food production system

Silent Spring, written by Rachel Carson, identified a critical problem and it was so influential. The results and the impact that this has had on our entire society and our whole perception of the natural environment is profound. At least personally, I don't think it went far enough. Pesticides should not be the focus of the problem. We focus so much on "let's get rid of these pesticides, let's point out all of the problems with pesticides." You know what, even if we banned all pesticides tomorrow, we're still going to have the same issues that we have today. This is not a pesticide problem. This is not a

bee problem. This is not any of these problems. This is a problem with our food production system. Until we revise, reform, transform our food production system, away from the simplified monoculture model, we are not going to solve these issues. That's what makes this conference so special. Let's figure out what causes pest problems to begin with, rather than always reacting to the symptoms as they start to outsmart us.

If we manage a healthy ecosystem, these pests are just not an issue as much anymore. That doesn't mean that I'm saying we should abandon all pest management principles. I'm not telling you to ignore your pests. If we use some very simple, conceptual ideas, we can dramatically reduce our reliance on pesticides –profitably. We can reduce disturbance and increase diversity in our food production systems, and reduce disturbance that kills soil. Disturbance kills the biology of the soil.

> ***"Let's figure out what causes pest problems to begin with, rather than always reacting to the symptoms as they start to outsmart us. If we manage a healthy ecosystem, these pests are just not an issue as much anymore."***

Step one in this process is to reduce or eliminate tillage. Soil biology is the basis upon which our food production systems relies. When you till, you extirpate all the natural biotic resistance to pest proliferation. You come in and plant thousands of acres of a single plant species that is genetically limited to producing a large seed that we like to eat. The primary pest arrives and the soil no longer has any biotic resistance to its proliferation, so you must replace biodiversity with a chemical. That is the pesticide treadmill in a nutshell.

The next thing is that energy gets into our food production system via photosynthesis. Photosynthesis is produced by plants. We need more vegetation diversity within our food production systems in order to provide and feed the rest of the biodiversity in that system. There are agronomically proven ways of doing this.

In South Dakota, we have the corn-snow-corn rotation. That is not diversity. The science is clear on this. We need to be extending these out to 4-5 year rotations, oftentimes with a perennial phase. That is the most resilient to profitable rotation in the long run of food production systems. When you have 30-inch rows, you have 30 inches of bare soil. We need to be filling that up with intercropping. We need to be feeding it and capturing the energy down into the soil. We need to be using cover crops in the fallow period. We need to be covering the soil and having roots in the soil. We need to be connecting growing seasons so that we don't extirpate the biology from our food production system. Field margins and conservation strips are tools for us. Weeds have a role to play. A zero tolerance policy towards weeds is not okay.

Production without insecticides

I'm traditionally trained as an entomologist that reacts to pests. But, I always questioned this in the back of my mind, and I started to interact more with farmers who are doing things differently. In Colorado, they are growing potatoes, which is an insecticide-intensive crop. Brendon Rockey, in Alamosa, CO, hasn't used insecticides in 20 years. He uses a pivot corner (patches of land beyond the reach of irrigation) for conservation strips. He actually plants cover flowers into his potato rows while he is planting. Then he's eliminated one phase, the barley phase, of his rotation and, instead of having that second crop, he plants a green manure (cover crops that add nutrients and organic matter to the soil) that he then grazes. By taking that second crop out of the rotation, he's actually increased the profitability of his long-term operation because he no longer needs fertilizers or insecticides during the potato phase. He's looking at the longer term, rather than just a single season at a time.

In Burleigh County, North Dakota, there is so much regenerative agriculture going on, it is really profound. Gabe Brown from Bismarck, North Dakota hasn't used insecticides in 26 years. Dwayne Beck, from Pierre, South Dakota, doesn't use insecticides. He will use Bt, simply because he can't find corn seed that doesn't have it. Then, there is Dave Brandt from Carroll, Ohio. He actually has his own soil type. He's changed his soil over the last few decades using no-till and covers, and he now has on his farm a soil type that has never been defined before. When I was having breakfast with him, I asked him, "When's the last time you used insecticides?" He said, "Oh, it's been about seven years. Oh, except for that one 10-acre field" [of corn]. I asked, "Why do you do that?" He says he puts a neonicotinoid seed treatment out there because his agronomist told him that all of his neighbors get a

six bushel yield bump. And I asked him if he saw this and he said, instead, he sees a nine bushel yield drag. I asked, "Well, why do you do that?" And he said, "Well, to prove that my agronomist is full of crap." When you change the soil and when you restore the soil biology, you find that it doesn't behave by the same rules. The same rules do not apply any longer.

Heal the soil, protect bees

This talk is about pollinators and I will tell you the solution to the pollinator crisis. It's not about varroa mite. It's not about the diseases, and it's not about the pesticides. Heal the soil and you will solve the bee problem. These issues are not just a bee problem. This is a biodiversity crisis that we are facing right now. We've lost wetland habitats. Entire habitats are diminishing rapidly. We're currently living in the Holocene extinction event, which is one of the most severe extinction events that the planet Earth has ever experienced throughout geologic history. The data is pretty clear on this. We are losing species at a rapid rate. Where did the prairie go? Insect communities are being lost. Butterflies, birds and bats. Come on, wake up! Let's connect the dots.

Challenging paradigms

To sum up, a little bit about science. It's our job to ask questions. Sometimes the answers to those questions are inconvenient. Throughout history, whenever we've asked, or scientists have challenged, the current paradigm, if the paradigm is big enough, that scientist tends to experience problems.

Rachel Carson certainly is a great example. She persevered, and perseverance like that is so important, as far as advancing our society. The formation of the U.S. Environmental Protection Agency and the *Federal Insecticide, Fungicide, and Rodenticide Act* are related to this lady who was ostracized. So, I've thought about this many times over the last few years. I went from being one of the golden boys of science. I was elected one of the top young scientists in the country. I got to meet President Obama in the White House. Then, the farmers and the beekeepers were seeing things in their operations that oftentimes defied science or it was exactly contrary to science. They were doing things on their farms that science said couldn't happen. They were seeing effects of pesticides that science was saying wasn't happening. So, I decided to devote my expertise to answering those questions. And those questions challenge the current paradigm of food production. Why this shift from golden boy to pariah within the USDA? Was it because of the questions? Was it because I changed the way I was presenting it so that people would actually understand what it is that I was trying to say? I don't know.

I think it ultimately comes down to fear. There's a lot of fear within USDA. That fear prompts good people to do bad things. I can tell you that things like integrity, perseverance, and strength were the motivation or the driving factor behind blowing the whistle like I did. But there's always an element of doubt. The motivation in making a disruptive decision, as I did, is really important, because there are consequences. I sacrificed a very long, comfortable, and promising career with USDA based on my decision. Everybody that I care about in my life was hurt because of my decision. Friends don't talk to me anymore. People that I care about despise me because I made this decision. But then on the flip side, there are people like yourselves [conference participants], and the support has been very strong, and I do appreciate that. I don't hold it against anybody for not wanting to go the whistleblower route, because there are a lot of scientists that have been in the same place I was and didn't make the same decision I did. Part of the reason I ran into so much trouble is because they didn't stand up to the tremendous pressures that you end up going through by going down this path. In fact, on Thursday morning, I met with a colleague who said that part of his annual duties is to make his boss look good. That's part of his scientific duties now, working for USDA. Yes, it bothers me, but at the same time, his motivation is that he has a family at home and people in his lab who are depending on him for their employment. What is my motivation? There's two really good reasons, my kids and yours.

Supporting beekeepers and farmers with research

I believe that the only way that we can really solve some of these planetary scale problems is by having open and respectful discourse on these issues. In seeing a lack of scientific support for the people who are trying to innovate our food production systems, I've taken a new path. We have founded a non-profit, Ecdysis Foundation and Blue Dasher Farm. Ecdysis means metamorphosis, shedding the old skin in insects. It's a geeky entomological term and it is very applicable. Blue Dasher is a dragonfly species. We are starting an initiative, Centers for Excellence and Regenerative Farming Principles. We hope to establish a nationwide network where we pair cutting-edge research and science with education, training the next generation of scientists and farmers. We want to manage a demonstration farm, because seeing is believing. That is what we are doing right now.

We've said to the farmers and the beekeepers, if you believe in this, consider supporting it. They did. They bankrolled the research lab. I don't believe that's ever happened before. We need to figure out how to crack this nut. Thirty-five percent of the terrestrial land surface of our planet is devoted to food production systems. That means conservation of species needs to happen and involve farmers. No good scientist is able to present without the tremendous support of a fine group of young and enthusiastic scientists. My research team is fantastic and a lot of them are coming with me to the new Blue Dasher Farm initiative. If I wasn't here right now, I'd be at home building beehives, getting the farming operation up and running, and getting the lab all built up. We're actively getting going. We've been open for about a month and a half. Alright, that's all I got!