

# Environmental Impact of Neonicotinoids on Our Lakes—Too Much of a Good Thing?

CNY Regional NYSFOLA Conference on August 11, 2023

Douglas Merrill, Board Member: Canandaigua Lake Watershed Association  
Political Education Committee: Finger Lakes Regional Watershed Alliance



# “The Birds and Bees Protection Act” is a proposal to amend the NY Environmental Conservation Law

- Title 33 of the NY Environmental Conservation Law pertains to pesticides.
- Section 33-1301 identifies “Unlawful Acts” pertaining the pesticides
- Each subdivision of 33-1301 specifies what is an “unlawful act.”
- The BBPA proposes to amend the NYEC Law by adding a new subdivision (13a and 13b) pertaining specifically to what are unlawful acts regarding neonicotinoid pesticides



# Provisions of the Birds and Bees Protection Act

- 13.a. Beginning 1 January 2026 [It shall be unlawful] for any person to sell, offer for sale or use, or distribute within the state any **corn, soybean or wheat seeds coated or treated with pesticides** with the active ingredients clothianidin, imidacloprid, thiamethoxam, dinotefuran, or acetamiprid [five most common neonicotinoid formulations]
- 13.b. [It shall be unlawful] to **apply or treat outdoor ornamental plants and turf** with pesticides with the active ingredients
  - Imidacloprid, thiamethoxam, or acetamiprid on or after 1 July 2025
  - Clothianidin or dinotefuran effective immediately

# Neonicotinoids and the Birds and Bees: What Does the Science Say?



<https://www.earth.com/news/honey-bees-are-very-loyal-to-their-flower-patches/>



<https://www.gardendesign.com/flowers/hummingbirds.html>

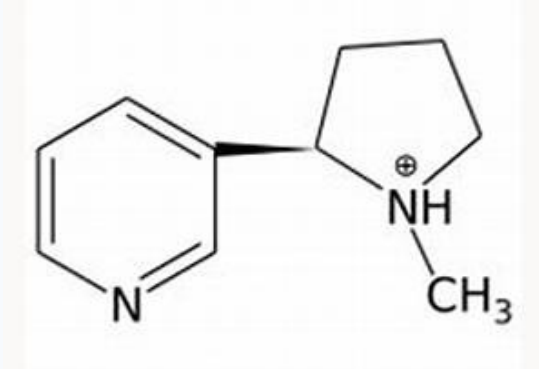
# What are Neonicotinoids (Neonics)?

- Most widely used insecticide in the world—25% of the global market worth in excess of \$3B.
- On the market since 1991 and used for:
  - Agriculture
  - Lawns and gardens
  - Ornamental trees and shrubs
  - Golf courses
  - Forests
  - Flea and tick pet treatments (treated collars)
- Versatile: applied as foliar sprays, soil drenches, trunk injections, seed coatings
- Exist in several different chemical formulations
- Systemic insecticide—they are water soluble
  - Moves through the fluid transport systems into all plant tissues
  - Moves through circulatory systems of exposed organisms

# Action of Neonicotinoids

- Based on nicotine chemistry--neurotoxin
- Specific toxins that attack the nervous system of arthropods\* —gradually destroys nerve cells
  - Indiscriminate—toxic to all insects and many terrestrial and aquatic invertebrates, not just pests
  - Sub-lethal levels create behavioral and functional impairments
    - Uncontrollable twitching and erratic motor activities
    - Paralysis
    - Reduced fertility and stamina
    - Impaired immunity and increased infections
    - Altered learning and memory
    - Impaired navigation and foraging
    - Increased susceptibility to parasites and infections
  - Effects are irreversible and cumulative—time cumulative mortality

\* Insects, spiders, crustaceans, millipedes/centipedes



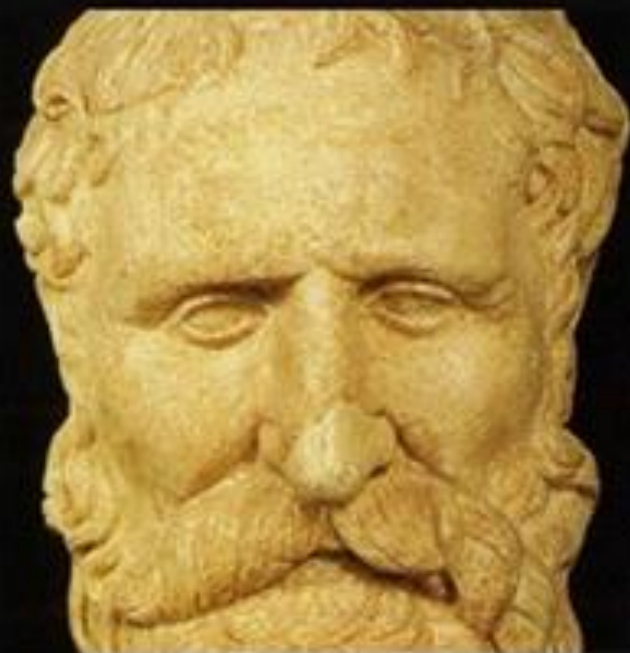
# Ecological, Environmental, and Health Advantages of Neonicotinoids

NYS DEC: New York State Pollinator Protection Plan 2016

- Because they are systemic, they protect all parts of the plant;
- Protection from boring, sucking, chewing, and root-feeding insects;
- Replacing the more toxic organophosphate (e.g. parathion), organochlorines (e.g. DDT) and carbamate (e.g. Sevin®) insecticides
  - Lower toxicity to mammals, birds, and fish than older classes of insecticides;
  - Lower risk to agricultural workers and consumers;
- Improved crop yields in areas with high pest pressures;
- Effectiveness reduces need for multiple applications;
- Reduced need for foliar spraying, which can be associated with non-target organism pesticide exposure and issues associated with drift; and
- Longevity (long half-life) and variety (several different formulations), which help prevent the buildup of resistance in pests.

In other words, neonics were a gift from the gods!



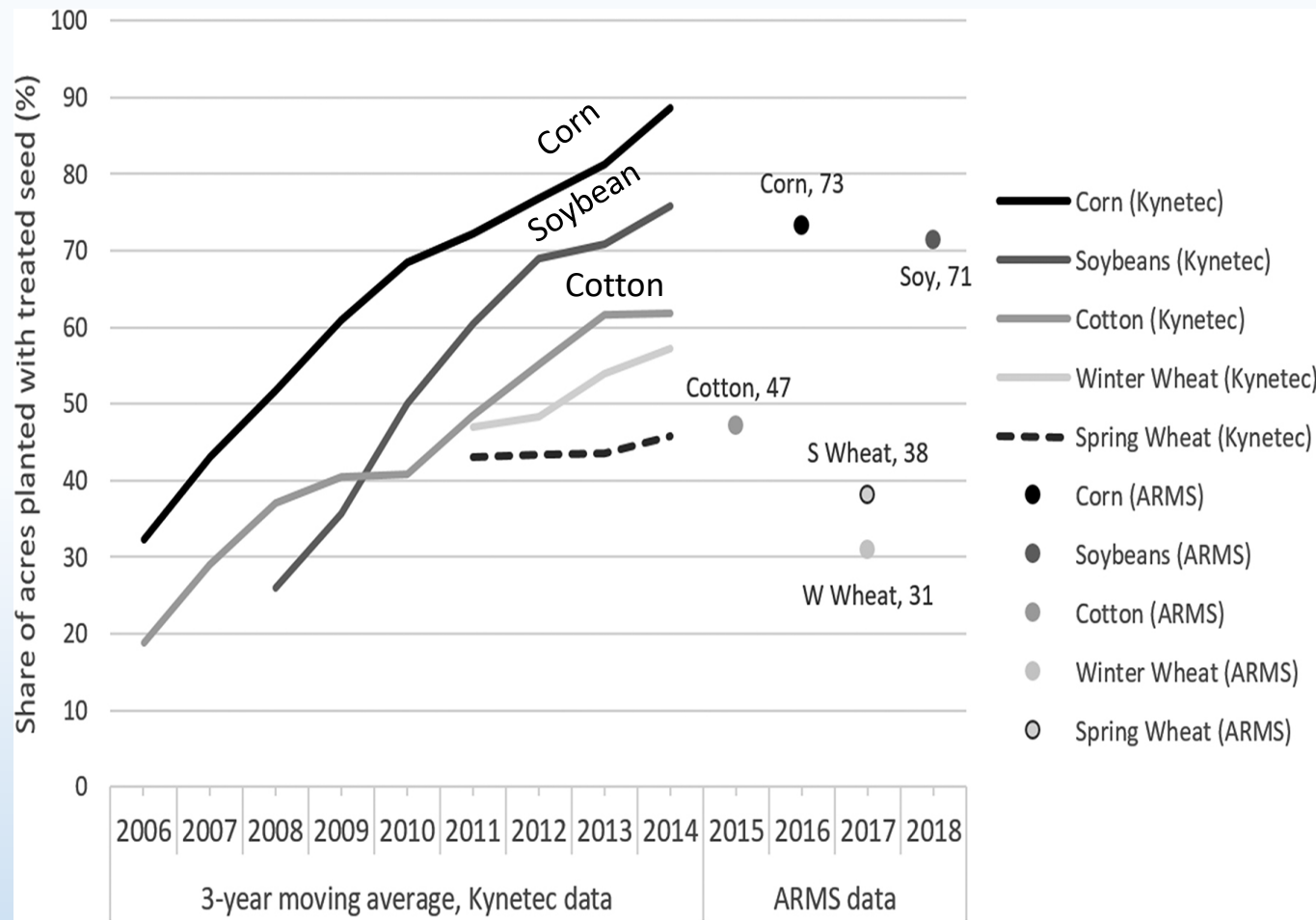


We have complicated every  
simple gift of the gods.

~ Diogenes



# Explosion in the Use of Insecticides in Agriculture



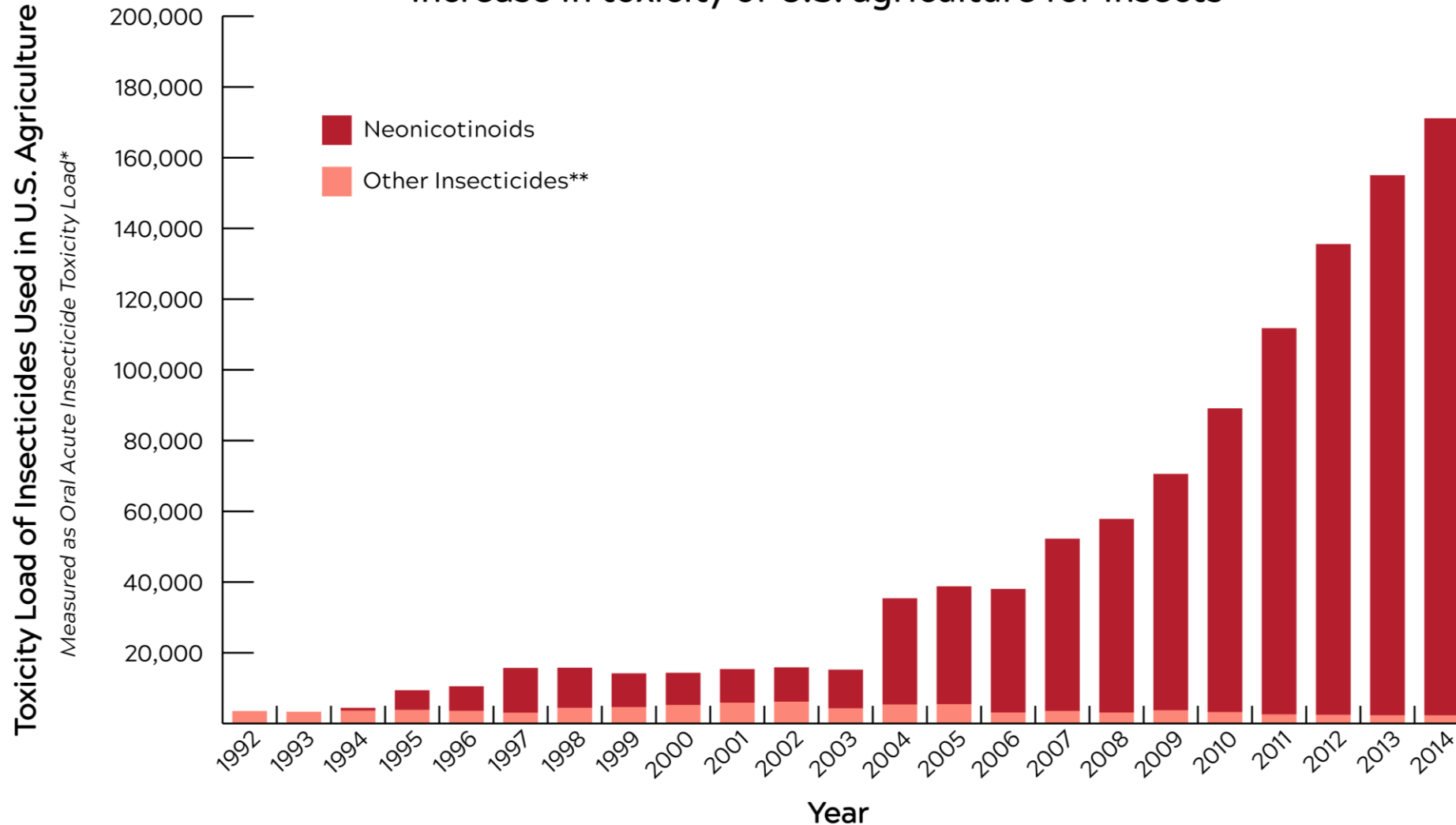
- Intensification of agricultural practice—maximize yield
- Merging of seed and chemical companies—one stop shop
- Effective ad campaign
  - Insurance against unexpected loss
  - Safety
  - Efficiency—bundle insecticides, nematicides, fungicides, growth promoters in a single application
- Prevention vs. IPM strategies



Est: 10,000 tons applied on US fields each year  
 Est: 90-100 tons applied to NYS fields each year

# Neonicotinoids are Non-Selective Insect Killers

Increase in toxicity of U.S. agriculture for insects



48-fold  
increase  
in toxicity  
for all  
insect life

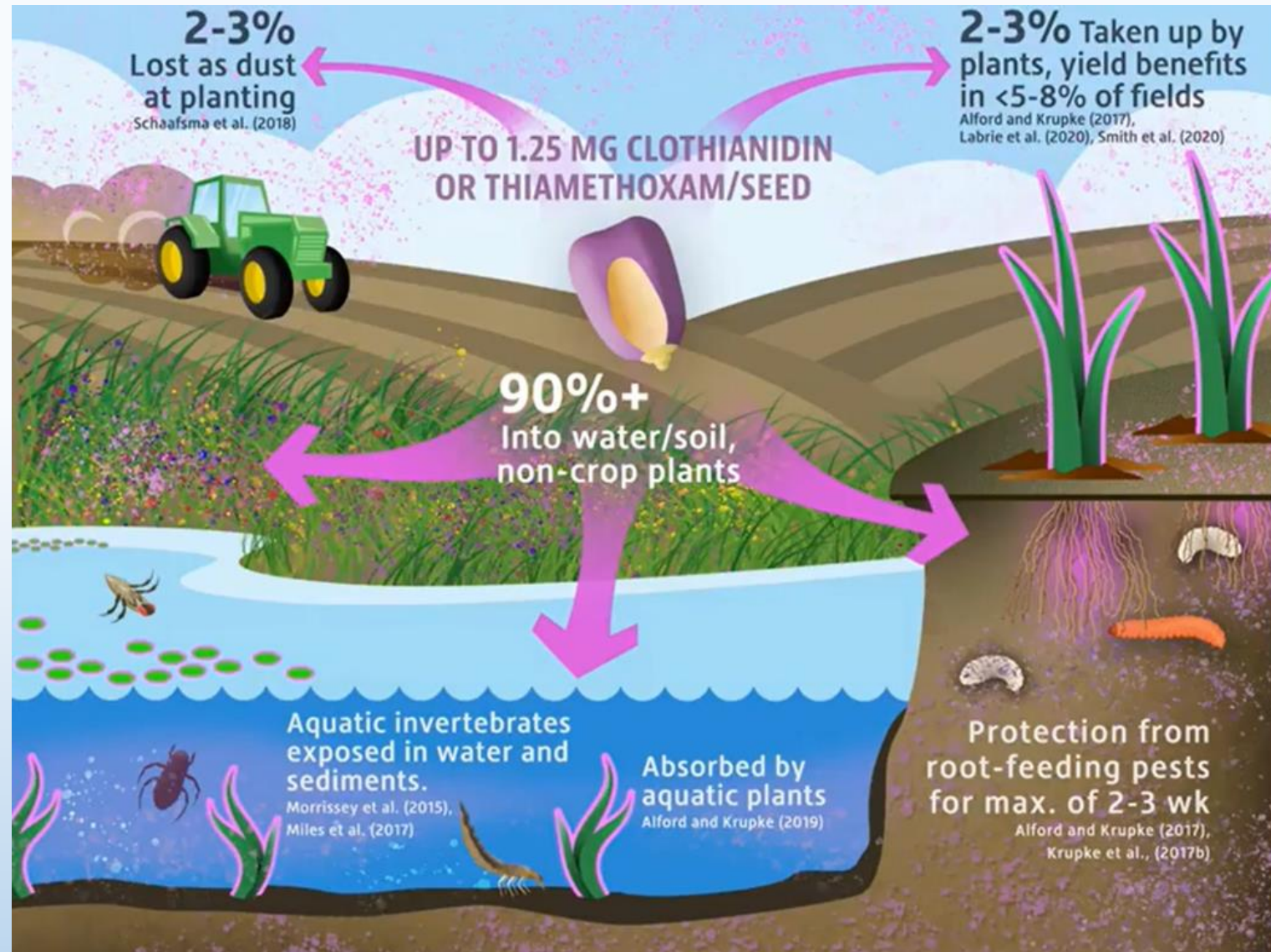
Harmful to  
insectivorous  
and seed-  
eating birds

\*For method, see DiBartolomeis and Kegley et al., 2019. An assessment of acute insecticide toxicity loading of chemical pesticides used on agricultural land in the United States, PLOS One.

\*\*pyrethroids, organophosphates, pyrazoles, spinosyn, N-methyl carbamates, others

# Environmental Impacts of Neonicotinoids

- Highly soluble in water and low volatility
- Low tendency to adsorb to soil particles
- Not readily biodegradable by soil microbes
- Environmentally persistent
  - Half-life in soil ranges from 12-6,931 days





Related Topics: [Pesticide Science and Assessing Pesticide Risks](#)

## Aquatic Life Benchmarks and Ecological Risk Assessments for Registered Pesticides

**Table 2: A comparison of current USEPA aquatic benchmarks to proposed benchmarks by Canada's PMRA (in µg/L)**

| Compound     | USEPA acute benchmark <sup>a</sup> | PMRA acute benchmark | USEPA chronic benchmark <sup>a</sup> | PMRA chronic benchmark |
|--------------|------------------------------------|----------------------|--------------------------------------|------------------------|
| Imidacloprid | 0.385                              | 0.36 <sup>b</sup>    | 0.01                                 | 0.041 <sup>b</sup>     |
| Thiamethoxam | 17.5                               | 9.0 <sup>c</sup>     | 0.74                                 | 0.026 <sup>c</sup>     |
| Clothianidin | 11                                 | 1.5 <sup>d</sup>     | 0.05                                 | 0.0015 <sup>d</sup>    |

<sup>a</sup> USEPA 2019.

<sup>b</sup> PMRA 2016.








<sup>c</sup> PMRA 2018a.

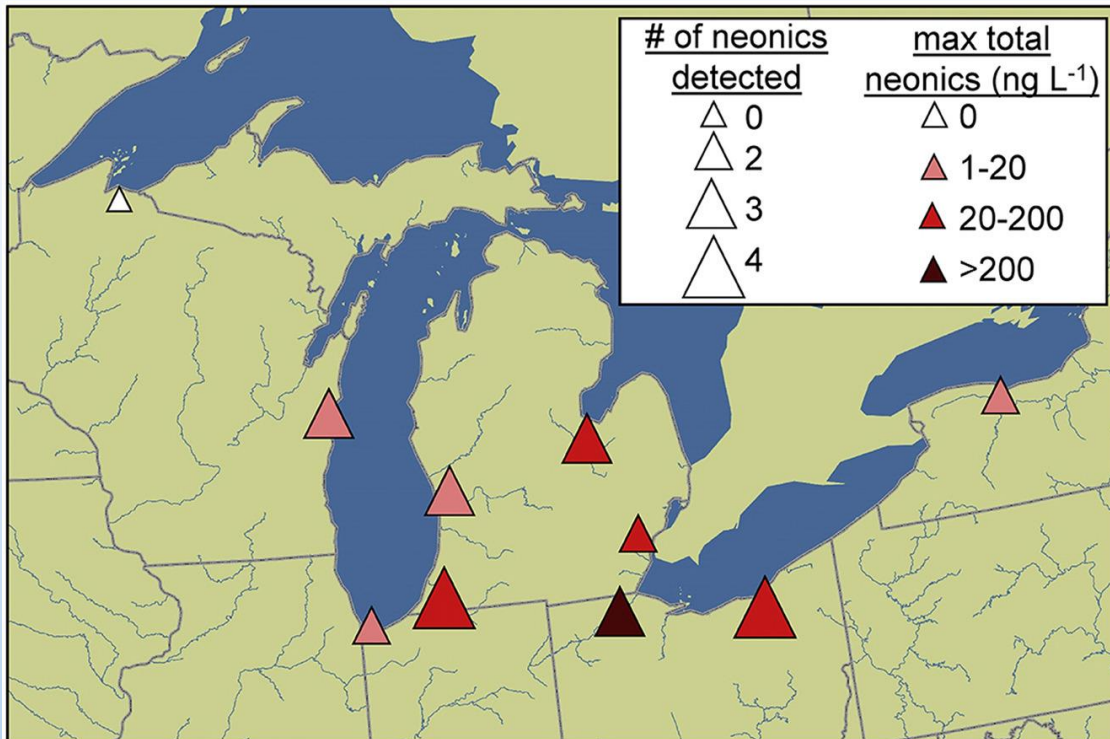
<sup>d</sup> PMRA 2018b.

Aquatic Life Benchmarks are estimates of the concentrations below which pesticides are not expected to represent a risk of concern for aquatic life. The higher the measured value relative to the Benchmark, the greater the risk to aquatic life



## Year-round presence of neonicotinoid insecticides in tributaries to the Great Lakes, USA ☆

Michelle L. Hladik<sup>a</sup>  , Steven R. Corsi<sup>b</sup> , Dana W. Kolpin<sup>c</sup> , Austin K. Baldwin<sup>d</sup> , Brett R. Blackwell<sup>e</sup> , Jenna E. Cavallin<sup>f</sup> 



# Neonicotinoids in the Aquatic Ecosystem

- Three major neonicotinoids were found to be prevalent throughout the year in sampled tributaries to the Great Lakes
- This represents a direct year-round exposure of neonicotinoids to aquatic organisms.
- Higher neonicotinoid concentrations occurred in spring and summer which may align with sensitive stages for aquatic organisms.

# Literature Review: Global Neonicotinoid Insecticide Occurrence in Aquatic Environments

Boruah et al., *Water* 2020, 12, 3388; doi:10.3390/w12123388

|                     |              |             |             |
|---------------------|--------------|-------------|-------------|
| <b>Chronic ALB:</b> | <b>0.01</b>  | <b>0.74</b> | <b>0.05</b> |
| <b>Acute ALB:</b>   | <b>0.385</b> | <b>17.5</b> | <b>11</b>   |

Review of 55 studies on neonicotinoids and the aquatic environment in eight countries. Study was funded by the US Department of Agriculture

- Canada: Detected in over half of fifteen sites with concentrations up to 11.9 µg/L
- US, Netherlands and Sweden: detected in 89-100% of surface water sites with concentrations ranging from 0.22-200 µg/L
- USGS study: Detected in >50% of 38 streams sampled across the US
- Iowa Study: 79 water samples from 7 stream basins detected in all samples with maximum concentrations ranging from 0.043 µg/L – 0.257 µg/L
- China: Concentrations in Pearl River system range from 0.024 to 0.322 µg/L

# Experimental evidence for neonicotinoid driven decline in aquatic emerging insects

Barmentlo et al. PNAS 2021 Vol. 118 No. 44 e2105692118 <https://doi.org/10.1073/pnas.2105692118jS>

- Causal relationship was found between increasing levels of neonicotinoids and a steady decline in the emergence of aquatic insects.
- Neonicotinoid insecticides in surface waters have negative effects on abundance, biomass, and diversity of emerging aquatic insects.

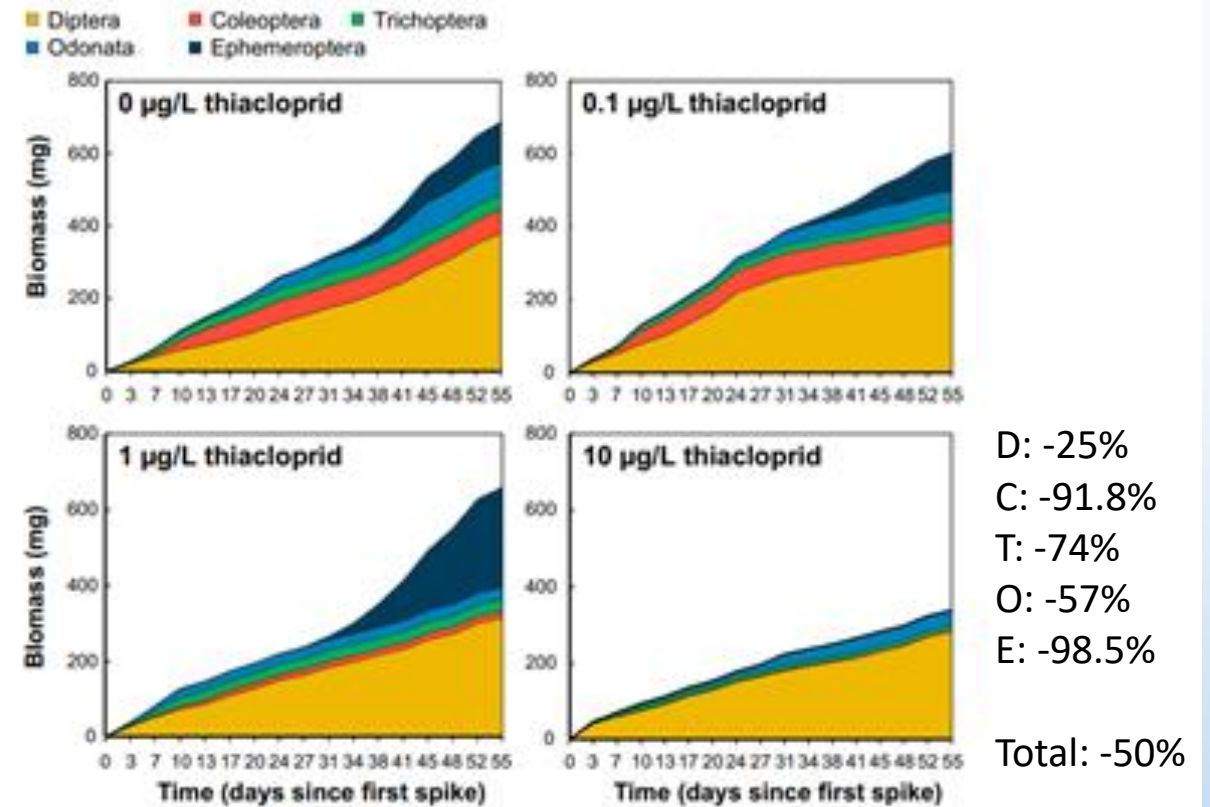


Fig. 3. Thiadiprid-induced changes in average insect biomass of the different taxonomic orders over time per nominal spike concentration of neonicotinoid. The neonicotinoid thiadiprid was applied at  $t = 0$  and  $t = 15$  d.

D:flies/mosquitos, O:dragon/damselflies,  
C:beetles, E:mayflies, T:caddisflies

EPA ALB for thiadiprid: Acute = 18.9 µg/L, Chronic = 0.97 µg/L

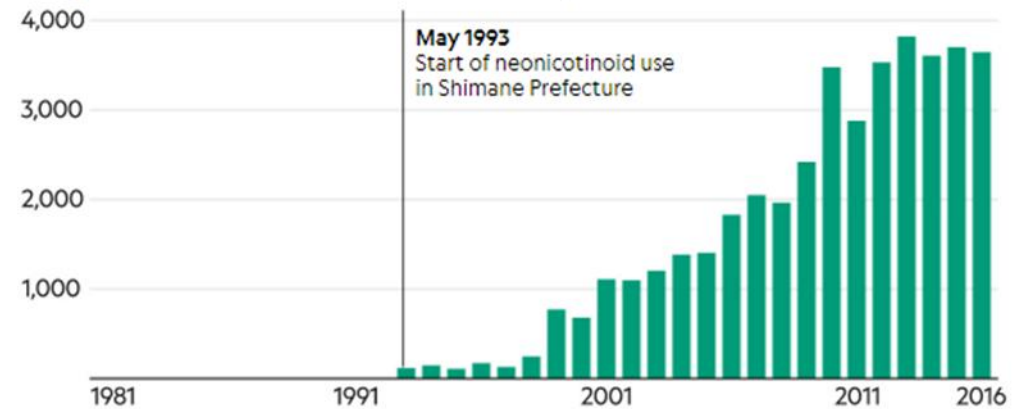
# Neonicotinoids disrupt aquatic food webs and decrease fishery yields

- Neonicotinoid application to watersheds since 1993 coincided with an 83% decrease in average zooplankton biomass in spring, causing the smelt and eel harvest to collapsed
- “The strong conclusions made in the publication are clearly not supported, since it is well known that aquatic environments are dynamic systems that may be influenced by many physical and chemical variables.”

Spokesperson for Bayer Crop Science

In 1993, farmers in Shimane Prefecture, Japan began using neonicotinoids in their rice paddies and agricultural fields.

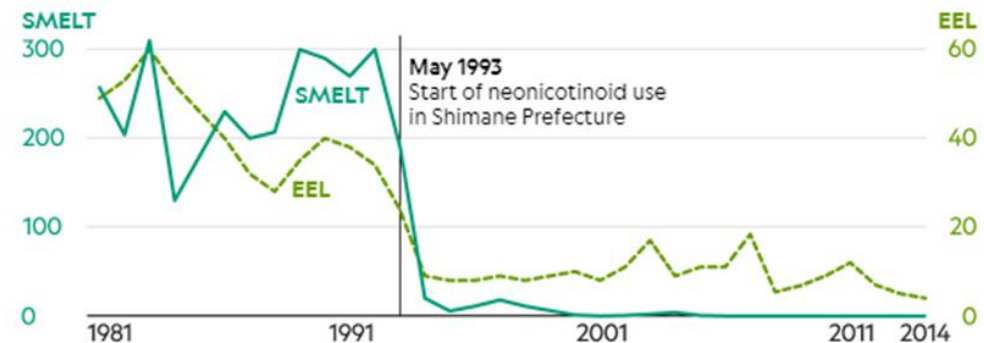
Kilograms of neonicotinoids sold annually in Shimane Prefecture



45 tons

Populations of commercial smelt and eel in Lake Shinji, which were reliant on zooplankton and benthos as a source of food, began to collapse.

Tons of smelt and eel, caught annually in Lake Shinji





## EPA Confirms Three Widely Used Neonicotinoid Pesticides Likely Harm Vast Majority of Endangered Plants, Animals (2022)

- 67% of all endangered species — 1,225 different plants and animal species — are likely to be adversely affected by clothianidin.
- 79% of all endangered species — 1,445 different plants and animal species -- are likely adversely affected by imidacloprid.
- 77% of all endangered species — 1,396 different plants and animal species -- are likely adversely affected by thiamethoxam.

# Exposure to Neonicotinoid Insecticides in the U.S. General Population: Data from the 2015–2016 National Health and Nutrition Examination Survey

Ospina et al., Environ. Res. 2019 176: 108555

- Because neonicotinoids are taken up by the plant and transported throughout it they cannot be washed off easily from food and have been detected in honey, fruits, vegetables, cereals, grape berries, grape leaves, and tea leaves.
- In 2015–2016, acetamiprid was detected in more than 20% of nectarines, 60% of cherries and apple sauce, and in about 30% of apples and strawberries
- From 29 samples of fruits and vegetables, neonicotinoids were detected in 72% of the fruits and 45% of the vegetables (Boruah et al., *Water* 2020, 12, 3388; doi:10.3390/w12123388)
- 49.1% of the U.S. general population 3 years of age and older had been recently exposed to neonicotinoids.

# Neonicotinoid Insecticides in New York State

economic benefits and risk to pollinators

Travis A. Grout, Phoebe A. Koenig, Julie K. Kapuvvari  
& Scott H. McArt



- Cornell University Study took 2.5 years to complete
- Published in 2020
- Conducted 5,000 paired field trials
- Analyzed 400 peer-reviewed studies
- Collected into a 432 page document
- Funding provided by the Environmental Protection Fund

“The economic benefits to [corn and soybean] farmers are very fleeting and very small, if they exist at all. That’s the most important conclusion of the entire report. Probably less than 10 percent of farmers are actually getting economic benefits from using these seed treatments.”

Interview of Scott McArt by Ambrook Research



# Environmental Impact of Neonicotinoids on Our Lakes—A Story About the Birds and Bees

Thank You!

Douglas Merrill: [douglas.merrill@rit.edu](mailto:douglas.merrill@rit.edu)

