Pesticides and You

News from Beyond Pesticides: Protecting Health and the Environment with Science, Policy & Action

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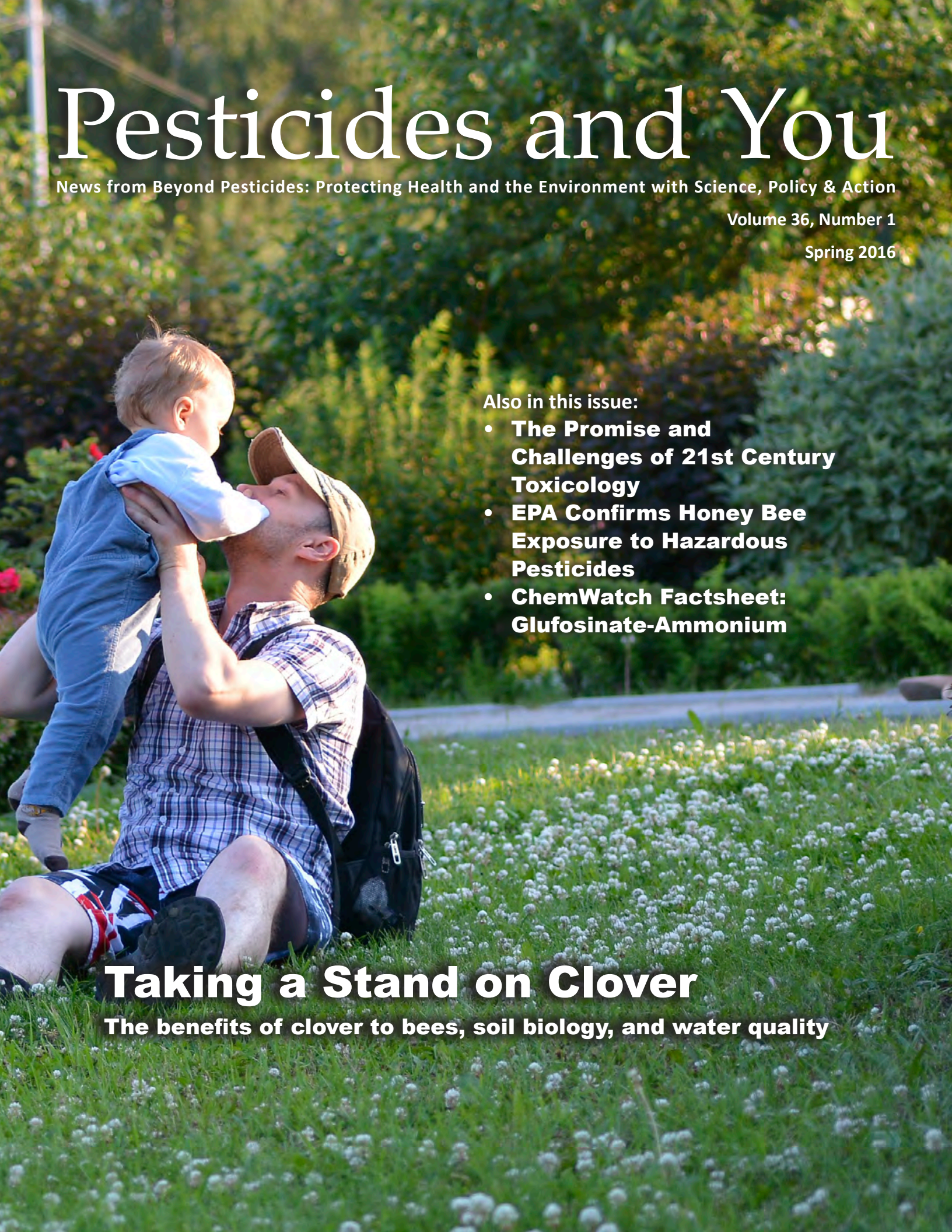


Also in this issue:

- **The Promise and Challenges of 21st Century Toxicology**
- **EPA Confirms Honey Bee Exposure to Hazardous Pesticides**
- **ChemWatch Factsheet: Glufosinate-Ammonium**

Taking a Stand on Clover

The benefits of clover to bees, soil biology, and water quality

Letter from Washington

Ending the Toxic Assault on Soil to Protect Health and the Environment

Soil. We have long understood the importance of soil at Beyond Pesticides, as have those who began advancing organic and regenerative land management systems decades ago. With the escalating dependency on toxic chemicals in land management and the resulting toxic assault on soil, adverse effects to people and the environment emerged, leading to campaigns, past and present, to remove hazardous pesticides from the market.

Part of a larger plan

In reality, an extraordinary number of chemicals should be removed from commerce, regulatory reviews are inadequate, and too many national and state policy makers are unresponsive to daily poisoning and environmental contamination. Federal and state laws compromise health and environment by allowing the use of toxic pesticides that can be replaced by nontoxic practices and products. As a result, campaigns seeking to restrict chemicals must advance a transformative message by shining a spotlight on the full range of institutional barriers, including unprotective risk mitigation measures and regulatory decisions that allow unnecessary hazards, the failure of the political process to curtail chemical use, and the inherent weakness of governing statutes.

Incorporating complexities into strategies

Soil represents both the complexity of the contamination problem and the simplicity of the solution. When we talk about ecological balance and biodiversity, we only need to look to the soil to recognize that meaningful solutions are not achieved by eliminating or reducing individual chemicals, but through a comprehensive shift to an approach that supports nature. In soil, we find tens of thousands of microorganisms, including species of bacteria, fungi, protozoa, and nematodes, all contributing to an ecological system that provides food for plants, maintains a biological balance of organisms, enables the flow of water and gases, and sequesters atmospheric carbon. The contamination of this complex community, whether through small or large amounts of toxic chemical applications, disturbs this balance, inhibiting or destroying the mechanisms at work. Nurturing this ecosystem enables our coexistence with nature.

Getting into the field

Years ago, in addition to working in the policy arena, we began field work in order to provide the practical tools in communities that nurture soil biology, turning education and policy into practice. Decision makers on city or county councils who become educated on pesticide hazards and then embrace the transition to safe parks and playing fields need the technical support to implement organic land management systems that respect the complex biological community in the soil. With these systems, the community will see the benefits that healthy soils offer in cycling the nutrients that turfgrass and landscapes need to flourish. Because land managers are often wedded to chemical-intensive programs that they have used or been taught, the programs typically use synthetic fertilizers that deliver nitrogen, phosphorus, and potassium directly to the plant, while applying pre-emergent weed killer. The managers typically know the pH and chemistry of their soil, but not the amount of organic matter in the soil. They have tested for soil chemistry, but not for soil biology. However, many of the managers are excited by the prospect of trying an organic approach, either because they are concerned about toxic chemical use, and/or their program experiences ongoing repetitive weed or disease problems.

In this issue, we review the book *The Soil Will Save Us* (2014), which, while focused on agriculture for the most part, captures the science of soil biology, traces the experience of farmers who have transitioned away from chemical dependency, links to the environmental benefits, which includes capturing all the carbon that is contributing to global climate change, and shows competitive and, in most cases, reduced costs and improved productivity. Another important book, *Teaming with Microbes: The Organic Gardener's Guide to the Soil Food Web* (2010), was described in the *Seattle Post-Intelligencer* as follows: "Smart gardeners know that soil is anything but an inert substance. Healthy soil is teeming with life –not just earthworms and insects, but a staggering multitude of bacteria, fungi, and other microorganisms. When we use chemical fertilizers, we injure the microbial life that sustains healthy plants and become increasingly dependent on an arsenal of artificial, often toxic, substances. But there is an alternative to this vicious cycle. We can garden in a way that strengthens the soil food web –the complex world of soil-dwelling organisms whose interactions create a nurturing environment for plants."

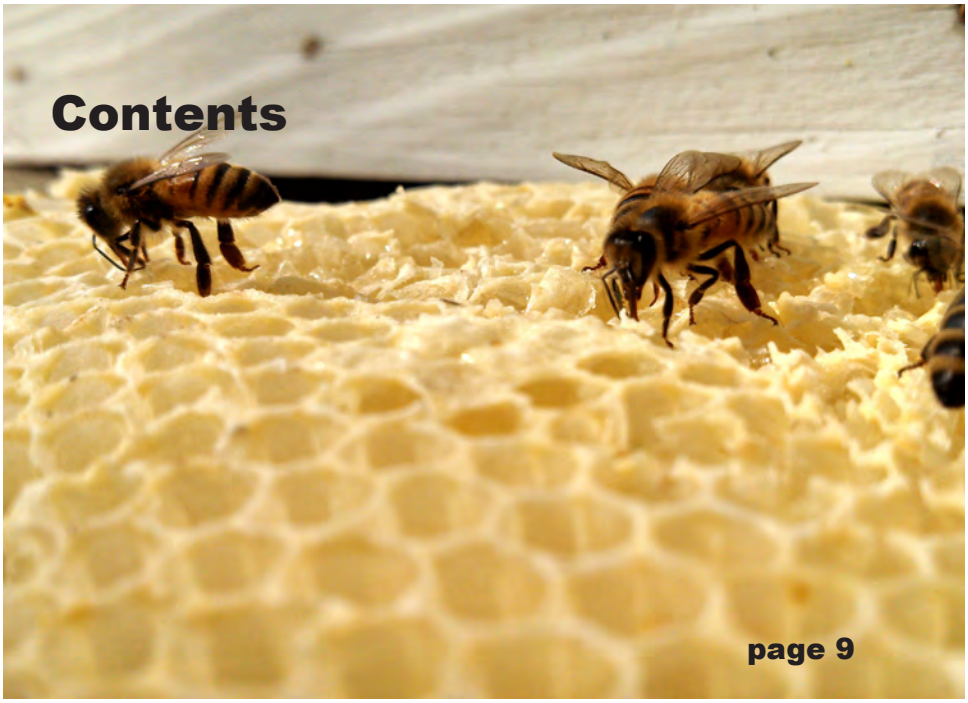
This orientation is integral to certified practices under the *Organic Foods Production Act*, which states: (7 USC 6513) Organic Plan (b) (1), "An organic plan shall contain provision designed to foster soil fertility, primarily through the management of the organic content of the soil through proper tillage, crop rotation, and manuring." The National Organic Standards Board, in reviewing allowed materials, must consider "the effects of the substance on biological and chemical interactions in the agroecosystem, including the physiological effects of the substance on soil organisms (including the salt index and solubility of the soil), crops and livestock."

Cultural Shift

With this understanding, we introduce or reintroduce in this issue the idea of bringing back clover as a part of lawns, explaining the biological benefits of this plant in *Taking a Stand on Clover: The benefits of clover to bees, soil biology, and water quality*. Organic practices can achieve a clover-free lawn, but is that always best?

Organic land management is a systems approach that values healthy, biologically active soils to support plant life and provide critical environmental benefits. It is through this soil-based systems approach that we will eliminate toxic chemicals in land management.

Jay Feldman is executive director of Beyond Pesticides.



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Responding to the Pesticide Use at Schools in the Face of Zika

Dear Beyond Pesticides,
I am working overseas in Central America and concern over the spread of the Zika virus has led my child's school to begin regularly spraying the insecticide permethrin outside of the school, and the chemical cypermethrin inside the school and in classrooms. I am worried about both Zika and the effects of pesticides on my child and his classmates. Are there alternatives to pesticide spraying, or a more balanced approach that can be taken?
Mark G., Nicaragua

Hi Mark,
Thank you for reaching out to Beyond Pesticides on the chemicals your child's school is using. Our organization is very sensitive to the emerging public health crisis that is caused by the mosquito-borne Zika virus. However, as with all emerging insect-borne diseases, it is important to emphasize action be taken in a way that is most effective. Research finds that vigilant monitoring of mosquito populations, and actions that prevent mosquito larvae from hatching is the best way to control the spread of disease. Eliminating standing water, or otherwise using larvacides containing *Bacillus thurengiensis* where this is not possible, puts a focus on source control. The *Aedes aegypti* mosquito that carries the Zika virus, dengue, and chikungunya, lays its eggs in standing water as small as bottle caps and flower pots. Once mosquitoes hatch, it is very difficult to apply a pesticide so that it makes contact with a flying adult mosquito. If spraying for adult mosquitoes (adulticiding) is occurring or planned, it should only be performed when monitoring confirms a disease vector is present that would endanger public health. Adulticiding should never be done on a regular schedule and, when performed, should be conducted in the most limited way possible. Beyond Pesticides details this common-sense approach in our *Public Health Mosquito Management Strategy*, which can be accessed at this link: http://bit.ly/1M4Suik.

The chemicals being used in your child's school are synthetic pyrethroids, which, while less acutely toxic than organophosphate insecticides, have been linked to cancer, neurological and respiratory effects, ADHD and other learning disorders in recent studies. While it seems as though the school has been very open about its adulticiding program, it would be helpful to ask school administrators the extent of their prevention and source reduction practices. Getting this information would help provide a baseline to suggest improvements that may reduce pesticide use. We urge the use of natural repellents, encourage the use of screens and bed netting where possible, and long sleeve clothing when feasible.
-Beyond Pesticides

(Follow up from Mark G),
Thank you so much. This was exactly the kind of information we were looking for. I really like the Mosquito Management Strategy –this seems to be a common sense approach– the standard in the U.S., as I have been reading and seeing similar formats under the broad definition of Integrated Pest Management strategies, usually at the city/town or school district level. I have been bombarding the school's director with additional questions, and a new communication came out from the school today saying that they are relying more on closed doors and air conditioners in an effort to reduce indoor spraying. Yeah! Thanks for your help and I hope you don't mind if I ask you again for your opinion or assistance in the future.
- Mark G.

Beyond Pesticides welcomes your questions, comments or concerns. Have something you'd like to share or ask us? We'd like to know! If we think something might be particularly useful for others, we will print your comments in this section. Mail will be edited for length and clarity, and we will not publish your contact information. There are many ways you can contact us: Send us an email at info@beyondpesticides.org, give us a call at 202-543-5450, or simply send questions and comments to 701 E Street SE, Washington, DC 20003.

Getting My Garden Center to Go Green!

Beyond Pesticides,
Thank you for the work you do and the information you share. I am a professional gardener and have been fighting against pesticide use for over 40 years. My local hardware store means well, but they simply don't stock enough least-toxic and organic

products. Is it possible for you to reach out to them to get them to change? They're socially conscious, good people, but I think it more likely they'd respond to you than to the old lady who's been harping at them for years.
Paula M, MA

Paula,
We understand it is frustrating to be confronted with an aisle of toxic pesticides in garden centers and hardware stores, as well as neighbors using these products, given their known hazards and the wide availability of alternative organic-compatible products now on the market. That's why Beyond Pesticides has put together a new toolkit, *The Well Stocked Hardware Store*, to assist retailers in the transition from selling hazardous pesticides, to safer, least-toxic and organic products. The toolkit is available on our website at http://bit.ly/1UbaatZ, or in a print brochure by sending an email to info@beyondpesticides.org.

The toolkit supports a natural system to lawn and landscape care by encouraging stores to educate their customers on good cultural practices, and carry the basic materials necessary to the successful implementation of this approach. *The Well-Stocked Hardware Store* addresses informational materials, tools and watering supplies, fertility products, lawn maintenance products, as well as mechanical, biological, and least-toxic weed and pest management options.

It would be wonderful to share this resource with your local hardware store. While it is possible for us to reach out to them, we first encourage members and supporters to act as a point of contact in the community, in order to effect real progress in the locality. We find this approach, when frequent customers and community members are empowered by research and information, to be the most successful in enacting meaningful change. To help encourage your local retailer, we've also produced a video, *Making the Switch* [http://bit.ly/1QV4rHQ], which features Eldredge Lumber and Hardware of York, ME.

Like a growing number of retailers, Eldredge, an ACE hardware store, has been successful in transitioning their supply of land care products from toxic synthetic to natural organic compatible products, with an educational component that provides customers with background information. When you approach managers at your store, remember it's important to stick to the facts, and remain calm and straightforward. Please encourage the store manager and employees to contact Beyond Pesticides and we will be happy to respond with additional information. We look forward to working with you and your local store to promote safer practices for the health of your community and the local environment.

From the Web

Beyond Pesticides' Daily News Blog features a post each weekday on the health and environmental hazards of pesticides, pesticide regulation and policy, pesticide alternatives and cutting-edge science, www.beyondpesticides.org/dailynewsblog. Want to get in on the conversation? "Like" us on Facebook, www.facebook.com/beyondpesticides, or send us a "tweet" on Twitter, @bpncamp!

Bayer Refuses to Cancel Insecticide Toxic to Aquatic Life

Excerpt from Beyond Pesticides original blog post (2/9/2016): Bayer Refuses to Cancel Insecticide Toxic to Aquatic Life. Last week, Bayer CropScience reneged on an agreement with the U.S. Environmental Protection Agency (EPA) to voluntarily cancel the conditionally registered insecticide flubendiamide, if the agency received data that identified adverse ecological effects [which it did].

Tammy N. comments:

"Why do we, the consumers, need to demand protection from a company that produces products it claims will assist in our protection? Bayer, own up to your agreement and protect our environment! There are enough problems in our world, and for Bayer to tip-toe out is completely unacceptable, selfish, and quite pathetic…knowing what damage you cause and ignoring the consequences makes for an irresponsible company."

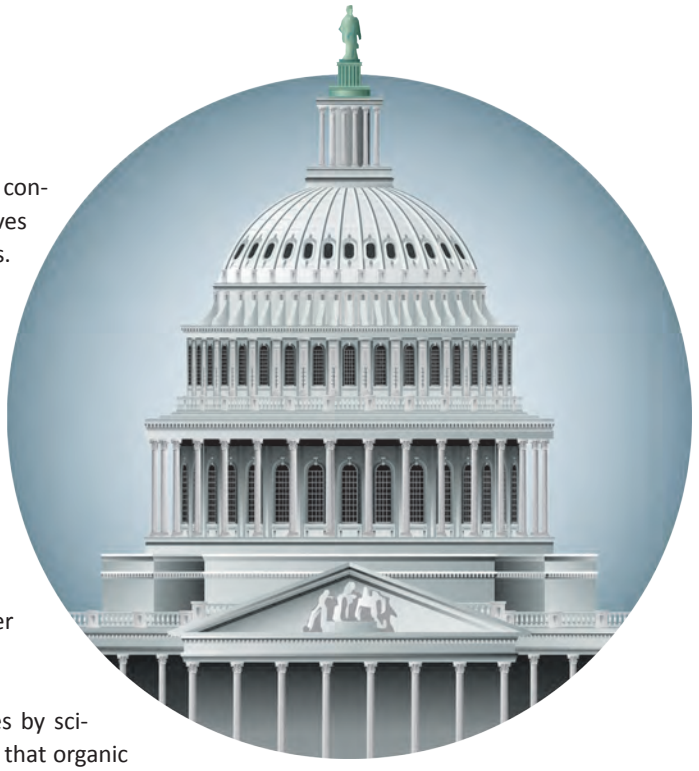
Major Supermarket Bans Bee-Toxic Pesticides in Produce Production

Excerpt from Beyond Pesticides original blog post (1/20/2016):Major Supermarket Bans Bee-Toxic Pesticides in Produce Production. Aldi Süd, the German supermarket chain with stores in the U.S., has become the first major European retailer to ban pesticides toxic to bees, including the neonicotinoids imidacloprid, clothianidin and thiamethoxam, from fruits and vegetables produced for their stores.

J. Medlin comments:

"That is great news for the bee population and our soil. Hopefully one day not too far into the future, we can get rid of the toxins that have been overused and have a healthier environment."

Organic Agriculture Essential to a Sustainable Future



In early February, two Washington State University (WSU) researchers published a review study that deemed organic agriculture as a necessary tool for feeding the global population. In their review, which analyzed hundreds of studies about organic and conventional agriculture, soil science and agroecology professor John Reganold, Ph.D., and doctoral candidate Jonathan Wachter referred to organic agriculture as an untapped resource for feeding the Earth's population, "especially in the face of climate change and other global challenges." The study, *Organic Agriculture in the 21st Century*, aptly refers to organic agriculture as the solution to the globe's current and future food crises and conventional farming as an undeniable catalyst in the Earth's demise.

The study addresses critics of organic agriculture, who argue that conventional agriculture produces higher yields than organic. However, while Dr. Reganold notes that organic agriculture may produce about 10 to 20 percent less than its conventional counterpart, it thrives in environmental advantages. According to the WSU press release, "Numerous studies in the review also prove the environmental benefits of organic production. Overall, organic farms tend to store more soil carbon, have better soil quality and reduce soil erosion. Organic agriculture creates less soil and water pollution and lower greenhouse gas emissions."

Later in February, two studies by scientists from Europe reported that organic meat and milk have 50 percent more nutrients, like omega-3 fatty acids, that are important for human health. Organic meat has slightly lower concentrations of saturated fats, while organic milk contains 40 percent more linoleic acid, and carries slightly higher concentrations of iron, vitamin E, and carotenoids. This new information adds to the debate over the benefits of organic and strengthens the argument that there is a nutritional advantage to eating organic, which complements the environmental benefits.

Congressional Reps Want EPA Review of Glyphosate-2,4-D Mixture

In early February, 35 members of Congress, led by U.S. Representatives Earl Blumenauer (OR-3) and Peter DeFazio (OR-4), signed a letter to Environmental Protection Agency (EPA) Administrator Gina McCarthy, challenging EPA's review process for the glyphosate and 2,4-D herbicide mixture known as Enlist Duo. It is produced by Dow AgroSciences for use in genetically engineered crop production.

The letter requests "more information about EPA's plan to reevaluate Enlist Duo's health and environmental risks." The letter comes just weeks after the 9th U.S. Circuit Court of Appeals, in January, denied a request from EPA to vacate its own decision to approve the toxic herbicide cocktail. Of course, EPA must take sole responsibility for the decision to allow Enlist Duo use in the first place.

"This is part of a vicious cycle that is leading to more potent, dangerous chemicals being widely used on crops across the United States," said Rep. Blumenauer. He continued, "With the rise of herbicide-resistant genetically modified crops, herbicides are more widely sprayed, causing weeds to grow more resistant –ultimately, requiring the application of even stronger herbicides. EPA must take action to make sure products entering the market to be used on our food are safe for human health and the environment."

In November 2015, EPA sought to revoke the registration of Dow's Enlist Duo based on new information on the toxic effects associated with the synergistic interactions of the chemical cocktail, including 2,4-D, glyphosate, and other undisclosed ingredients, to plants outside the treated area. With EPA facing pressure from environmental groups and Dow's legal team, it will have to choose whether it will cancel the pesticides, acknowledging the imminent hazard and removing it from the market immediately, or undergo a lengthy cancellation process that may not resolve the threat for years. Additionally, to protect farmers and dealers, EPA could issue a product notice immediately, identifying new issues and findings that were not available at the time of registration.

Bayer Refuses to Cancel Insecticide Toxic to Aquatic Life

In early February, Bayer CropScience reneged on an agreement with the U.S. Environmental Protection Agency (EPA) to voluntarily cancel the conditionally registered insecticide flubendiamide. Bayer's defiance in the face of EPA's finding points to a fundamental weakness in the agency's conditional pesticide registration process, which allows toxic chemicals onto the market without a complete and comprehensive assessment of their potential harm, in this case to wildlife and the vital ecosystem services they provide.

In 2008, EPA granted Bayer a "conditional" registration for flubendiamide, a classification that allows a new pesticide to be registered and used in the field, despite outstanding data points on its toxicological impact. In this case, original data submitted to EPA by Bayer shows hazards associated with the chemical and its breakdown product on freshwater benthic invertebrates, species such as crustaceans and aquatic insects that live in stream sediment and provide important ecosystem services, such as decomposition and nutrient cycling. Rather than declining to proceed with registration of the chemical, EPA negotiated a deal –in a novel move, EPA's agreement with Bayer stipulated that the pesticide's conditional registration would expire in 2013, and if additional data revealed "unreasonable adverse effects," it would notify the company, which would then voluntarily withdraw the chemical from the market.

In January 2016, when EPA sent a letter to Bayer indicating that, "[T]he continued use of the currently registered flubendiamide products will result in unreasonable adverse effects on the environment." Rather than cancelling flubendiamide, Bayer lashed out at EPA's interpretation of the data and conclusion that the chemical results in unreasonable adverse effects to benthic organisms. Further, Bayer asserts that EPA's "forced 'voluntary' cancellation request…is unlawful." "In making this demand," Bayer wrote, "EPA relies on an unlawful condition of registration that EPA devised in an effort to bypass required statutory cancellation proceedings, deny Bayer and Nichino due process rights in their registrations granted by Congress, and shield EPA's future scientific and regulatory determinations from required interagency and scientific peer review." Subsequently, in March, EPA initiated cancellation of all currently registered flubendiamide products, given the manufacturers' failure to comply with the terms of the registration. This could take years to resolve, while the pesticide remains on the market.

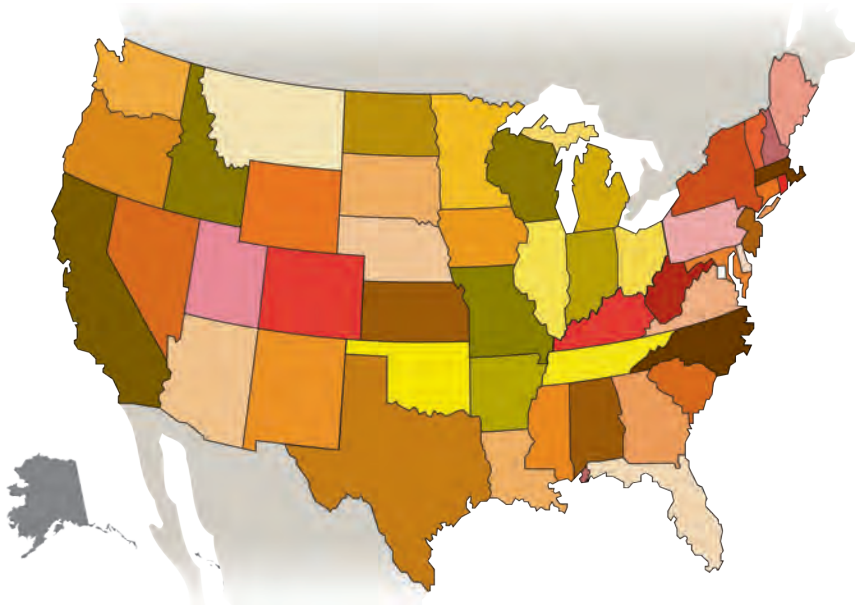
Clean Water Protections in Trouble Again in the Senate

In mid-January, the U.S. Senate Environment and Public Works Committee added an amendment to the *Sportsman Act of 2015* that will remove important protections from pesticides sprayed into the nation's waterways. After years of failed attempts to pass a version of the amendment as a stand-alone bill, called the "*Sensible Environmental Protection Act*," the latest attack against clean water was advanced by Senator Deb Fisher (R-NE), and passed by a committee vote of 12-8. It moved to the Senate floor in a piece of bipartisan legislation.

This amendment will reverse a 2009 federal court decision in *National Cotton Council v. EPA* that directed EPA to require permits from applicators who spray over "navigable waters," as outlined in the *Clean Water Act* (CWA). The bill's proponents claim that the need for water permits is duplicative, given that pesticide applicators also comply with the *Federal Insecticide, Fungicide and Rodenticide Act* (FIFRA), the law that requires applicators to follow instructions on pesticide labels.

However, the fact is that CWA permits let authorities know what is sprayed and when it is sprayed, so that the public may know what chemicals are used in their waterways and the potential dangers to sensitive aquatic ecosystems and unique conditions. Existing pesticide regulations under FIFRA do not achieve these protections and, contrary to the assertions made by supporters of the bill that it will harm farmers, most agricultural pesticide applications are exempt from CWA permit requirements.

Under this dangerous amendment to the *Sportsman Act of 2015*, pesticide applicators would be able to discharge pesticides into waterways without EPA oversight under the standards of CWA and the permitting process, which takes into account local conditions that are not addressed under FIFRA.



California Health Advocates Continue Call for Increased Buffer Zones Near Schools

A coalition of local parents and community health groups from California's Central Valley are calling on the state to set one mile buffer zones around schools in order to reduce children's exposure to highly toxic pesticides. The request comes after research from the University of California Los Angeles (UCLA), *Exposure and Interaction*, found widely used fumigant pesticides in central California interact synergistically and increase health hazards.

Although California is subject to a regressive pesticide preemption law, county agricultural commissioners have the authority to regulate pesticides and enforce against use violations at the local level. While the state currently sets minimum buffer zones around schools at 500 ft., certain California counties require increased levels of protection around these sensitive sites. However, activists charge that state standards and even locally wider buffer zones are not adequately protecting community health, and comprehensive statewide regulations are needed. In July of 2015, after years of pressure from activists, the California Department of Pesticide Regulation (CDPR) held a series of workshops to gather community input on new rules governing pesticide use near schools. CDPR was expected to release its first draft of the new regulations for public comment at the end of February, but it has still yet to be released.

The stakes are high for families living in the Central Valley. Fumigant pesticides are highly toxic and have a strong propensity to drift far off a target site. UCLA's recent report found that mixtures of fumigant pesticides may increase the possibility of gene mutations and decrease the body's ability to repair damaged DNA. While increased buffer zones may provide some reprieve from pesticide trespass, it will not eliminate all health concerns for children in the region. Virginia Zaunbrecher, JD, of UCLA's Science and Technology program, remarked to the *Fresno Bee*, "In general, a buffer zone is going to decrease exposure, but it's not going to eliminate exposure." Beyond Pesticides has long encouraged a minimum two mile buffer zone for agricultural pesticide use around sensitive areas.

City of St. Paul, MN Acts to Protect Pollinators

In January, the city council of St. Paul, MN adopted a resolution to make the city more pollinator friendly by banning bee-toxic neonicotinoids and other pesticides "proven to be harmful to pollinators" and requiring a strengthened Integrated Pest Management (IPM) program to prioritize non-chemical methods.

The resolution recognizes that the city's authority to restrict pesticide use on private land is preempted by the State of Minnesota and then directs the city to encourage property owners within its jurisdiction to practice pollinator stewardship.

Under the resolution, St. Paul will: strengthen its IPM program; eliminate the use of neonicotinoid insecticides on city grounds (with specific exceptions for golf courses and certain athletic fields); require all city departments with any inventory of materials containing neonicotinoids to discontinue their use; and, explore piloting an alternative pest management system on a portion of a golf course tee, green, or fairway, and on a premier athletic field in 2016.

The city will: reduce the use of all pesticides and systemic insecticides whenever possible and phase out entirely as safer and reasonable alternatives become available; provide education to city employees promoting ways to protect pollinators; and, continue advocating at the state and federal level for increased authority to address the nonagricultural use of pesticides.

The resolution commitments focus heavily on neonicotinoids, which affect the central nervous system of insects and have consistently been implicated as a key factor in pollinator decline, not only linked to acute exposure and immediate bee deaths, but also sublethal exposure that adversely affects bee reproduction, navigation, and foraging.

Canada Discontinues Conditional Registrations for New Pesticides

The Pest Management Regulatory Agency (PMRA) of Health Canada in January announced that it intends to discontinue the granting of new conditional registrations under the *Pest Control Products Act*.

In the U.S., conditional registrations have been controversial because they allow pesticide use without complete data, as was the case with the neonicotinoid insecticide chlothianidin, linked to the serious decline in bee health. [See article, *Bayer Refuses to Cancel Insecticide* on p.5.]

A startling number of pesticides, nearly 65% of the more than 16,000 pesticides now on the market, were first approved by the process of "conditional registration," a loophole in which the Environmental Protection Agency (EPA) allows new pesticides on the market without the full range of legally mandated toxicity tests.

Currently, the *Pest Control Products Regulation* allows conditional registration for pesticides only when "the review of the scientific data and information is sufficient to determine that the risks of a pesticide are acceptable, but PMRA requires additional information, such as monitoring data after a product registration, to confirm the results of models used in the risk assessment."

Because this change will only affect new registration applications and less than one percent of all existing pesticide registrations in Canada are conditional, this action is unlikely to have a large impact. The discontinuation is set to take effect on June 1, 2016. Even though the discontinuation of conditional regulation will not make a large impact on Canada's current registration process, it does shed light on this problematic program in the U.S.

In the U.S., EPA has continuously approved pesticides proven to be toxic to human health or the environment without key pieces of information that have not been received until years later.

Hawaii Pesticide Disclosure Bill Passes Committee

In early February, Hawaii's House Energy and Environmental Protection Committee, chaired by Representative Chris Lee, unanimously passed a measure to require large-scale, outdoor commercial agricultural businesses to publicly disclose the application of pesticides in various environmentally sensitive areas. House Bill 2574 will make the reporting guidelines for the voluntary Kauai program mandatory across the state and will also establish "disclosure and public notification requirements for applications of pesticides in the proximity of schools, health care facilities, child care facilities, elder care facilities, and other environmentally sensitive areas," according to the bill. The bill's next step is the Agriculture Committee, where the chair, Representative Clift Tsuji, has killed pesticide-related bills in the past.

House Bill 2574 is the latest in a string of laws proposed by local and state governments in Hawaii to try to protect citizens from toxic pesticides hazards. In 2015, Hawaiian legislators proposed House Bill 1514 to establish school and hospital buffer zones. The bill, which would have prohibited farmers from using large amounts of pesticides within a specified distance of schools and hospitals, stemmed from concerns about the impact of genetically engineered (GE) farming and its inherent dependency on increasing pesticide use. The measure sought to require companies' disclosure of the pesticides used and the volume of use.

Despite having strong backing from island residents and the Hawaii chapter of the Center for Food Safety (CFS), the bill was eventually rejected by the state House Agriculture Committee. Proponents of HB 2574 fear that under Representative Tsuji's leadership the newly proposed language may meet the same fate. However, there is optimism that HB 2574 will fare better than its predecessors, as the agriculture committee has already received at least 625 pages of written testimony it will consider in making its final decision. Aside from the state-level attempts to curb pesticide use in Hawaii, recent years have seen the passage of local legislation on pesticide and GE restrictions in several land jurisdictions, which are all too often met with industry challenges.

Hardware Store Acts to Protect Bees, Promotes Natural Alternatives

Boulder, Colorado's McGuckin Hardware is setting an example for hardware stores across the country by removing bee-toxic neonicotinoids from its store shelves, and working to reorient its customers toward natural holistic practices. McGuckin's change is the latest in a movement among local hardware businesses and nurseries to take a stand against toxic pesticides that are harmful to pollinators and can be replaced by organic systems.

An example of holistic, system-based products, Eldredge Hardware in Maine. Photo by Jay Feldman.

Local and national advocates are praising McGuckin's shift away from products that harm pollinators. "People are very excited about the dramatic steps McGuckin's has taken to get [neonicotinoids] out of our environment," said David Wheeler of the local pollinator-advocacy organization Bee Safe Boulder (BSB). BSB is a coalition of concerned Boulder residents that successfully fought for the passage of a pollinator resolution in the cities of Boulder and Layfayette, and Boulder County, Colorado. In addition to creating Bee Safe neighborhoods, the organization also has a project that encourages local retailers to stop selling plants contaminated with neonicotinoids. Eighteen retailers in the area, including McGuckin Hardware, have signed the group's pledge.

In 2014, Beyond Pesticides, and other allies joined in the release of a report that found over half of garden plant samples purchased at major retailers, like Lowe's and Home Depot, contain neonicotinoid pesticides. In response, concerned residents donned bee outfits and took to the streets to encourage national retailers (Lowe's, Home Depot, Ace, and TrueValue) to remove from their shelves neonicotinoids and plants grown with the chemical. Lowe's and Home Depot have committed to phasing out neonicotinoids, and Ace has provided some indication it will move in that direction.

Other local hardware stores are taking toxic pesticides off their shelves. Eldredge Lumber and Hardware, an ACE store, has converted its product line to be organic compatible, as captured in the video, *Making the Switch*. See the following link to view the video: http://bit.ly/1UbaatZ.

Legislation to Protect Farmers and Consumers from GE Contamination Passes Oregon House

In late January, Oregon Representative Paul Holyey introduced legislation that will protect conventional crops from contamination by their genetically engineered (GE) counterparts. With the help of advocates representing family farms and food safety, *The Transgenic Contamination Prevention Bill* (HB 4122) will repeal sections of Senate-passed Bill 863, which preempts local governments, and restore the right of local jurisdictions to regulate the planting of GE seed.

The law, Bill 863, dubbed *Oregon's Monsanto Protection Act* by environmentalists, farmers and consumers, was passed in 2013 and signed into law by then-Governor John Kitzhaber. The new language in HB 4122 seeks to repeal the chemical company-driven language of the former bill and restore protection for conventional and organic farmers.

In May, 2014, the voters of Jackson and Josephine Counties, Oregon, passed a ballot initiative, *Genetically Modified Organism Ban*, Measure 15-119, which sparked the backlash in the state legislature. A federal court decision upheld the ballot initiatives, and the county laws were grandfathered in, or allowed to stay in effect.

Supporters of the new bill spoke about the accomplishment of getting the bill introduced, but the fight is far from over.

Once introduced, the bill had the difficult task of receiving a committee assignment, and was referred to the House Committee on Consumer Protection and Government Effectiveness. The Family Farm Coalition reported that the committee held work sessions and gave the bill a fair hearing, leading to the passage in the House. As of this writing, the bill is in the Senate, where a public hearing was held in late February.

EPA Confirms Honey Bee Exposure to Hazardous Pesticides

Five take-home messages on EPA's long-awaited preliminary pollinator risk assessment of the neonicotinoid imidacloprid

Photo by Anneliese Markle.

by Nichelle Harriott

As the pollinator crisis continues, calls for the suspension of bee-toxic pesticides have gone ignored by U.S. regulators. Instead, the U.S. Environmental Protection Agency (EPA) promised to fast-track its review of the neonicotinoid (neonic) class of chemicals, a group of systemic insecticides that contaminates the entire plant, including pollen and nectar, is highly toxic to bees, and contributes significantly to pollinator decline.

In early January 2016, EPA released its long-awaited preliminary pollinator assessment for the neonicotinoid imidacloprid, a review process it began in 2008. The assessment, a joint review effort with Health Canada's Pest Management Regulatory Agency (PMRA) and the State of California's Department of Pesticide Regulation (CDPR), is the first of several neonic assessments scheduled to be released this year. The findings of EPA's 300-plus page assessment are not surprising –imidacloprid is highly toxic to bees, and contaminates nectar and pollen of crops to which bees are exposed. While EPA acknowledges that bees can be exposed through various pathways, including soil, surface water and guttation droplets, the agency notes that it lacks the information to understand and quantify the risks from these exposure routes. The high degree of uncertainties that are cited in this assessment and potentially in the revised version supports advocates' position that EPA should take action to remove imidacloprid from the market.

What follows are the major take-aways from this latest assessment and what can be expected from the other neonic reviews due out at the end of 2016.

1. Imidacloprid Toxicity to Bees Is Undisputed

EPA establishes that for acute (short-term) and chronic (long-term) exposures imidacloprid is classified as *very highly toxic* to individual adult honey bees with an acute oral LD50 value of 0.0039µg/bee (micrograms) and an acute contact LD50 value of 0.043 µg/bee, with chronic impacts observed around 0.00016 µg/bee. These levels demonstrate just how highly toxic imidacloprid is to honey bees.

Significant Increase in Imidacloprid Use

From 1998 to 2012, the land area treated with imidacloprid grew from five million to 30 million acres, a six-fold increase. According to EPA, this increase occurred as a result of a massive expansion of neonic use in seed coatings for grain crops like soybeans and wheat, in addition to foliar applications and seed coatings in specialty crops, such as cherries, apples, carrots, and cauliflower. Application of imidacloprid is mainly via foliar and soil applications (including seed coatings).

Impacts to the colony are manifested in the "reduction in number of worker bees available for foraging or maintaining hive temperature (during over-wintering), reduction in foraging efficiency via sublethal effects on workers, decreased number or delayed development of brood either from direct exposure or indirectly from reduced brood feeding and maintenance by hive bees, and reduced fecundity and survival of queens." Contaminated nectar brought back to the colony lead to reduced adult workers, numbers of pupae, pollen stores and honey stores. For the colony, EPA finds the highest nectar residue level at which no effects (No Observed Adverse Effect Level or NOAEC) were observed in honey bees is 25 ppb, while the lowest level (Lowest Observed

The Honey Bee Continues To Be the Surrogates for Risk Assessment

EPA's imidacloprid assessment focuses on impacts to the honey bee (*Apis mellifera*), even though other bee species are oftentimes more sensitive to exposures. EPA reasons that it is the honey bee that has a dominant role in providing managed pollination services for agricultural crops. For the assessment, the agency looked at effects related to development, growth, survival and reproduction of the individual bee, as well as the colony.

Glaringly, despite this being called a "pollinator risk assessment," no mention is made of other insect pollinators like the butterfly, especially the Monarch butterfly, which has seen precipitous losses over the last 10 years.

Photo by Gary Tate, Riverside, California.

Table: EPA Preliminary Risk Findings Conflict with Independent Science, Confirm Exposure to Bees

EPA's crop by crop analysis of imidacloprid belies important real-world additive and interactive exposure pathways that underscore a need for a more holistic approach to understanding the impact of neonicotinoid contamination.

Summary of EPA's Findings for honey bee exposure to crops on-field		Studies demonstrate that neonicotinoid contamination is pervasive across landscapes and warrants a cumulative ecological assessment:	
Low Risk to Bees	All application methods of root/tuberous, bulb, leafy greens, and brassica vegetables, globe artichoke, and tobacco (harvested before bloom). Soil applications to blueberries (berries and small fruits). Seed treatment to corn and other cereal grains: wheat, barley, oats, rye, and millet which are either not attractive to honey bees or primarily wind pollinated. Fruiting vegetables (except okra) are largely unattractive to honey bees.	**Definite Risks to Bees**	**Seed Coatings** ■ Samson-Robert, et al. (2015) find that neonicotinoid seed coating particles during the planting season can alter bumble bee neuronal activity. ■ Douglas, et al. (2014) conclude that neonic seed coatings can lead to damaging pest outbreaks by killing off natural pest predators that would otherwise keep certain pest populations under control. **On-Field** ■ Alburaki, et al. (2015) observe elevated acetylcholinesterase (AChE) activity among honey bees that collected corn pollen from treated field, which can induce physiological stress and increase pathogen loads. ■ Stanley, et al. (2015) show that neonics impair pollination services; the apple trees visited by bees exposed to neonicotinoids produced apples with fewer seeds—leading to lower overall yields. ■ Hladik, et al. (2015) found neonicotinoid residues frequently in 70 percent of the native bees tested foraging on or near U.S. farmland. ■ Stanley and Raine (2016) report that very low levels neonicotinoid affects the foraging behavior of bumble bees, changing their floral preferences, hindering their ability to learn and extract nectar and pollen. **Off-Field Impacts** ■ Schaafsma, et al. (2015) report that neonicotinoids move off-target by wind erosion of contaminated soil from neonicotinoid-treated fields. ■ Samson-Robert, et al. (2014) find that water samples collected from corn fields were contaminated with at least one neonicotinoid compound, although most contained more than one.
Risks Concerns Exists with Uncertainties in Assessment	Residue data unavailable[a]: legumes, tree nuts, and certain application methods of stone fruits, berries/small fruits, oilseed, herbs and spices, pome fruits.* Limitations in available studies[b]: cucurbit vegetables, citrus fruits, and berries/small fruits.		
Definite Risks to Bees	Citrus fruits (foliar). Cotton (foliar, soil & seed treatment applications).		

[a] EPA notes that there is the potential to extrapolate data from other neonicotinoid chemicals for the same use pattern and application method. For some application methods, data are not available and there are no data expected for the other neonicotinoid chemicals.

[b] Available residue studies create uncertainty in the risk determinations.

**Residue data for imidacloprid are expected in 2016.*

Pollinators continue to be threatened by neonicotinoids

Recently published studies continue to confirm neonicotinoids' harmful effect on bees and other pollinators, as well as their widespread presence in the environment. Pollinators are not only exposed via pollen and nectar from treated crops or soil, but also from natural vegetation and surface water that have become contaminated as a result of pervasive use. Sánchez-Bayo et al. (2016) note that bees are threatened not only from insecticides like neonicotinoids that are highly toxic to bees, but also from herbicides that reduce their food resources, indirectly affecting survival and reproduction. According to David et al. (2016) and Botías et al. (2015), even wildflower pollen is contaminated with a wide range of pesticides, including neonicotinoids, indicating that exposures are higher and more prolonged than currently recognized.

Neonicotinoids have been linked to impairments in bee foraging, learning ability, growth and reproduction, and overall decline in colony health. Imidacloprid, in particular, has been linked to decreases to the olfactory learning ability of adults, and damages the development of the nervous system in regions responsible for both olfaction and vision during the larval stage (Peng, et al., 2016). In fact, one study, *Neonicotinoid pesticides severely affect honey bee queens* (Williams et al., 2015) observe that exposure to field-realistic concentrations of neonicotinoids during development can severely affect queens of honey bees in adulthood.

These impacts are also observed in wild bees. Bumble bee colonies exposed to imidacloprid were observed to have deficits in colony growth and nest condition, with the pesticide found accumulating in their brains three days after exposure, resulting in neuronal impairment. Feltham et al. (2014), in their study, find that near infinitesimal exposure to neonicotinoids reduces bumble bees' ability to gather food by 57%, demonstrating that field-realistic concentrations of these pesticides substantially impact foraging ability of these bees, and reduces queen production in exposed colonies.

Immune suppression in bees is another phenomena observed after bee exposure to neonicotinoids. This opens the way to parasite infections and viral diseases that are spread among individuals and bee colonies. A study by Brandt et al. (2016) finds that the neonicotinoids imidacloprid, clothianidin and thiacloprid affect the individual immunocompetence of honey bees, possibly leading to an impaired disease resistance capacity at sublethal levels.

A team of scientists led by Dave Goulson, Ph.D. (2015) puts into perspective the state of bee health in relation to the numerous pressures they face in the modern world: chronic exposure to multiple interacting stressors, including pesticide exposure and reduced immune response, is driving honey bee colony losses and declines of wild pollinators. The scientists suggest taking steps to reduce stress on bees, incorporating flower-rich habitat into farmland, and reducing pesticide use through the adoption of more sustainable farming methods.

Adverse Effect level or LOAEC) at which effects were observed was 50 ppb. Honey bees consuming contaminated nectar had reduced numbers of pupae, adult workers, and pollen and honey stores. For long-term exposures, young, larval bees were determined to be less sensitive to the effects of imidacloprid than adult honey bees.

> ***Note:*** *When compared to pollen, EPA determined that exposure to contaminated nectar is a more significant route of exposure for bees and their colonies. This is important as nectar is the primary source of food for adult workers and drone bees.*

2. There Are Many Routes of Exposure, but EPA Is Not Quantifying Them All

For its assessment, EPA primarily recognizes bees' direct exposure to foliar sprays, including drift, and oral ingestion, e.g., consumption of contaminated pollen and nectar as a result of various imidacloprid applications. The agency does also acknowledge that bees experience many other exposure pathways, including contaminated surface water, plant guttation fluids, honey dew, soil (for ground-nesting bees), and leaves. However, EPA explains that it "lacks information to understand the relative importance of these other routes of exposure and/or to quantify risks from these other routes." Unfortunately, bees' risks to these other routes of exposure are critical to a comprehensive hazard assessment. In fact, neonics have been detected in water puddles on treated fields at levels as high as 63 ppb –levels that can "elicit a wide array of sublethal effects in individuals and colony."[1]

> ***Note:*** *In this assessment, EPA does not include exposures from ornamental/garden plants and their potential hazards to bees. These are expected to be addressed later this year.*

3. Limited Data on Wild Bees Keeps Them at Risk

Wild and native bees, like bumble bees and solitary bees, differ from honey bees in their exposure patterns and sensitivity to imidacloprid. For instance, bumble bee colonies are adversely affected by imidacloprid at levels "considerably lower than those observed for the honey bee." A study by Cresswell et al. (2012) in the journal *Zoology* also finds that bumble bees experience a more deleterious effect when exposed to imidacloprid-contaminated nectar compared to honey bees.[2] EPA has very limited data for wild bees, and thus uncertainties remain in extrapolating data from honey bees. However, EPA believes that the honey bee assessment can be used to bridge the gap to the other bee species, despite these biological differences.

1. *Samson-Robert O, Labrie G, Chagnon M, Fournier V. 2014. Neonicotinoid-contaminated puddles of water represent a risk of intoxication for honey bees. PLoS One. 9(12):e108443.*
2. *Cresswell JE, Page CJ, Uygun MB, et al. 2012. Differential sensitivity of honey bees and bumble bees to a dietary insecticide (imidacloprid). Zoology (Jena). 115(6):365-71.*

Imidacloprid Spray Drift Endangers Bees. What About Dust Drift from Coated Seeds?

According to EPA's assessment, off-field spray drift poses risks regardless of the treated crop's attractiveness to bees, or the type of agronomic practices on the treated field. For all foliar spraying, drift exposure may occur on the treated field, adjacent land, and surrounding areas. EPA utilized the spray drift model AgDRIFT to evaluate various drift scenarios and estimates the potential for off-field risks. Unsurprisingly, the most egregious spray drift risks come from aerial applications, where risks are expected at distances more than 1000 ft. from treated fields.

Contaminated dust that results from machine planting of coated seeds, while acknowledged as an exposure pathway, was not addressed in this assessment. This contaminated dust can lead to residues on nearby plants, soil and surface water, resulting in bee exposures. The amount of dust ejected into the air is determined by the type of seed coating, the planting equipment and lubrication agents, along with environmental factors like wind speed and humidity. EPA simply states that it is working with stakeholders on developing best management practices to limit the dust.

4. Real-World Data Finds Imidacloprid Contamination Low Level but Pervasive

According to EPA, pollen samples from corn and sunflower fields where sown seed was treated with imidacloprid contain residues that are detected frequently (ranging from 36 – 58% detection). While the average concentrations detected ranged from 0.6 – 3.0 ppb, which are considered low and just above the limit of detection for these studies, EPA points out (without identifying a hazard) that, "Despite widespread use of imidacloprid on crops through multiple application methods, the magnitude and frequency of detection in hive matrices is relatively low." But, according to Feltham et al. (2014), even at extremely low levels, imidacloprid (0.7ppb) can impact bees' foraging.[3] Similarly, other studies have found that at concentrations between 1ppb and 10ppb imidacloprid can impair the neurological systems of bees and the survival of the colony.[4,5]

Photo by Layla Brooks Maida, Vale, London.

> ***Note:*** Hive monitoring studies across the U.S. and Europe also found similar trends, in that when imidacloprid was frequently detected, the levels were very low.

5. Treated Crops Endanger Foraging Bees

For crops that can be treated with imidacloprid, EPA identifies the applications that pose risks to bees. According to EPA, applications to citrus fruits (foliar) and cotton pose definite risks to bees, while leafy greens, soil treatment to blueberries, and fruits/vegetables that are not attractive to bees are considered low risk.

EPA's assessment relies on whether crops are attractive to bees, wind pollinated, or harvested before bloom as determinants in establishing the extent of the associated exposure risks. However, it should be noted that due to the systemic nature of the insecticide, residues can and do remain in and on plant material, soil, and even water for long periods of time, creating continuous exposure patterns and risks which cannot be dismissed or ignored.

What Is Needed from the Future Neonic Reviews in 2016?

EPA announced that the pollinator risk assessments for neonicotinoids (clothianidin, thiamethoxam, and dinotefuran) will be released in December 2016. Based on the assessment for imidacloprid, the expectation is that these future assessments may also be limited in scope and data, ignoring the full range of use patterns, exposed wildlife, and exposure pathways.

In its upcoming ecological assessments of neonicotinoids, EPA must address the following (some of which it has identified):

- Wildlife effects to birds, fish, aquatic organisms, and others.
- Uses on ornamentals, turf, forestry, and other residential and non-agricultural sites.
- Registered crop uses.
- Vulnerable wild bees and other insect pollinators.
- All routes of wildlife exposure, including soil and water contamination, for all neonics.
- Data gaps and uncertainties that leave future assessments incomplete and unacceptable for any crops and exposure routes.
- Indiscriminate ecological poisoning of these systemic pesticides, raising the need to consider suspending or cancelling registrations.

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4. *Feltham, H, Park, K, Goulson, D. 2014. Field realistic doses of pesticide imidacloprid reduce bumblebee pollen foraging efficiency. Ecotoxicology. 23(3) pp 317-323.*
5. *Peng, YC and Yang, EC. 2016. Sublethal Dosage of Imidacloprid Reduces the Microglomerular Density of Honey Bee Mushroom Bodies. Sci Rep. 6: 19298.*
6. *Yang E. C., Chang H. C., Wu W. Y. & Chen Y. W. 2012. Impaired olfactory associative behavior of honeybee workers due to contamination of imidacloprid in the larval stage. PLoS One 7, e49472.*

The Promise and Challenges of 21st Century Toxicology

by Terry Shistar, Ph.D.

Recent advances in estimating real world chemical interactions and exposure through computer models, known as "computational toxicology," offer some promise for identifying chemicals that adversely affect the endocrine system and have other toxic effects. They also present critical challenges for integrating standards for precaution, transparency, and effective public involvement. It has been 20 years since Congress passed the *Food Quality Protection Act of 1996*, and the Environmental Protection Agency (EPA) has not fulfilled its obligation to screen pesticides for endocrine disrupting effects. To help meet the requirements of the act, EPA, nearly a decade ago, sponsored a National Research Council (NRC)/National Academy of Sciences report, *Toxicity Testing in the 21st Century –A Vision and a Strategy* (2007), which recommended the use of "computational toxicology."

What is computational toxicology?

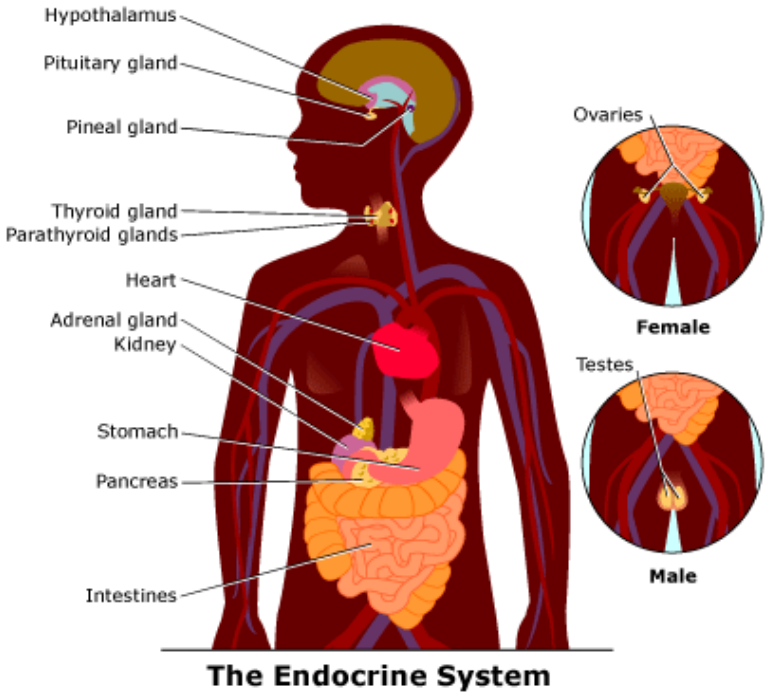
Computational toxicology uses computer models to combine data generated by a variety of real world tests, both *in vivo* (in organisms) and *in vitro* (in glass containers), with theoretical knowledge based on factors like structural relationships to chemicals with known toxicological properties. These models replace risk assessments based on testing of actual organisms with "toxicity-pathway-based risk assessments" based on virtual organisms having virtual tissues composed of virtual cells that interact with virtual chemicals. Exposure estimates are also based on computer models of how toxic chemicals and their metabolites reach cells in the body where they can affect physiological processes. The assessment of virtual risk produced by this process is anticipated to replace conventional risk assessment over the next decade or two. Meanwhile, EPA is considering its use as a tool for chemical screening or prioritizing reviews.

The Uses of Computational Toxicology

The role that computational toxicology might play in evaluating potential endocrine disrupting chemicals (EDCs) differs in the views of EPA, the European Union (EU), and a group of independent scientists.

Environmental Protection Agency. The EPA strategy that emerged from the 2007 NRC report recommendations envisions computational toxicology as replacing conventional toxicology, eliminating currently used uncertainty factors.[1] The thinking is that this new approach will replace traditional toxicology after a transition pe-

riod in which computational models will be used "to predict chemicals most likely to cause hazards of concern for humans. . . and enable risk assessors to determine the specific effects, *in vivo* data, and exposures that would be most useful to assess, quantify, and manage." EPA foresees the transition taking 10 to 20 years.[2]



The Endocrine System

In particular, EPA sees the screening of chemicals for endocrine disrupting potential as an important application of computational toxicology. Screening is the first step –"Tier 1" in the testing program for endocrine disrupting chemicals (EDCs) that EPA identified in its protocol released in 2014.[3] Tier 1 identifies chemicals with the potential to interact with estrogen, androgen, or thyroid hormonal pathways and assesses the need for Tier 2 testing to further characterize those effects by using *in vivo* studies to establish dose-response relationships for any "potential adverse effects" for a risk assessment. The agency does not appear to accept what endocrinologists call an inverse dose response curve (U-shaped dose response curve or non-monotonic dose response curve), characterizing effects seen at minute or very low doses, instead of a diagonal straight line graphic that shows higher dose exposures associated with elevated effects (higher "dose makes the poison" theory). In fact, EPA's Scientific Advisory Panel reinforces this thinking with its statement that, "Monotonic dose-responses are assumed to be dominant in the assays."[4]

European Union (EU) Chemical Review Law. The EU's *Registration, Evaluation, Authorisation and Restriction of Chemicals* (REACH) regulations allows consumers to learn from any supplier whether its products contain officially recognized *Substances of Very High Concern* (SVHC) (substances that have been identified as carcinogens, mutagens or reproductive toxicants, that are persistent and bioaccumulative, or that warrant similar concern). Access to information on SVHCs in products is viewed as a powerful tool for promoting the substitution of harmful chemicals with safe alternatives.[5] Some uses of SVHCs may require prior authorization from the European Chemicals Agency (ECHA), and applicants for authorization will have to include plans to replace the use of the SVHC with a safer alternative (or, if no safer alternative exists, the applicant must work to find one). As of June 2014, 155 SVHCs are on the candidate list for authorization.[6]

Article 13(1) of REACH states that information on intrinsic properties of substances may be generated by means other than tests, provided that the conditions set out (Annex XI) are met. In particular for human toxicity, it requires information to be generated whenever possible by means other than vertebrate animal tests. This includes using *in vitro* methods, qualitative or quantitative structure-activity relationship (QSAR) models, or information from structurally related substances (grouping or "read-across").[7]

It is not clear how effective alternative testing methods have been for regulation, since non-governmental organizations in 2011 called on the Member States and the Commission to agree that, in the absence of data from animal studies, it is necessary to accept regulation on the basis of *in vitro* test methods. The risk assessments performed under REACH incorporate exposure assessment in a conventional risk assessment protocol, and regulation of chemicals under REACH may consist of reducing exposure.

In summary, REACH encourages non-animal studies, but requires manufacturers to demonstrate the adequacy of their methods. Alternative methods and strategies (computational toxicology and *in vitro* testing) are used, but it is not clear how effective they are as a basis for regulation.

Tiered Protocol for Endocrine Disruption (TiPED)

The Tiered Protocol for Endocrine Disruption (TiPED), developed by a multi-disciplinary group of independent scientists, is a testing methodology using a tiered approach for evaluating chemicals for endocrine disruption. It consists of five testing tiers ranging from broad *in silico* (computer simulation) evaluation through specific cell- and whole organism-based assays. Like "green chemistry," it approaches risk reduction through the elimination or reduction of the hazardous chemical in favor of a safer alternative, rather than allowing a hazardous chemical agent, but attempting to mitigate risk by reducing exposure. This is consistent with the method for evaluating materials allowed in organic production and processing under the *Organic Foods Production Act* (OFPA), but contrary to the regulatory approach taken by EPA, which depends heavily on exposure assessment and management.

TiPED incorporates computational methods as a first step in identifying safer chemicals. Chemicals that "pass" Tiers 1-3 without detecting EDC activity are further studied by *in vivo* experiments –Tier 4 in fish and amphibians and Tier 5 in mammals– to reduce the likelihood of false negatives, since the use of whole animals can identify EDC effects caused by mechanisms that target different functions of the endocrine system –including developmental disruptions that may not manifest themselves until much later in life– or identify EDC effects even though the mechanism may not be known. Because mammals differ from fish and amphibians in hormones and pathways, it is important to include testing in mammals that is used only when prior tests detect no EDC activity.[8] To reduce the likelihood of false negatives, TiPED protocol states that, "Power analyses should be performed in preparation for the full assay."[9]

In applying TiPED to known endocrine disruptors, the researchers have found that some –e.g., bisphenol A and phthalates– are identified by computational studies, while others –such as perchlorate and atrazine– might not be identified until Tiers 3 or 4. They found that, "The proposed assays are clearly robust enough that these chemicals would not make it to market, providing supportive evidence that the TiPED screens will be sufficient to identify putative EDCs."[10]

Promises and Challenges

Computational toxicology promises to eliminate the logjam in screening a large number of pesticides for their endocrine disrupting properties. In addition, it presents a way to screen industrial chemicals coming on to the market, and could be used in overhauling the *Toxic Substances Control Act* (TSCA) review process. In theory, this approach makes the maximum use of existing data and minimizes the extensive animal testing conducted under current toxic chemical regulatory testing protocols. However, as is the case with current toxic chemical regulatory schemes, new models do not inherently address the need for a precautionary regulatory approach to toxic chemical approval.

The comparison of the different ways in which computational toxicology could be used by EPA under the *Federal Insecticide, Fungicide, and Rodenticide Act* (FIFRA) and TSCA, by ECHA under REACH, and under TiPED protocol illustrates some of the problems that might arise in EPA's proposed use for screening pesticides for EDCs. Potential problems include:

- **Reduced transparency for the public.** First of all, reliance on computer models can reduce transparency in regulation. Animal testing looks for actual effects on actual animals. Computational toxicology extrapolates estimates of actual effects from study results on related chemicals or effects inferred from results on cells in *in vitro* testing. This may not be transparent to the general lay public. Only those few with training in these methods will be able to understand and comment on their use. The chemical Industry has always challenged the extrapolation of toxicological testing on laboratory animals to the human population, so it is expected that EPA's ability to restrict, cancel, or suspend the use of a pesticide based on results of comprehensive computational models will be questioned.

Objectives of EPA's 2014 workplan for the Endocrine Disruptor Screening Program[11]

1. Prioritization

The near-term goal (less than 2 years) is to use existing data, *in silico* (computer simulation) models, and *in vitro* HTP [high throughput] assays to determine the relative order in which non-pesticide chemicals and pesticide active ingredients going through registration review should be screened.

2. Screening (Tier 1)

The intermediate-term goal (2-5 years) is to replace current validated *in vitro* screening assays with validated *in vitro* high throughput screening computer-based assays; use the results to inform and target current in vivo estrogen- or androgen-specific screening assays; and, where possible, reduce the use of animals for screening purposes.

3. Replacement

The long-term goal (over 5 years) is to consider full replacement of the in vivo screening assays with validated *in vitro* HTP assays and eliminate the use of animals for screening purposes.

- **Lack of attention to complexities.** The extreme reductionist approach, depending on computer models with an unknown range of applicability, poses a problem for dependence on computational toxicology as the sole source of toxicity information. Particularly concerning is EPA's view that it could "eliminate currently used uncertainty factors." In fact, dependence on computational toxicology can increase uncertainty. Whenever relying on computer models, caution is essential to avoid the phenomenon of "garbage in, garbage out" (GIGO). Computer models must be based on sound science and have solid data as inputs.

In order to be protective, ["computational toxicology"] must be used in concert with other methods and embedded in a regulatory system that allows chemicals to be removed from the market when hazards or safer alternatives are demonstrated.

The creators of TiPED point out that, although computational methods have a place, reliance on them alone would create many false negatives. They state, "The complex biology of endocrine disruption means that *no single assay nor single approach* [emphasis in original] can be used to identify chemicals with EDC characteristics. Instead, a combination of approaches is necessary, including computational methods as well as both *in vitro* and *in vivo* testing. . . Today's *in vitro* and computer models do not incorporate the complexity that this involves. For this reason, *in vivo* assays will also be necessary."[12]

- **Sacrificing precaution for a simpler testing scheme.** Under REACH, chemical manufacturers are required to both avoid animal testing and justify the need for the chemical based on the availability of safer alternatives. This adds an additional layer of protection that is not present in EPA's proposed methodology.

A Perspective on the Bigger Picture

Much of the emphasis in proposals for using computational toxicology is focused on evaluating new chemicals – probably because taking existing chemicals off the market is such a daunting task. However, the current situation allows humans and all other organisms to be exposed daily to many chemicals that should not be present in the environment. Any methods of evaluating chemicals that are used must be embedded in a regulatory system that allows for the removal of EDCs and other problematic chemicals.

In addition to the need to evaluate and eliminate hazardous chemicals, the framework in which chemicals are evaluated needs to change. A good model is the *Organic Foods Production Act* (OFPA), since the law creates a default bias against synthetic chemical use –natural materials are acceptable unless shown to be hazardous, and synthetic materials are unacceptable unless it is determined that there is an absence of harm (in chemical life cycle analysis)– and the material is essential to and compatible with an organic management system, as defined by law and certified by a third-party. As in the TiPED protocol, harm is evaluated regardless of exposure. Synthetic chemicals should not be allowed to be used unless they are essential, and unless their use is sustainable.

Summary/Conclusion

The computer-based methods encompassed by the term "computational toxicology" offer great promise for reducing exposure to EDCs and other toxic chemicals. In order to be protective, however, they must be used in concert with other methods and embedded in a regulatory system that allows chemicals to be removed from the market when hazards or safer alternatives are demonstrated. The methods should be used with a precautionary approach –in other words, if a chemical "fails" a computer model (or *in silico* test), it should not be allowed to be marketed. However, materials that "pass" such tests should move on to *in vitro* and *in vivo* tests to ensure that the complexity of endocrine and other physiological functions is fully considered.

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Taking a Stand on Clover

The benefits of clover to bees, soil biology, and water quality

by Drew Toher

"If you see little white flowers in your yard with bees active around them, chances are you have clover," says Scotts Miracle-Gro's website on *How to Kill Clover in Lawns*.[1] Each spring, a wave of commercials and advertisements encourage consumers to rush to their hardware store or garden center and purchase a bag of 'weed and feed' before unwanted plants invade their otherwise lush, green, unvaried turf. To rid lawns of those pesky white flowers, Scotts and many other lawn chemical companies typically prescribe a broadscale application of synthetic nitrogen fertilizer, the chemical 2,4-Dichlorophenoxyaceticacid (2,4-D), and a mix of other herbicides, such dicamba, mecoprop, or triclopyr. 2,4-D, linked to neurotoxicity and endocrine (hormone) disruption,[2] and classified as a possible human carcinogen by the World Health Organization,[3] may be tracked inside of homes,[4] drift through windows, or run-off into local streams and rivers. The other herbicides that may be in 'weed and feed' products are linked to a range of health effects, from neurological to reproductive. [See *Beyond Pesticides' Gateway on Pesticide Hazards and Safe Pest Management.*] Meanwhile, the loss of clover in the landscape eliminates a natural source of nitrogen, food for those active bees, and habitat for earthworms.

Growing awareness of the function and benefits of 'weeds' like clover, their importance to rapidly declining pollinator populations, and the high costs related to the hazards associated with chemical herbicides has more and more homeowners rethinking the 'weed and feed' paradigm and opting for more diverse, resilient lawns and landscapes. Clover has a rich history in American lawns and plays an important ecological role in a turfgrass landscape. Ultimately, it will take consumer action to restore this unjustly maligned plant on lawns and property community-wide.

The Rise of the American Lawn, Complete With Clover

The idea of cultivating a lawn was unimportant to most Americans until the mid-19th century. Historically, lawns were confined to the estates of English nobleman, who often grazed sheep or otherwise used the turf for lawn games.[5] Author and journalist Michael Pollan, who has written on the history of gardening and landscaping, attributes the rise of the American lawn to two men, landscape architects Fredrick Law Olmsted and Frank J Scott.[6] Mr. Olmsted, who helped design New York City's Central Park and the grounds of U.S. Capitol, pioneered one of the nation's first planned

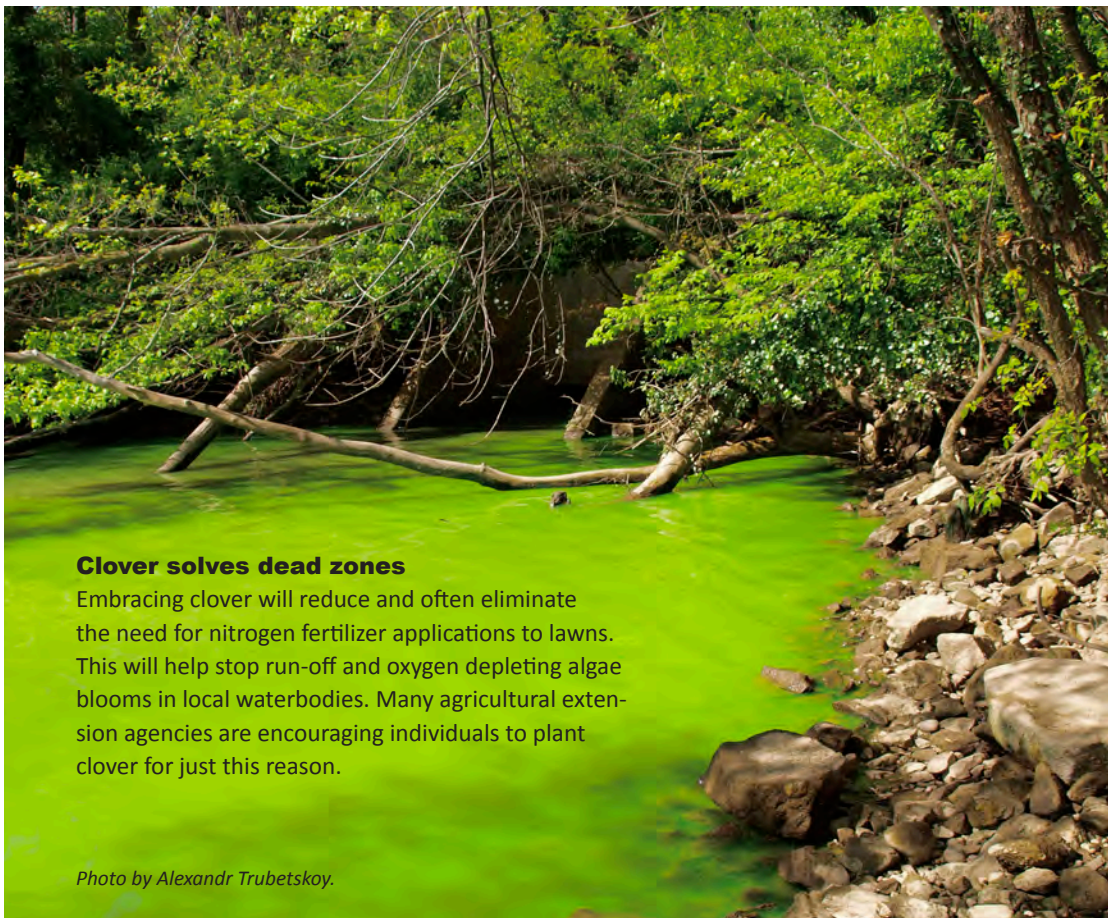
communities in suburban Chicago in the late 1860s, setting houses back 30 feet from the street with green, trimmed lawns contiguous to one another. Later in the century, as Mr. Pollan recounts, Mr. Scott applied Olmstead's landscape aesthetics across the country, publishing the book *The Art of Beautifying Suburban Home Grounds* (1870).[8] Mr. Scott wrote, "It is not necessary to have an acre of pleasure ground to secure a charming lawn. Its extent may always be proportioned to the size of the place; and if the selection of flowers and shrubs and their arrangement is properly made, it is surprising how small a lawn will release some of the most pleasing effects of larger ones."

With the American public firmly sold on the beauty and benefits of managing a small patch of lawn on their property, one component would still stand out as unseemly to today's lawn purists –clover. "No better varieties of grass for lawns can be found than those that form the turf of old and closely fed pastures," wrote Mr. Scott. "Blue-grass and white clover are the staple grasses in them, though many other varieties are usually found with these, in smaller proportions."

As the lawn rose to prominence in the U.S., clover was a critical part of the scenery, with small white blossoms and busy bees dotting over dark green landscapes. "White clover used to be a standard ingredient in every grass seed mix; 75 years ago no one planted a lawn without mixing a little white clover in with the grass seed," recounts Roger Swain, host of PBS' *The Victory Garden*.[9] After World War II, as the middle class grew and moved to suburban communities, chemicals developed during wartime found new uses on U.S. lawns. Chief among them was 2,4-D, an herbicide originally developed with the intent to wipe out potatoes in Germany and rice crops in Japan, in a plan to starve the Axis powers into surrender.[10] While 2,4-D was never used for that purpose, its selectivity, or ability to kill broadleaf plants, but spare grass species, made it desirable on the farm for removing weeds around crops like wheat, corn, and rice.[11] Chemical companies hoped these same characteristics would win over American homeowners, who would simply need one blanket application to rid their lawn of weeds. In 1945, the American Chemical Paint Company released the first residential use 2,4-D herbicide, Weedone, and later in the decade, Scotts packaged its first 'weed and feed' product. Some say that it was not until the 1966 Masters golf tournament's bright green turf was broadcast on color television that the idea of a monoculture lawn really took hold. Despite clover's role in the rise of the American lawn, its susceptibility to broadleaf herbicides, like 2,4-D, put it at loggerheads with the new technology, and through aggressive marketing and advertisements, by the 1950s it began to be regarded as a weed.

Clover's Long-Awaited Comeback

The dramatic declines in honey bee and other wild pollinator populations, spurred by the damaging effects of systemic insecticides, like neonicotinoids, habitat loss, and synthetic fertilizers, have reignited the debate about the ecological utility of clover in green spaces. Public awareness of the largely human-driven pollinator crisis has galvanized individuals to think about their landscaping practices. Urban meadows, suburban hedgerows, and flower-filled "bee lawns" are making their way into American yards. Monoculture lawns are not disappearing completely, but more and more homeowners, businesses, and local governments are making space for clover and other broadleaf plants that provide food and shelter for pollinators and wildlife.



Clover solves dead zones
Embracing clover will reduce and often eliminate the need for nitrogen fertilizer applications to lawns. This will help stop run-off and oxygen depleting algae blooms in local waterbodies. Many agricultural extension agencies are encouraging individuals to plant clover for just this reason.

Photo by Alexandr Trubetskoy.

Benefits of Clover in the Landscape

Incorporating clover into green spaces is a boon not only for bees and soil-dwelling organisms like earthworms, but also for the wallet. Clover is a low-growing, drought tolerant perennial that reproduces through the growth of stolons, or runners, which spread horizontally through stems located just at or below the ground. There are nearly 250 species of clover in the world,[12] and though red, crimson, and white are the most familiar, it is white, or dutch, clover that is best suited to be incorporated into turfgrass. A variety of low growing white clover called microclover is becoming increasingly popular, as it can provide all the benefits of clover yet produce fewer flowers attractive to bees, and is somewhat hidden below the grass.

Photo by Jürgen, Sandesneben, Germany.

Contrary to the perception that clover is an eyesore, the plant will remain verdant green all year round. This is because clover, as a member of the legume family, is able to "fix," or accumulate nitrogen from the air through beneficial soil bacteria that form nodules on its roots. Clover makes quick use of this nutrient, with data showing that roughly 75-80% of its nitrogen is stored in its topgrowth.[13] Clippings left on a lawn after a mixed grass-clover turf is mowed can provide a significant source of free nitrogen. Sowing roughly one to two ounces of white clover per 1,000 square feet will provide a lawn with between 5 and 10% clover cover (up to 10 ounces for the whole lawn to be a bouquet of clover).[14] At this rate, leaving clippings on the lawn will add between one to two pounds of slow release nitrogen per 1,000 square feet.[15] For many soils and grass types, this is enough nitrogen to eliminate the need for any additional nitrogen fertilizer applications over the course of the year.[16]

Increased pollinator populations. Recent research finds that clover acts as a food source for a wide range of important pollinator species. A 2014 study published by Larson et al. in the *Journal of Insect Conservation* on species richness in mixed grass-clover lawns in the Lexington, KY metro area documented over 200 pollinator species over the course of spring sampling, including approximately 21 different species of bees. On average, each lawn contained between 2-12 different pollinator species. City-dwellers tending a small patch of lawn certainly are not doing so in vain, as researchers found species richness to be similar in urban, suburban, and periurban-rural areas.

Improved soil health. In addition to providing food for pollinators, clover's benefits extend below the surface to soil-dwelling organisms. Studies performed on grazing lands show that when clover is mixed into grass-dominated landscapes, earthworm abundance increases.[17] Research published by van Eekern et al. in the *Journal of Applied Ecology* (2009) found that planting grass-clover mixtures provide a wide range of positive benefits to the landscape and increase soil health and microbial diversity. "We suggest that when clover is introduced in grassland to reduce the reliance on inorganic fertilizer, the mixture of grass and clover maintains the positive impact of grass roots on soil structure and increases the supply of nutrients via the soil food web," the author's note.[18] When managed organically, clover can support a soil system that sequesters carbon and helps to reduce the advancement of global climate change.

The use of insecticides diminishes the numerous services that clover provides for lawns and landscapes. While the use of herbicides eliminates this critical habitat for a range of species, insecticides pose a direct danger to pollinators and soil dwelling organisms. Neonicotinoid pesticides represent the greatest threat, as scientists have shown that these chemicals interfere with the mobility, navigation, feeding behavior, reproduction, and overall colony health of bees.[19] Studies find that these hazards are just as real in urban and suburban green space as they are on agricultural lands.

Limited use on playing fields

Clover on, but take note: clover is a needed addition to a lawn, but it's not a panacea. Don't plant pure clover or a high percentage of clover in areas where there will be frequent high intensity sports or foot traffic, simply because dense stands of clover can be a bit slippery.

Photo courtesy of Imgur.

Other clover applications

Clover is useful in a number of other areas apart from the lawn. Plant a ring of pure clover around your garden to both attract earthworms and deter rabbits, which will stop at the clover before reaching your veggies. Also use it as a ground cover, to accent walking paths, or as a cover crop during the winter months. Let pure clover stands grow around your garden and "chop and drop" by letting it grow out and using the cuttings as nitrogen-rich mulch.

Larson et al's 2014 article in the journal *Ecotoxicology*, which examines the effects of common lawn care insecticides, finds significant adverse impacts to beneficial insects and parasitoids. Applications of the neonicotinoid clothianidin, as well as a formulated clothiandin-bifenthrin mixture (bifenthrin being a synthetic insecticide in the pyrethroid class) to residential lawns, results in high mortality to ground beetles and wasps that prey on black cutworm pests. Another species of wasp that parasitizes the larval stages (grubs) of various species of scarab beetles show reduced predation, and bumble bee colonies that forage on white clover in clothianidin-treated turf show, unsurprisingly, reduced numbers of workers, honey pots, and immature bees.[20] A 2013 study by Cycon et al. found slight changes to soil diversity occur after applications of the neonicotinoid imidacloprid at recommended label rates, with significant adverse effects seen at higher doses. In a 2012 study published in *Pest Management Science* by Larson et al., clothianidin applications to turfgrass reduced earthworm biomass by 32% after one week, while a clothinidin-bifenthrin mixture reduced biomass by 49% during the same period of time.[21]

Joining in Defense of Clover: What you can do

Bringing clover back into American lawns is predominately a cultural issue. It requires a change in perception about what constitutes an aesthetically pleasing landscape, and education about the ecological benefits and cost-savings that clover can provide. Individuals can press their local government to incorporate grass-clover seed mixes into their public parks and green spaces, and inform residents of the benefits of doing so. At the same time, they can make the case for restrictions on the use of synthetic herbicides that treat clover as a weed, and insecticides that undermine the services the plant provides. However, the beauty of reviving clover on the American lawn is that every individual with a patch of green space can make a stand. Let the clover already present flower, and don't be afraid of seeding more. Yes, your lawn will contain small white flowers, and yes, you'll attract bees to your yard, but you know that's a good thing for your wallet and the environment, and when your neighbor asks what you're doing, you'll be ready to respond.

Reviving the American Lawn with Clover

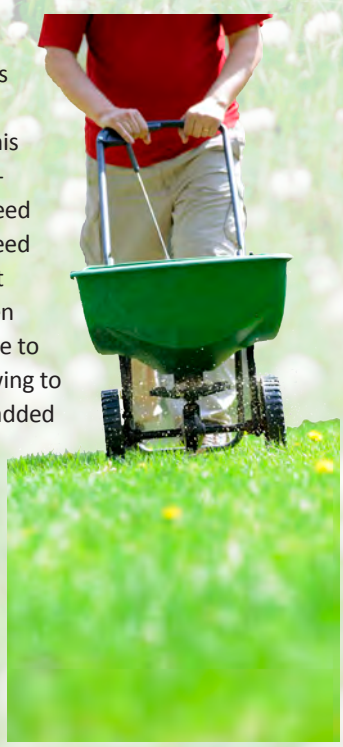
Clover was not always considered a weed. In fact, 75 years ago every lawn contained some amount of clover. Incorporating this three leaved (four if you're lucky!) plant into public and private green spaces is a great idea. Here's why:

Clover:

- Provides your lawn with a free source of nitrogen for your grass (usually enough to eliminate any need for additional fertilizer applications), replacing ecologically hazardous synthetic fertilizers
- Acts as an important food source for declining pollinator populations
- Attracts earthworms and other beneficial soil microorganisms
- Remains green year-round
- Resists drought
- Helps your lawn resist disease

Seeding your lawn:

When planting a new lawn, pure clover seed can be added at a rate of 1 to 2 ounces per 1,000 sq ft, which will produce about 5 to 10% clover cover. With grass clippings, this will add 1 to 2 pounds of slow release nitrogen per 1,000 square ft. You can also overseed with clover at the same rate. Since clover seed is too small for most spreaders, try mixing it with sand, soil or compost to ensure an even distribution throughout the lawn. Make sure to cut the lawn and remove thatch before sowing to allow for good germination. Clover can be added throughout the growing season, though spring is ideal. It may take a few years of overseeding to establish clover, but this will still be less expensive than nitrogen fertilizer applications. If you already have clover on your lawn, let it spread! Adding clover and leaving clippings on the lawn will provide enough nitrogen fertilizer most lawns need for the year!



Buying Clover:

Dutch White clover is the traditional option to add to turf grass. Many garden centers and hardware stores now carry clover seed, and it can also be purchased online at retailers like Gardeners Supply Company. For folks who want the economic benefits of clover, but are still concerned about aesthetics and less enthused about attracting pollinators, microclover is a new option on the market. It will grow lower than grass and produce fewer flowers while still remaining dark green and fixing nitrogen from the air. DFL organics and EarthTurf are two companies which specialize in grass-microclover seed mixes.

Maintaining Clover:

Tend to your grass-clover lawn just as you would a pure grass lawn. Organic practices are the best way to keep your lawn healthy. Visit www.beyondpesticides.org/lawns for details on organic lawn care.

Tell Your Neighbors, Your Local Government, and Beyond Pesticides

Educate your neighbors, friends, and family about the benefits of clover! Ask your local government to help pollinators and reduce nitrogen pollution by incorporating clover-grass mixes at local parks. Hold a workshop at the local library or public event about why and how to add clover to a lawn. Let Beyond Pesticides know when you or your community has established a clover-grass lawn by signing the pesticide-free and pollinator-friendly yard declaration http://bit.ly/LawnDeclaration, and sending us a picture of your clover-filled green space to info@beyondpesticides.org!

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ChemicalWatch Factsheet

GLUFOSINATE-AMMONIUM

Background Information

Glufosinate-ammonium (glufosinate) is, according to the U.S. Environmental Protection Agency (EPA), an organophosphorus chemical that is primarily a foliar-active herbicide with limited systemic activity,[1] and is linked to a range of human health and environmental effects. Remarkably, in 2013, EPA identified multi-generational hazards in mammals when the chemical is used in accordance with product label instructions, but has not imposed new restrictions to account for this.

Glufosinate was first registered in the U.S. for use as an herbicide in 1993 by Hoechst Celanese.[2] Also known as phosphinothricin, this herbicide is commonly marketed under the trade names Basta, Rely, Finale, Ignite, Challenge, and Liberty and is registered for use on golf course turf, residential lawns, ornamentals, and a variety of industrial, residential and public areas, on fruit and nut orchards and vineyards, and as well as a wide range of genetically engineered (GE) crops (since 1995). Glufosinate use is expected to increase dramatically in the coming years as a result of widespread pervasive glyphosate-resistant weeds, and the subsequent incorporation of glufosinate tolerance into new stacked varieties of GE crops as of 2014 that are also resistant to 2,4-D and glyphosate (see box).

ChemicalWatch Stats

CAS Registry Number: 77182-82-2
Trade Name: Basta, Rely, Finale, Ignite, Challenge, Liberty
Use: Non-selective foliar herbicide used for pre-plant and post-emergent control of broadleaf weeds
Signal Word: Warning!
Toxicity Rating: Toxic
Health Effects: Known reproductive/developmental effects, neurotoxicant
Environmental Effects: Toxic to aquatic organisms and mammals

Regulation Status and Current Use

Glufosinate is registered for use on almonds, apples, bananas, berries, canola, corn, cotton, grapes, potatoes, rice, soybeans, tree nuts, and more.[3,4] According to EPA's 2008 Summary Document for glufosinate, the majority of agricultural uses occur in corn (900,000 lb active ingredient (ai)/acre), followed by cotton (300,000 lb ai/A), canola (60,000 lb ai/A), almonds (30,000 lb ai/A), and grapes (20,000 lb ai/A).

Glufosinate-tolerant crops are not approved for use in the European Union (EU).[5] While the EU has a process in place for approving GE crops, and has approved many, France, Germany, Northern Ireland, Scotland, Bulgaria, and many others have banned their cultivation, opting out of the EU approval process.[6]

Mode of Herbicidal Action

As a phosphinic acid, glufosinate-ammonium is a structural analogue of glutamate and acts in plants via the inhibition of the activity of glutamine synthetase, the enzyme that converts glutamate and ammonia into the amino acid glutamine in both animals and plants, although the extent to which this occurs differs significantly within each type of organism.[7] Through the inhibition of this enzyme, ammonia accumulates within the plant, resulting in cell destruction and the direct inhibition of photosynthesis reactions and eventual death of the plant.[8,9] However, crops genetically engineered to tolerate glufosinate contain a bacterial gene that produces an enzyme that detoxifies the chemical and prevents it from doing damage.[10]

Human Health Effects

Acute Toxicity. Glufosinate can cause of range of effects from substantial, but temporary eye injury, skin irritation, respiratory failure, to death through dermal absorption or ingestion. Any contact with the substance can result in some sort of deleterious effect. These effects may vary according to glufosinate formulations and in comparison to technical grade glufosinate.[11,12]

Case reports describe symptoms of ingestion that include convulsions, respiratory distress, disturbed and loss of consciousness, tremor, speech impairment, circulatory failure, and loss of short-term memory.[13,14,15,16] Neurotoxicity can result from glufosinate poisoning, although the mechanism in not clear. Glufosinate toxicity appears to come from both the active ingredient and the surfactants in the formulation.[17]

Mild to moderate toxicity includes symptoms of nausea, vomiting, and diarrhea within two hours of ingestion. Within 24 hours, generalized edema and mild leukocytosis commonly develop, along with elevated liver enzymes. Cases of severe toxicity may result in initial gastrointestinal upset followed by severe neurological effects 8 to 32 hours after ingestion. These effects include seizures, coma, nystagmus (uncontrollable eye movements), retrograde and anterograde amnesia, and respiratory failure.[18]

Chronic Toxicity. In laboratory animals, glufosinate has been shown to cause an inhibition of glutamine synthetase activity in different tissues. This inhibition resulted in slight increases of glutamate and ammonia levels at high sublethal and lethal doses. Mammals metabolize glufosinate in a way that allows for the compensation of the inhibition of glutamine synthetase activity by other metabolic pathways.[19] Exposure to glufosinate in mice at 5 and 10 mg/kg over a period of 10 weeks is shown to result in cerebral alterations, specifically mild memory impairments, modification of hippocampal texture, and a significant increase in hippocampal glutamine synthetase activity.[20]

Studies have reported that glufosinate is toxic to mouse embryos *in vitro* (in glass containers) and causes growth retardation and neuroepithelial

cell death.[21] Paternal exposure to glufosinate in humans has been found to correlate with a possible risk in congenital malformations.[22]

The herbicide is also being detected in humans. In a 2011 study by Canadian researchers, pregnant women exposed to pesticides associated with genetically engineered food, specifically glyphosate and glufosinate, were examined to investigate whether these toxicants cross the placenta to reach the fetus. Glufosinate's metabolite, 3-MPPA, was detected in 100% of maternal and umbilical blood samples, and in 67% of non-pregnant women's blood samples.[23] Glufosinate is classified as having known reproductive/developmental effects and is a known toxicant, according to the *Pesticide Properties Database*.[24] EPA classifies glufosinate as "Not Likely to be Carcinogenic to Humans."[25]

Environmental Fate

According to EPA, the half-life of glufosinate in soil ranges from 8.5 to 23.0 days in aerobic (with oxygen) soil, depending on application rate.[26] Other sources document a range of 4 to 10 days in aerobic soil. In anaerobic (absence of oxygen) soil, half-life increases to 37 days. Aerobic water half-lives range from 38 to 87 days. Glufosinate is mobile to highly mobile. Mobility of residues in soil is a function of organic content, meaning that mobility of glufosinate in soil may be less for soils with higher organic content.[27] In one study comparing the persistence of five herbicides, including glyphosate, glufosinate ammonium was found to be the least persistent in sandy loam and clay soil types, with 90% dissipating within 2.5 months.[28] Glufosinate residues resulting from root uptake following soil application have been found in apples, grapevine, potatoes, and cereals (maize and wheat).[29]

A U.S. Geological Survey (USGS) study examining the presence of this herbicide in the environment has found that glufosinate is seldom found in surface water, rainfall, and soil samples.[30] However, due to glufosinate's high mobility, solubility (about 1,370 g/L), and resistance to breakdown by light and water,[31] there is still potential for contamination and risk of harm for aquatic species. Indeed, fish kill incidents have been documented by EPA in association with nearby terrestrial application of glufosinate in surrounding agricultural areas.[32]

Effects on Non-Target Organisms

Acute Effects. Acute effects in non-target organisms from exposure to both the active ingredient glufosinate ammonium and its formulated products have been documented. Acute glufosinate exposure to the aquatic unicellular alga Chlorella vulgaris was shown to affect the activities of antioxidant enzymes, disrupting the structure of chloroplasts, and reducing transcription of photosynthesis-related genes.[33] Field application rate levels of glufosinate ammonium are found to be highly toxic to nymphs and adults of certain predatory mite species.[34] An investigation of the effects of sublethal concentrations on tadpoles exposed during a period of 48 to 96 hours to the products Liberty® and Ly® found that there is a concentration-dependent increase in micronucleated erythrocytes in blood. Researchers found that the commercial formulation of glufosinate induced micronucleus formation in tadpoles in contrast to the active ingredient, indicating that the inert ingredients of the commercial formulation played an important role in the production of genotoxic damage in the red blood cells of amphibian tadpoles.[35] A similar study examining the effects of sublethal glufosinate ammonium exposure found an inhibition in the activities of both the acetylcholinesterase (ACh) and butyrylcholinesterase (BCh) enzymes, which are important for motor function, in tadpoles, showing a concentration-dependent inhibitory effect. At an exposure of 15 mg glufosinate-ammonium per liter, there is a significant increase (compared to unexposed tadpoles) in swimming speed and the mean distance they are able to swim as well as a significant negative correlation between swimming speed and BCh enzyme activity. These results suggest that this enzyme inhibition is related to an increase in swimming speed, an effect that may have adverse consequences at the population level since neurotransmission and swimming performance are essential for tadpole survival.[36] Fish kill incidents have been reported to EPA in association with terrestrial application of glufosinate in surrounding agricultural areas.[37]

Chronic Effects. In its Environmental Fate and Ecological Risk Assessment for the herbicide, EPA, in 2013, states that glufosinate use "in accordance with registered labels results in chronic risk to mammals that exceeds the Agency's chronic risk Level of Concern (LOC)."[38] Adverse effects to mammals after chronic exposure in laboratory studies includes reductions in growth and in offspring fitness and viability. The agency adds that these "effects are not only seen across generations, but in multiple species as well." Some uses of glufosinate may also result in acute risk to mammals and chronic risks to birds, reptiles, and amphibians due to exposure through diet. The potential for acute risk to birds, reptiles, and amphibians exposed through a terrestrial diet is based on sublethal effects of lethargy and diarrhea. EPA found LOC exceedances for off-site transport of glufosinate to surface water for federally listed threatened and endangered species of aquatic nonvascular plants (e.g. algae) and estuarine/marine invertebrates. As touched on above, formulated glufosinate is generally more toxic to aquatic and terrestrial animals than the technical grade active ingredient.[39] Despite the numerous LOC exceedances outlined in its preliminary ecological risk assessment, EPA has failed to propose mitigation measures, and will not do so possibly until later in 2016.

Glufosinate and GE Crops

Glufosinate has been approved for use on GE crops since 1995.[40] Currently, there are approved cotton, corn, soy, sugar beet, rice and canola varieties that are genetically engineered (GE) to be glufosinate-tolerant. These crops have been genetically engineered to express phosphinothricin-acetyltransferase (PAT), which allows the plant to metabolize glufosinate ammonium into N-acetylglufosinate.[41] Glufosinate formulations have been marketed as a non-selective chemical control alternative for weeds that have become resistant to glyphosate (Roundup). As such, formulations containing glufosinate are being used on glufosinate-tolerant crops. For example, LibertyLink, a set of genetically-engineered crops developed by Bayer CropScience, is used in conjunction with glufosinate-containing herbicides, like Liberty or Ignite, on GE crops.[42]

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The Soil Will Save Us

The Soil Will Save Us, Kristin Ohlson, 2014, 242pp.

The author takes us through the U.S. and around the world on her journey to understand the value of soil health and the dramatic benefits it provides to the environment and those who inhabit and depend on it for sustenance. Kristin Ohlson's personal interactions with research scientists, farmers, and land managers and the transformative experiences that they relate weave a gripping and informative story that is critical to solving the world's environmental and public health problems. It is the respect, nurturing and management of soil that will determine the livability of the planet, whether we strive to eliminate toxic pesticide use, stop chemical fertilizer runoff into waterways, or reverse global climate change. The story begins with the microbial life in the soil.

Any land manager, whether a farmer or a parks manager, probably knows the structure of the soil being managed, its content of sand, silt and clay, as well as the pH and the soil chemistry. However, typically there is little knowledge about the management of the site's soil biology and the benefits that it delivers. This is not a new problem. In fact, a 1938 publication of the U.S. Department of Agriculture (USDA), *Soils and Men: A Yearbook in Agriculture*, stated, "Do civilizations fail because soils fail or do soils fail because civilizations don't know how to take care of the ground beneath their feet?" Ironically, as the author points out, much of the lack of attention to soil health has been driven by USDA's promotion of chemical farming and industrial scale agriculture that does not incorporate basic soil health practices, as described by Jeff Moyer, long time farm manager and executive director of the Rodale Institute –compost as top dressing, cover crops with atmospheric nitrogen grabbing legumes, and crop rotation, what he calls the three C's.

Here are some numbers conveyed by Ms. Ohlson: the soil may account for up to 95% of our planet's species diversity, and, as many as 75,000 species of bacteria (much of them beneficial) are in a teaspoon of healthy soil, 25,000 species of fungi, 1,000 species of protozoa, and, 200 species of nematodes. These organisms work together and are mutually beneficial as they cycle nutrients that contribute to plant growth, resulting in great environmental benefits. Fungi and bacteria secrete enzymes that liberate minerals from the clay, silt and sand. Microorganisms provide food, protection from predators, and control the underground flow of water, and gases by building soil structure called aggregates –and there are trillions of them. Minimal soil disturbance with no-till practices is beneficial. All of this serves to provide protection during droughts because the soil holds moisture and water and protection against floods because water can move through it instead of running off.

In addition to the fossil fuel intensive production process for chemical fertilizers, Ms. Ohlson writes that their use "interferes with one of nature's great partnerships. By the terms of the partnership, plants are supposed to distribute carbon sugars through their roots to the microorganisms in exchange for nutrients. Fertilizer disrupts this. . ." Quoting Rodale's soil microbiologist, Kristine Nichols, Ph.D. (formerly USDA), "When we add fertilizer, we're putting nutrients right next to the plant roots and the plant doesn't have to give up any carbon to get them. Therefore, the soil organisms can't get enough food."

As the author sums it up, farmers have shown that, "When you understand nature and work with her, farming becomes easier and cheaper, not harder and more costly." Ms. Ohlson, in Burleigh County, North Dakota, talked to farmers who no longer use chemical fertilizers or insecticides and generate 127 bushels of corn per acre (27 bushels more than the county average), spending $1.00 to $1.25 per bushel, compared with the county average of $3.00 to $3.50 a bushel.

The book addresses the value of animals moving through landscapes, quoting Alan Savory, originator of holistic management: "When you graze and then let the plants recover, they pulse carbon and moisture into the soil." Invasive weeds, according to Mr. Savory, are a symptom of the loss of biodiversity in the landscape.

The author notes that parks have successfully converted to organic soil management, from Battery Park in New York City, Harvard Yard, to the Luthy Botanical Garden in Peoria, IL. Finally, on carbon sequestration, the author concludes that, "No other natural process steadily removes such vast amounts of carbon from the atmosphere as photosynthesis." The book concludes with research data from the University of New Mexico's institute for Sustainable Agricultural Research, which finds that enough CO_2 (50 tons CO_2 per acre) can be captured and retained in healthy soil on less than 11% of the world's cropland to offset all anthropogenic CO_2 emission.

The Bee Protective
Ambassador Project

On college campuses nationwide, grounds crews and landscapers maintain land with toxic pesticides, even though safe alternatives exist. The widespread use of pesticides, specifically, a class of insecticides known as neonicotinoids (neonics), has been driving the decline of honey bees and other wild pollinators.

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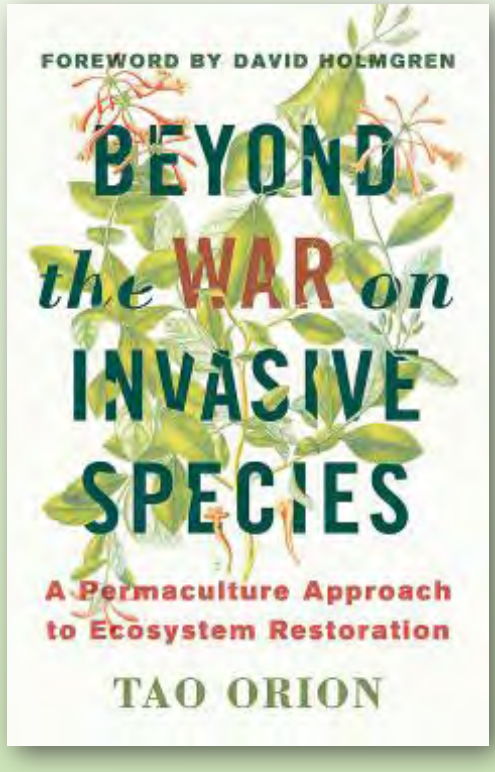

Kristin Ohlson is a journalist and bestselling author. Her book, *The Soil Will Save Us*, makes an elegantly argued, passionate case for "our great green hope" –a way in which we can not only heal the land ,but also turn atmospheric carbon into beneficial soil carbon –and potentially reverse global warming. (See Review on p24.)

Tao Orion is a permaculture designer, teacher, homesteader, and mother living in the southern Willamette Valley of Oregon. She holds a degree in agroecology and sustainable agriculture from UC Santa Cruz, and has a keen interest in integrating the disciplines of organic agriculture, sustainable land-use planning, ethnobotany, and ecosystem restoration in order to create beneficial social, economic, and ecological outcomes.