# Occurrence and potential biological effects of pesticides in tributaries of the Great Lakes

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USGS science for a changing world

Great Lakes RESTORATION

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Environmental Toxicology


# Prioritizing Pesticides of Potential Concern and Identifying Potential Mixture Effects in Great Lakes Tributaries Using Passive Samplers

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Thanks to the many coauthors who contributed to this body of work!

All results presented today can be found in Oliver et al. 2022 or Loken et al. 2022

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Environmental Toxicology

# Pesticide Prioritization by Potential Biological Effects in Tributaries of the Laurentian Great Lakes

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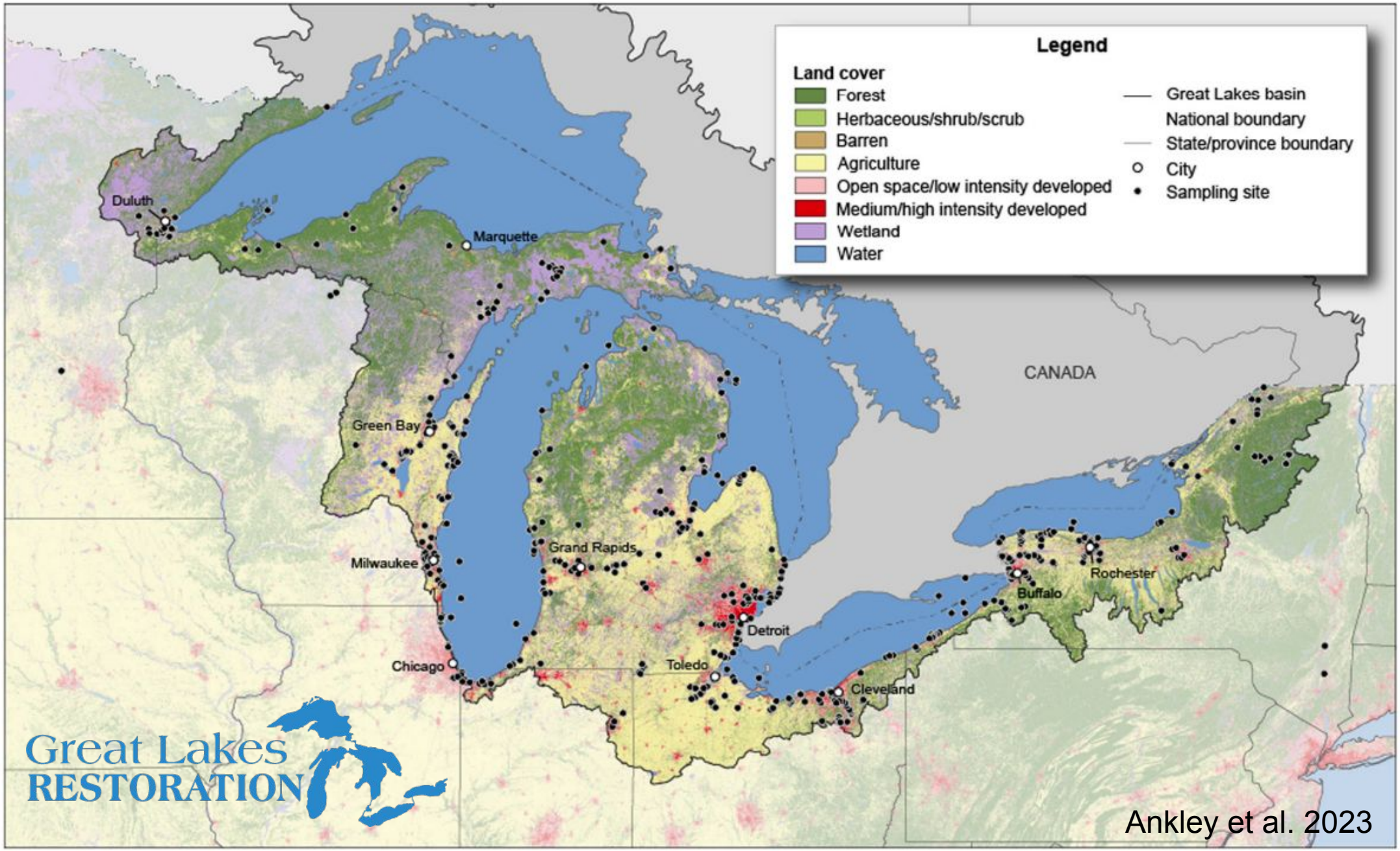



**FIGURE 1:** Map of sampling locations for the Great Lakes Restoration Initiative—Contaminants of Emerging Concern collaborative project.

# Background

GLRI Phase I: Identified a few contaminant classes as priorities

- Monitored at 57 Great Lakes tributaries
- 69 compounds → 15 chemical classes
- Priority chemical classes based on concentrations and comparison to water quality benchmarks
    - Pesticides
    - PAHs
    - Pharmaceuticals

GLRI Phase II, Water Year 2016: Pesticides

# What questions did we want to answer about pesticides in the Great Lakes?

What and where:

- What pesticides are present in Great Lakes tributaries? How does land use impact the presence of pesticides in tributaries?

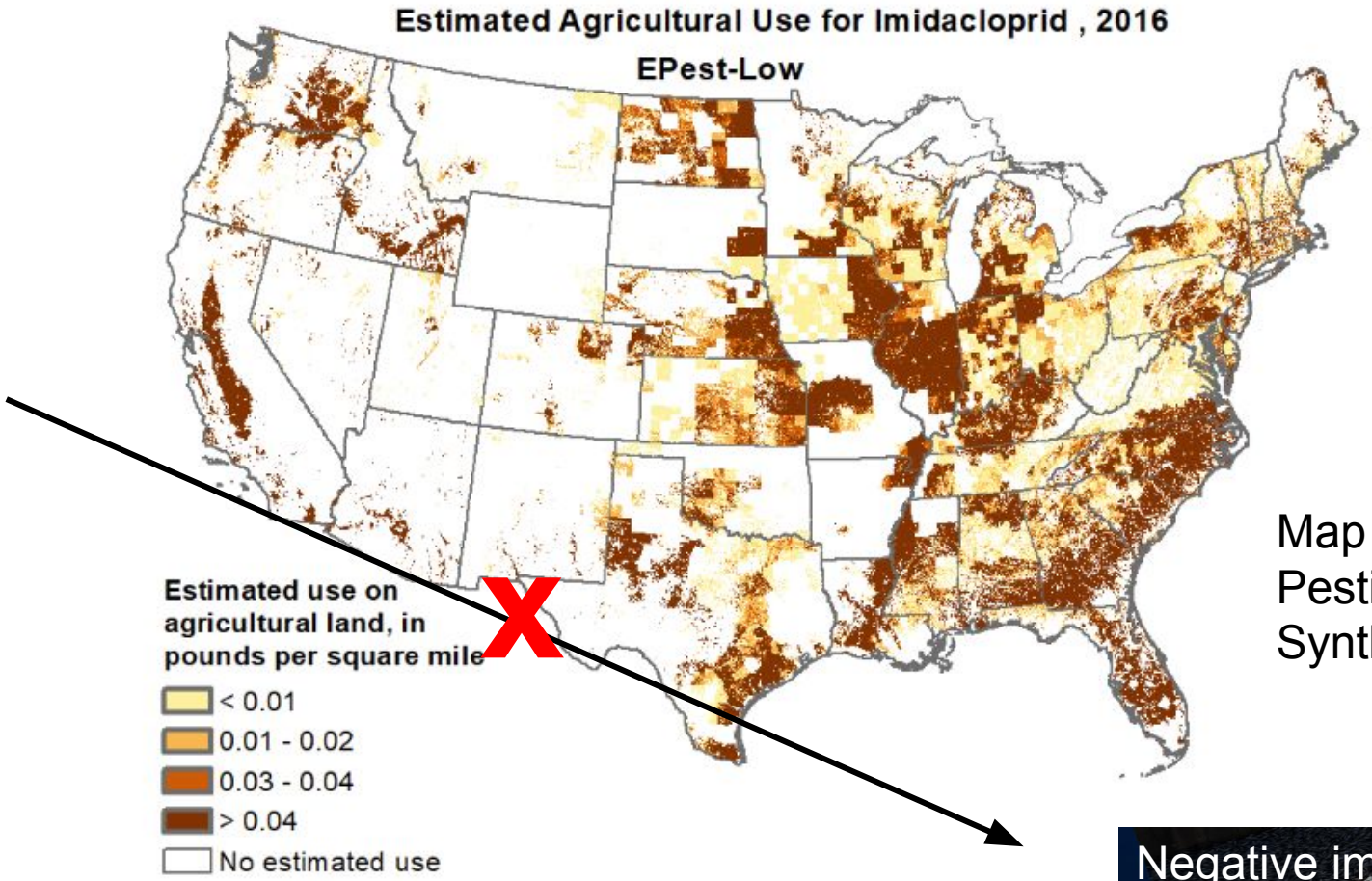
Prioritization:

- Which compounds are the most likely to negatively impact aquatic biota? Which sites should we prioritize for further investigation or management actions?

Seasonality:

- Are pesticides an episodic (growing season) or year-round threat to aquatic biota?


Transformation
Transport


Map from the USGS Pesticide National Synthesis Project

Concentration
Exposure pathways
Toxicity
Mode of action
Multiple stressors
Community structure

# Summary of Data Collected

Pesticides

- 232 compounds: Herbicides, Insecticides, Fungicides
  - Parent compounds and (some) degradates
- 16 Great Lakes tributaries
  - Watershed characteristics: Gradient of agriculture to urban to forest/wetland
- Monthly surface water sampling: October 2015 - September 2016


* All results can be found in Oliver et al. 2022 or Loken et al. 2022


Transformation
Transport



**Concentration relevance**

**ToxCast/Tox21**

Concentration that induced cellular or molecular response to chemicals (*in vitro* assay)

**Aquatic Life Benchmarks**

Concentration that induced organismal response to chemicals (*in vivo* assay)

- Relatively inexpensive & fast (many compounds, many biological endpoints)
- Cannot directly translate to biological impacts

- Relatively expensive & slow (few compounds, few target species)
- Directly related to organism-level impacts

Concentration
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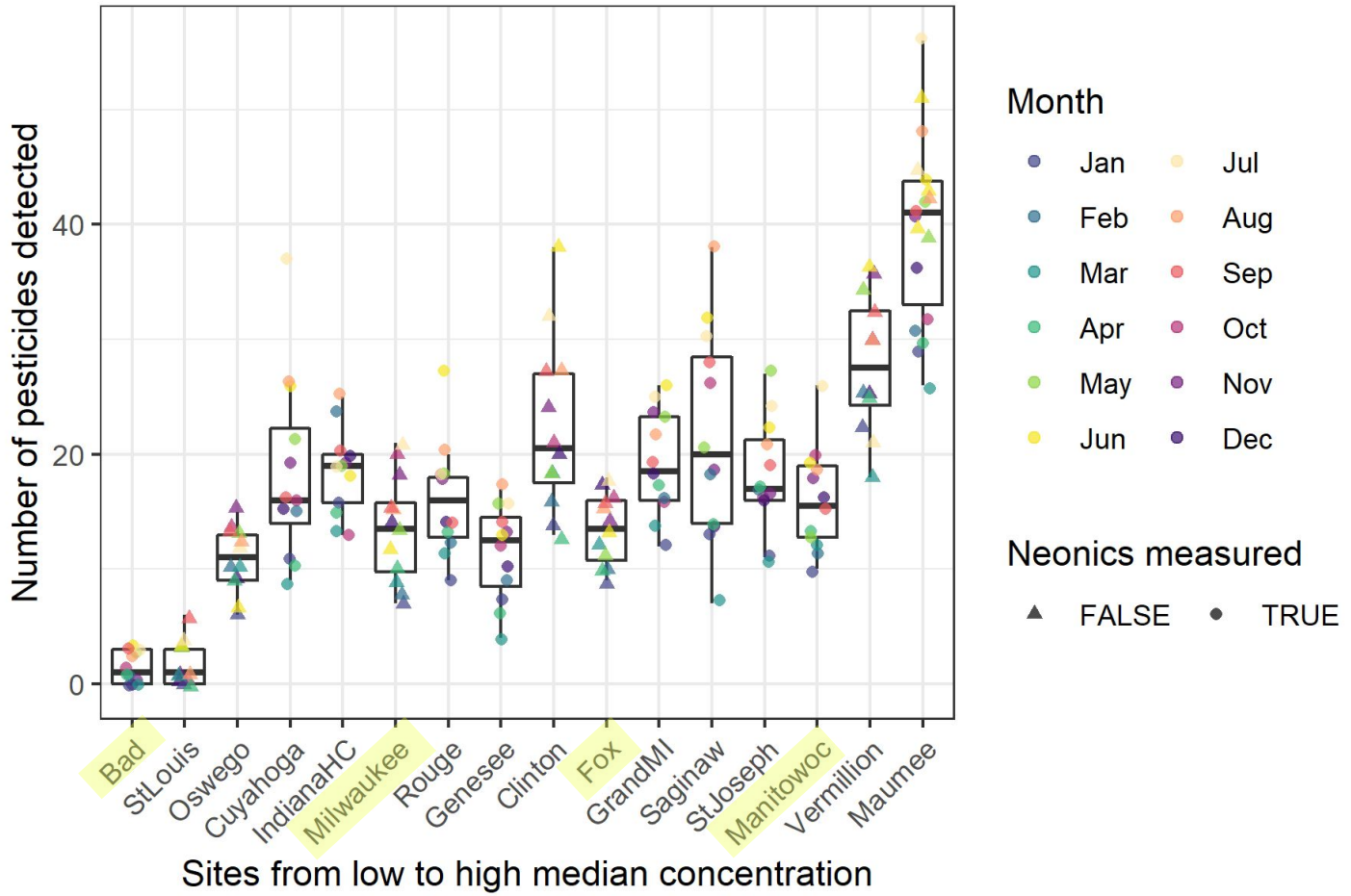
# How prevalent are pesticides in tributaries of the Great Lakes?

- Pesticides were detected in 190/198 (96%) samples
- Pesticides were detected in all 16 tributaries
- Of the 232 compounds measured, 104 were detected
- 80% of samples had 10 or more pesticides detected

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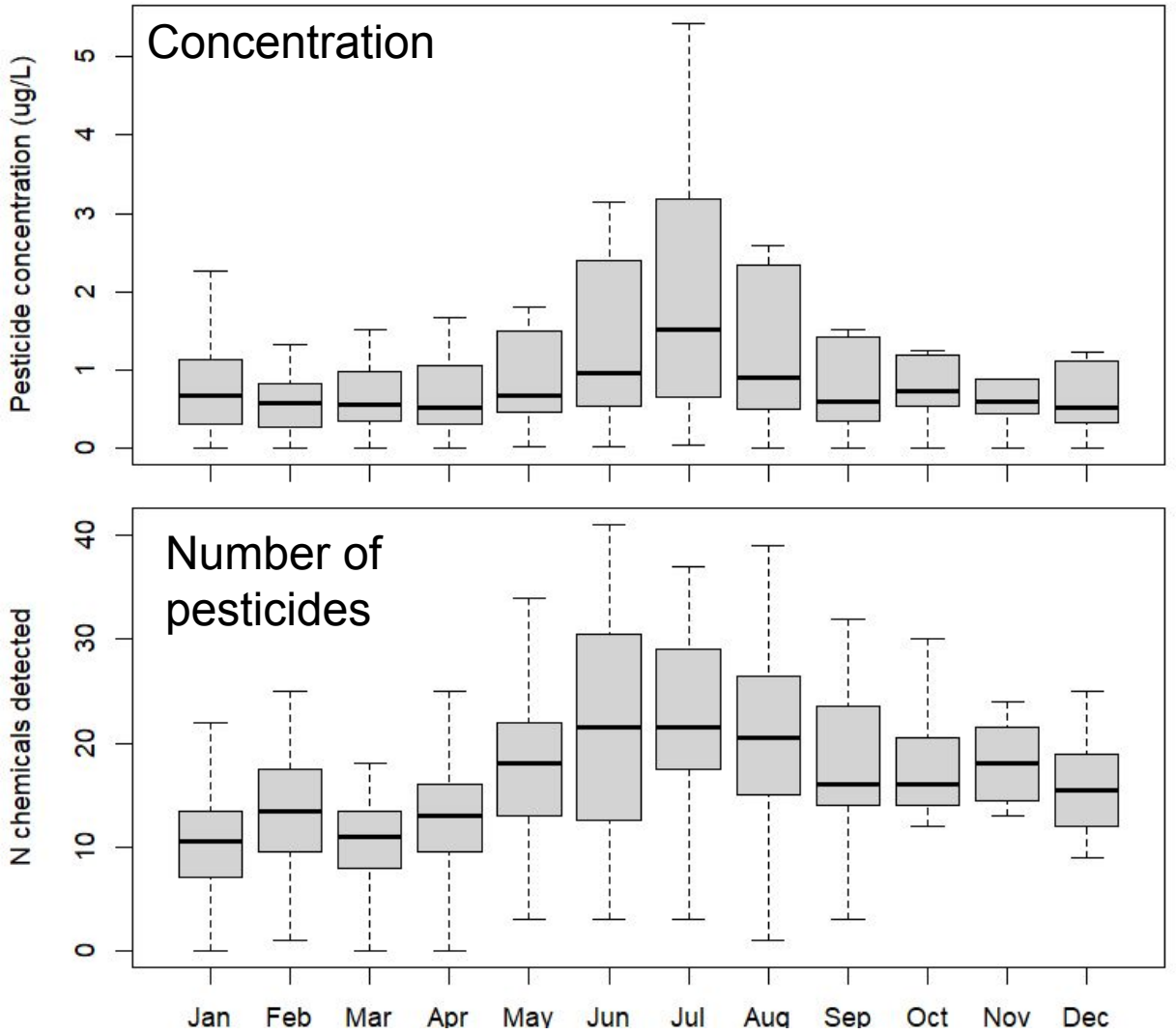
# When are pesticides present in tributaries of the Great Lakes?

- Pesticides are detected year-round at all sites
- Concentrations and the number of detected compounds peak June through August

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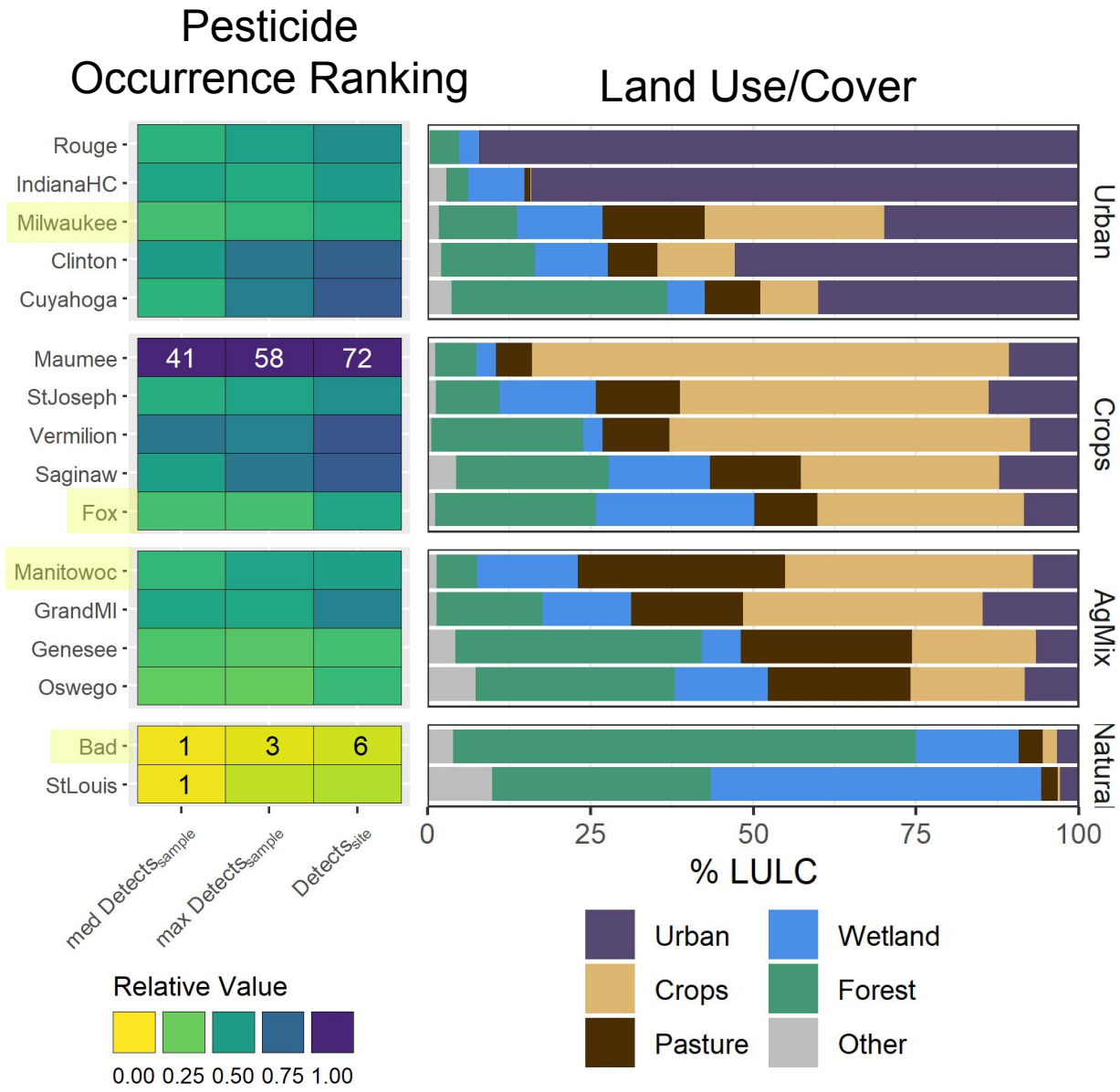
# In which tributaries of the Great Lakes are pesticides present?

- Pesticides are detected year-round at all sites
- Concentrations and the number of detected compounds peak June through August
- Between 6-72 unique compounds detected per site across the study duration
- Few compounds detected at the wetland and forested sites

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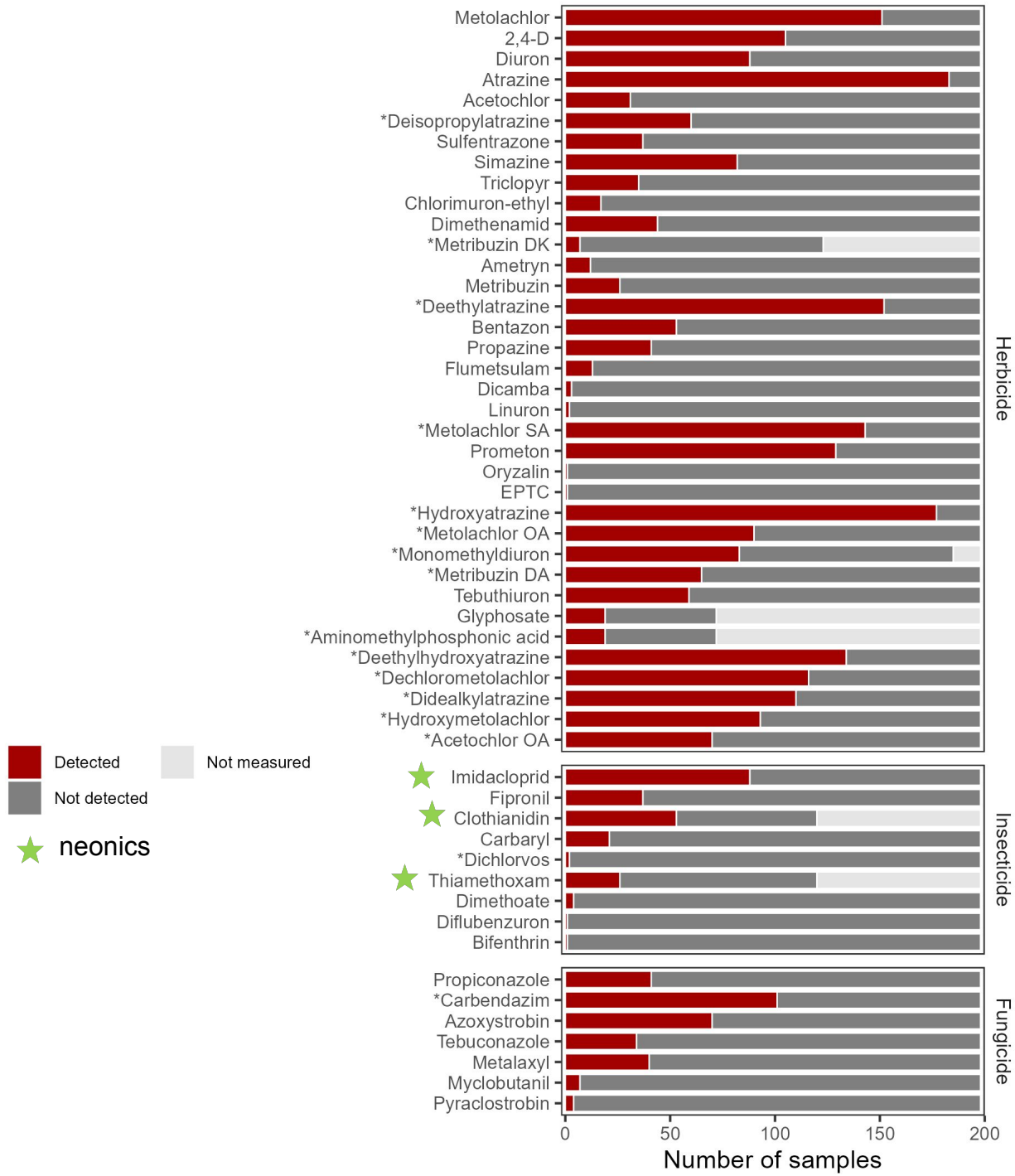
# What pesticides are present in tributaries of the Great Lakes?

- Herbicides and related transformation products (TPs) were the most frequently detected class of pesticides
  - Atrazine and two TPs were present in 75% of samples at all sites
- Neonicotinoid insecticides imidacloprid and clothianidin were most frequently detected insecticides (44% of samples)

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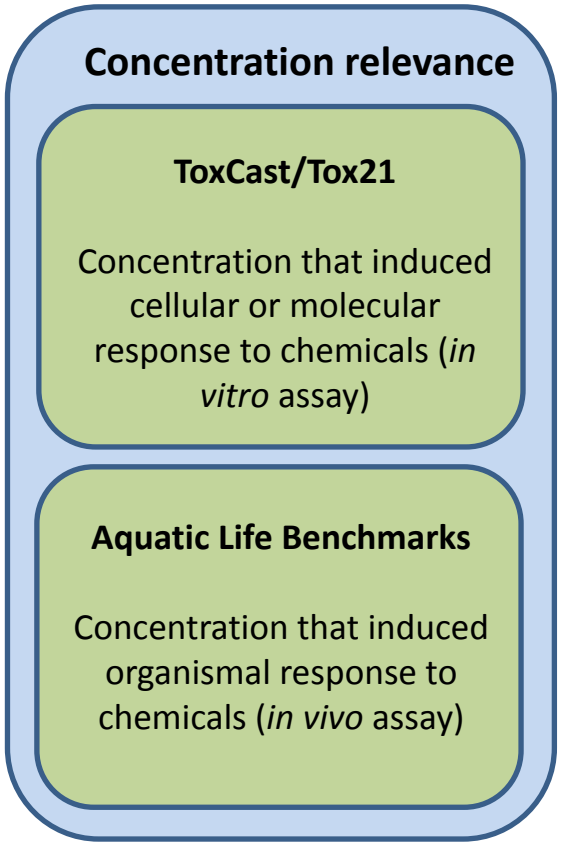
Pesticides are in all Great Lakes tributaries where we sampled.

Is this biologically meaningful?

We can estimate potential for negative biological impact by dividing our measured concentration by a benchmark value reported from either ToxCast or ALB

$$\frac{\text{Measured Concentration}}{\text{Benchmark concentration}} = \text{Exposure Activity Ratio (EAR) or Toxicity Quotient (TQ)}$$




** We used EAR > 0.001 and TQ > 0.1 as conservative thresholds for potential negative impact*

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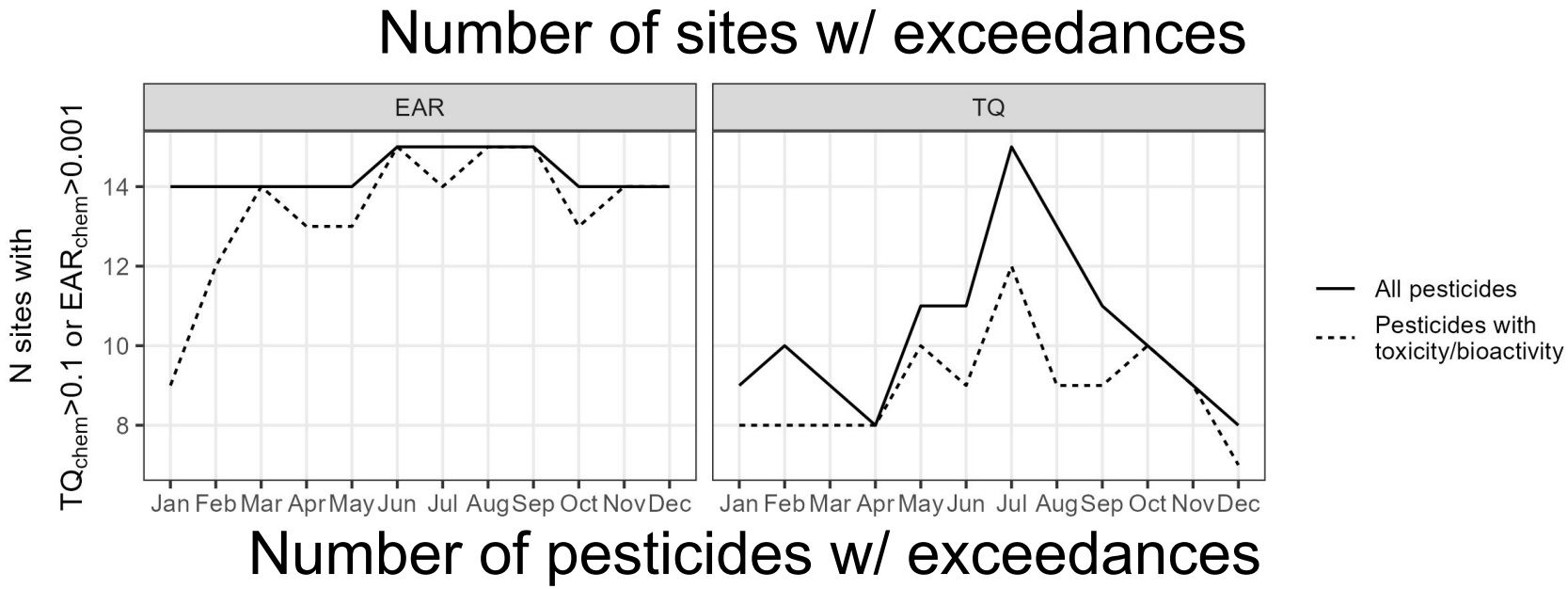
# Pesticide exceedances of water quality benchmarks



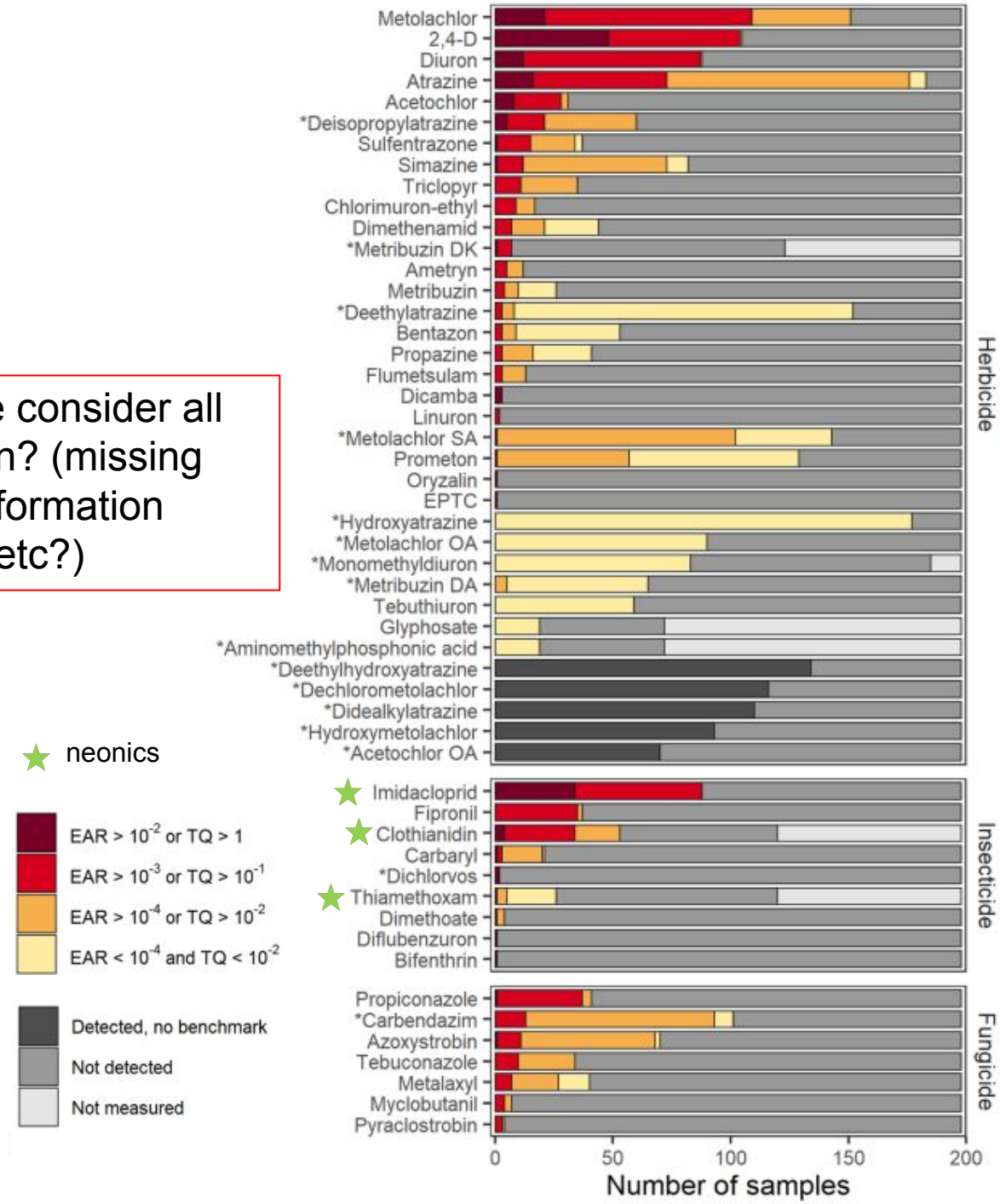

~Half of sites potentially negatively impacted by pesticides year-round

In any given month, ~5 or more chemicals contributing to exceedances.

# Which pesticides may negatively impact aquatic biota?

- 65/104 detected chemicals had Aquatic Life Benchmarks
- 15 chemicals had TQ > 0.1 (exceeded our conservative ALB)
- Insecticides **imidacloprid** (44%), **clothianidin** (28%), and **fipronil** (17%) had high ALB exceedances
- Herbicides **atrazine** and **metolachlor** also had ALB exceedances in 16% and 11% of samples, respectively

What if we consider all information? (missing info, transformation products, etc?)

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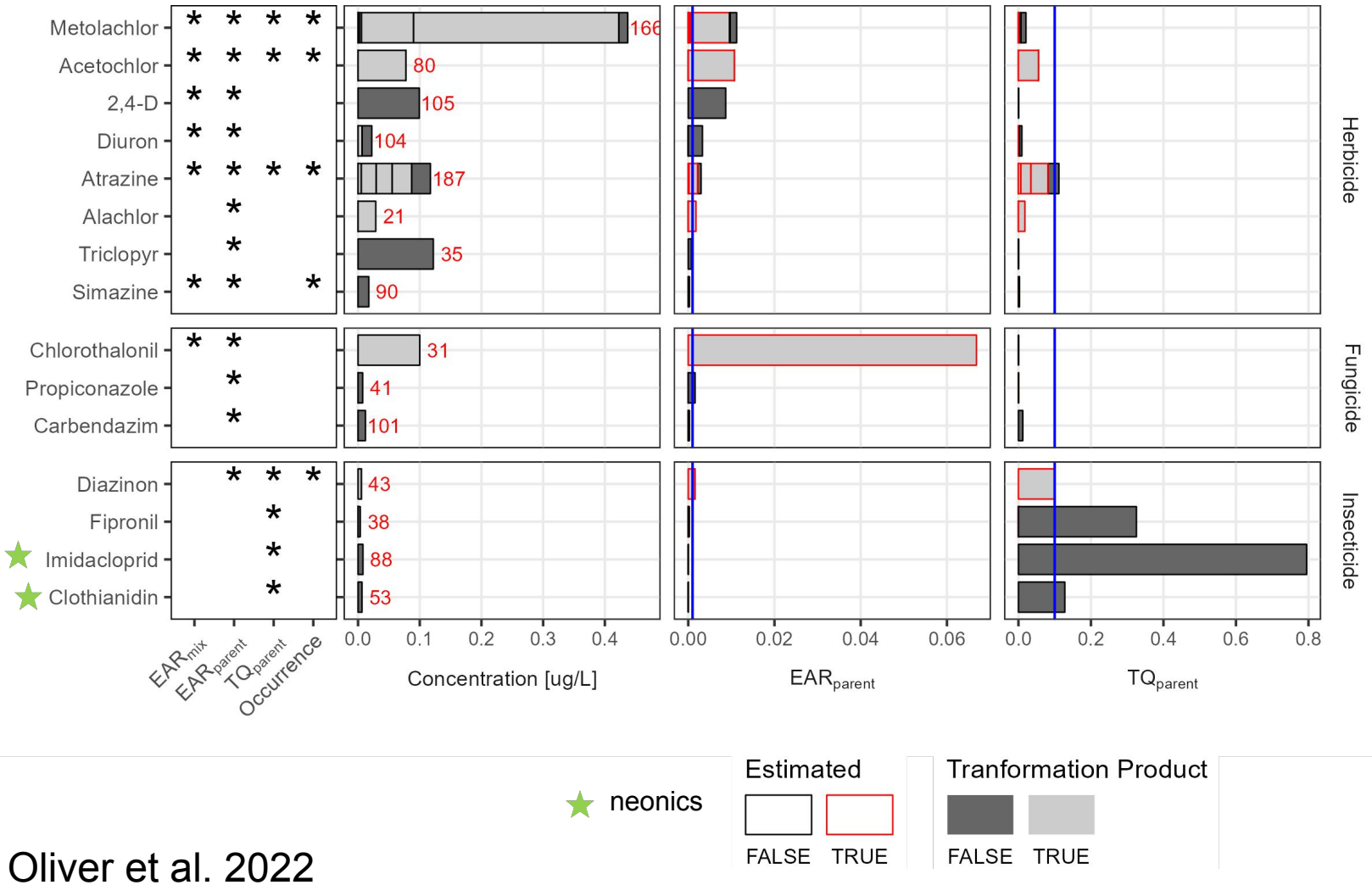
# Which pesticides may negatively impact aquatic biota?

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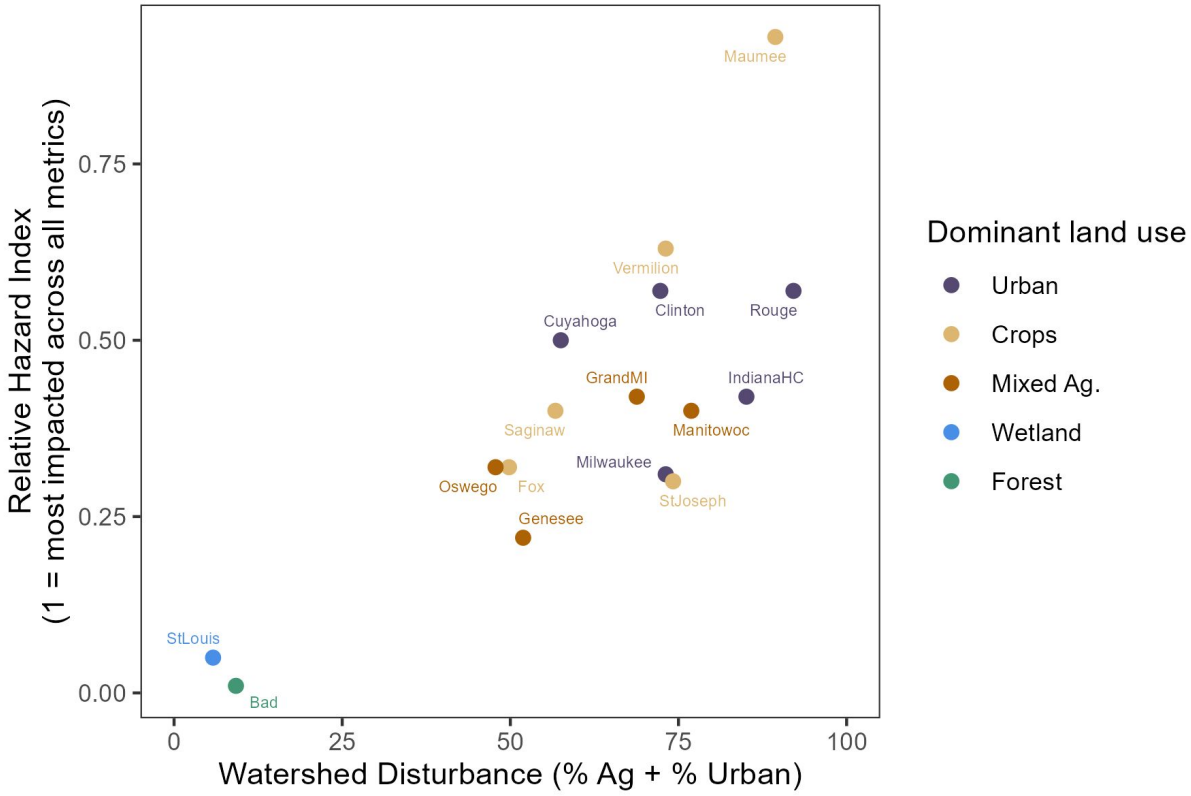
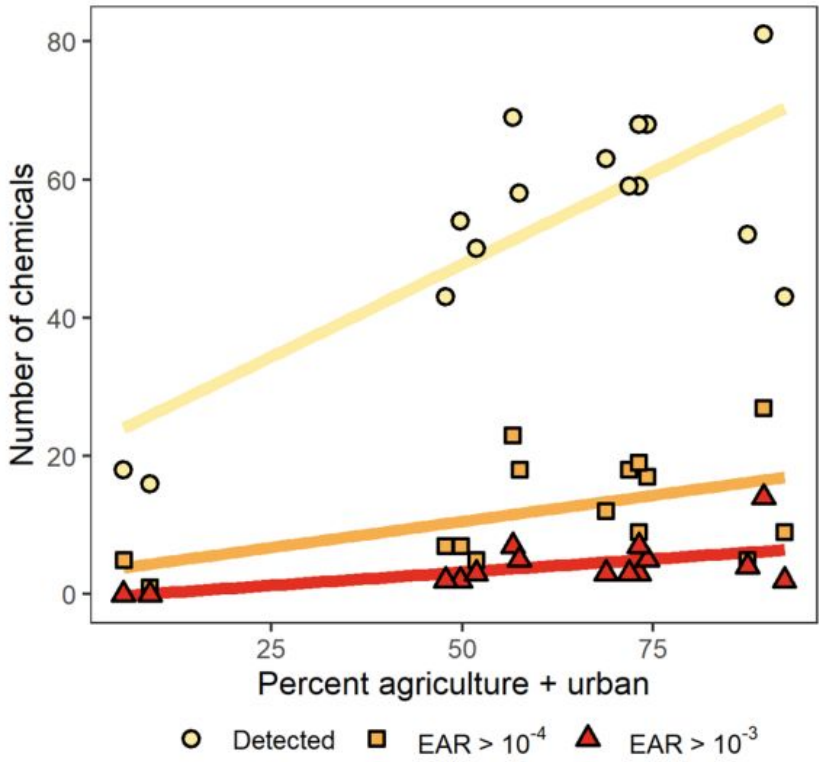
We identified 16 priority parent compounds based on:

- Occurrence (if no toxicity information but at 50% sites or 20% samples)
- TQ > 0.1 or EAR > 0.001 (>25% sites and >10% samples)
- Compound contributed to mixture with EAR > 0.001 (>25% sites and >10% of samples)

# Which sites are likely to have negative impacts to biota?

Sites with the highest human disturbance in the watershed (ag + urban) had the highest potential negative impacts from pesticides

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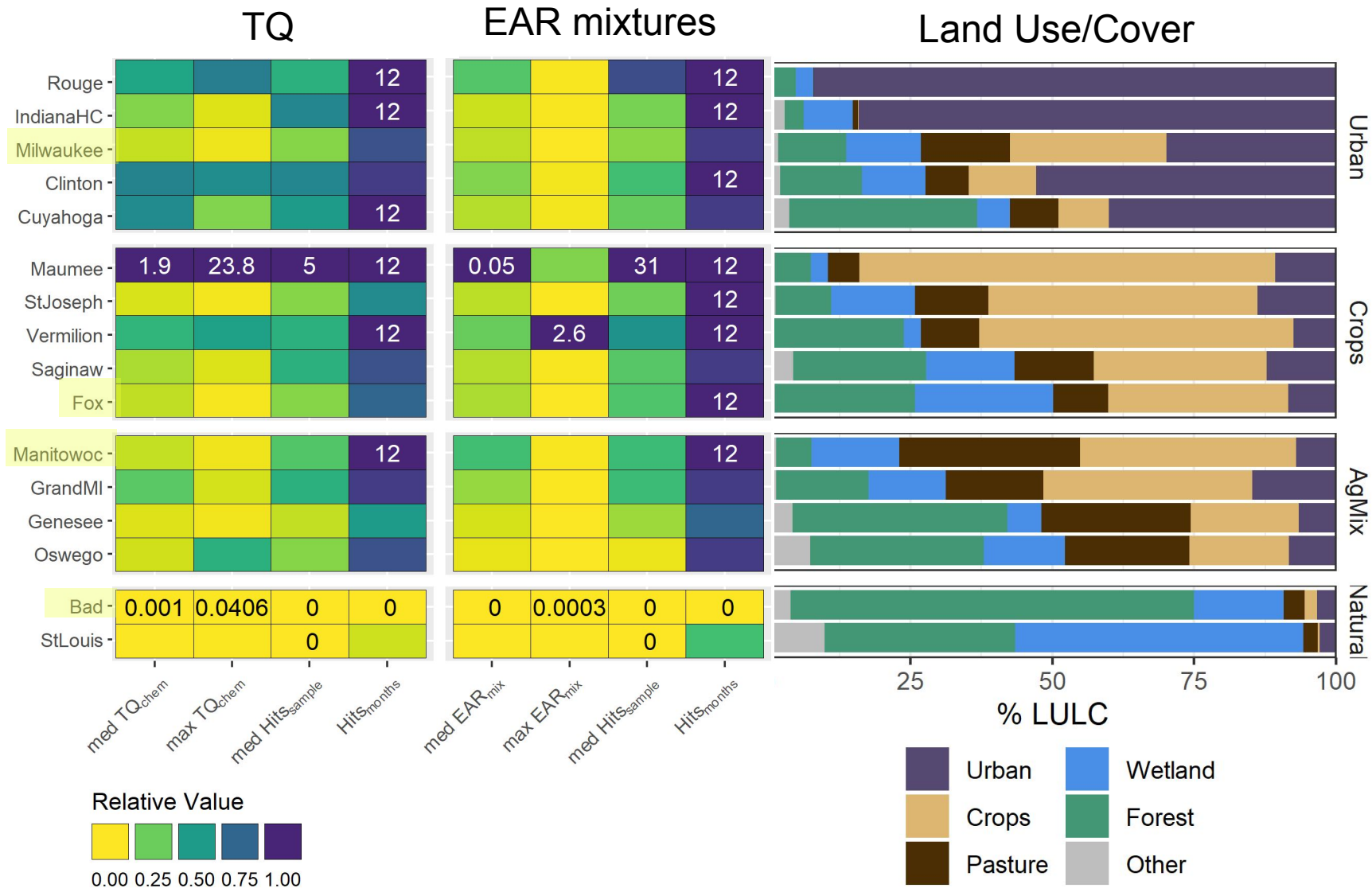
# Which tributaries have the greatest potential for negative effects from pesticides?

Many sites had year-round exceedances.

The Maumee & Vermillion (row crops) and Clinton, Cuyahoga, and Rouge (urban) were prioritized based on ranking metrics.

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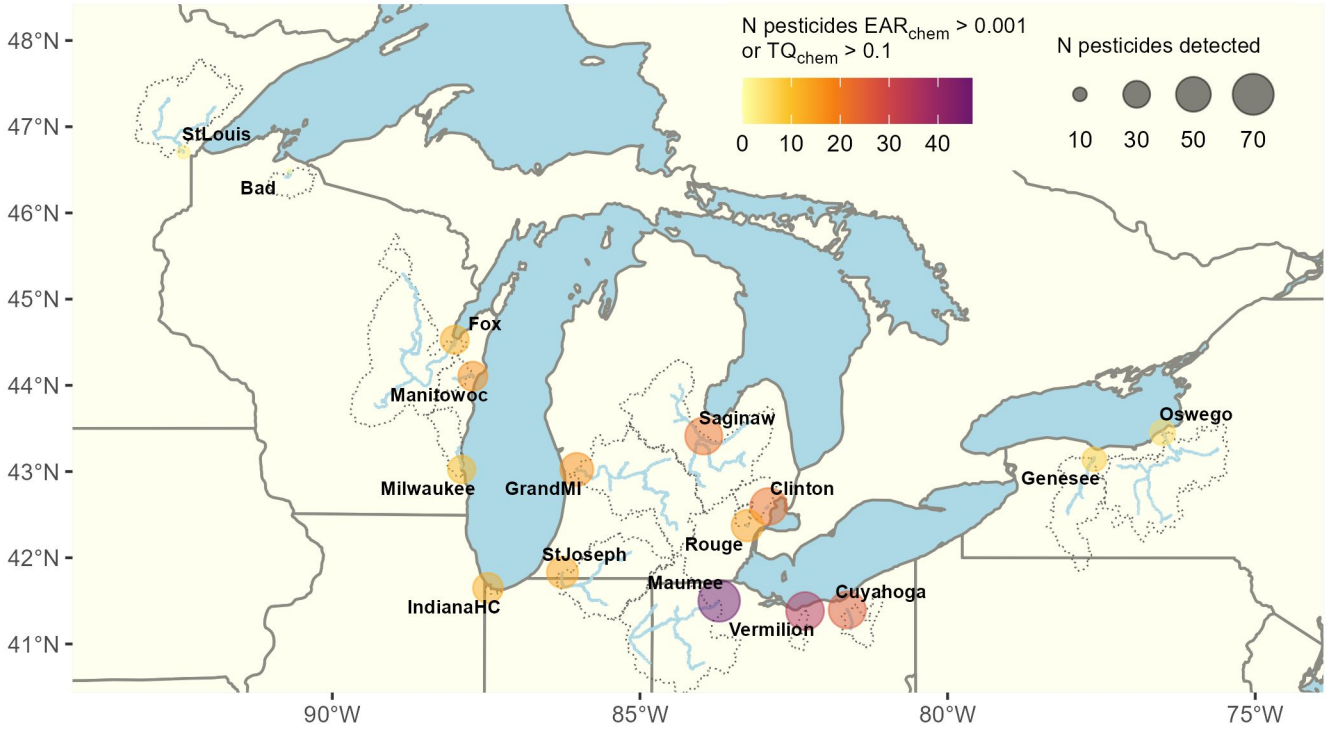
# Conclusions

- High potential for biota in tributaries of the Great Lakes to be negatively impacted by pesticides
  - Potential increases with % ag + % urban in watershed
- Pesticides likely impacting biota in GL tributaries year-round
  - Highlights the importance of transformation + transport/storage
- These screening tools (ALB and ToxCast) suggest that neonics (particularly imidacloprid and clothianidin) are a few of many pesticides that have potential for negative biological impacts

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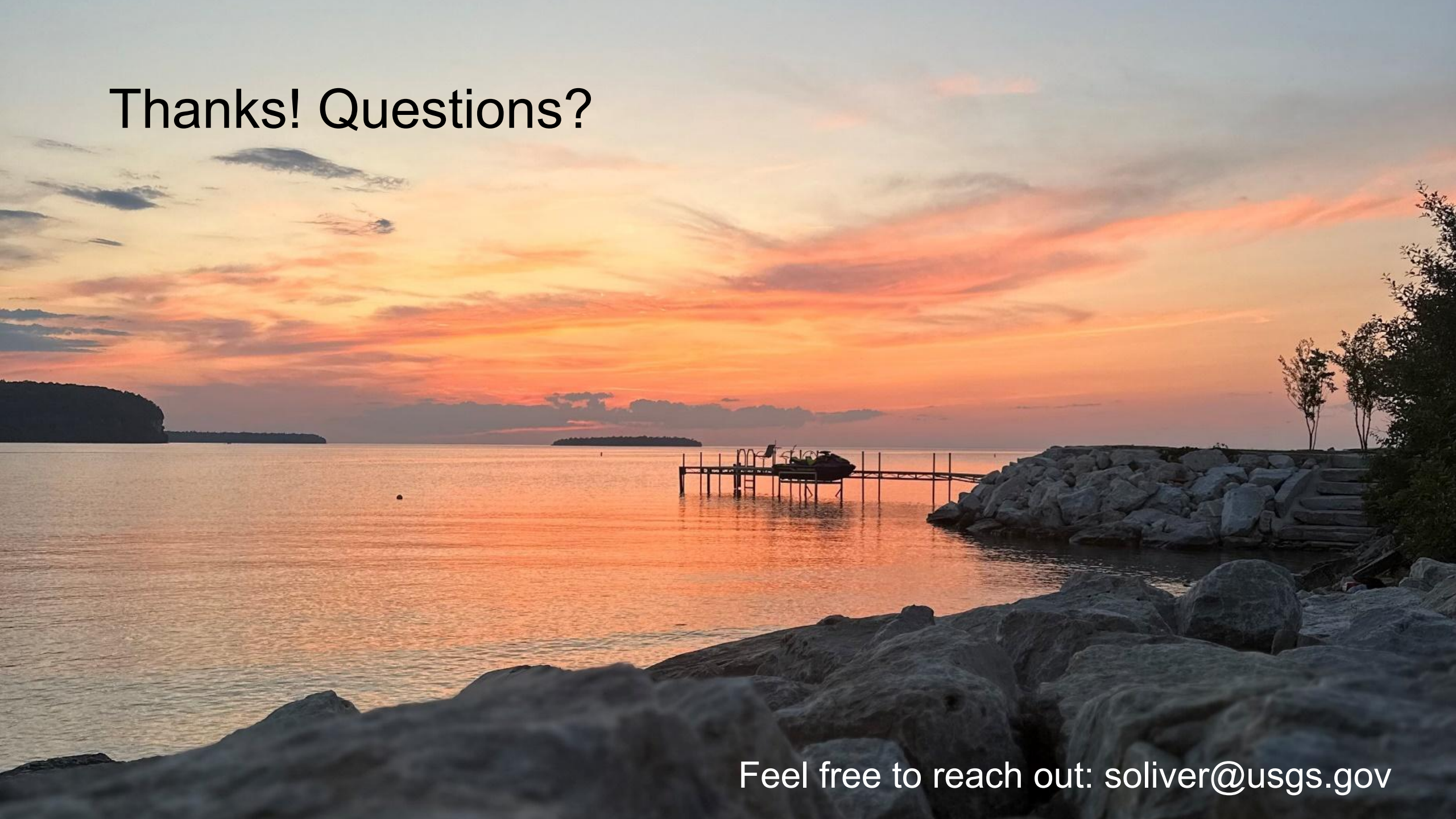
# Thanks! Questions?



Feel free to reach out: soliver@usgs.gov