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Pest Management Regulatory Agency (PMRA)
Health Canada
2720 Riverside Drive
Ottawa, Ontario

March 22, 2017

<u>Comments to Health Canada Pest Management Regulatory Agency on Proposed Re-evaluation Decision PRVD2016-20, Imidacloprid</u>

The Center for Food Safety (CFS)[1] in conjunction with the Save the Oak Ridges Moraine Coalition (STORM)[2] and Avaaz[3] submit the following comment in support of Health Canada Pest Management Regulatory Agency's (PMRA) proposal to prohibit the use of imidacloprid and further encourages PMRA to expedite the proposed phase out process.

We are writing on behalf of over 4.4 million people worldwide, including 200,474 Canadians, who have signed an Avaaz petition urging Canada and others to "immediately ban the use of neonicotinoid pesticides" particularly imidacloprid. Additionally CFS has 5,275 Canadian members who are increasingly concerned about the impacts that pesticides, especially neonicotinoids, are having on pollinators and our environment. Given the weight of evidence showing detrimental impacts of imidacloprid to aquatic ecosystems and the comprehensive evaluation of possible mitigation strategies, we encourage PMRA to accelerate its proposed phase out of this agent for agricultural and outdoors uses.

The Pest Control Products Act makes clear that Health Canada is responsible for regulating the use of pesticides "to protect human health and safety and the environment." Thousands of Canadians have also submitted comments to this consultation, through Avaaz, reaffirming their expectation that PMRA fulfill this responsibility by acting swiftly to prohibit the use of imidacloprid.

[1] CFS is a nonprofit, membership organization with a mission to empower people, support farmers, and protect the earth from the harmful impacts of industrial agriculture. Through groundbreaking legal, scientific, and grassroots action, CFS protects and promotes the public's right to safe food and the environment. CFS has more than 830,000 consumer and farmer supporters—including 5,275 Canadian members.

[2] The STORM Coalition is focused on protecting the ecological integrity of the Oak Ridges Moraine. Since 1989, STORM has been working to ensure that local and regional governments' planning decisions respect the environmental significance of the moraine and take into account its ecological and hydrological functions.

[3] Avaaz is a 44-million-person global campaign network that works to ensure that the views and values of the world's people shape global decision-making. "Avaaz" means "voice" or "song" in many languages. Avaaz members live in every nation of the world.

Sonya V. Thursby of Toronto, an Avaaz member, wrote:

Demonstrate leadership by banning Imidacloprid! We know how critical a balanced ecosystem is to sustain life—the harm this chemical causes to aquatic insects throws off this significant balance. The phase out period needs to be shortened to now—the time to act is now because we have the knowledge to understand how harmful this chemical is to our ecosystems and biodiversity. What state will our ecosystem be in when my 13 and 17 year old children reach adulthood if leaders like you act now.

This submission asserts that:

a. The proposed three - five year phase out period is unnecessarily long, given the data presented by PMRA, and the weight of scientific evidence demonstrating imidacloprid's harm to wildlife, including aquatic insects, terrestrial organisms, birds and pollinators.
b. Neither alternative use reduction plans, nor precautionary label statements will adequately or reliably reduce the risks posed to the environment by imidacloprid.
c. PMRA must also act to review and phase out other neonicotinoids to ensure that the environmental benefits of imidacloprid's prohibition are not offset by increases in the use of other similarly harmful agents.

Expedite the Phase Out: Imdacloprid is Found at Unsafe Levels Known to Cause Harm To a Variety of Species

A growing number of studies show that Canadian waters are in jeopardy from continued contamination by neonicotinoid insecticides used widely for agricultural and outdoor uses. In fact a three-year investigation of neonicotinoid insecticide contamination in surface water sites across southern Ontario revealed three of the five neonicotinoids tested (imidacloprid, clothianidin, thiamethoxam), had more than 90 percent detection rates in over half of the sites.[i] The Canadian government's threshold for imidacloprid residues in freshwater is .23 ppb, which was exceeded in 75 percent of the samples collected in two sampling sites.[ii] The data from the three-year investigation show a strong correlation between pesticide detection, precipitation, and stream discharge. Other studies of Canadian monitoring data by government and independent researchers revealed 98.7 percent detection frequency of thiamethoxam and 100 percent detection frequency of clothianidin in Southwestern Ontario water samples from corn-producing counties[iii], and 91 percent neonicotinoid detection (imidacloprid, thiamethoxam, clothianidin, acetamiprid) in wetlands sampled across the Prairie Pothole region.[iv] Health Canada reported imidacloprid at concentrations as high as 290 times greater than the level of acceptable risk.[v] Across all studies, researchers noted neonicotinoids long- term persistence and highlighted specific concerns for wetlands in colder climates where the chemicals persist in soil and transport via snowmelt to nearby surface water.[vi]

A prohibition will only be implemented after the publication of the government's final re-evaluation decision. If PMRA's suggested three - five year phase-out period is adopted then imidacloprid will continue to be used until 2020 or 2022, depending on the re-evaluation decision's final publication date. This is particularly troubling given the above noted findings, imidacloprid's half-life of up to 229 days in soils,[vii] and PMRA's own conclusion that "under current conditions of use, the environmental risks for most products containing imidacloprid do not meet current safety standards.” France has committed to prohibit all neonicotinoid chemicals as early as 2018 and we strongly encourage the Canadian government to match these target dates.

Imidacloprid Impacts More Than Just Aquatic Insects

PMRA correctly identifies that imidacloprid places aquatic insects at risk; however, as the agency progresses with its final re-evaluation, it must also thoroughly assess risks to other species, including pollinators, birds, and beneficial insects (such as earthworms).

For earthworms, Wang et al. 2015 note a LC_{50} of 3.05 mg/kg of imidacloprid and that a sub-lethal dose of 2.0 mg/kg, caused an 84 percent decrease in fecundity.[viii] Because earthworms are critical to soil health, we feel it is imperative that harms to these beneficial insects are thoroughly evaluated in current and future risk assessments.

Hallman et al. 2014 determined that commonly-found levels of imidacloprid in Holland’s surface water correlates to a 3.5 percent annual decline in bird populations.[ix] Gibbons et al. 2015 found, in a comprehensive review of 150 studies, that ingestion of even a few neonicotinoid-coated seeds could cause mortality or reproductive impairment to sensitive bird species.[x] While, PMRA acknowledges that coated seeds may be harmful for birds, it’s suggested mitigation strategies (including label cautions and removing coated seeds from field surfaces) are inadequate when considering the minimal exposure required to cause harm.

Other Jurisdictions

The U.S. Environmental Protection Agency (EPA) made similar findings about aquatic ecosystems in the 2017 *Preliminary Aquatic Risk Assessment to Support the Registration Review of Imidacloprid*. The comprehensive report incorporated data from PMRA as well as the European Food Safety Authority. Based on the evidence compiled, the EPA underlined the threat of imidacloprid to aquatic communities concluding, “It is evident …that concentrations of imidacloprid detected in streams, rivers, lakes and drainage canals routinely exceed acute and chronic toxicity endpoints derived for freshwater invertebrates.” and explained that acute and chronic risks were identified with a majority of registered uses of imidacloprid.[xi] Because the farming practices and water bodies in the nations are comparable, these conclusions bolster those of PMRA and further emphasize the need for strong regulatory action.

Alternative Use Reduction Plans and Precautionary Labels Will Not Sufficiently Reduce Risks

We also want to support and reiterate PMRA’s caution against an alternative use reduction plan. As outlined in the assessment, any possible mitigation plans are hindered by an inability to accurately predict the degree of reduction necessary to meet acceptable imidacloprid levels without extensive and costly water monitoring information. Further any plans are limited by difficulties in specifying the uses causing high concentration levels and finding means of ensuring that approved imidacloprid use does not increase in areas in which it is not used extensively now. Finally, PMRA has identified immediate contamination concerns and there is no way to gauge how long an effective reduction plan would take.

The PMRA's Proposed Re-Evaluation Decision explains that water based imidacloprid is found at unsafe levels at agricultural sites, even though imidacloprid products have precautionary labels designed specifically to minimize this risk. For this reason, we again urge the agency to move forward with an expedited phase-out of imidacloprid, as current best management practices and pesticide product labels are insufficient for protecting aquatic species, birds, pollinators, and other beneficial insects.

Strong Actions Are Also Needed For Clothianidin and Thiamethoxam

While imidacloprid poses a significant threat to the environment, so to, do other neonicotinoid insecticides, such as clothianidin and thiamethoxam. We strongly encourage PMRA to take immediate action to curtail the use of all neonicotinoids, so as to ensure that the environmental benefits associated with an imidacloprid phase out are not suppressed by the increased use of similarly detrimental alternatives.

A 2017 report from Chretien et al. of Agriculture and Agri-Food Canada, as well as Quebec Ministry of Sustainable Development, raises concerns about contamination from surface runoff and subsurface tile drain losses with a particular focus on the contamination by clothianidin and thiamethoxam. The report documents a two year study in which 14 surface runoff and tile drain discharge events were monitored. The researchers reported, "detection frequencies close to 100 percent in edge-of-field, surface runoff and tile drain water samples...for thiamethoxam and clothianidin even though only thiamethoxam had been applied in the first year."[xii] These findings highlight the persistent nature of these chemicals in certain climates and soil conditions as well as the potential harm of their degradates. The insecticides were reported at median concentrations of .46 ppb and .16 ppb and many concentrations exceeded the .0083 ppb chronic threshold for effect on aquatic life recommended by Government of Quebec.[xiii] The authors of the report echoed the proposal established in the Quebec Pesticide Strategy 2015-2018, and explained that any plans for reduced use or mitigation to control dust and surface runoff would not be sufficient.

Despite these findings, with a majority of environmental monitoring programs and toxicity testing dedicated to imidacloprid use, "no ecological thresholds exist for thiamethoxam and clothianidin."[xiv] This major shortcoming is particularly an issue in Quebec where nearly 100 percent of corn and 50 percent of soybean seeds are planted with neonicotinoid seed coatings—covering nearly 500,000 ha.[xv] Giroux et al. found detection frequencies of thiamethoxam and clothianidin ranging from 93 percent to 98 percent from 2012 to 2014 in four Quebec watersheds.[xvi] Canada's increasing documentation of this contamination supports PMRA's analysis and is an indication of the critical need for setting stronger regulatory protections for the environment, including the proposed prohibition of imidacloprid, as well as other neonicotinoid insecticides.

Conclusions and Recommendations

Perhaps the most important point in PMRA's own conclusion was the realization that imidacloprid is indeed causing harm to aquatic environments and current uses are "not sustainable"[xvii]. CFS, Avaaz, and STORM fully agree with PMRA's strong conclusion - it is evident that a complete phase out is a necessary action to protect aquatic ecosystems from imidacloprid contamination. Furthermore, we support PMRA's call for similar evaluations to be conducted for additional neonicotinoid insecticides, particularly thiamethoxam and clothianidin. We commend PMRA for its decision to move forward with strong regulations based on the chemical's water solubility, persistence, and propensity for unintended contamination of critical waterbodies.

We would further like to highlight the analysis and recommendations in the two attached CFS reports, which are incorporated into this comment by reference: *2017 Updates to Water Hazard: Aquatic Contamination by Neonicotinoid Insecticides in the United States* and *Water Hazard: Aquatic Contamination by Neonicotinoid Insecticides in the United States.* Also incorporated are the attached testimonies of Avaaz members across Canada concerned with the continued use of neonicotinoid insecticides.

> Joe Thauberger of Canada, an Avaaz member, wrote:
>
> *To the PMRA, I am a retired farmer from Saskatchewan. I have seen with my own eyes the devastating affects on our wildlife. Insecticides of all kinds should be banned and used only under very special situations.*

Due to the reasons above, CFS, Avaaz, and STORM urge Health Canada to implement the proposed phase out of imidacloprid for agricultural and outdoor uses and to conduct similar evaluations of other neonicotinoid insecticides in order to put an end to the widespread contamination, the increasing concentration rates, and the observed decline in vital aquatic species. Finally, we urge you to consider shortening the phase out period to the shortest time feasible in view of the imminent hazards posed.

Thank you for your thoughtful consideration of this important matter.

Sincerely,
Center for Food Safety
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Save the Oak Ridges Moraine Coalition

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2017 Updates to *Water Hazard: Aquatic Contamination by Neonicotinoid Insecticides in the United States*

Background

Over the past 10 years, research linking the use of neonicotinoids and other systemic insecticides with severe pollinator declines—including a U.S. Department of Agriculture (USDA) supported survey documenting a 44% reduction of managed honey bees in 2015—has continued to build.[1] However, while impacts to pollinator species are still a priority concern, emerging research exposes neonicotinoids as a leading environmental contaminant, poisoning landscapes across the country; most notably our aquatic ecosystems.

Resilient and diverse aquatic ecosystems are essential to environmental stability. Within the last decade the use of highly toxic and persistent neonicotinoids has become a hazard to the waters that wildlife such as fish, amphibians, and birds—and people—rely upon.

Introduced in the 1990s, neonicotinoids[1] are water soluble and systemic in nature, meaning they are taken up in the vascular system of a treated plant, thereby rendering the whole plant toxic. This systemic quality allows for both foliar and more traditional applications of neonicotinoids as well as seed coatings—a prophylactic approach to pest management that not only does not reliably produce higher crop yields, but also has caused an array of environmental contamination concerns (see 2016 Net Loss Report).[2]

Despite severe risks of unintended contamination, these products are applied on approximately 150 million acres annually or about one-fourteenth of the land area of the contiguous United States.[3] The runoff from their use then flows—both above and below ground—far beyond the agricultural fields, gardens, trees, lawns, and many other areas where they were first applied, causing inadvertent insecticidal effects on non-target species across a vast measure of additional wetlands and water bodies. The 2015 Center for Food Safety report, *Water Hazard: Aquatic Contamination by Neonicotinoid Insecticides in the United States*, explores the high levels of neonicotinoid water contamination reported across the country, often at levels that exceed vital standards set to protect aquatic life. The report calls for stronger regulation of these insecticides to prevent further damage to fragile aquatic ecosystems. Since the release of this report, the U.S. Environmental Protection Agency (EPA) has taken steps to acknowledge the levels of contamination from these chemicals and has developed more conservative benchmarks for contamination thresholds, but the agency has yet to take any concrete actions to implement stronger regulations, restrict their uses, or enforce more comprehensive water quality monitoring. Rather, the EPA extended both the timeline for completing the final neonicotinoid registration reviews until winter 2018/2019. Given the research outlined in *Water Hazard,*[4] supported by other countries' assessments and subsequent actions,

[1] Imidacloprid, Clothianidin, Thiamethoxam, Dinotefuran, Acetamiprid

and further confirmed by EPA's own aquatic risk analysis, this delayed timeline and lack of action is a threat to our aquatic ecosystems and by extension the country's long term environmental health and economic prosperity.

This supplemental report explores new data on water contamination as well as key findings about the damage caused by this class of insecticides. It will conclude with updates from Canadian monitoring data and subsequent agency analysis, an overview of EPA's aquatic risk assessment for imidacloprid, as well as policy recommendations for EPA moving forward.

Contamination Continues

A 2016, U.S. Geological Survey (USGS) review of pesticide detections in streams across the Midwest found high concentrations of imidacloprid—the most widely used neonicotinoid—in 98% of the sites sampled.[5] Exceeding the detection frequency of all insecticides tested, imidacloprid revealed the highest concentrations reported at 2.86 ppb—a concentration that far exceeds levels known to cause harm to aquatic invertebrates.[6] This research is part of a growing number of studies highlighting the alarming levels of contamination exposed in national and regional monitoring data.[7] This data builds on other reported detection frequencies such as: the 76% detection rate of one or more neonicotinoids in streams across the Midwest in 2013,[8] 70% detection frequency of downstream samples in the southern Appalachians in 2012 and 2013,[9] and an overall 63% detection rate in streams sampled across the United States.[10]

This data likely underestimates the overall contamination rates of the entire neonicotinoid class. Imidacloprid was the first neonicotinoid on the market and thus the most monitoring data as well as most research has been done on this specific chemical within the neonicotinoid class. However, in a 15 year analysis by USGS, as presented in the EPA's *Preliminary Aquatic Risk Assessment to Support the Registration Review of Imidacloprid*, imidacloprid use increased from nearly ¼ million pounds around the year 2000 to more than 2 million pounds in 2014. Yet during this time, monitoring data for the chemical, with one exception, decreased significantly.[11] Despite these limitations, in the 15 year study USGS still found an average imidacloprid detection rate of 36.5% across all surface water bodies tested.[12] Left out of this statistic are clothianidin and thiamethoxam, which are the primary insecticides used on commodity crops such as corn and soy via seed-coating application in the United States. If the data encompassed all neonicotinoid insecticides and was regularly monitored by scale of use, the detection frequencies would likely be higher.

The 2015 *Water Hazard* report explored not only detection frequencies, but more specifically the high risk posed by the concentration levels and lax EPA guidelines. At the time the report was released, the EPA proposed aquatic life benchmarks were some of the highest in the world and there was little consensus in the academic community to the method by which they were determined. However, in EPA's 2017 *Preliminary Aquatic Risk Assessment to Support the Registration Review of Imidacloprid,* EPA acknowledged the threat of imidacloprid to aquatic communities.[13] The assessment found that a startling 94% of the agricultural use scenarios modeled identified acute risk to freshwater invertebrates. The agency report concluded its findings explaining, "It is evident ...that concentrations of imidacloprid detected in streams, rivers, lakes and drainage canals routinely exceed acute and chronic toxicity endpoints derived for freshwater invertebrates."[14] Also in the assessment, the EPA established new toxicity benchmarks, based on both acute and chronic lab testing as well as field realistic studies. The proposed thresholds were set at .39 ppb for acute exposure and .01 ppb for chronic exposure. These benchmarks are in line with the standards set by Canada's Pest Management Regulatory Agency and the European Union's European Food Safety Authority. However, EPA is not enforcing them.

Damages to Species both Directly and Through Changes to Ecosystem Functioning

With the increase in research showing widespread contamination of surface and ground water from neonicotinoid insecticides it is critical to examine the impacts on aquatic invertebrates as well as the larger repercussions for watershed ecosystems. A 2016 review paper, *Contamination of the Aquatic Environment with Neonicotinoid and its Implication for Ecosystems* by Sanchez-Bayo et al., exposes the dangers of the high levels of neonicotinoids reported in waterways around the world. In synthesizing key research on ecosystem services, species sensitivity, and long-term mesocosm studies, the authors of the conclude, "Negative impacts of neonicotinoids in aquatic environments are a reality" and continue, "Solutions must be found soon if we are to save the biodiversity not only of aquatic ecosystems, but all other ecosystems linked by the food web."[15]

Although the study evaluates several methods of application and analyzes the unique toxicity of this class of systemic insecticides, the authors emphasize that a majority of soil and water contamination is a result of the prophylactic use of neonicotinoid insecticides as seed-coatings. While much of the research focuses on the sub-lethal impacts of neonicotinoids to aquatic species, the authors extrapolate the larger repercussions of these changes to the ecosystem, and warn against the continued unregulated and typically unnecessary use in agriculture.

The increasing detection frequencies and concentrations are an indication of the even higher residues likely to be found in soil sampling, as most neonicotinoid insecticides are applied to seeds directly and 80-90% of the insecticide on the coated seed remains in the soil after planting.[16] Sanchez-Bayo et al. explain that due to the slower dissipation rate in soil than in water, it is probable that, "the increasing use of products containing neonicotinoids and their repeated application as coated seeds in agricultural fields adds every year a new layer of residues to the soil and hence to the waters, where residue levels are a reflection of those present in soil at any time."[17]

Unique Threats to Species Impacted

While neonicotinoids are proven to be toxic to a vast array of species at fairly low doses, new long term research in field realistic scenarios shows that neonicotinoids not only pose unique threats that are hard to quantify using toxicity benchmarks, but that the neonicotinoids also pose specific concerns to the species impacted.

Perhaps the greatest threat postured by this class of agrichemicals is the distinctive mode of action that has led to extreme variation of median toxicity values based on exposure time. Neonicotinoids kill invertebrates by binding irreversibly to receptors within the nervous system.[18] At high doses this can be instantly lethal. At low doses, the continued binding from this chemical eventually leads to death of individual neurons.[19] However, continued exposure at low doses leads to growing number of destroyed neurons over time. During the period of neural damage, species experience confusion, weakened immune systems, changes in body size, emergence timing, and feeding habits—all of which contribute to larger impacts to overall species survival as well as ecosystem health.[20] Eventually, after prolonged exposure, the species nervous system can no longer survive the damage, leading to paralysis and ultimate death.

In an aquatic environment, this is particularly concerning, as species are continually exposed to concentrations of the chemicals and once the environment is contaminated, typically they cannot escape exposure in the same ways terrestrial invertebrates may be able to move to less contaminated areas. The increase in long term mesocosm studies conducted in the past 10 years has demonstrated delayed mortality.[21] In other words, rather than immediate death from direct exposure, large numbers of species die after several weeks of exposure. This showcases the weaknesses of acute and short term lab testing in developing protective benchmarks.

What sets neonicotinoids apart from other inhibitors such as pyrethroids and organophosphates is that the neurons destroyed by exposure, do not regenerate overtime.[22] This exemplifies the urgent need for strong action on neonicotinoid regulation to avoid continued irreparable damage to species impacted.

Larger portion of Species Effected than Previously Assumed

Many of the regulatory guidelines for water quality thresholds around the world are set using acute lab testing and assorted chronic data.[23] However, due to the systemic nature of neonicotinoids, their propensity for accumulating in the environment, and ability to cause sub-lethal impacts at low doses, Sanchez-Bayo et al. argues, "protective levels for neonicotinoids cannot be achieved by setting a concentration benchmark because…the effects of neonicotinoids increase with exposure time."[24] To better understand the rippling effects and gain a more holistic view of the threats from contamination, the authors used an alternative assessment—still noting its faults—that utilized monitoring data and species sensitivity distribution data to calculate the predicted fraction of species affected. Applying this analysis to a California case study offers a more holistic understanding of levels of contamination observed.

California is the top agricultural production state, contributing more than 50% of the nation's vegetables, fruits, and nuts.[25] Today, extensive agriculture correlates with extensive insecticide use. In fact, within a 20 year period (1994-2014), imidacloprid use rose from 5,179 lbs. to 373,734 lbs. per year on crops in California.[26] This statistic underestimates the degree of wide scale use as it does not include seed coating applications or ornamental and urban uses shown to cause contamination in waterways across the Golden State. According to California monitoring records of 132 sites and 790 samples from 2010 to 2015, there was a 55% detection rate for imidacloprid across sites, and 59% detection rate across all samples.[27]

The landmark 2011 study, "Detections of the Neonicotinoid Insecticide Imidacloprid in Surface Waters of Three Agricultural Regions of California, USA, 2010-2011" by Starner and Goh, was one of the first to report neonicotinoids as broadly contaminating U.S. surface waters.[28] Starner and Goh solely addressed imidacloprid but they noted the likelihood of other neonicotinoids in many of the samples collected as well as the potential for additive and synergistic effects.

The authors of the report found imidacloprid in 89% of the samples tested, with concentrations as high as 3.29 ppb.[29] Using this data and comparisons to species sensitivity distribution evaluations, Sanchez-Bayo et al. 2016 estimated that imidacloprid alone is **currently affecting up to 11% of aquatic species**.[30] Field-realistic conditions expose aquatic invertebrates to multiple active ingredients in the water, as well as to harmful adjuvants and inerts in the formulations applied (typically "tank mixes" by the applicator). Due to aquatic species' susceptibility to exposure from multiple stressors, the overall fraction of species impacted is likely higher.

Ecosystem Functions Compromised as a Result

Data showing direct risk to aquatic species such as fish or amphibians is limited but growing.[31] However, the widespread contamination exhibited by previous monitoring studies show concentration rates known to be harmful to aquatic invertebrates—the foundations aquatic ecosystems. Even at notably low doses, neonicotinoids affect critical ecosystem functions and alter population ratios and predator prey relationships, causing rippling effects throughout the entire food web.

For example, chronic impacts to species may include feeding inhibition. Some of the species shown to be most sensitive to neonicotinoid contamination include mayflies, caddisflies, and stoneflies, all of which aid in the decomposition of organic matter in water bodies. Through shredding of leaves and debris found in creek and stream floors, these species not only feed themselves and maintain healthy population levels, but they also safeguard water quality standards for other organisms.[32] When exposed to low doses of neonicotinoids over time, the decomposers do not carry out vital ecosystem services, and are also unfit to reproduce—exacerbating the problem through population decline.[33] According to Sanchez-Bayo et al., "Given that more than half of the waters are contaminated with neonicotinoid levels that impair this important ecosystem function, higher organic and inorganic pollution can be expected wherever these insecticides are present. Microbial degradation of the debris may still occur, but it would be slower and produce undesirable byproducts such as methane and sulfides."[34] This is but one of the ecosystem services jeopardized by continued use of neonicotinoid insecticides that must be considered in holistic cost-benefit analyses.

Although aquatic insects may seem like an underwhelming target for conservation efforts, they play a critical role to the ecosystem. They also, perhaps most importantly, are the primary food source for fish, amphibians, and other aquatic wildlife.

The significant threat to aquatic insect populations from neonicotinoids can lead to the depletion of insectivore fish stocks through unintended starvation. Although neonics are not typically found in concentrations known to be lethal to most fish species,[35] the documented decline of insect species they rely upon will likely have an impact on their survival.[36] Similar effects are foreseeable for aquatic birds.[37]

Updates from Canada

In 2016 in response to a weight of evidence showing detrimental impacts of neonicotinoid insecticides to aquatic ecosystems, Canada's Pest Management Regulatory Agency (PMRA) released a comprehensive re-evaluation of imidacloprid use. The review included a wealth of data from both government and peer-reviewed research and concluded (emphasis added):

> *"The environmental assessment showed that, in aquatic environments in Canada,* ***imidacloprid is being measured at levels that are harmful to aquatic insects****. These insects are an important part of the ecosystem, including as a food source for fish, birds and other animals. Based on currently available information,* ***the continued high volume use of imidacloprid in agricultural areas is not sustainable."*** [38]

Noting the continued exceedance of water quality thresholds and aquatic life benchmarks in monitoring data, PMRA proposed necessary action to protect aquatic ecosystems from imidacloprid and called for similar evaluations for other neonicotinoid insecticides. Specifically, PMRA proposed to *"phase-out all the agricultural and a majority of other outdoor uses of imidacloprid over three to five years."*[39]

While this proposal received industry pushback,[2] in a webinar to discuss the imidacloprid reevaluation and proposed phase out, PMRA defended the need for strong regulation noting the chemical's water solubility, persistence, and capacity for unintended contamination of vital waterbodies. PMRA officials stated that based on the research provided by the reevaluation, a phase out of the chemical was the best option for risk mitigation. Further within the phase out proposal, PMRA reasoned against an alternative use reduction plans stating (emphasis added):

> *"Given the risks that have been identified and considering the available information, effective risk mitigation through a use-reduction strategy would be difficult to achieve for several reasons. It would be difficult to identify the specific uses that are causing the elevated levels in water given that much of the water monitoring data were from mixed-use areas of agriculture. In addition,* ***it is not possible to accurately predict how much use reduction would be necessary to achieve acceptable levels of imidacloprid in the environment*** *and, therefore, any use-reduction strategy would require extensive and comprehensive water monitoring information to confirm that risk reduction targets are being achieved.* ***It is also not possible to estimate how long a reduction in environmental levels would take****. In addition, in sectors where imidacloprid is approved for use but not currently used extensively, intensification of use in the future may lead to additional risks of concern. Given the above, phase-out of all outdoor agricultural, ornamental, turf, and tree uses (except tree injection uses) and greenhouse uses of imidacloprid is being proposed."*[40]

PMRA's analysis and subsequent proposed action is consistent with the 2016 study conducted by Struger et al. This 3-year investigation of neonicotinoid insecticide contamination in surface water sites across southern Ontario revealed 3 of the 5 neonicotinoids tested (imidacloprid, clothianidin, thiamethoxam), had more than 90% detection rates in over half of the sites.[41] The Canadian government's threshold for imidacloprid residues in freshwater is .23 ppb, which was exceeded in 75% of the samples collected in two sampling sites. The data from the 3-year investigation shows a strong correlation between pesticide detection, precipitation, and stream discharge.[42] Other studies of Canadian monitory data by government and independent researchers, revealed 98.7% detection frequency of thiamethoxam and 100% detection frequency of clothianidin in Southwestern Ontario water samples from corn-producing counties,[43] and 91% neonicotinoid detection (imidacloprid, thiamethoxam, clothianidin, acetamiprid) in wetlands sampled across the Prairie Pothole region.[44] Across all studies, researchers noted neonicotinoids long-

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[2] Additional industry pushback was received during the Canadian Parliament's Standing Committee on Agriculture and Agri-Food meeting on the PMRA Decision Concerning the Neonicotinoid Insecticide Imidacloprid. During the hearing industry expressed concerns about resistance issues if farmers no longer had access to imidacloprid and instead had to use other pesticides. CFS strongly disagrees with these concerns about resistance given that there are already documented instances of imidacloprid resistance. Furthermore the industry should not be focused on what chemicals to replace imidacloprid with but rather what alternative pest management practices exist that are more sustainable.

term persistence and highlighted specific concerns for wetlands in colder climates where the chemicals persist in soil and transport via snowmelt to nearby surface water.[45]

A 2017 report from Chretien et al. of Agriculture and Agri-Food Canada, as well as Quebec Ministry of Sustainable Development, raises concerns about neonicotinoid contamination from surface runoff and subsurface tile drain losses with a particular focus on the contamination by clothianidin and thiamethoxam. The report documents a two year study where 14 surface runoff and tile drain discharge events were monitored. The researchers reported, "detection frequencies close to 100% in edge-of-field, surface runoff and tile drain water samples…for thiamethoxam and clothianidin even though only thiamethoxam had been applied in the first year."[46] These findings highlight the persistent nature of these agrichemicals in certain climates and soil conditions as well as the potential harm of their degradants. The insecticides were reported at median concentrations of .46ppb and .16ppb and many concentrations exceeded the .0083 ppb chronic threshold for effect on aquatic life recommended by Government of Quebec.[47] The authors of the report concluded by echoing the proposal established in the Quebec Pesticide Strategy 2015-2018, and explained that any plans for reduced use or mitigation strategies to control dust and surface runoff would not be sufficient.

Despite these findings, with a majority of environmental monitoring programs and toxicity testing dedicated to imidacloprid use, "no ecological thresholds exist for thiamethoxam and clothianidin."[48] This major shortcoming is particularly an issue in Quebec where nearly 100% of corn and 50% of soybean seeds are planted with neonicotinoid seed coatings—covering nearly 500,000 ha.[49] Giroux et al. found detection frequencies of thiamethoxam and clothianidin ranging from 93% to 98% from 2012 to 2014 in four Quebec watersheds.[50] Canada's increasing documentation of neonicotinoid contamination supports PMRA's analysis and is an indication of the critical need for setting stronger regulatory protections for the environment.

EPA's Aquatic Risk Assessment: Strong Science, No Action

Shortly following the release of the PMRA analysis in early 2017, EPA's Office of Chemical Safety and Pollution Prevention released the *Preliminary Aquatic Risk Assessment to Support the Registration Review of Imidacloprid* as part of the agency's ongoing registration review of neonicotinoid insecticides. The comprehensive report includes detailed outlines of the assessment procedures and qualitative risk analysis. The findings incorporated data from PMRA as well as the European Food Safety Authority and found similar findings regarding aquatic risk—yet these findings resulted in no further regulation or restrictions to parallel the actions of Canada and Europe.

Notable Shortcomings of EPA's *Preliminary Aquatic Risk Assessment to Support the Registration Review of Imidacloprid*

1. **Underestimating Seed Treatment Contamination and Risk**

   The EPA analysis proposes the unrealistic assumption that neonicotinoid chemicals applied as treatments on seeds planted below 2 cm do not move into surface waters and therefore are low risk.[51] It is unacceptable that EPA's models do not incorporate accounting for lateral movement of these chemicals in soil and run-off. It is well known these chemicals move vertically down into the groundwater - to assume they don't move laterally through surface soil (especially surface soil broken up by tillage) with precipitation is indefensible in view of numerous published reports showing that they do so.[52]

Roughly 1,116,000 pounds of imidacloprid were used on crops in the United States between 2004 and 2013. 56% of this usage was as seed coatings—and more specifically 36% was as a coating on soybeans.[53] The risk assessment identified acute risks to listed freshwater invertebrate species with 29 of the 31 agricultural use scenarios modeled (94%)—of which a majority are seed coating uses. The following graphic from the EPA assessment, depicts the surface water contamination across the United States in relation to impacts on freshwater invertebrate species.[54] As shown, water bodies are routinely exceeding concentration levels known to cause harm to critical aquatic species.

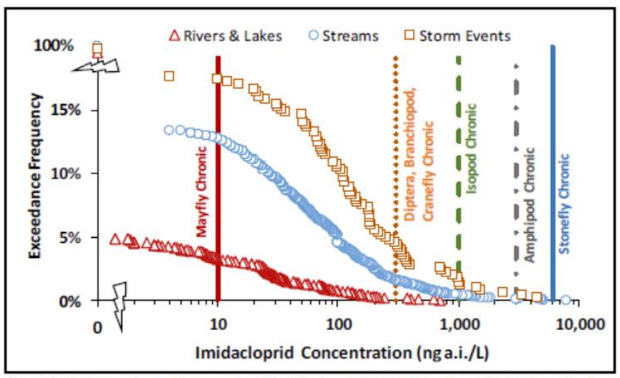

Figure 5-8. Exceedance Frequency of Imidacloprid in USGS Surface Water Monitoring Samples Relative to Chronic Toxicity Endpoints for Freshwater Invertebrates (non-detects assumed = 0)

EPA *Preliminary Aquatic Risk Assessment to Support the Registration Review of Imidacloprid*
https://www.regulations.gov/document?D=EPA-HQ-OPP-2008-0844-1086

While imidacloprid use is vast and poses a considerable threat via seed coating application, it does not accurately portray the widespread neonicotinoid contamination by seed coating from clothianidin and thiamethoxam. More than 90% of corn and almost 50% of soybeans grown in the United States is coated with a neonicotinoid, most often by clothianidin and thiamethoxam.[55] The risk analysis of imidacloprid, while similar in toxicological effect to species impacted, is non-representative for all neonicotinoids which vary in use and application rate.

2. New Endpoints but No Mandates for Water Quality Monitoring

Through analyzing comprehensive aquatic toxicity research, international toxicity benchmarks, and available monitoring data and conducting acute lab testing, EPA's risk assessment proposed new acute and chronic endpoints for imidacloprid for freshwater invertebrates. Prior to the assessment, EPA's endpoints were exponentially higher than other regulatory and non-regulatory benchmarks from around the world.[56] The new proposed endpoints of .39 ppb (acute) and .01 ppb (chronic) are not only more in line with the conclusions of PMRA but they also are more consistent with the thresholds proposed by

Morrissey et al., and discussed in the 2015 *Water Hazard* Report. However, these endpoints have not been updated on EPA's Aquatic Life Benchmarks for Pesticide Registration website. Moreover, there is no mandate by which toxicity benchmarks are regulated and their development is only to aid in interpretation of monitoring data. EPA's Office of Water may use the "aquatic toxicity data to develop ambient water quality criteria that can be adopted by states and tribes to establish water quality standards under the Clean Water Act"[57] however there are no mandates for establishing such standards. Given that current monitoring data shows exceedances of the proposed thresholds across the United States in various surface water bodies, EPA should include proposed water quality standards and mandated neonicotinoid testing in their final risk assessment.

3. **No Mention of Pesticide Synergies**

The risk assessment has almost no mention of pesticide synergies and the particular threat to aquatic communities unable to escape continued exposure to multiple pesticide stressors. According to Morrissey et al., "neonicotinoids are known to be additively or synergistically toxic when they occur together or when combined with certain fungicides..."[58] These combined "tank mixes" of pesticide formulations are even patented by agrichemical companies for their increased toxicity. In fact, a 2016 analysis of recently approved products from major pesticide companies found that 69% of patent applications claimed or demonstrated synergistic action.[59] Additionally, when neonicotinoids were tested together for impacts on *Daphnia magna* species, a species known to be highly tolerant to neonicotinoid toxicity, the effects included notable impacts on reproduction, growth and survival in correlation to chemical synergism.[60] Due to the tendency for aquatic ecosystems to be contaminated by several neonicotinoid chemicals from a range of application sites as well as other chemicals present in surface water bodies, EPA's risk assessment should include the threat from combined exposure and synergism in their final ecological risk assessment.

4. **Limited Field Realistic Conditions and Lack of Evaluation of Sub-lethal Impacts to Ecosystem Functioning and Food Chains**

The preliminary risk assessment addressed the lack of higher tier data stating:

> *"Due to resource and time constraints, an independent review of the higher tier aquatic toxicity data for imidacloprid was not conducted as part of this preliminary ecological risk assessment…However, the Agency expects to revise the preliminary ecological risk assessment to reflect public comment and any additional refinements deemed necessary to support risk management decisions. Such refinements, if deemed necessary, would likely include an independent review of the mesocosm data."*

Given that EPA in their assessment of impacts to fish and aquatic phase amphibians noted that:

"While the risk of direct effects of imidacloprid to fish and amphibians is considered low, the potential exists for indirect risks to fish and aquatic-phase amphibians through reduction in their invertebrate prey base."

And further noting the concerns to ecosystem services and food-chain stability outlined earlier in this review, it is critical that EPA include higher-tier and mesocosm analysis to fully determine the risk to fish and amphibian species in the final risk assessment.

5. Ignores Risks to Other Species

Initially intended to be an ecological risk assessment of imidacloprid, EPA justified its decision to only include aquatic risks, stating:

Furthermore, a substantial body of aquatic monitoring and toxicity data have been generated for imidacloprid since the Agency's last comprehensive risk assessment was conducted. In contrast, very little new data have been generated on the toxicity of imidacloprid to birds and mammals since the Agency's most recent ecological risk assessments. The Agency therefore will rely on its previously conducted assessments for characterizing the risk of imidacloprid to non-insect terrestrial organisms. For its final ecological risk assessment, the Agency will fully evaluate risks to birds, mammals, and terrestrial plants.

However, EPA pushed back the timeline for the final assessment, jeopardizing non-aquatic species—in particular birds—which have been shown to be impacted by the use of neonicotinoid chemicals. Based on the findings of the comprehensive Palmer and Mineau report, *The Impact of the Nation's Most Widely Used Insecticides on Birds,*[61] EPA should provide a full ecological risk assessment addressing the interconnection of species impacted between aquatic and terrestrial environments.

6. No Endangered Species Act Analysis

EPA acknowledges the lack of Endangered Species Act analysis stating:

Given that the agencies are continuing to develop and work toward implementation of the Interim Approaches to assess the potential risks of pesticides to listed species and their designated critical habitat, this ecological problem formulation supporting the Preliminary Work Plan for imidacloprid does not describe the specific ESA analysis, including effects determinations for specific listed species or designated critical habitat, to be conducted during registration review..

However, with the documented contamination of neonicotinoids and proposed concerns to aquatic ecosystems, it is critical that EPA include a thorough analysis of potential threats to species listed through the endangered species act.

7. Strong Evidence of Risk, Yet No Regulatory Action

EPA concluded in their risk assessment (emphasis added):

> "*It is evident, however that* ***concentrations of imidacloprid*** *detected in streams, rivers, lakes and drainage canals* ***routinely exceed acute and chronic toxicity endpoints*** *derived for freshwater invertebrates*"

Based on the substantial risk to aquatic invertebrates, including ESA-protected species, happening on a wide scale by registered uses, it is clear that EPA needs to take immediate action to restrict uses of imidacloprid and other neonicotinoid insecticides to prevent further damage to ecosystem services.

Furthermore, EPA acknowledges that:

> *"..the risk findings summarized in this assessment are in general agreement with recent findings published by Canada's Pest Management Regulatory Agency and the European Food Safety Authority"*

EPA should follow PMRA's example in proposing a prompt full phase out of imidacloprid in agricultural and outdoor uses. PMRA recognizes that due to imidacloprid's persistence and water solubility that regional restrictions will not be sufficient in mitigating risks. EPA needs to enforce strong action now, to prevent continued, potentially irreparable, damages to vulnerable species and ecosystems.

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WATER HAZARD

AQUATIC CONTAMINATION BY NEONICOTINOID INSECTICIDES IN THE UNITED STATES

CENTER FOR FOOD SAFETY

SEPTEMBER 2015

ABOUT CENTER FOR FOOD SAFETY

CENTER FOR FOOD SAFETY (CFS) is a non-profit public interest and environmental advocacy membership organization established in 1997 for the purpose of challenging harmful food production technologies and promoting sustainable alternatives. CFS combines multiple tools and strategies in pursuing its goals, including litigation and legal petitions for rulemaking, legal support for various sustainable agriculture and food safety constituencies, as well as public education, grassroots organizing and media outreach.

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CONTENTS

Researchers across the United States, Canada, and Europe are repeatedly finding high levels of neonicotinoid residues that exceed vital standards set to protect aquatic life.

EXECUTIVE SUMMARY

Vast swathes of aquatic life and the food webs they support are in jeopardy across the United States. While harmful impacts to aquatic invertebrates and their environments often go unnoticed, their well-being is essential to healthy ecosystems. Within the last several decades the use of highly toxic and long-lasting insecticides, in particular a class of chemicals known as **neonicotinoids**, have become hazardous to the waters that wildlife such as fish, amphibians, and birds—and people—rely upon.

Neonicotinoids are water soluble and systemic in nature, meaning they are taken up in the vascular system of a treated plant, thereby rendering the whole plant toxic. It doesn't stop there; the use of neonicotinoids has led to widespread contamination of soil, fields, puddles, ditches, streams, groundwater, lakes, rivers, and marine areas; this issue is exploding as a new topic for scientists. Researchers across the United States, Canada, and Europe are repeatedly finding high levels of neonicotinoid residues that exceed vital standards set to protect aquatic life. Neonicotinoid coatings applied to crop seeds are one of the leading causes of contamination. These toxic seed coatings are almost tailor-made to contaminate the environment. Instead of staying on the plants, for corn seeds (the single most extensive use of these coatings) approximately 95% of the neonicotinoid coating is scraped, blown, sloughed off, or otherwise dispersed into the surrounding air, soil, and water.

This report shines light for the first time on the full scope of this unrecognized threat to our waters. Representative case studies from Maryland, Iowa, and California are examined. Each of these States is experiencing widespread neonicotinoid contamination exceeding recommended standards set by leading experts in aquatic species toxicology. This report also highlights contamination elsewhere, including New York, South Dakota, Texas, and Wisconsin. It describes the key roles of irrigation and field drainage and discusses the growing risks to aquifers and vulnerable wetland areas. This nationwide water contamination and the numerous high-level findings in monitoring studies suggest that we are approaching an ecological crisis—a second *Silent Spring*.

These products are applied on more than 150 million acres annually—about one-twelfth of the area of the contiguous United States.

Alarmingly, the Environmental Protection Agency's (EPA) approvals of hundreds of neonicotinoid insecticide products have major data gaps in terms of their foreseeable impacts on surface and ground water. Furthermore, EPA's benchmarks for aquatic invertebrate toxicity lack scientific support and are far too lax. Yet, these products are applied on more than 150 million acres annually—about one-twelfth of the area of the contiguous United States. The runoff from their use flows—both above and below ground—far beyond the agricultural fields, gardens, trees, lawns, and many other areas where they were first applied, causing unintended insecticidal effects on non-target animal species across a vast measure of additional wetlands and water bodies. The downstream victims are aquatic insects, other key invertebrates like crayfish, and innumerable birds that depend on aquatic life for food. Peer-reviewed published studies from Holland show that neonicotinoid water contamination correlates significantly with bird population declines. Similar research is amassing in the United States. Furthest downstream, preliminary science indicates that neonicotinoids are also harmful to blue crabs and other marine species.

We cannot afford to wait until more of these environmental declines are documented in peer-reviewed journal articles to take action. Reforms are needed now – not just for birds, but also for keystone aquatic species and to protect drinking water aquifers and marine areas. To achieve this, Center for Food Safety offers eleven policy recommendations, mostly directed to EPA:

1. Suspend neonicotinoid insecticide registrations due to their unreasonable adverse effects in aquatic ecosystems.

2. Adopt rigorous national aquatic contamination thresholds to avoid lasting effects on aquatic invertebrates specifically: 0.2 ppb for short-term acute exposures, and 0.035 ppb for long-term chronic exposures.

3. Eliminate the "Coated Seeds" exemption from pesticide

Working together, governments and citizens can and must reverse this widespread rise in long-lasting neonicotinoid contamination.

registration requirements.

4. Stop classifying neonicotinoids as "reduced risk" pesticides and fast-tracking their registrations; also end Conditional Registrations for them.

5. Use more representative aquatic test species and long-term mesocosm studies for determining biological risks.

6. Comply with Section 7 of the Endangered Species Act in order to protect threatened and endangered aquatic-dependent species and their habitats.

7. Drastically change neonicotinoid product labels for all uses that foreseeably will impact aquatic ecosystems.

8. Conduct more systematic research and monitoring on the effects of aquatic contamination, including the human health implications.

9. Marine protection campaigns should specifically address neonicotinoid contamination.

10. Apply the Clean Water Act to initiate remedial actions.

11. Take action at the State and local levels to protect affected waters.

Working together, governments and citizens can and must reverse this widespread rise in long-lasting neonicotinoid contamination. If we don't, we will leave future generations with degraded waters and barren aquatic systems.

Little by little the vast orchestra of life, the chorus of the natural world, is in the process of being quietened.

— Bernie Kraus, *The Great Animal Orchestra*, 2012[1]

Within the last several decades the use of highly toxic, persistent insecticides has become one of the greatest threats to the nation's intricate aquatic ecosystems.

BACKGROUND

Across the United States, aquatic invertebrate life and the natural food webs they support are in jeopardy. While the peril of these species and ecosystems often goes unnoticed, they play integral environmental roles as decomposers, grazers, filter feeders, and sediment feeders. They also provide much of the food base for fish, amphibians, birds, and other species.

Within the last several decades the use of highly toxic, persistent insecticides has become one of the greatest threats to these intricate aquatic ecosystems. Most recently, the use of a class of systemic insecticides called neonicotinoids has become a hazard for countless beneficial insects, like bees, other wildlife, and vulnerable ecosystems. Rachel Carson expressed concerns about these types of chemicals 53 years ago in her seminal book on pesticides, *Silent Spring*. The debate she started over the consequences of the use of systemic insecticides continues today in a vastly amplified form.

Neonicotinoids, the topic of this report, are the fastest growing class of insecticides in the United States and globally.[2] They are used for agricultural, horticultural, and landscaping purposes on a variety of plants and habitats. Neonicotinoids, consisting of

acetamiprid, clothianidin, dinotefuran, imidacloprid, thiacloprid, and thiamethoxam, are systemic chemicals, meaning they disperse through the vascular system of a treated plant rendering the whole plant potentially toxic. They are designed to kill insects by damaging their central nervous systems, leading to a variety of acute and chronic harms.[3] They also have the potential to impair many other classes of animals.

There are currently over 500 different neonicotinoid-formulated products on the market, and applications are estimated to exceed 150 million acres annually nationwide.[4] Their predominant use is as seed coatings for annual field crops (corn, soybeans, cotton, wheat, and canola), comprising the vast majority of the lands and waters impacted. However, they are also applied as foliar sprays, soil drenches, granules, and via direct injections into tree trunks. Research in the last few years has exposed their risks and questioned their cost-effectiveness.[5]

One of the most alarming aspects about seed coating applications is they appear almost tailor-made for contaminating aquatic environments. On corn seeds (neonicotinoids most extensive single use by far) typically only about 5% of the active chemical coated on the seed actually enters the growing plant, leaving the remaining 95% to be scraped, blown, sloughed off, or otherwise dispersed into the air, soil, or water.[6] Most neonicotinoids that farmers, landscapers, and homeowners apply to their land do not stay within the intended target areas; large portions run off during rainfall or snowmelt into surface waters or leach through the soil into groundwater.

This report gathers information from numerous sources and details the significant risks these insecticides pose through widespread contamination of both surface and ground water. Monitoring studies are detecting neonicotinoids in a broad range of environments at levels exceeding the thresholds scientists say are necessary to protect aquatic life. Even species that are not directly exposed to acute or chronic levels of these toxicants may be in jeopardy because of the impacts on their ecosystems and within food chains. While declines in aquatic invertebrates may not be as apparent as declines in migratory birds or terrestrial invertebrates (like bees), aquatic invertebrates are of vital importance to healthy ecosystems extending from the smallest creek or pond, downstream to lakes and oceans.

The full scope of water pollution from the myriad outdoor applications of neonicotinoids is the target of this report.[i] It starts with an overview of recent science, and continues with an analysis of the water contamination concerns in three "case study" states—Maryland, Iowa, and California. The report then addresses cross-cutting themes relevant to aquatic systems across the United States and concludes with policy recommendations to remedy the problem.

[i] Neonicotinoids can also be applied indoors, e.g., for pest control, or for flea and tick control on pets.

The researchers noted major flaws in past regulatory approaches using inappropriate toxicity tests.

KEY OVERVIEW STUDY

In October 2014, the noted Canadian toxicologist Professor Christy Morrissey of the University of Saskatchewan and numerous expert colleagues published a key overview paper, "Neonicotinoid contamination of global surface waters and associated risk to aquatic invertebrates: a review."[7] To date, it is the most comprehensive assessment of impacts on aquatic life from observed levels of these insecticides worldwide, covering 29 studies—some from peer-reviewed journals, some from government or industry reports—representing nine countries. The authors collected, evaluated, and compared data on acute and chronic toxicity to 49 aquatic species spanning twelve invertebrate orders, and included 16 additional long term, multi-species field and mesocosm studies. The researchers noted major flaws in past regulatory approaches due to inadequate toxicity testing.

Morrissey et al. documented widespread neonicotinoid levels in the field that pose measurable risks to aquatic invertebrates and the ecosystems they inhabit. The expert review indicates that pesticide regulators are allowing contamination to occur at levels that pose risks to the diversity of aquatic life.

FINDINGS

Of the 29 studies reviewed, Morrissey et al. found neonicotinoids in a majority of the surface waters sampled, dispersed throughout a variety of environments. Chemically engineered for persistence,[8] these compounds are not easily adsorbed into soil and are highly water-soluble,[9] making them readily susceptible to transport into surface and

The chemicals are not only easily transported into surface waters, but they are also highly persistent.

ground waters. The studies show neonicotinoids are carried by rain and snowmelt,[10] groundwater leaching,[11] dust associated with seeding drills,[12] treated plant decay,[13] breakdown of treated seeds,[14] and unintended drifting of soils and sprays.[15] Because of their broad use in everything from city landscaping to agricultural crops, they impact a wide range of aquatic environments including both rural and urbanized areas.

The chemicals are not only easily transported into surface waters, but they are also highly persistent. They reach peak concentrations in water during the first 24 hours following post-application run-off, after which they begin to break down. What starts as rapid breakdown in the first few days then slows in the following weeks.[16] Although the duration of neonicotinoid half-life in water appears short, data shows that concentrations capable of affecting aquatic species can last up to a year post-application and sometimes longer depending on environmental factors.[17][ii]

FLAWS IN PREVIOUS STUDIES

Despite neonicotinoids' propensity for water contamination, little consensus exists among regulatory agencies around the world in determining safe concentration thresholds. After reviewing the studies collected, Morrissey et al. found several common research flaws contributing to these inconsistencies. The primary reasons for conflicting data and conflicting standards are: varying lengths of studies,

[ii] A 2015 study showed thiamethoxam can take several days to degrade in water when present just inches below the surface. Direct sunlight typically helps degrade thiamethoxam, reducing the risk of harm. However, when tested in waters deeper than about 3 inches, its degradation rate was negligible. This could increase the potential for aquatic life to be exposed to harmful levels.[18]

underestimated field concentrations, and lack of relevance in the aquatic species tested.

Length of Studies

For invertebrates in water bodies exposed to agricultural runoff containing these insecticides, continuous exposure is the norm. While acute toxicity testing—which accounts for the majority of government and industry studies—may find low doses safe for certain species, it does not take into consideration repeated exposures to low sub-acute levels that chronically harm an organism's nervous system over time.[19]

Additive and Synergistic Effects

Another gap in toxicology research often overlooked by EPA and other regulatory agencies is inadequate accounting for additive and synergistic effects of combined neonicotinoids, their metabolites, and associated compounds. Many tests only account for exposure to isolated neonicotinoids, but field-realistic conditions expose aquatic invertebrates to multiple active ingredients in the water, as well as to harmful adjuvants and inerts in the formulations applied (typically "tank mixes" by the applicator).[20]

Neonicotinoids have been shown to be additively or synergistically toxic to some terrestrial invertebrates when combined with other active and inert ingredients.[21] Due to their propensity to be transported widely and their persistence, additive combinations are frequently found in the same habitat even if they originated from different sources or in different years.[22] Further, some of the neonicotinoid compounds are known to act synergistically with the azole and strobilurin fungicides with which they frequently are combined on coated seeds.[23] This remains an understudied risk for aquatic species.

Many laboratory studies also do not consider sub-lethal effects caused by the various metabolites, such as 1-[(6-chloro-3-pyridinyl) methyl]-2-imidazolidone, a metabolite of imidacloprid. Noted effects from neonicotinoid metabolites include impacts to immune systems, neurophysiology, larval development, molting, adult longevity, reproductive capacity, sex ratio, mobility, navigation, feeding, behavior, memory, and learning, all of which can adversely affect survival at the individual organism and population levels.[24]

Inadequate Species Testing

A lack of ecologically relevant species for toxicity testing on aquatic organisms produces unreliable results. Sensitivities of species can vary broadly. Morrissey

et al. found the overall lack of multi-species and mesocosm water studies resulted in threshold recommendations that frequently underestimated the actual risks neonicotinoids will pose to untested species.

Acute studies performed on notably insensitive species do not accurately represent the sub-lethal effects that can cause rippling impacts throughout an ecosystem. Although most studies focus on half-life values and lethal thresholds, other studies show that even very low concentrations of these chemicals can impact such key measures as growth, emergence, reproduction, and feeding.[25] These sub-lethal effects can magnify through multiple trophic levels thereby harming other species both directly and indirectly.

Morrissey et al. noted that *Daphnia magna*—an aquatic flea—accounted for "16% of all neonicotinoid toxicity tests reviewed." Despite being an industry favorite, *D. magna*, as compared to other aquatic invertebrates, is highly tolerant to neonicotinoid exposure, surpassing all other aquatic invertebrate thresholds by 2-3 orders of magnitude. In contrast, lesser studied species such as the mayflies and caddisflies, which both serve ecologically important roles to the ecosystem and the food web, are some of the most sensitive species examined. This disparity highlights the importance of long term mesocosm studies when considering ecosystem-relevant toxicity thresholds.[26]

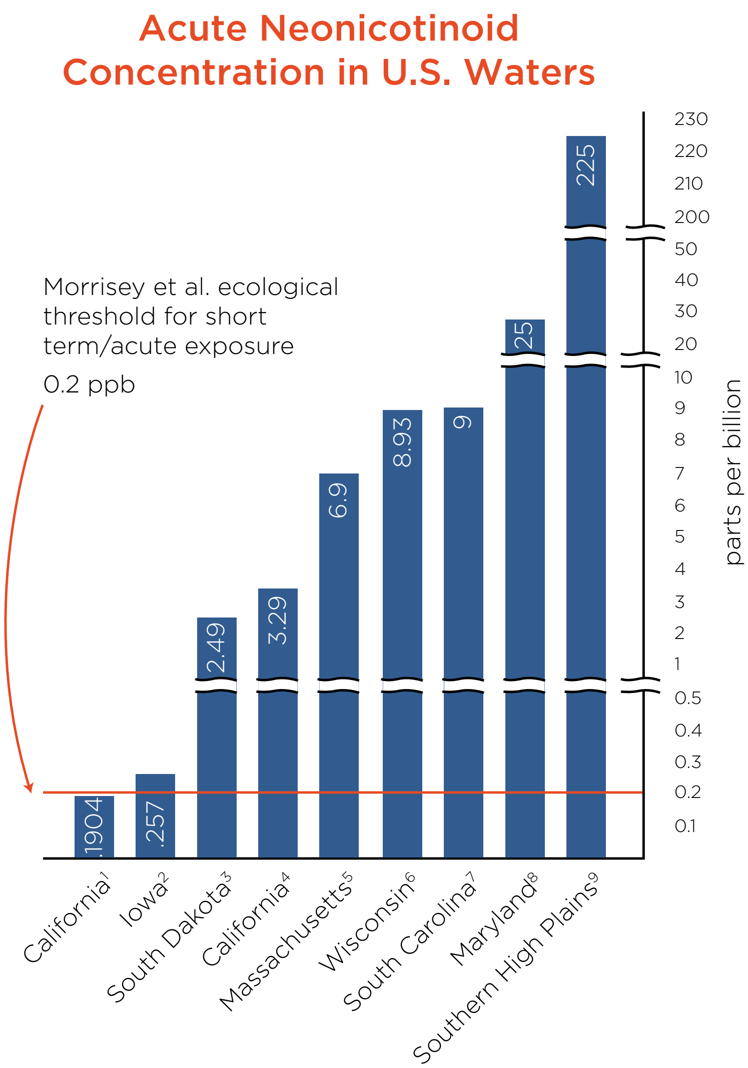
New Toxicity Threshold Guidelines

Taking into consideration the results of documented studies, as well as the above-mentioned flaws in the earlier analyses, Morrissey et al. reviewed various existing national and international standards. Recognizing the lack of scientific support and the inadequate protectiveness of many of the standards, Morrissey et al. recommends new "ecological thresholds for neonicotinoid water concentrations…below **[0.2 ppb] (short term acute) or [0.035 ppb] (long-term chronic)** to avoid lasting effects on aquatic invertebrates communities."[27][iii] The authors also note that these thresholds may still warrant additional safety factors due to "slow recovery, additive or synergistic effects and multiple stressors that can occur in the field."[28]

Comparing their proposed neonicotinoid standards to the field studies they reviewed, Morrissey et al. found their recommended acute and chronic thresholds were exceeded in 74% and 81%, respectively, of those studies. Their conclusion: "environmentally relevant concentrations of neonicotinoids in surface waters

[iii] Emphasis added; for purposes of consistency all values have been changed to parts per billion (ppb). Note that 1 µg/L is equivalent to 1 ppb[29]

worldwide are well within the range where both short-term and long-term impacts on aquatic invertebrate species are possible over broad spatial scales."[30]



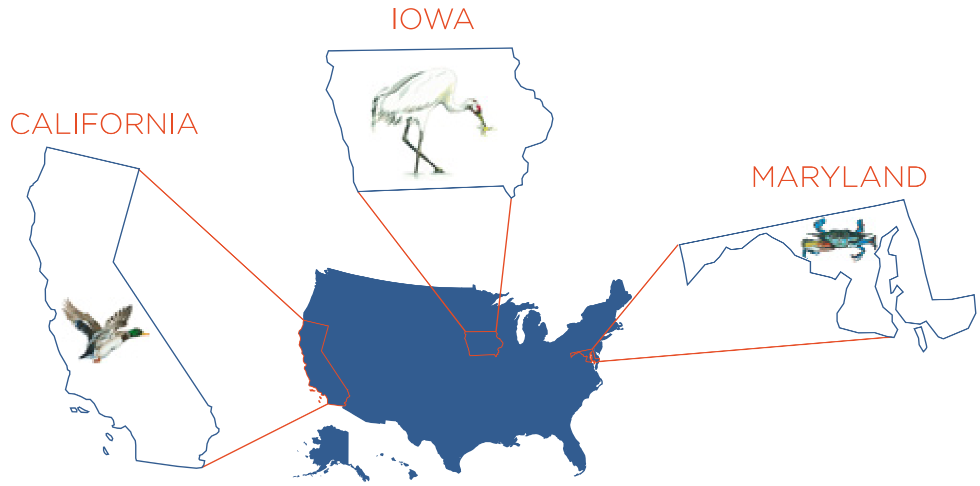
Note: Values are maximum concentrations found in various waterbodies ranging from rivers to wetlands to ponds and exclude higher concentrations found in puddles; ≈ indicates scale break.

Sources: [1]Hladik and Kolpin 2015 (thiamethoxam); [2]Hladik et al. 2014 (clothianidin); [3]US FWS South Dakota Field Office 2014 (thiamethoxam); [4]Starner and Goh 2012 (imidacloprid); [5]Wijnja et al. 2014 (imidacloprid); [6]Huseth and Groves 2014 (thiamethoxam); [7]Delorenzo et al. 2011 (imidacloprid); [8]Johnson and Pettis 2014 (imidacloprid); [9]Anderson et al. 2013 (thiamethoxam). *See Figure References.*

63% of all streams sampled by USGS had detectable levels of neonicotinoid contamination.

NEW NATIONAL CONTAMINATION SURVEY

A 2015 U.S. Geological Survey (USGS) report by Michelle Hladik and Dana Kolpin, recently published in *Environmental Chemistry*, was the first nationwide survey of neonicotinoid detections in streams across the United States.[31] The study included national sampling of 38 streams in 24 States and Puerto Rico between December 2012 and June 2014 and additional sampling from four complementary studies. Overall, 149 samples were analyzed for contamination by six different active ingredients. Hladik and Kolpin reported at least one neonicotinoid in 53% of the samples from the national assessment of 38 sites and more than one in 26% of the samples. When the complementary studies were included, 63% of all streams sampled had detectable levels of neonicotinoid contamination. Furthermore, a USGS press release about the study noted that "the insecticides also were detected prior to their first use during the growing season, which indicates that they can persist from applications in prior years." The fact that a U.S. government agency has documented not only the widespread contamination of neonicotinoids, but also their extreme persistence, highlights the short falls of EPA's risk assessments and subsequent regulation of these chemicals.[32]



STATE CASE STUDIES

The following case studies highlight the real-world ineffectiveness of past regulatory approaches in protecting the environment from damaging levels of these insecticides in waters across three representative States: Maryland, Iowa, and California.

MARYLAND

Maryland is a special interest State for two reasons: 1) it is proximate to Washington, DC, and upstream, so what happens in Maryland waters may be noticed by decision makers in the capital, and 2) it is the site of the United States Department of Agriculture Agricultural Research Service (USDA ARS) headquarters in Beltsville, just northeast of Washington. ARS researchers have conducted extensive studies on neonicotinoids.

A 2014 USDA ARS report by Johnson and Pettis, "A Survey of Imidacloprid Levels in Water Sources Potentially Frequented by Honeybees in the Eastern USA," examines the presence of imidacloprid in samples of slow-moving or stagnant water sources from 18 Maryland sites representing a broad range of environments from agricultural areas to urban cityscapes to suburban neighborhoods and golf courses.[33] All sites sampled were within 0.5 miles of honeybee hives. Although the study has limitations, including its limit of detection and that it did not test for neonicotinoids that likely were present other than imidacloprid, it is a good presentation of the far-reaching impacts of imidacloprid contamination.

Findings

The water samples were tested using an assay with a limit of detection of <0.2 ppb.[34] Johnson and Pettis detected imidacloprid in 21% of the 108 sample and the average concentration was 11.5 ppb in the 21% that were positive.[35] Based on these results, the authors concluded imidacloprid was present in all the environment types in their study.[36] Interestingly, while agricultural runoff areas—the environments where neonicotinoid exposure is most expected—were impacted, the highest levels observed were near golf courses and plant nurseries. This points to the often overlooked, but widespread, contamination in run-off from turfgrass and ornamental applications.

Although the ARS researchers focused on toxicity to honey bees, the limited data they collected can also help to gauge the risk to aquatic invertebrate life. According to the guidelines set forth by Morrissey et al., the water samples collected throughout Maryland pose a substantial risk to many species. In fact, 21% of the samples had imidacloprid concentrations above 0.2 ppb—the acute threshold for aquatic invertebrates—and the study does not account for the many samples that were below 0.2 ppb (the study's limit of detection), but likely still above the recommended threshold for chronic exposure of 0.035 ppb.

This type of vast unregulated contamination is of particular concern to the many species living in the ecologically vulnerable Chesapeake Bay Watershed. The USGS report of national aquatic contamination levels included sampling from the Chesapeake Watershed, in particular samples from Antietam Creek, Big Pipe Creek, and Chillisquaque Creek (in Pennsylvania).[37] That report identified neonicotinoids in 59% of stream samples and it correlated higher concentrations with runoff after agricultural plantings. Although the researchers did not detect concentrations known to cause fish mortality, they did call for future studies to assess sub-lethal impacts and the possibility of synergistic effects on the already-jeopardized aquatic community. This includes Maryland's economically important and culturally iconic Blue crabs (*see Risks to Marine Species*).

IOWA

Nearly all corn seeds in the U.S. and roughly one-third of soybean seeds are coated with neonicotinoids.[38] This causes high concern for the contamination detected in waters throughout the vast Midwestern corn and soybean regions, which have experienced dramatic rises in use of these insecticides over the last 20 years.[iv] Iowa sits at the heart of this. Iowa is the number one state in the nation for corn and soybean production, growing approximately 2.1 billion bushels of corn and 525

[iv] Fig. 1 in Hladik, M., et al., 2014.

million bushels of soybeans annually.[39]

The USGS study, "Widespread occurrence of neonicotinoid insecticides in streams in a high corn and soybean producing region, USA" by Hladik et al., found neonicotinoid residues in all 79 water samples collected from nine sites in Iowa during the 2013 growing season. The researchers analyzed imidacloprid, thiamethoxam, clothianidin, acetamiprid, and dinotefuran. The highest occurrences were with the first three, which are the most commonly-used in corn and soybean treatments. Of the nine sites, seven were stream basins within the state and the other two were on the Missouri and Mississippi Rivers outside of Iowa.[40] The majority of concentrations and detection frequencies correlated directly with seasonal agricultural use.

Findings

Clothianidin was detected overall in 75% of samples taken across nine sites with a maximum of 0.257 ppb. Imidacloprid was in 23% of samples with a maximum of 0.0427 ppb. Thiamethoxam was in 47% of samples with a maximum of 0.185 ppb. The clothianidin levels exceeded the acute toxicity guidelines of 0.2 ppb. Further, 76% of the samples contained more than one neonicotinoid and 23% contained at least three, highlighting additional concerns about potential chronic, additive, and synergistic effects. The continued exposure to these compounds at the levels and frequency detected is a direct threat to many of Iowa's aquatic invertebrates and ecosystems.

Neonicotinoid Solubility and High Persistence

What is perhaps most significant about this study is the comparison to similar past studies. Hladik et al. explained that from 1992 to 2001, insecticides of any type were

It is clear from these results that repeated uses of persistent neonicotinoids pose an unprecedented threat to the waters of Iowa and to comparable corn and soybean-heavy States nearby.

detected in fewer than 20% of samples in the U.S. and, more specifically, a study of Iowa streams from 1996 to 1998 found carbofuran and chlorpyrifos to be the most highly detected insecticides, with only 16% and 7% of samples contaminated, respectively.[41] This is drastically different from the almost 50% average detection rate for neonicotinoids in the modern study. Hladik et al. explains this significant difference:

> *The substantially greater neonicotinoid detection frequency observed for this study compared to historical detections of other insecticides despite lower annual use could be influenced by their high mobility (e.g., higher water solubility) and greater persistence.*[42]

It is clear from these results that repeated uses of persistent neonicotinoids pose an unprecedented threat to the waters of Iowa and to comparable corn and soybean-heavy States nearby.

Updated Findings

Hladik and Kolpin followed up on these results in 2014 using many of the same sampling sites. However, this time their research focused on the impact of elevated precipitation and streamflow on contamination rates.[43] The researchers reported neonicotinoid concentrations in 100% of the samples collected in Iowa streams. There was remarkable consistency between the detected concentrations across 2013 and 2014 even though the precipitation and flow levels differed. The USGS authors concluded the "results confirm that precipitation is an important driver of neonicotinoid transport to streams following period of use; even when such precipitation is heavy enough to cause substantial stream flooding the neonicotinoid concentrations were not reduced."[44] These results are important particularly as the Midwest has documented increases in extreme rainfall events and flooding over the past century.[45] Despite substantial increases in flows, the consistent concentration levels are likely the result of transportation of stored residues in soil; however this is an issue in need of further investigation.

CALIFORNIA

California is the top agricultural production state, contributing more than 50% of the nation's vegetables, fruits, and nuts.[46] Extensive agriculture correlates with extensive insecticide use. In fact, in 2010, over 198,000 lbs. of imidacloprid, the most widely-used neonicotinoid, was applied to crops in California.[47]

The 2011 study, "Detections of the Neonicotinoid Insecticide Imidacloprid in Surface Waters of Three Agricultural Regions of California, USA, 2010-2011" by Starner and

Goh, was one of the first to report these insecticides as broadly contaminating U.S. surface waters.[48] Starner and Goh solely addressed imidacloprid but they noted the likelihood of other neonicotinoids in many of the samples collected, as well as the potential for additive and synergistic effects.

Of the 75 samples found across three agricultural regions researchers reported imidacloprid in 89%.

The authors analyzed 75 samples from 23 sites in three agricultural regions: Salinas Valley, Santa Maria Valley, and Imperial Valley. The samples were from rivers, creeks, and drains and collected between March and October. Of the 75 samples, they reported imidacloprid in 89% (67 samples), with concentrations as high as 3.29 ppb.

Surpassing Threshold Guidelines

It is not only the frequency at which imidacloprid was detected that causes alarm, but also the levels reported. Starner and Goh noted that 19% of the samples exceeded the lax EPA Toxicity Benchmark for aquatic invertebrates of 1.05 ppb for chronic exposures.[47] Comparing the sample concentrations to the thresholds set by Morrissey et al. reveals a great risk to aquatic invertebrates in or near sampled sites. Of the 67 positive samples, 100% exceeded the chronic threshold of 0.035 ppb and 74% exceeded the acute threshold of 0.2 ppb. Salinas Valley, Santa Maria Valley, and Imperial Valley "represent different California climates, soil types, and agricultural practices," as well as differing exposure time scenarios, yet high concentrations of imidacloprid were reported from each region.[50]

This widespread contamination concern was echoed in the 2014 USGS national survey. Of the 38 sampled sites across the nation, the highest concentrations of five neonicotinoids were found in March 2014 in Castroville, California, with combined additive concentrations of 0.45 ppb—over double the recommended acute threshold.

Of the 67 positive samples, 100% exceeded the chronic threshold and 74% exceeded the acute threshold.

Overall, three of the four sites sampled by USGS in California contained more than one neonicotinoid compound and 25% of the detections exceeded the chronic effects threshold.[51]

Further information on neonicotinoid contamination in California is in Weston et al.'s "Stormwater-related transport of the insecticides bifenthrin, fipronil, imidacloprid, and chlorpyrifos into a tidal wetland, San Francisco Bay, California."[52] This 2015 study examined residues in creeks and marshlands from both agricultural and urban run-off. It discovered imidacloprid concentrations as high as 1.4 ppb, with 50% of detections exceeding Morrissey et al.'s chronic threshold of 0.035 ppb. Two samples—both from Laurel Creek, an urbanized site—exceeded the acute threshold of 0.2 ppb. The highest Laurel Creek concentrations were noted to "represent a threat to resident macroinvertebrates."[v]

The previous California analyses are consistent with 2014-2015 findings from the City of Santa Barbara, Creeks Division. After routine testing of streams, as well as some urban environments, the Creeks Division found imidacloprid in all creek sites (Mission, Sycamore, Laguna, and Arroyo Burro). Water Quality Research Coordinator Jill Murray responded to these results stating, "We don't usually find the same pesticide in all of our creeks at once which to me means there's a lot of this pesticide out there, in the environment," and stated, "[imidacloprid is] having effect on the food chain or the ecosystems at really low concentrations, much lower than were determined in typical standard laboratory toxicity tests."[53] Following these incidents, a March 2015 release from the Creeks Division summarized the gravity of the situation and asked EPA and the California Department of Pesticide Regulation to take immediate risk mitigation actions.[54]

The data from the multiple researchers raises alarms. Current applications are causing widespread, biologically significant, contamination in the Golden State.

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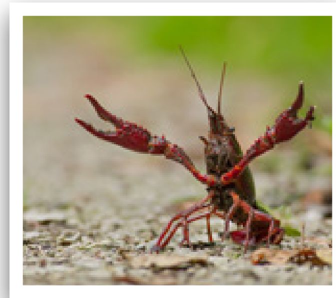
[v] Weston et al. downplay the concentrations of imidacloprid as far as risks to their tested species (*Hyalla azteca* and *Chironomus dilutus*). However, those species have relatively low sensitivity to that compound. Consistent with the argument by Morrissey et al. for more varied species use in testing, it should be noted that imidacloprid levels found by Weston et al. at many sites exceed levels found to depress population growth in another important species, *Ceriodaphnia dubia*.[55]

OVER-ARCHING CONCERNS



Risks to Aquatic Life

It should be clear that neonicotinoids pose a great risk of contaminating both surface and ground water and are capable of entering waterways through various unintended pathways. The three state case studies in this report found them in a broad range of environments at levels frequently exceeding the recommendations by Morrissey et al. to protect aquatic life.

Unfortunately, EPA's Aquatic Life Benchmark for invertebrates for imidacloprid is set at **1.05 ppb** for chronic (average) exposures and 35 ppb for acute (maximum) exposures.[56] In determining these thresholds, the agency "us[ed] methods that are unclear, though likely based on species such as *D. magna*."[57] Research reveals no solid underpinning for EPA's standards. Similar concerns exist for the other neonicotinoid benchmarks, which are comparable to that for imidacloprid, although EPA has set no benchmarks for several of the active ingredients.

EPA clearly recognized the aquatic risks of imidacloprid in its 2008 Registration Review analysis, stating:

> *Toxicity studies on aquatic invertebrates (freshwater and estuarine/ marine) show that these organisms are highly sensitive to imidacloprid, which is classified to be acutely very highly toxic to these organisms.*[58]

The same 2008 document identifies numerous areas of high risk to aquatic invertebrates and data gaps; it also describes aquatic poisoning, including run-off from a single lawn application in Ohio that killed an estimated **3,000 crayfish** the next day in a near-by stream.[60]

Similarly, a 2013 Dutch Paper, "Macro-Invertebrate Decline in Surface Water Polluted with Imidacloprid" concludes alarmingly (emphasis added):

> *While a large amount of evidence exists from laboratory single species and mesocosm experiments, our study is the first large scale research based on multiple years of actual field monitoring data that shows that* ***neonicotinoid insecticide pollution occurring in surface water has a strong negative effect on aquatic invertebrate life, with potentially far-reaching consequences for the food chain and ecosystem functions.***[59]

As use of all neonicotinoids increases in quantity applied and extent of the areas

Birds are one of the groups most at risk from both direct and indirect exposures to neonicotinoids.

impacted, it is increasingly critical for regulators to set science-based, precautionary, contamination standards that can help prevent both acute and chronic effects to the nation's aquatic wildlife.

Birds at High Risk

Birds are one of the groups most at risk from both direct and indirect exposures. Many bird species are susceptible to dying from ingestion of coated seeds or at risk of starvation or poor nutrition due to diminishing populations of aquatic insects and other invertebrates upon which they prey.[61] A 2013 report by the preeminent avian toxicologist, Pierre Mineau, together with Cynthia Palmer of the American Bird Conservancy (ABC), *The Impact of the Nation's Most Widely Used Insecticides on Birds*, found groundwater contamination levels that were "totally unprecedented in the history of pesticide registration."[62] Mineau and Palmer's warnings about the potential for bird declines resulting from this ongoing continent-wide contamination have gone unheeded by EPA officials. After the Mineau/ABC report was issued, the multi-year Hallman et al. 2014 study, "Declines in Insectivorous Birds are Associated with High Neonicotinoid Concentrations," published in the prestigious journal *Nature*, found that commonly-detected levels of imidacloprid in Holland's surface water were the strongest factor correlating with a 3.5% annual decline in bird populations over seven years.[63] Thrushes, sparrows, and swallows were among the most-impacted species. Plainly, bird populations cannot withstand many years of such declines.

There have been ongoing, disturbing declines in North American farmland/grassland and aerial insectivore bird populations, as there have been in Europe. Neonicotinoids and other insecticides appear strongly implicated.[64] Although no one wants a "Second Silent Spring," that is where the arrows are pointing. Aquatic invertebrate life and bird life are inextricably linked and must be protected.

Jeopardy to Aquatic Endangered Species

It is well-established that freshwater streams and wetlands in North America are vital for a high proportion of threatened and endangered animals.[65] Unfortunately, the insecticides at issue here threaten many vulnerable invertebrates in those habitats. Three such species, each classified "endangered" under the Endangered Species Act (ESA), are at risk from aquatic contamination; they are likely representative of the vulnerabilities of many other listed species:[66]

- **Hines Emerald Dragonfly** (*Somatochlora hineana*) lives in marshlands and sedge meadows in Illinois, Michigan, Missouri, and Wisconsin. Although habitat loss is the driver for its decline, pesticides also play a significant role.[67] Because the dragonfly depends on healthy wetlands, surface and groundwater contamination from neonicotinoid runoff poses direct and indirect threats to their survival. Species in the Odonata order are highly susceptible to direct toxicity. As far as indirect effects, neonicotinoid concentrations detected in the dragonfly's range are lethal to juvenile crayfish, whose burrows the Hine's Emerald dragonfly relies on for shelter.

- **Nashville Crayfish** (*Orconectes shoupi*) is endemic to Tennessee and inhabits Mill Creek—its only known habitat. All known populations of this species exist within urban Nashville.[68] Water quality deterioration is considered the primary cause of its decline. Applications to lawns and gardens, along roadways, in parks, to trees, and on golf courses could result in neonicotinoids entering the creek through runoff, leaching, and drift. Further, Mill Creek often floods. This means that persistent chemicals applied in adjoining areas may become inundated, moving them into the creek waters. Clothianidin in particular is known to be highly toxic to the similar, but more common, red swamp crayfish (*Procambarus clarkii*).[69] EPA's incident records show that runoff from one imidacloprid lawn application in Ohio killed 3,000 crayfish in a nearby stream. Thus, the use of the insecticides in or near the Nashville crayfish's habitat may result in reductions in its already-jeopardized population.

- **Salt Creek Tiger Beetle** (*Cicindela nevadica lincolniana*) is a rare insect whose habitat has shrunk to only two counties in Nebraska.[70] Although its range does not overlap with cornfields directly, studies show that neonicotinoids can move long distances particularly by way of groundwater. Continued leaching

New York State, because of its reliance on vulnerable aquifers, imposed a series of restrictions on neonicotinoid use, including bans on some products and in some counties due to contamination concerns.

and run-off from cornfields puts this beetle at significant risk because these chemicals are reported as toxic to other beetles of a similar size.[71] While the Salt Creek Tiger Beetle's decline may not now be attributed to neonicotinoid exposure, it is vital to fully assess the risk to avoid further jeopardy to this very vulnerable species.

Despite the risks to these and many other ESA-listed aquatic species, EPA has **never** consulted on foreseeable effects of neonicotinoid contamination with the U.S. Fish and Wildlife Service (FWS) or the National Marine Fisheries Service (NMFS), as is required under the ESA. If EPA were to consult the biologist experts in the FWS and NMFS, as it should, they would very likely recommend more restrictive alternatives to the status quo in order to conserve vulnerable listed species, and there would be much less of the ongoing, tragic, and unnecessary aquatic contamination this report describes.

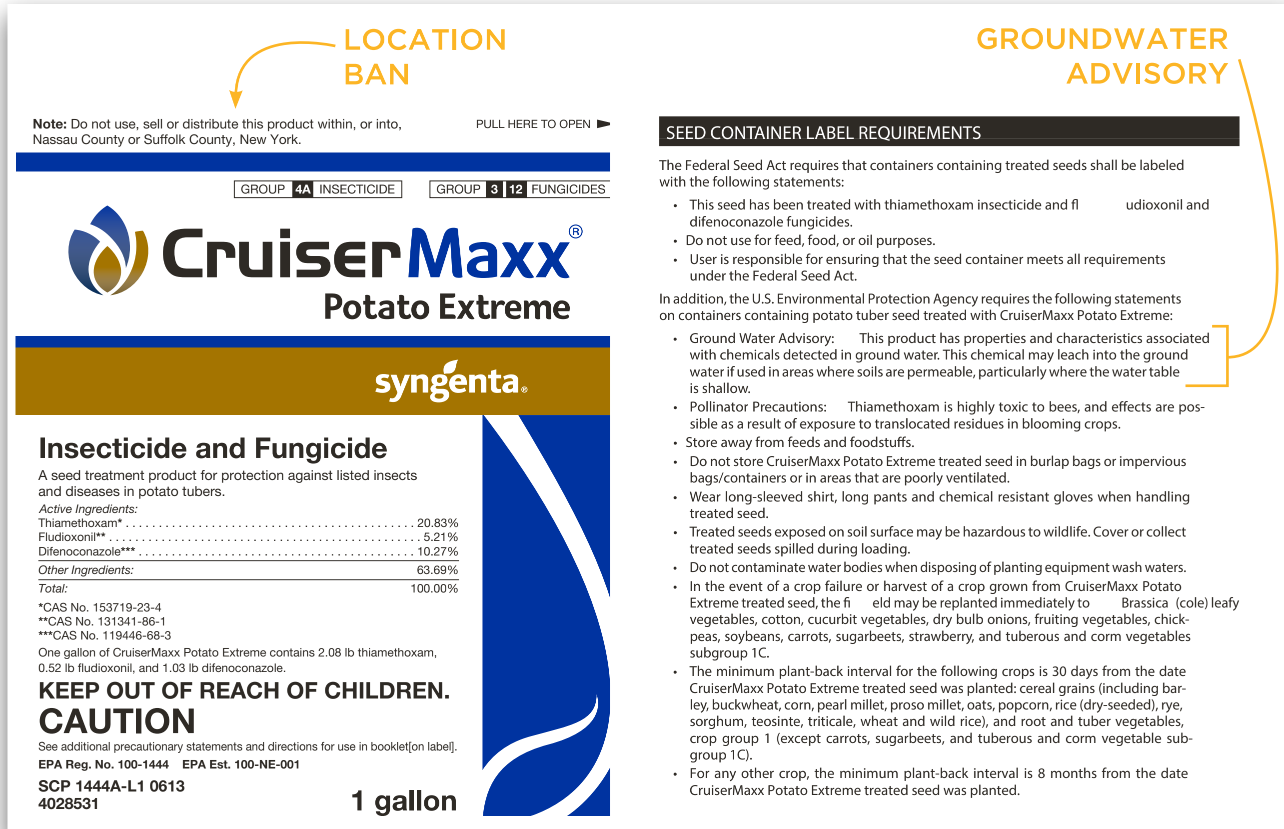
Aquifer Contamination

Water flows in interconnected ways, including under the surface. There are 16 million wells in the United States and over 15 million households rely on private well water.[72] Because of their propensity to leach, insecticides can potentially affect wells and whole aquifer systems that the U.S. population relies on for fresh water. The USGS recognizes 62 aquifers in the United States as "principal aquifers," meaning they are extensive and have "the potential to be used as a source of potable water."[73] Many of these are in close proximity to agriculturally intensive regions including the Cambrian-Ordovician aquifer system, which covers most of Iowa and parts of Wisconsin, Illinois, Missouri, and Michigan—the same area in which Hladik et al. found traces of neonicotinoids in all samples collected. This raises concern for possible unmonitored impacts on water quality.

New York State, because of its reliance on vulnerable aquifers, imposed a series of restrictions on neonicotinoid use, including bans on some products and in some counties due to contamination concerns (see restrictions on label for Cruiser Maxx Potato Extreme). New York's regulations are most strict in Nassau and Suffolk

> In a 2005 New York State Department of Environmental Conservation rejection of Bayer CropScience's application for "Poncho 600," the Department concluded that clothianidin is "...persistent and mobile. Modeling corn with middle of the road parameters, not worst case parameters, indicated a significant negative impact to groundwater when used as labeled. This product appears to have a **significant potential to cause a negative groundwater impact** just from use of treated seed."[74]

Counties which contain the vital Nassau-Suffolk Aquifer System—a sole source aquifer.[75] A sole source aquifer is defined by EPA as "an aquifer that supplies at least 50 percent of the drinking water consumed in the area overlying the aquifer," and the agency notes that "these areas may have no alternative drinking water source(s) that could physically, legally, or economically supply all those who depend on the aquifer for drinking water."[76] The system is highly vulnerable to contamination because of the geological conditions on Long Island.[77]



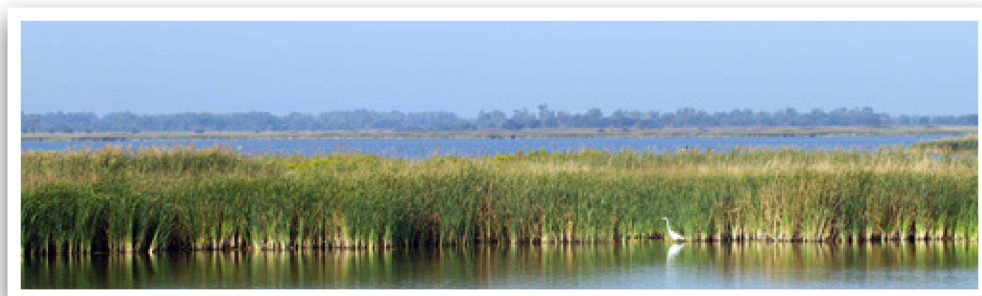
Despite the label restrictions and bans, these insecticides are still running or leaching into Nassau and Suffolk Counties' groundwater and threatening the aquifer's quality. Data from the Suffolk County Department of Health Services listed imidacloprid as the 3rd most frequently detected pesticide in groundwater, with 446 detections and the 6th most frequently detected pesticide in public water, with 315 detections (60 of which were wells).[78]

If New York is facing aquifer contamination despite governmental efforts to restrict neonicotinoid use, that raises questions about the lack of monitoring and regulation across the Nation's other vulnerable aquifers where the Federal and State governments are not taking special measures to protect them from these persistent compounds. The human health implications have not been adequately studied.

Irrigated fields sown with neonicotinoid-coated seeds receive repeated high doses via recirculated irrigation water.

Highly Vulnerable Regions

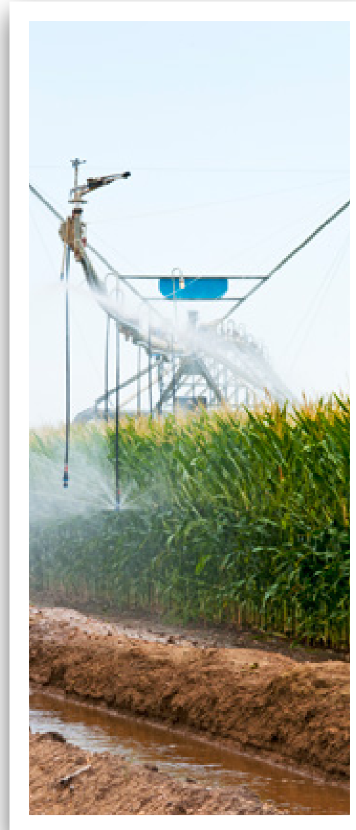
Beyond aquifers, other regions of special concern for contamination are where major wetland systems occur in close association with intensive agriculture. These include the Prairie Pothole Region (in the U.S., it generally consists of parts of Iowa, Minnesota, Montana, and North and South Dakota; in Canada, portions of Alberta, Manitoba, and Saskatchewan), the Rainwater Basin in south-central Nebraska and the Playa Wetlands in the southern high plains of Texas. In many of these areas the crop seeds are sown in the late spring or early summer alongside or directly into temporary or seasonal wetland basins. Seed coatings, leftover stalks and other forms of neonicotinoid contamination occur directly in these aquatic systems, which are essential for North America's migratory water birds such as ducks, shorebirds, and geese. These regions support more than half of North America's waterfowl during migration, staging, and breeding.[79] Hunters, birdwatchers and society as a whole plainly have huge stakes in the health of these waters.



One study from the Prairie Potholes in Canada detected at least one neonicotinoid in 36% of wetlands in Spring 2012 and in 91% of the wetlands the following spring.[80] Follow-up analysis showed more than 50% of the samples exceeded the chronic exposure standard.[81] This is comparable to results found in the Playa Wetlands, where two neonicotinoid active ingredients (acetamiprid and thiamethoxam) were found at very high concentrations—up to 225 ppb.[82] Both cases exceeded the recommended acute thresholds. Clearly wetland systems are highly vulnerable to this contamination, raising concern for the future of the invaluable species they support.

Role of Irrigation and Field Drains

Because neonicotinoids persist in soils, and are now documented widely as contaminating groundwater, re-circulated irrigation water needs to be accounted for when considering paths of exposure. Research in Wisconsin by Huseth and Groves in their 2014 report "Environmental Fate of Soil Applied Neonicotinoid Insecticides in an Irrigated Potato Agroecosystem," found detectable levels in **untreated** control plots. To explain this apparent mystery the researchers tested the groundwater sourced by the center pivot irrigation system and found concentrations as high as 8.9 ppb.[83] This indicates that irrigated fields sown with neonicotinoid-coated seeds or treated with spray applications receive repeated high doses via recirculated irrigation water. Additionally, it indicates runoff from treated fields can re-circulate onto unintended fields, risking the integrity of organic agriculture in nearby areas as well as other unintended and unwanted locations.



EPA's past analyses in approving the insecticides utterly failed to consider these irrigation exposure pathways, which contaminate not only groundwater but also ditches and other habitats outside field margins. Pollinating insects and many other beneficial species also rely on field margins and ditches for habitat. The flowing pollution can reach downstream surface waters such as streams, rivers, lakes, and marine bays and sounds.

With respect to field drainage systems, which may or may not be associated with irrigation, a recent overview study on neonicotinoid-coated seeds by Purdue University expert Christian Krupke and his colleague states:

> *Given that these compounds are highly water soluble and act systemically, there is the potential for dispersing residues (e.g., in planter dust) to be absorbed by plant tissues or dissolved in surface or ground water. This is of particular importance in many North American crop fields, where fields are drained using a system of perforated, buried pipes that convey excess water to drainage ditches at field margins.*[84]

Concerns about field drainage and especially its impacts on wetlands are real; they have been well-studied by the U.S. Fish and Wildlife Service's Field Office in South Dakota. The agency's Contaminants Branch stated:

> *Results are considered preliminary but it's clear that agricultural tile drains can be an exposure pathway for neonicotinoid insecticides into wetlands managed by the Service.....Since 2012, we have collected around 88 tile outfall samples and have detected neonicotinoids (clothianidin, imidacloprid or thiamethoxam) in about 49% of those samples. The highest concentrations detected from tile drains were 2.49 micrograms per liter (µg/L) [2.49 ppb] and 0.128 µg/L [0.128 ppb] for thiamethoxam and clothianidin, respectively. Neonicotinoid exposure to wetland aquatic invertebrates is a concern.*[85]

In short, wetlands that are vital for publicly-managed wildlife are exposed to

Wetlands that are vital for publicly-managed wildlife are exposed to runoff that exceeded acute and chronic thresholds when it left the field drains.

runoff that exceeded acute and chronic thresholds when it left the field drains.

Overlooked Puddles

Another publication, "Neonicotinoid-Contaminated Puddles of Water Represent a Risk of Intoxication for Honey Bees," by Samson-Robert et al., considered the importance of often overlooked puddles in Ontario's agricultural areas.[86] Bees use these stagnant water sources for multiple purposes including cooling, consumption, honey dilution, and humidity maintenance within the hive.[87] The chemicals detected in water not only affect the bee visiting the source in question, but also can contaminate and impact the entire hive.[88] Samson-Robert et al. found detectable levels of neonicotinoids in all puddles sampled and found that 83% contained more than one.[89] Concentrations ranged from a low 0.01 ppb to an exceedingly high 63.4 ppb. While these concentrations are below many standards for acute toxicity to bees, they do pose a substantial risk of chronic effects.[90]

The greater significance however, is the report's representations of persistence in soil. Concentrations reached as high as 55.7 ppb for clothianidin and 63.4 ppb for thiamethoxam during planting, and traces of both chemicals were found in all 34 samples collected a month after planting, at levels as high as 2.3 ppb for clothianidin and 2.8 ppb for thiamethoxam. These levels vastly exceed the Morrissey et al. thresholds for aquatic invertebrates.[91]

Although beekeepers often move their honey bees away from fields during planting and spraying, these results show that neonicotinoids persist in the soil during dry periods only to surface in puddle water after rain events, thus posing a threat to both bees and other beneficial organisms. When high precipitation occurs, of course, many of these puddles flow then into downstream waters—demonstrating another overlooked contamination pathway.

Marine Impacts

Despite being the ultimate downstream “sinks” where most water flows, bays, sounds, oceans, and marine ecosystems are alarmingly under monitored for neonicotinoid contamination. According to the World Integrated Assessment of Systemic Insecticides, “there are no published works regarding the marine environmental contamination of neonicotinoids.”[92] However, this class of contamination is becoming more evident. The potential risk of storm water run-off to marine areas has been highlighted in various studies.[93]

Marine contamination was also highlighted in 2015 in the Maryland Legislature. Professors Eric Schott and Carys Mitchelmore of the University of Maryland raised concerns over negative impacts to the lifecycle of the blue crab. Blue crabs are the official crustacean of Maryland, and for good reason: the Chesapeake Bay supplies roughly one-third of the nation’s blue crabs annually and their estimated dockside value in the Chesapeake was $78 million in 2009.[94] The blue crab is not only culturally and economically important to the Chesapeake, it is also a keystone for the Bay’s survival. The blue crab is an important scavenger as well as staple prey for many fish, such as the highly-valued striped bass. The added threat of neonicotinoid contamination is highly concerning for this iconic species, as it is already at risk from overfishing, habitat degradation, and disease.

In their testimony, Professors Schott and Mitchelmore relied on the study, “Acute toxicity and sub-lethal effects of common pesticides in post-larval and juvenile blue crabs, *Callinectes sapidas*” by Osterberg et al.[95] Of the multiple pesticides tested, the researchers found imidacloprid was the second most acutely toxic chemical with a LC50

"There are no published works regarding the marine environmental contamination of neonicotinoids." – World Integrated Assessment of Systemic Insecticides

value of 10.04 ppb for megalopae (larval crabs). Aside from the lethal concentrations, the researchers also observed chronic impacts. Only 57% of imidacloprid-exposed megalopae successfully molted, and of the molted juveniles that were exposed, 41% were found dead. Crustaceans are highly vulnerable during their molting phase and studies show that blue crabs are able to delay metamorphosis until "chemical cues indicating suitable juvenile habitat are sensed."[96] However, a delay in metamorphosis not only results in weakened populations, but "since tidal creeks and marches are forage areas for blue crabs as well as nursery areas for many important estuarine species, lethal and sub-lethal effects here could have serious implications for the broader estuarine ecosystem." Overall, these experts concluded imidacloprid posed a substantial risk and, compared to other pesticides studied, was "the most dangerous to developing crabs."[97] The blue crab is representative of many other marine species unable to avoid neonicotinoid concentrations in run-off flowing into their nearshore habitats. Rippling damage can occur throughout marine ecosystems. The lack of research and monitoring in this area must be addressed.

EPA'S CONDITIONAL REGISTRATION FAILURES RELATED TO WATER CONTAMINATION

One of the regulatory inadequacies that paved the way for widespread neonicotinoid contamination is EPA's abuse of "Conditional Registrations," which the agency has granted for the majority of the product registrations under the Federal Insecticide Fungicide and Rodenticide Act (FIFRA). Conditional Registrations allow key safety information to be provided up to several years after the products are approved for use and allowed onto the market.[98] This process has been heavily criticized by the Government Accounting Office as poorly administered by EPA, which has often failed to monitor and ensure compliance with key conditions, including those impacting the Nation's waters.[99]

The blue crab is representative of many other marine species unable to avoid neonicotinoid concentrations in run-off flowing into their nearshore habitats.

CFS reviewed the Conditional Registrations granted to scores of products over the last 15 years and found they are too risky, particularly in the area of aquatic contamination. For example, EPA has allowed clothianidin and thiamethoxam products (two of the most widely-used neonicotinoids) to be used for years with data gaps for these key topics:

a) Whole Sediment Acute Toxicity Invertebrates, Freshwater;

b) Whole Sediment Acute Toxicity Invertebrates, Estuarine and Marine;

c) Aerobic Aquatic Metabolism;

d) Seed Leaching; and

e) Small-Scale Prospective Groundwater Monitoring Study

These topics are precisely those that the water monitoring results highlighted in this report are pointing to. Absence of the needed risk assessment data before nationwide commercialization has led to the growing contamination crisis.

Despite the risks neonicotinoids post to economic interests and ecological values, EPA expedited their registration process, remarkably treating them as "reduced risk pesticides."[100] According to the Office of Pesticide Programs, the reduced risk pesticides' advantages include: "*low impact on human health, lower toxicity to non-target organisms (birds, fish, plants), low potential for groundwater contamination, low use rates, low pest resistance potential, and compatibility with Integrated Pest Management (IPM) practices*."[101]

This report demonstrates the fallacy of EPA's fast-tracking of neonicotinoids as posing low risk to aquatic non-target species and lower potential for ground or surface water contamination. The agency's actions and inactions undermine not only critical water sources that humans depend on, but also aquatic ecosystems fundamental to the future survival of many invertebrates, other freshwater and marine life, and birds.

In April, 2015, EPA announced a voluntary moratorium on agency approval of

CFS has reviewed the Conditional Registrations granted to scores of products over the last 15 years and found they are too risky, particularly in the area of aquatic contamination.

"new uses" of any neonicotinoids pending receipt of adequate information to fully assess their environmental risks.[102] While ostensibly limited to information gaps about adverse impacts to honey bees, that species is actually one of the most-studied topics as far as environmental impacts of these insecticides. EPA's admission that it lacks adequate information to protect honey bees from new uses raises even greater concerns about its lack of information about impacts on the much less-studied aquatic invertebrates and ecosystems, especially for the least studied marine systems.

POLICY RECOMMENDATIONS

This report consistently underscores that it is vital to reverse EPA's failures and promptly reduce the widespread neonicotinoid contamination of America's waters.[103] The following twelve recommendations will help turn the tide and prevent further harm:

1. **Suspend neonicotinoid registrations due to their "unreasonable adverse effects" on aquatic environments.** EPA has both the authority and an ongoing duty under FIFRA to suspend pesticides that are causing unreasonable adverse effects. It is impossible to conclude that broad undermining of the health of aquatic ecosystems nationwide is somehow an acceptable side effect. EPA must take action or else a "Silent Spring" will become a fact, not just a catch-phrase. Fault for this will rest solidly on the agency's decisionmakers.

2. **Adopt rigorous national aquatic contamination thresholds per Morrissey et al., specifically: 0.2 ppb (short-term acute) and 0.035 ppb (long-term chronic) to avoid lasting effects on aquatic invertebrates communities.** Inconsistent and too lax standards such as EPA's unsupported 1.05 ppb Toxicity Benchmark for imidacloprid chronic effects mask the ongoing harm to aquatic invertebrates.

3. **Eliminate the "Coated Seeds" exemption.** EPA allows millions of pounds of neonicotinoid-coated seeds to be planted annually on likely more than 150 million acres nationwide. Almost all of U.S. corn seeds and high percentages of many other crop seeds are coated.[104] Yet, the use of coated seeds is not considered a regulated "pesticide" use by EPA because it interprets them to fall under its "treated article exemption."[vi] The agency's interpretation leaves it no enforcement ability against misuse and overuse and little ability to impose strict label restrictions on seed bags in order to stop the harm to the nation's waters. This is unacceptable because coated

[vi] 40 CFR § 152.25(a)

seeds are by far the dominant use of neonicotinoids in terms of the land area and the area of waters that are contaminated as a result. EPA must bring these seeds under direct regulation.

4. **Stop classifying neonicotinoids as "reduced risk" pesticides and fast-tracking their registrations; also end Conditional Registrations for them.** This report demonstrates the fallacy of EPA's fast-tracking the neonicotinoids as "reduced risks" for ground or surface water contamination or for non-target aquatic species. The Conditional Registration process has allowed commercialization and resulting contamination to occur while the registrants in most cases still had not submitted basic information on groundwater contamination, threats to aquatic invertebrates and marine risks. EPA must halt its *laissez-faire* practices.

This report has demonstrated the fallacy of EPA's fast-tracking of neonicotinoids as posing low risk to aquatic non-target species and lower potential for ground or surface water contamination.

5. **Use more representative test species and long term mesocosm studies for determining biological risks.** Morrissey et al. and other researchers have shown that the highly neonicotinoid-tolerant *Daphnia magna* is not a suitable surrogate for most aquatic invertebrates. Rather, EPA and other agencies should use more representative species in toxicity testing, such as mayflies and caddisflies, and other more sensitive Ephemeroptera, Trichoptera, and Diptera, particularly the Chironomidae (midges), that are important food sources for many fish and bird species.[105]

6. **Comply with Section 7 of the ESA.** EPA has admitted its failure to consult on the neonicotinoids with the FWS or the NMFS, as required under Sec. 7(a)(2) of the ESA.[vii] Despite this admission, EPA still has not initiated consultation on the effects of these insecticides on Federally-listed threatened and endangered species. These include the Hines Emerald dragonfly, Nashville crayfish, and Salt Creek tiger beetle described in this report, as well as potentially scores of other listed aquatic animals. EPA should commit to fully complying with ESA requirements.

7. **Drastically improve labels for uses that foreseeably will impact aquatic ecosystems.** Current neonicotinoid labels are utterly inadequate to conserve fresh and marine waters. The labels typically include only generic language that is inadequate to prevent water contamination. They must be reformed.

[vii] The lack of ESA consultation is clear from neonic registration files. EPA admitted this in: Response to Public Comments on EPA's Proposed Registration of the New Active Ingredient Cyantraniliprole: An Insecticide for Use on Multiple Commodities, Ornamentals, Turfgrass, and in Commercial or Residential Buildings. (Jan. 24, 2014).

This report consistently underscores that it is vital to reverse EPA's failures and promptly reduce the widespread neonicotinoid contamination of America's waters.

8. **Conduct more systematic research and monitoring on the effects of aquatic contamination, including the human health implications.** USGS has undertaken key studies that complement those by academics and others. However, more inclusive data and ongoing monitoring for neonicotinoids is needed, particularly in view of the USDA NASS and USGS Pesticide Use data and maps generally excluding accounting for their use as seed coatings. The contamination of aquifers and other drinking water sources for millions of people is a serious, yet understudied, potential health concern.

9. **Marine protection campaigns should specifically address neonicotinoid contamination.** It is now demonstrated that blue crabs and other vital and iconic species could be threatened. Achieving healthy water goals for the Chesapeake Bay, San Francisco Bay, Puget Sound, and other at-risk waterbodies must not be undermined by insidious and pervasive neonicotinoids, which are growing in prominence as marine pollutants, but remain grossly understudied in marine habitats.

10. **Apply the Clean Water Act.** The Clean Water Act's (CWA) enabling statute provides: "[t]he [EPA] Administrator shall, after careful investigation… develop comprehensive programs for preventing, reducing, or eliminating the pollution of the navigable waters and ground waters and improving the sanitary condition of surface and underground waters."[viii] Excess run-off of the neonicotinoids can amount to pollutants under the CWA and their discharges into water can be considered from regulated "point sources." In view of the extensive and growing contamination described in this report, EPA should initiate a program to drastically curtail the ongoing pollution utilizing its full regulatory powers to improve the condition of the nation's surface and ground waters.

11. **Take action at State and local levels.** The Federal government tends to act at a much slower pace than State and local governments. Several states such as New York and municipalities (Spokane, Eugene, Seattle, Suffolk and Nassau Counties and many others) have already acted. Those models should be followed by others. Specifically, states and local governments should identify the aquatic contamination concerns that apply in their jurisdictions and prohibit or restrict neonicotinoids accordingly.

Working together, governments and citizens can and must reverse this widespread rise in long-lasting neonicotinoid contamination. If we don't, we will leave future generations with degraded waters and barren aquatic systems.

[viii] 33 U.S.C. § 1252(a).

Sprays, dusts and aerosols are now applied almost universally to farms, gardens, forests and homes – non-selective chemicals that have the power to kill every insect, the 'good' and the 'bad', to still the song of the birds and the leaping of fish in the streams, to coat the leaves with a deadly film and to linger on in the soil – all this though the intended target may be only a few weeds or insects. Can anyone believe it is possible to lay down such a barrage of poisons on the surface of the earth without making it unfit for all life? They should not be called "insecticides," but "biocides."

— Rachel Carson, *Silent Spring*, 1962[106]

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