

# Overview of Neonicotinoid Insecticides and Risks They Pose to the Environment

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“The streams of the Midwest have undoubtedly changed much in character since the country has become so thickly settled. I have been informed that many streams, formerly deep and narrow, and abounding in pickerel, bass, and catfishes, have grown wide and shallow, while the water in them varies greatly in different seasons, and they are inhabited by bullheads, suckers, and a few minnows.”

Seth Meek 1892



Where have all the insects gone?





A photograph of a river with sunlight reflecting off the water, creating a shimmering effect. The water is dark, and the reflections are bright and scattered across the surface. The background shows a dark, wooded area.

# Overview:

- Problem of Insect Population Declines
- Neonic Uses and Risks
- Occurrence in Wisconsin's Rivers and Streams

# Overview:

- What's the problem?



# The Problem:

RESEARCH ARTICLE

## More than 75 percent decline over 27 years in total flying insect biomass in protected areas

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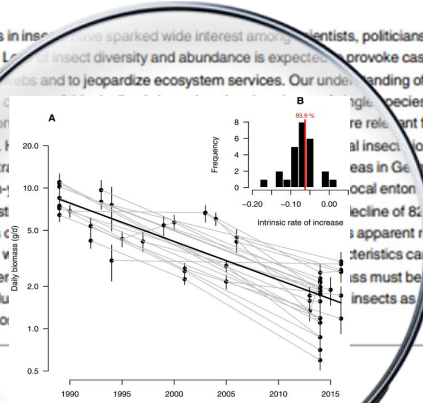


### Abstract

Global declines in insect diversity and abundance have sparked wide interest among scientists, politicians, and the general public. Loss of insect diversity and abundance is expected to provoke cascading effects on food webs and to jeopardize ecosystem services. Our understanding of the extent and underlying mechanisms of insect decline is limited. Here, we report on a 27-year study of total flying insect biomass in protected areas in Germany (96 local entomological monitoring stations). Our analysis estimates a 76% decline in total flying insect biomass over the period 1990–2017. This decline is consistent across habitat type, vegetation type, and elevation. The decline is most pronounced in the most protected areas, and is most pronounced in the most protected areas. The decline is most pronounced in the most protected areas.

### Introduction

Loss of insects is certainly to have adverse effects on ecosystem functioning. Insects play a central role in a variety of processes including pollination [1, 2], herbivory [3, 4], nutrient cycling [4] and providing a food source for higher trophic levels such as birds, mammals and amphibians. For example, 80% of wild plants are estimated to depend on insects for pollination [2], while 60% of birds rely on insects as a food source [5]. The economic value provided by wild insects has been estimated at \$57 billion annually in the US [6]. Preserving insect abundance and diversity should constitute a prime conservation goal. Current data suggest an overall pattern of decline in insect diversity and abundance. For example, populations of European grassland butterflies are estimated to have declined in abundance between 1990 and 2011 [7]. Data for other well-studied taxa such as bees



GLOBAL INSECT POPULATIONS ARE IN DECLINE! ...AND THEY ARE REALLY IMPORTANT FOR THE HEALTH OF OUR PLANET!!

### OPEN ACCESS

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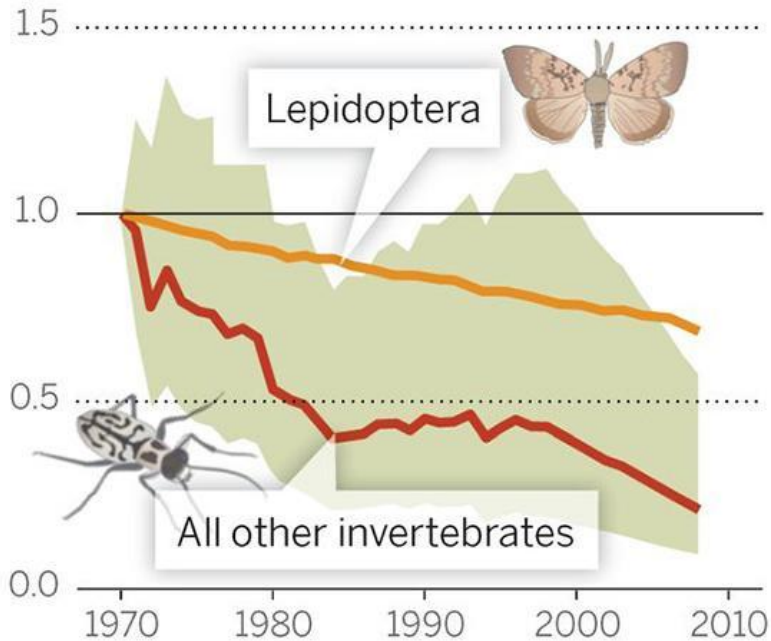
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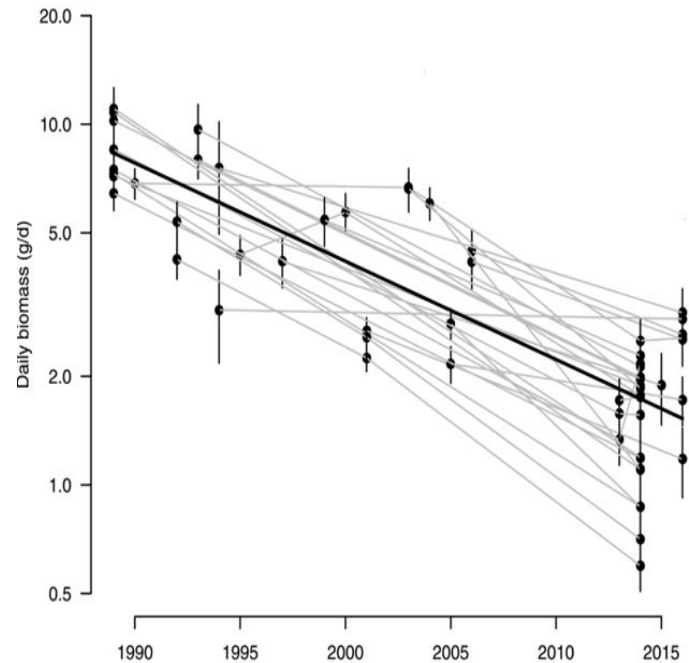
**Data Availability Statement:** All relevant data are within the paper and its Supporting Information files.

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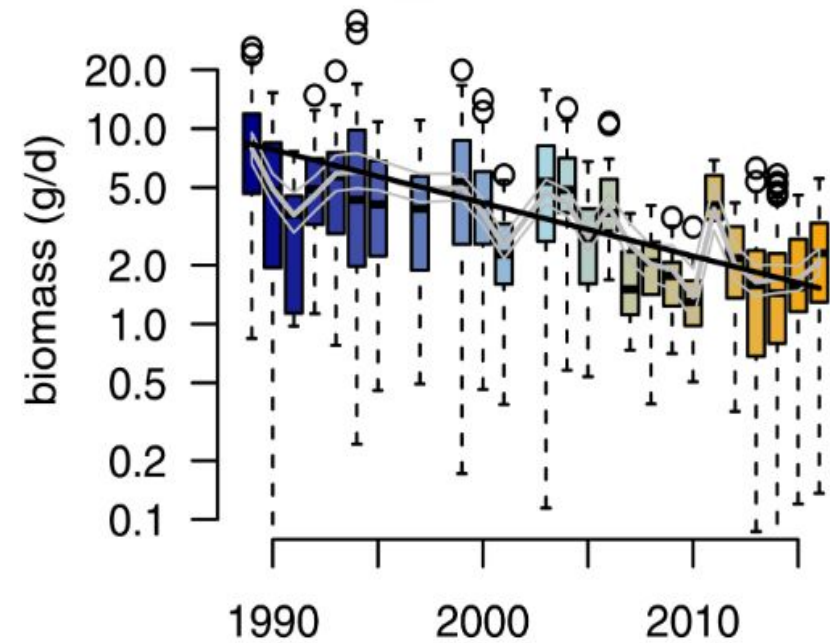
# Insect Population Trends



45% decline in invert populations past 40 years (452 species).  
*Dirzo 2014*



5% annual decline in flying insect biomass in Germany.  
*Hallman et al. 2017*



Summarization of multiple global studies.  
*Sanchez-Bayo and Wyckhuys 2019*



# Loss of Insect Numbers and Diversity

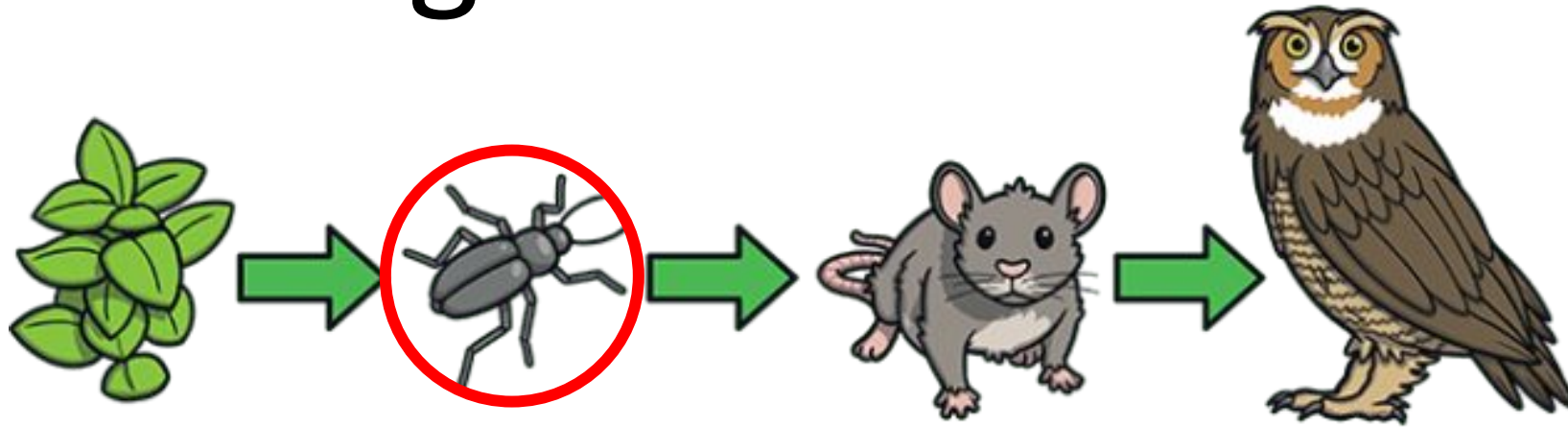
Light trapped Insects Time Series, Costa Rica 2007, 2019



Janzen and Hallwachs. 2021. PNAS



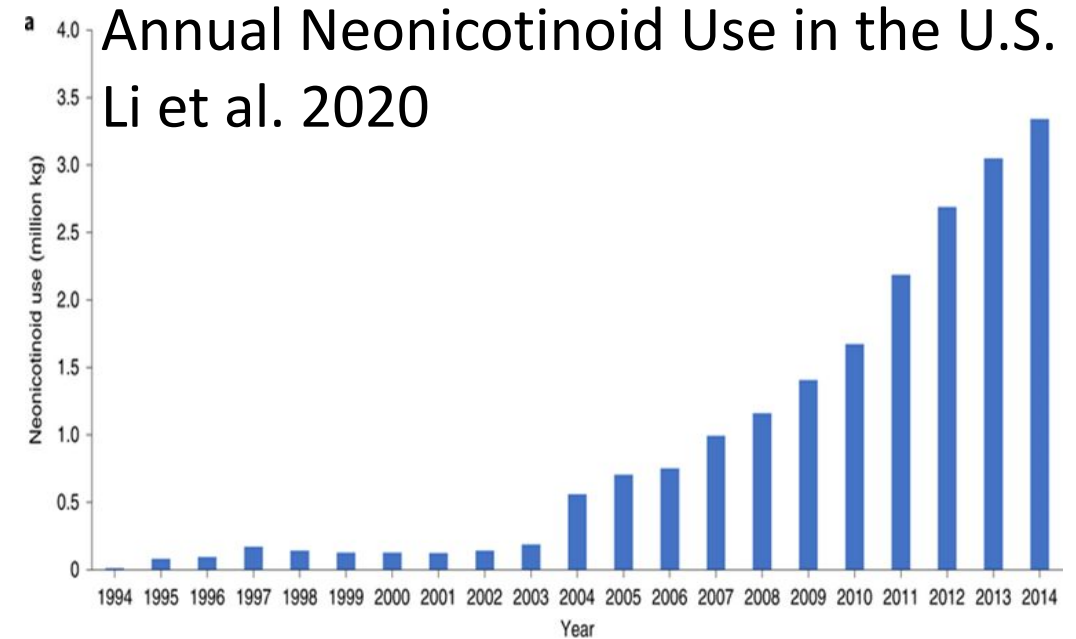
# Insect Ecological Services:



- **Primary consumers**
- Pollinators
- Seed dispersers
- Population control agents
- Janitors: breakdown and disperse dead plant and animal tissue
- Amend soil
- The list goes on...



# Why The



WHY!? Because of:

- HABITAT LOSS,
- CLIMATE CHANGE,
- INDISCRIMINATE USE OF INSECTICIDES.



# Neonics Overview:

- What are they?
- Uses
- Risks



Neonicotinoid insecticides: synthetic versions of nicotine compounds produced by plants (e.g. tobacco, tomatoes, potatoes) to kill insect pests.



Aphids feeding



# Neurotoxins: disrupt nervous system communication to and from nerves, muscles, and organs

- Bind permanently to neural receptors, exposure is additive,
- Various neonic compounds have similar modes of action
- More toxic to insects than vertebrates



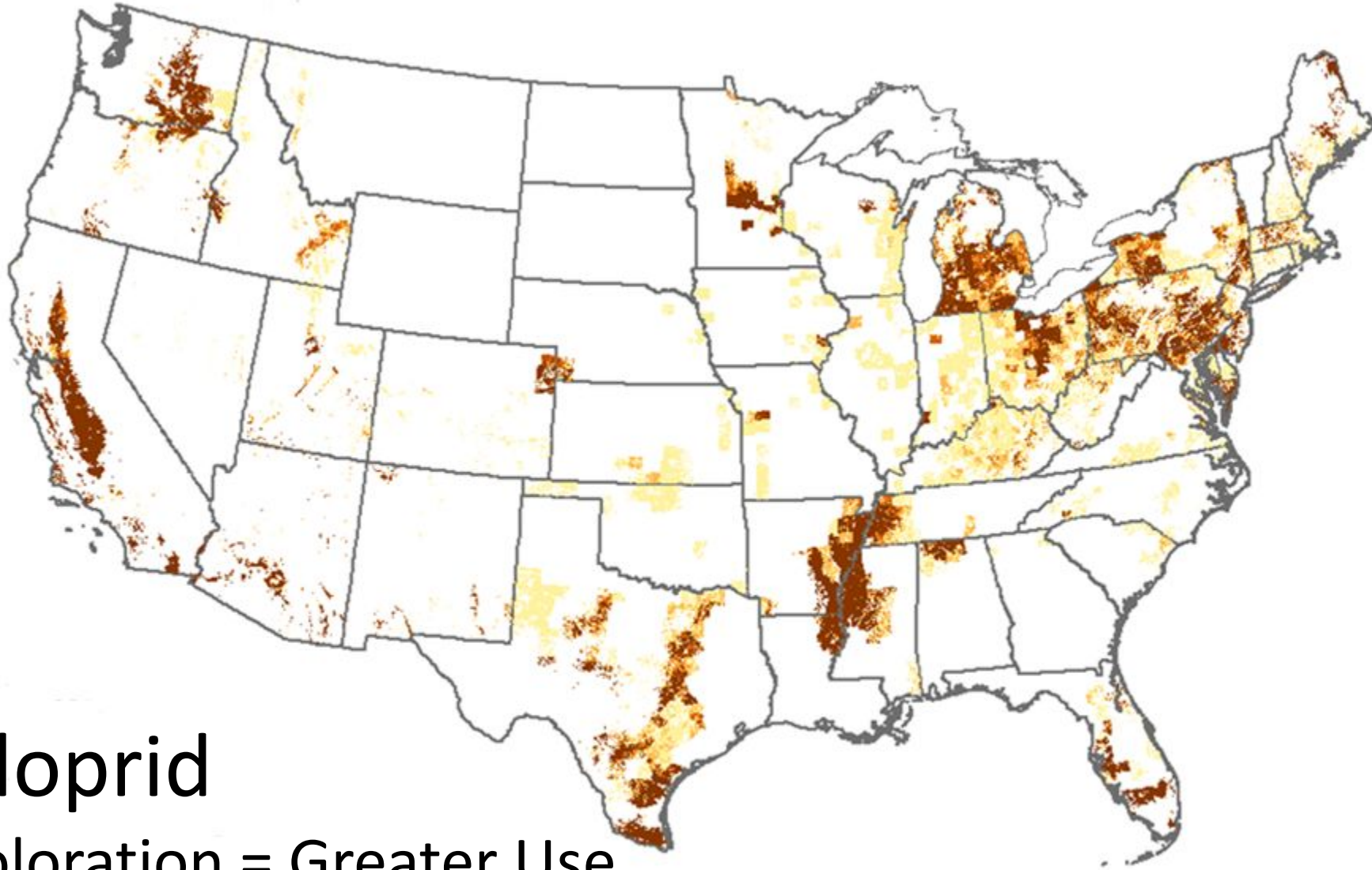


Neonicotinoids are the most widely used insecticides in WI, U.S., and globally.

Primary Applications:

- **Seed dressing** (~ 90% of use in Midwest)
- Foliar sprays
- Granulated
- Root drenches
- Baits
- Topical

# Neonic Use Time Series 1995 - 2015



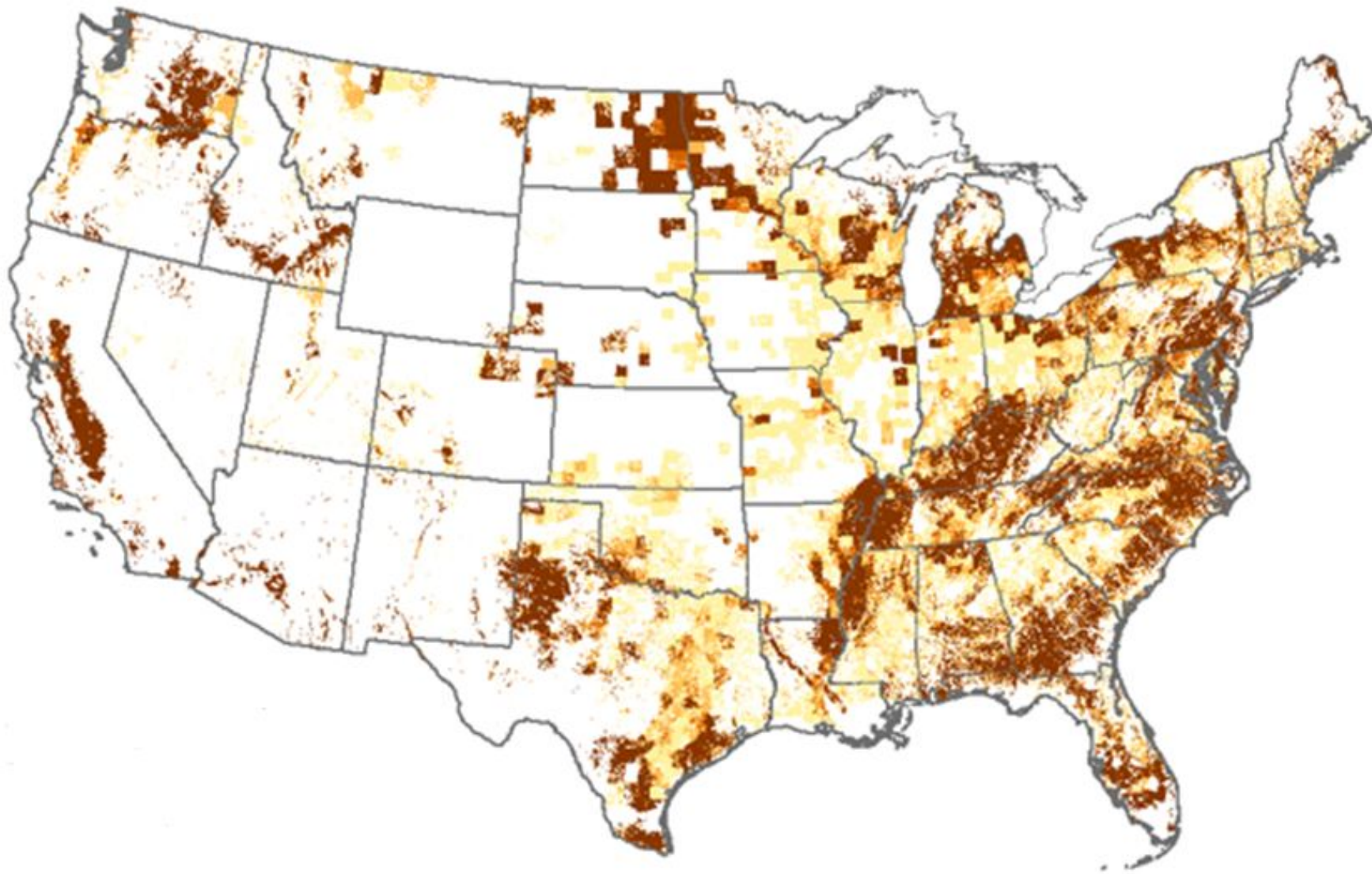
Imidacloprid

Darker Coloration = Greater Use

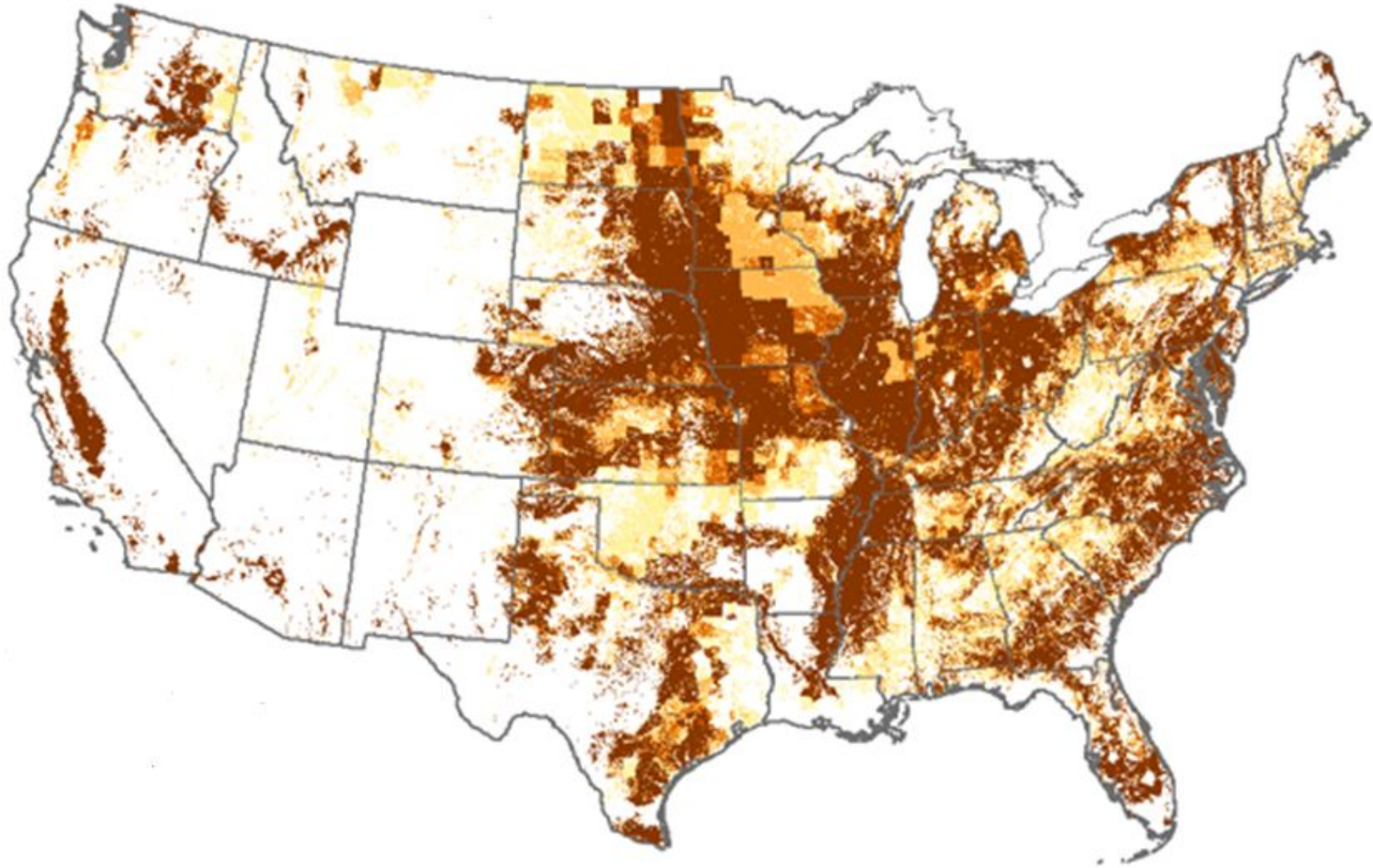
1995



2000

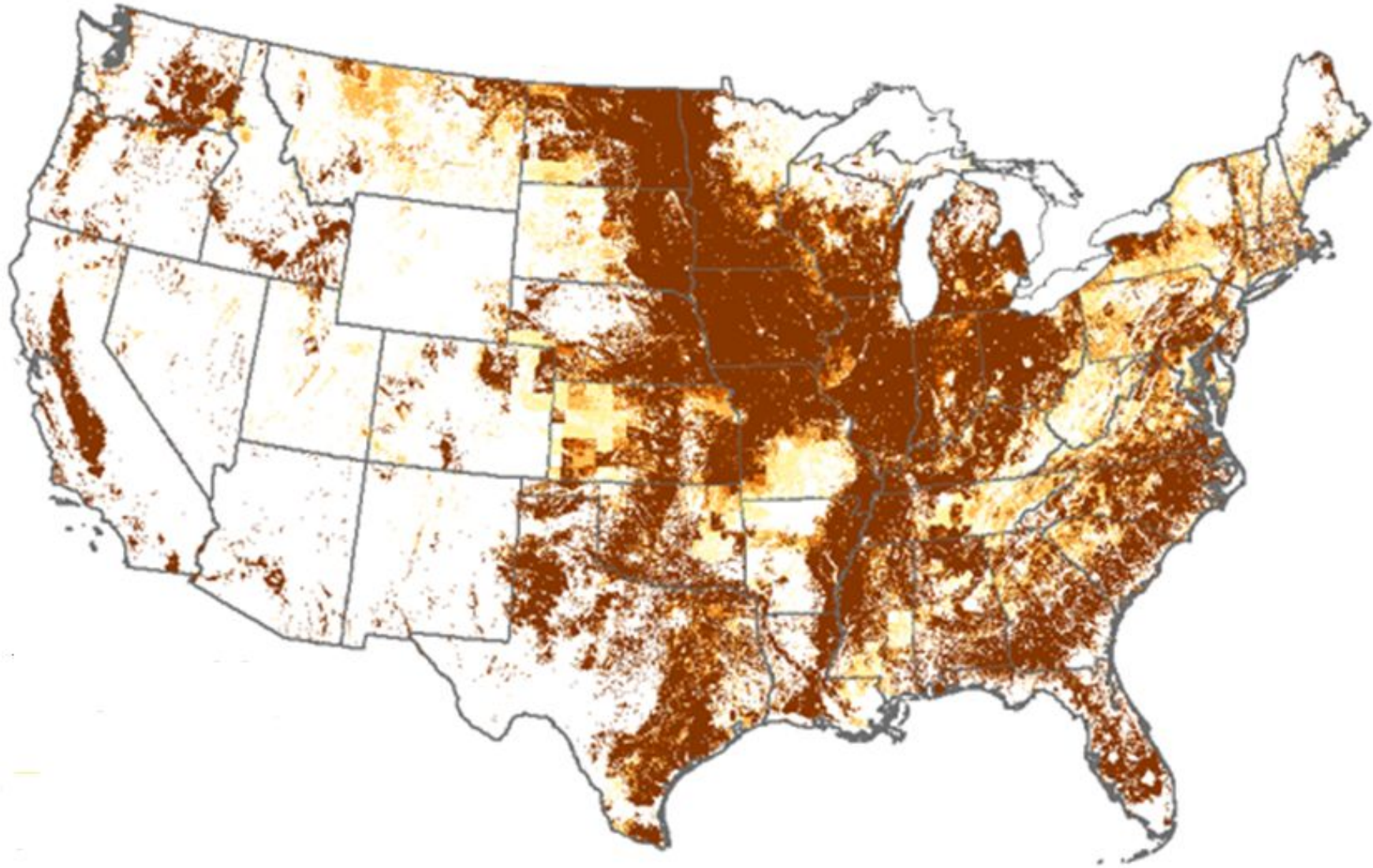


2005

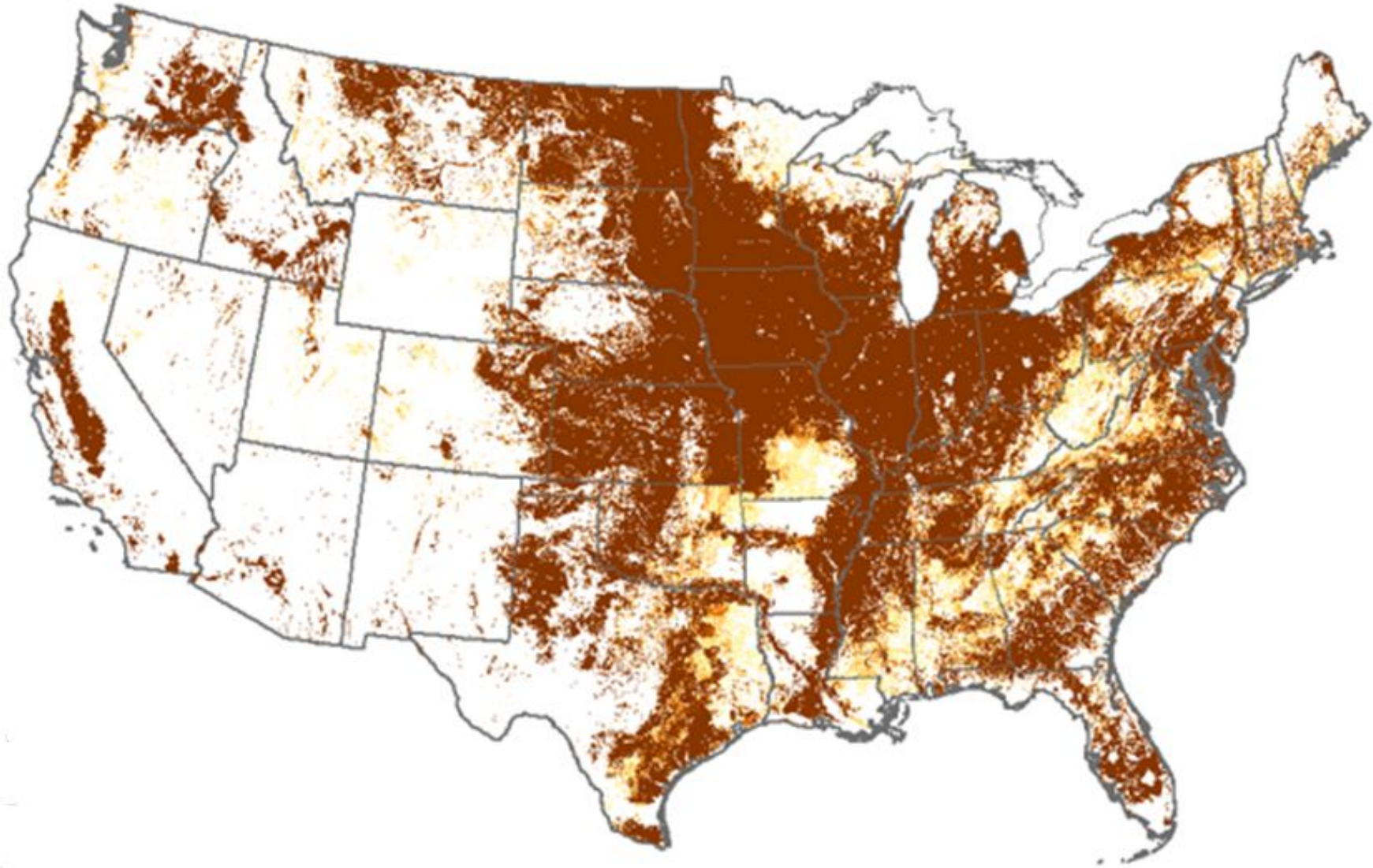




2010



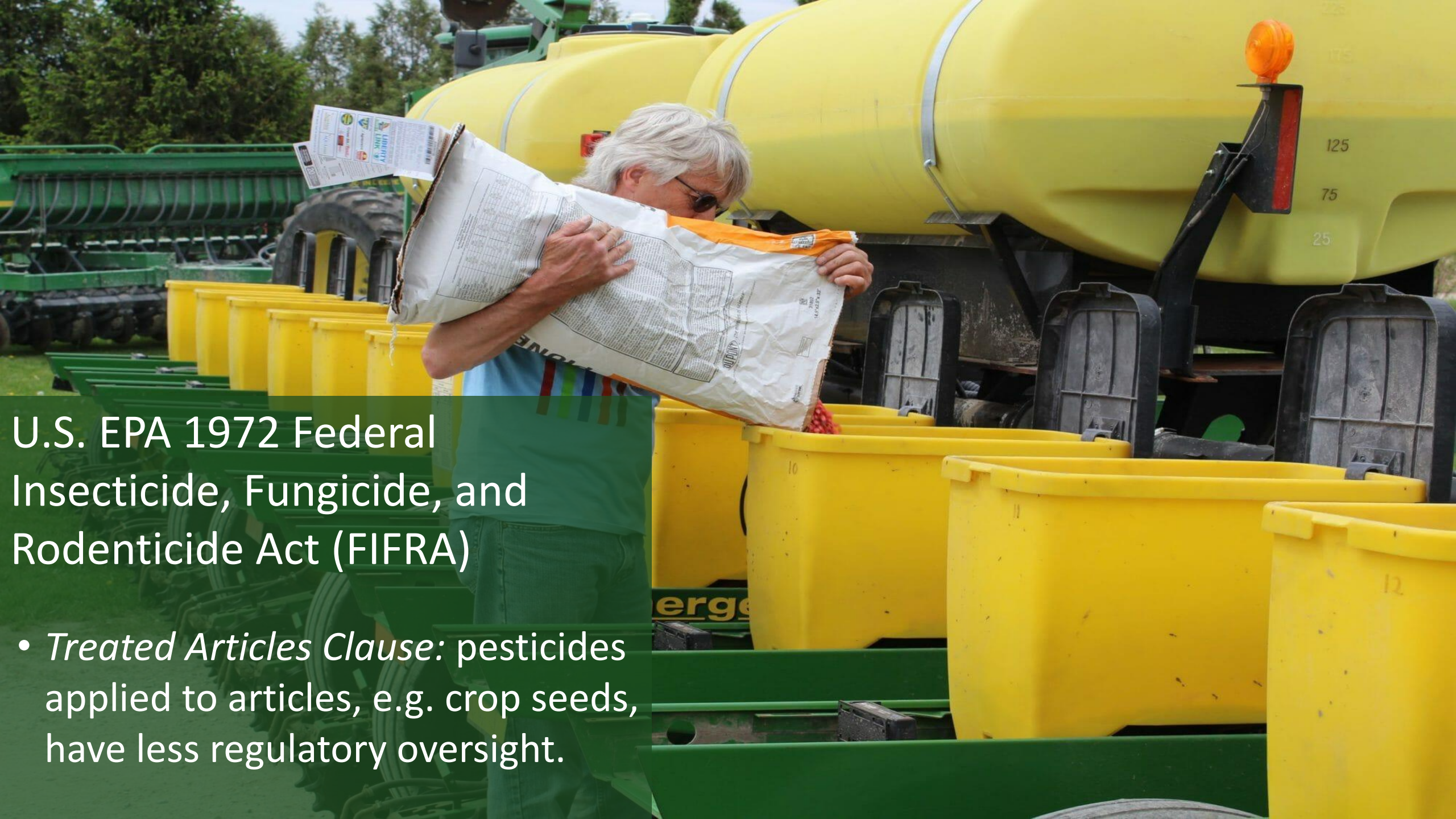
2015







Post – 2015



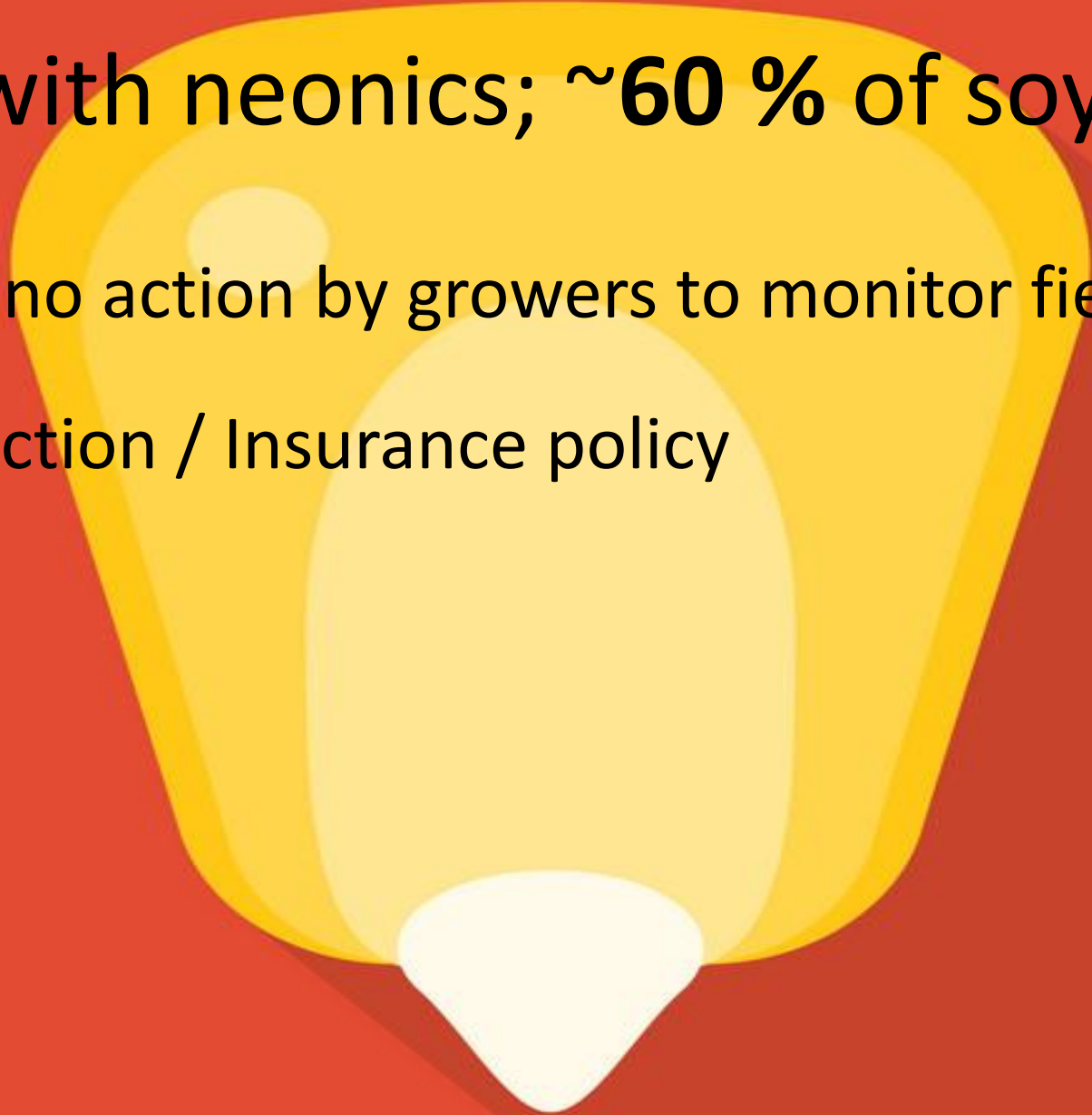
## U.S. EPA 1972 Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA)

- *Treated Articles Clause*: pesticides applied to articles, e.g. crop seeds, have less regulatory oversight.



Nearly **100%** of all field corn seed sold in U.S. dressed with neonics; ~**60 %** of soybeans

- Requires no action by growers to monitor fields for pests
- Risk reduction / Insurance policy



# Prophylactic use of pesticides has led to the abandonment of long-held principles of **Integrated Pest Management**:

- Rotate crops
- Monitor for pests
- Treat only when necessary
- Avoid broad-spectrum pesticides
- Avoid persistent chemicals





# What's on Your Seed?

- 143 different seed treatment products<sup>1</sup>
- 40 different unique active ingredients<sup>1</sup>
- 35% of corn growers couldn't name the treatment products on their seeds<sup>2</sup>
  - Insecticides
  - Fungicides
  - Nematocides
  - Plant growth regulators

<sup>1</sup> <https://ipcm.wisc.edu>

<sup>2</sup> C. Hitja. 2020. Bioscience



# Neonic Properties:

- Water soluble
- Mobile in environment
- Long - lived (7 – 6000 day  $\frac{1}{2}$  lives)
- > 90% washes off crop seeds and not taken up by the crop plants





Overview:

Environmental Risk



A sugar granule's weight of neonics,  
enough to kill 125,000 honeybees.



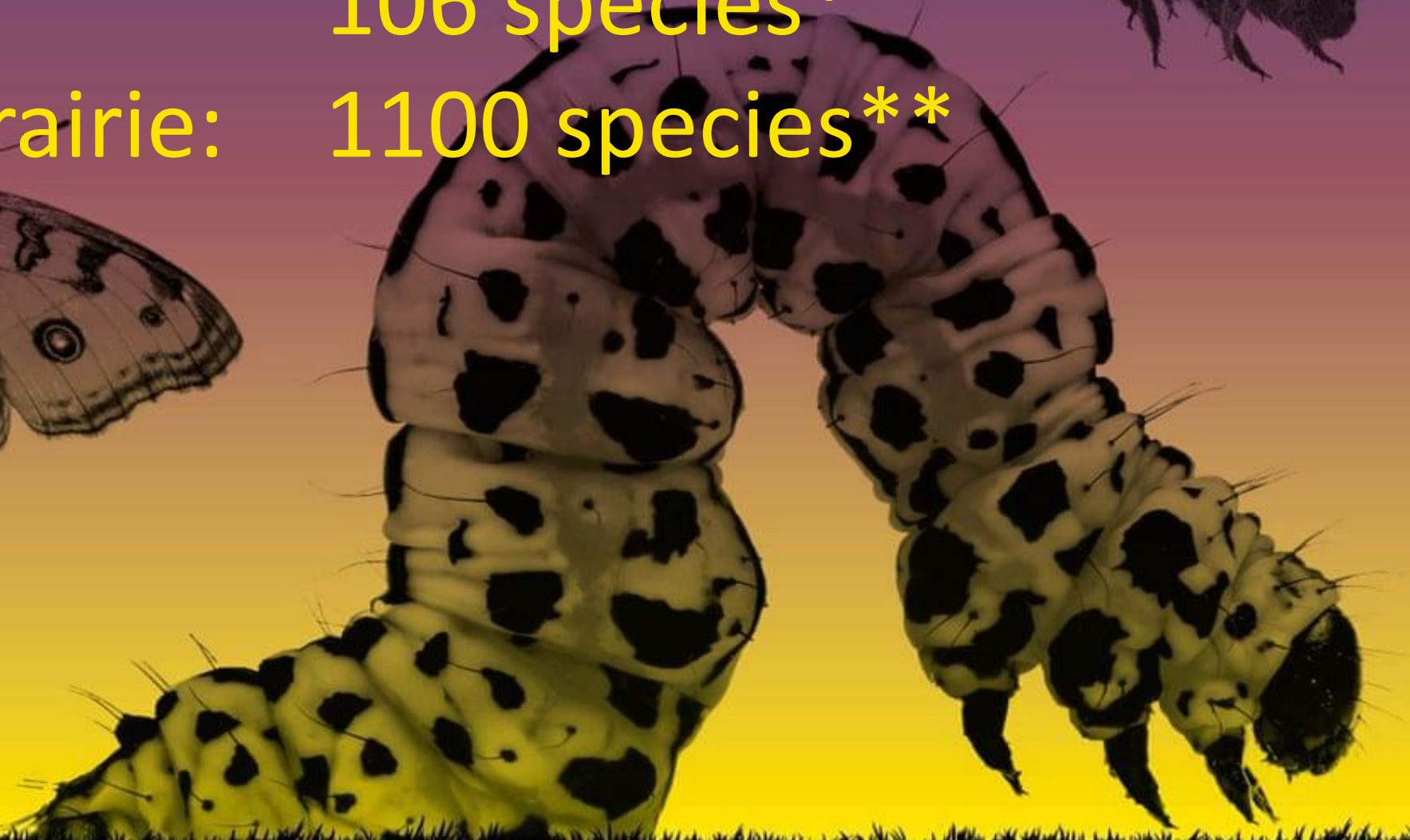


- Sugar packet: ~ 3 – 4 grams
- 3 grams of neonics enough to kill 600,000,000 honeybees
- Number of tons of neonics applied annually in Wisconsin?

# Insect Diversity

Cornfield: 106 species\*

Tallgrass Prairie: 1100 species\*\*

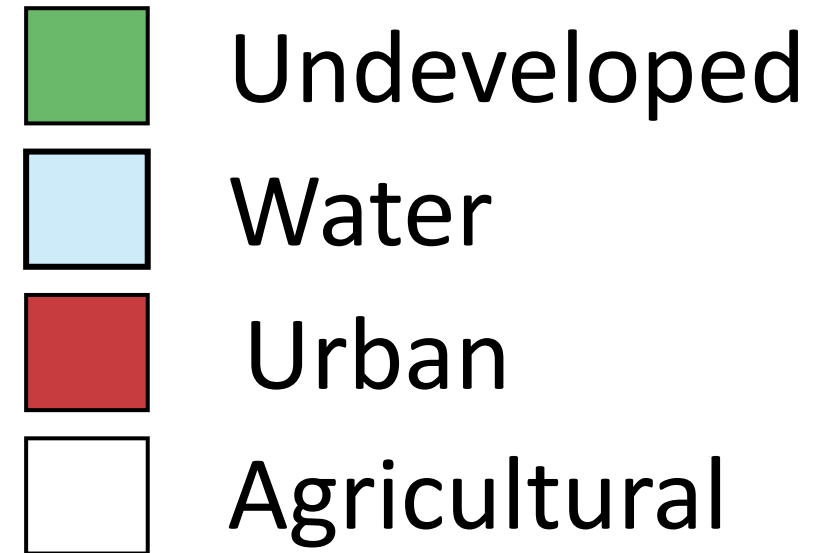
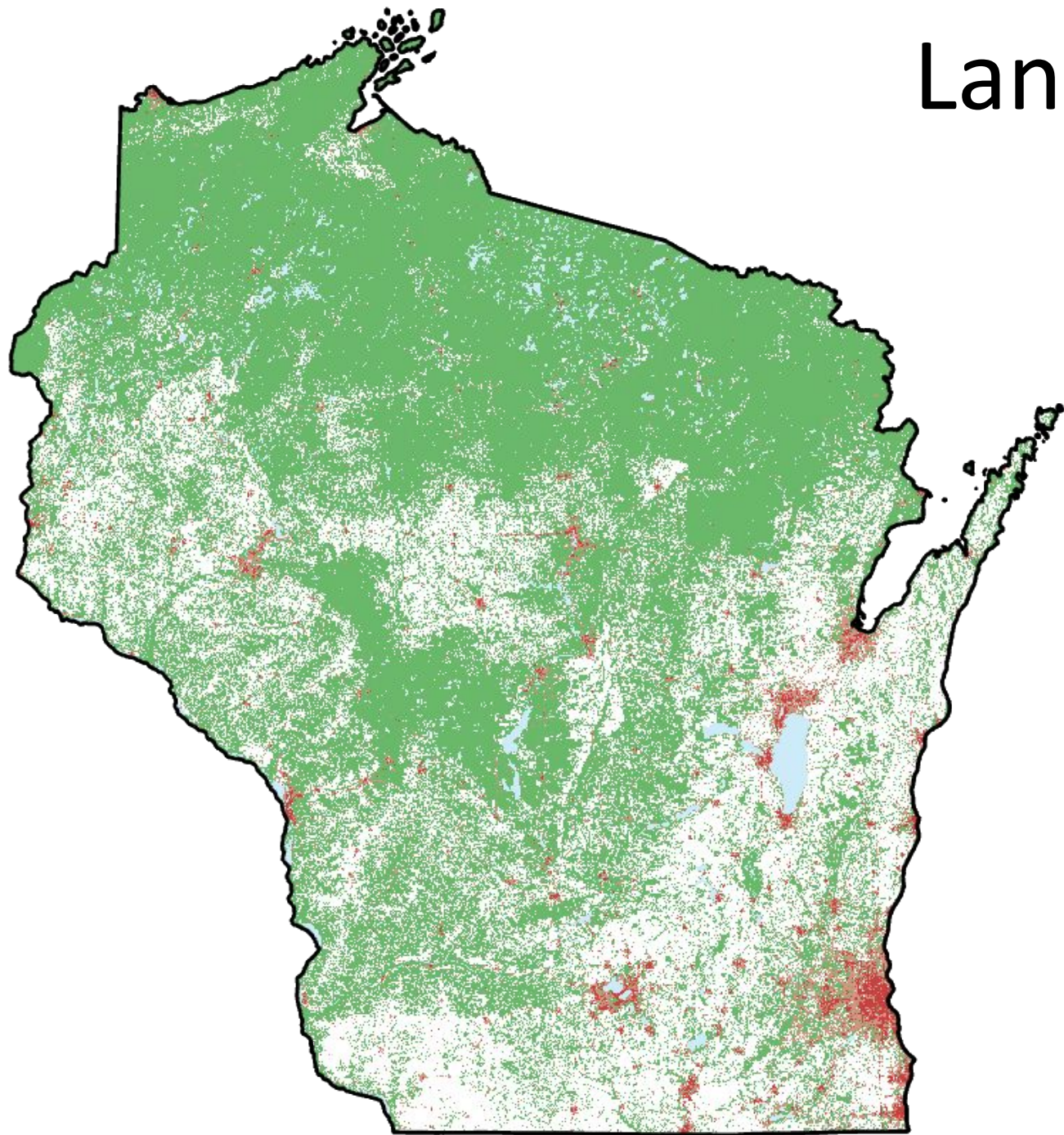


\*Lundgren and Fergen. 2014

\*\* U of MN, LTER



# Land Cover / Land Use



40% of WI land area  
is agricultural





RA 0906  
STEREO

*"Hey farmer, farmer,  
put away the DDT now,  
give me spots on my apples  
but leave me the birds and  
bees please"*

Neonics 7,000 – 10,000 times  
more toxic to insects than DDT

*"Don't it always seem to go,  
that you don't know what  
you've got till it's gone"*

1.2 million animal species  
described, 1 million are insects,  
likely around 8 million animals  
species actually exist





Earth's last western black rhino, RIP 2011



*“It’s a common misconception that vertebrates are the movers and shakers of the natural world. In most ecosystems, invertebrates are by far the most dominant animals sometimes comprising more than 90% of the animal biomass.”*

*E. O. Wilson*



Net-Spinning Caddisfly  
Family: Hydropsychidae





Dr. Gary Hevel  
Smithsonian Institution







To a child's eye, a firefly  
outshines the brightest star.





Wisconsin corn and soybean producers spend between \$20,000,000 and \$60,000,000 on seed-applied neonics each year

CHEMCHINA |

中国化工集团公司

China National Chemical Corporation

syngenta

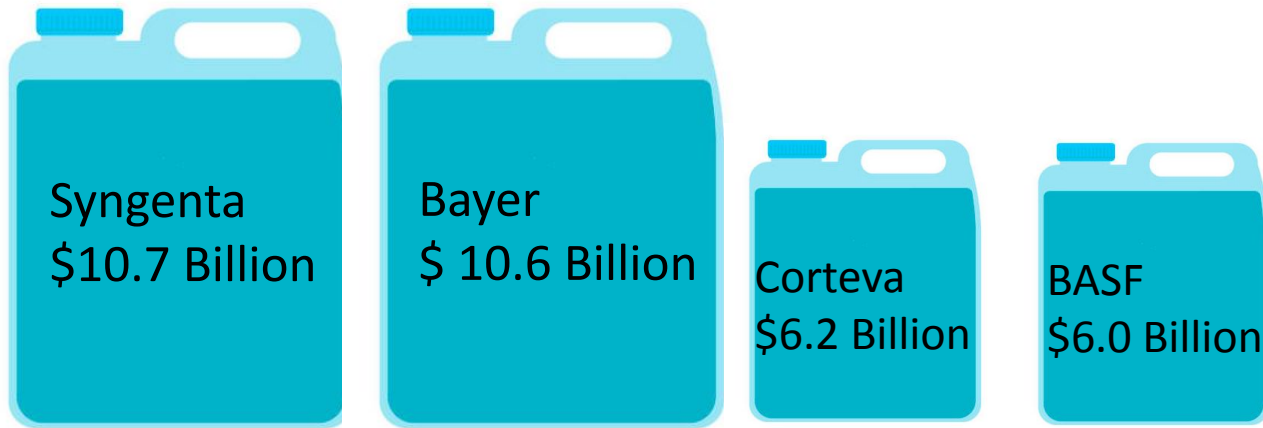


Bayer CropScience

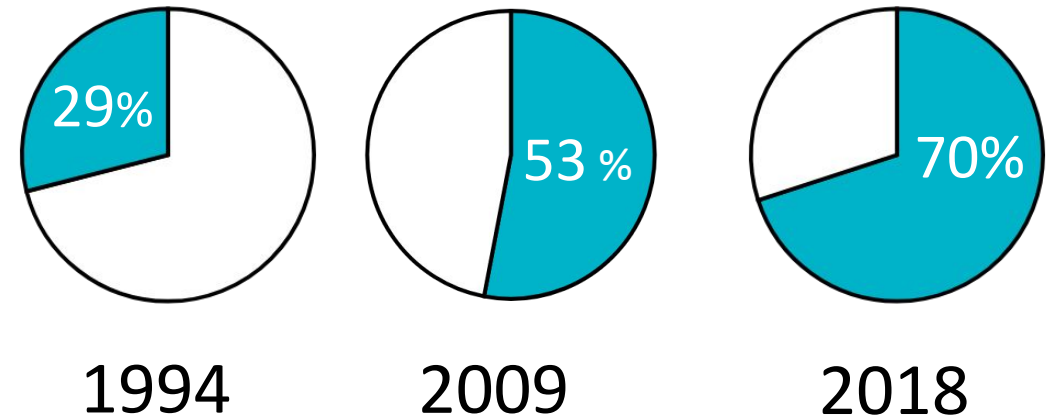
# EVER GROWING MARKET SHARE

The pesticide divisions' revenues of the four largest companies

## Annual Revenues



## Their Market Share





# 34,757\*

Number of Certified Pesticide Applicators in Wisconsin



# 5

Number of Agency Staff Assessing Pesticides in Wisconsin Waters




\*

DATCP

# Overview:

- Occurrence in Wisconsin Streams and Rivers

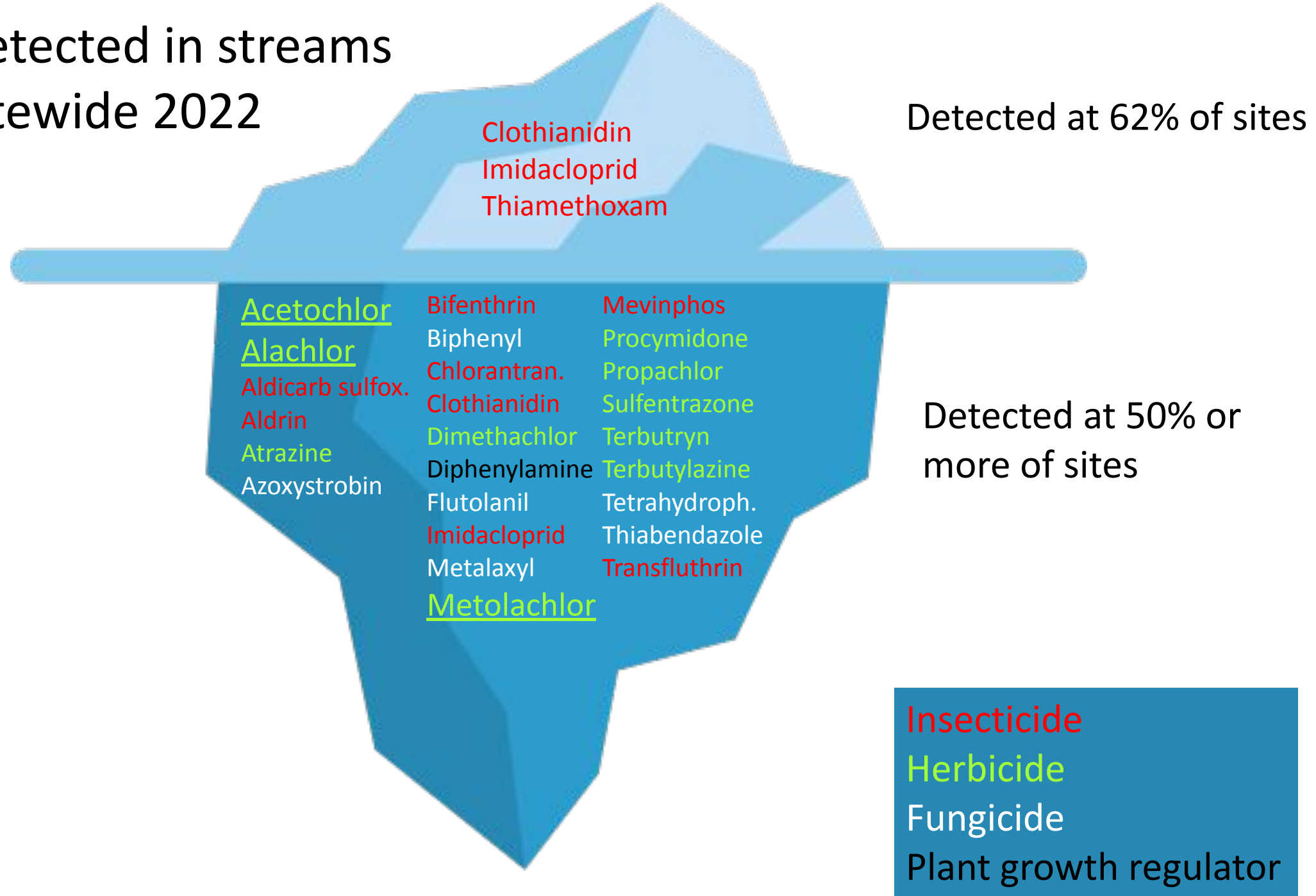




# 2022 DNR Stream and River Pesticide Survey

- 135 different pesticides detected statewide
- Herbicides, insecticides, fungicides
- 9 – 91 compounds detected per site
- Average of 28 compounds per site
- Neonics detected at 62% of sites

# Pesticides detected in streams sampled statewide 2022





Earth Circumference  
25,000 mi.

WI Stream Length  
42,000 mi.



WI Stream and River Neonic Occurrence Estimates

- 7% (2,940 mi.) with acute concentrations
- 17% (7,140 mi.) with chronic concentrations

# Review of Neonicotinoid Insecticides:

- Neonics most widely used insecticides
- Widespread prophylactic use
- Accumulate in soil, mobilize in water
- Acute and chronic concentrations in WI streams and rivers



"Never doubt that a small group of thoughtful committed individuals can change the world. In fact, it is the only thing that ever has."

- Margret Mead





A photograph of a river with sunlight reflecting off the water, creating a shimmering effect. The text is overlaid on a semi-transparent dark rectangle in the center of the image.

Thanks for your attention!  
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