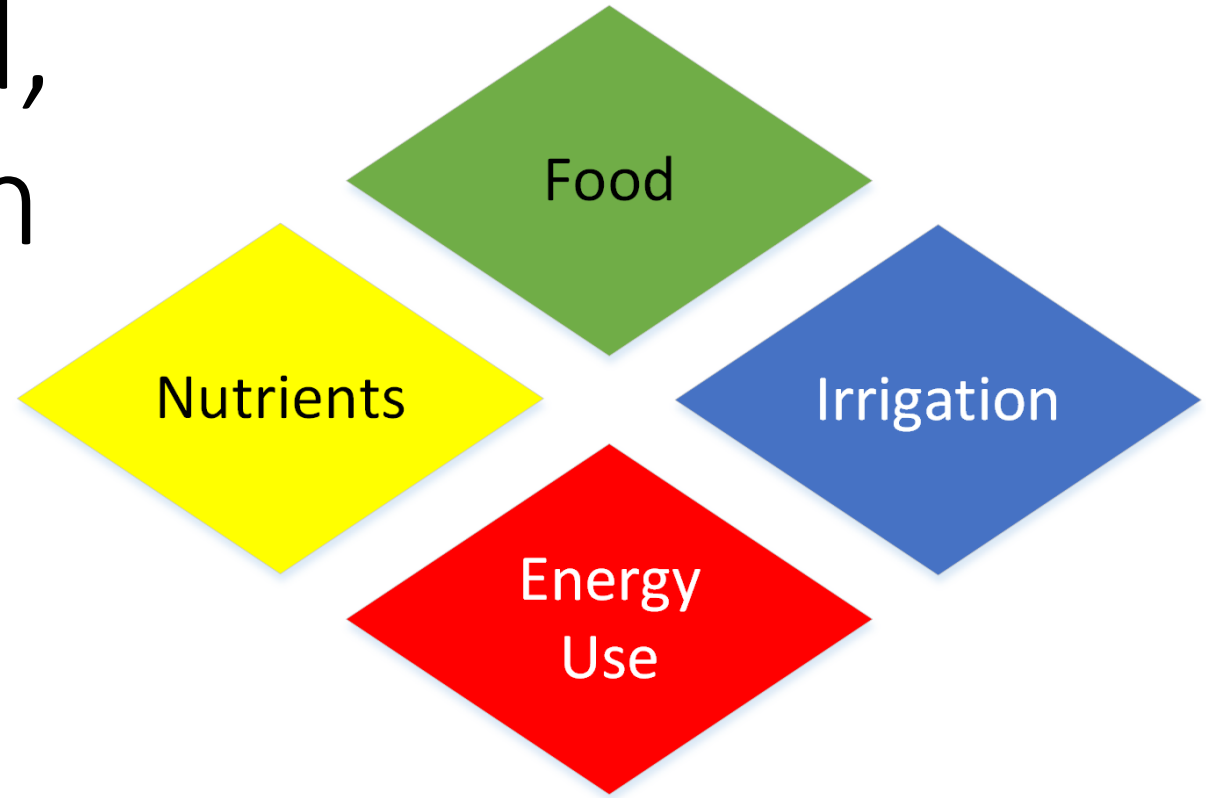


Groundwater at the Intersection of Food, Energy and Water in the Great Lakes

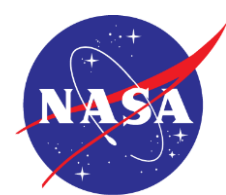
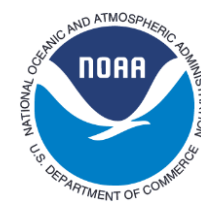
Anthony Kendall

David Hyndman, Sherry Martin

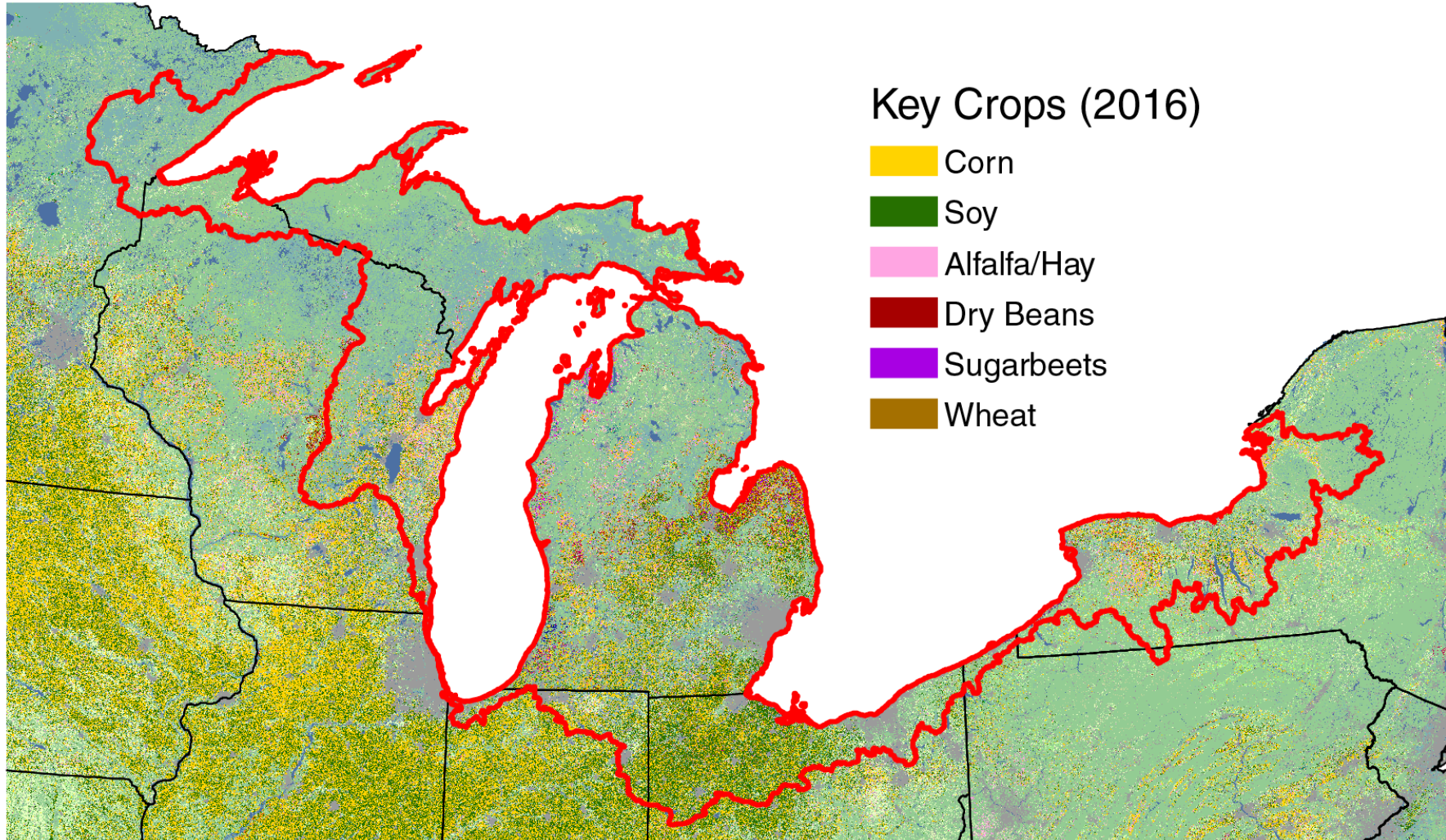
Quercus Hamlin, Jake Roush, Bailey Hannah,
Tianfang Xu



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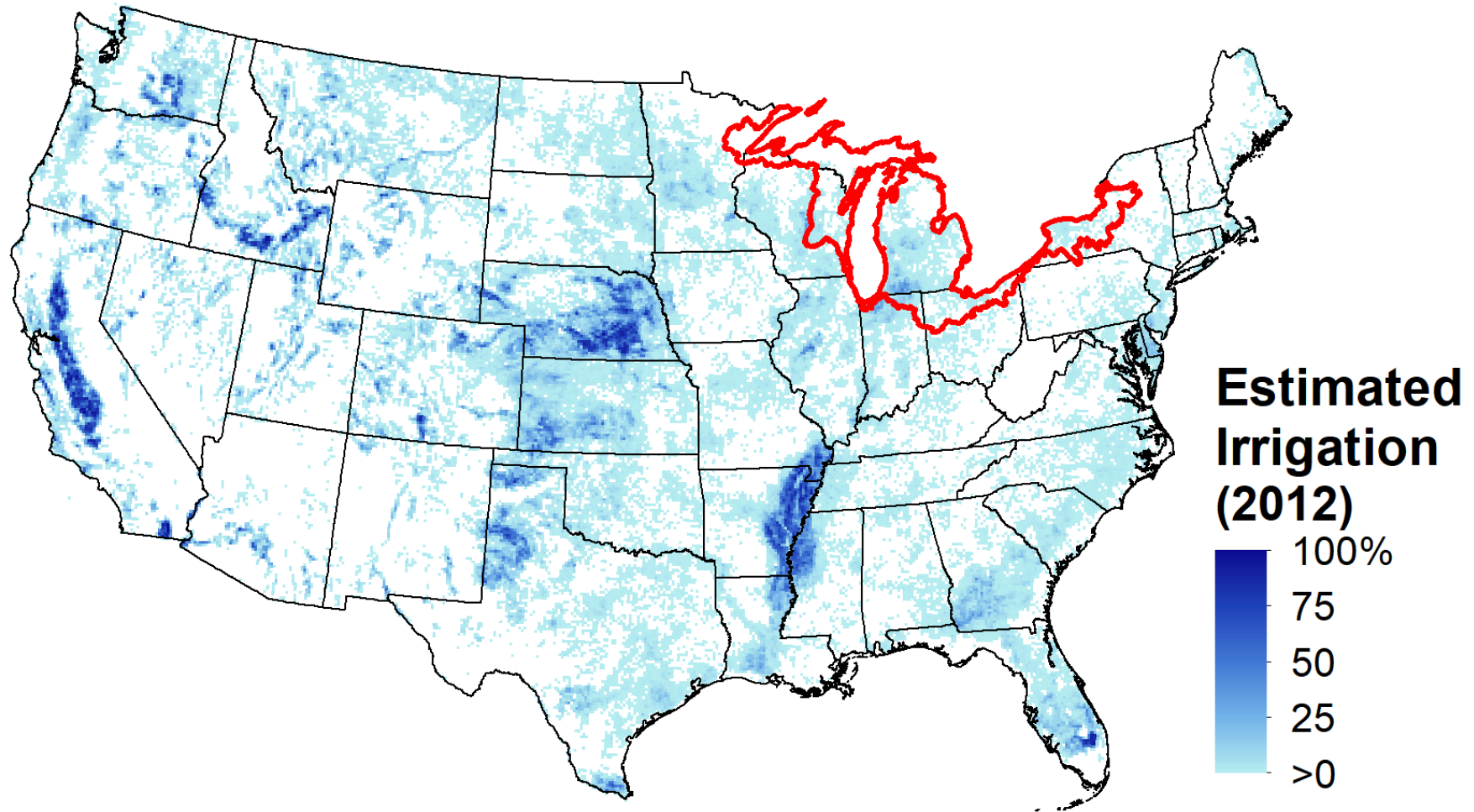


Agriculture in the Great Lakes basin



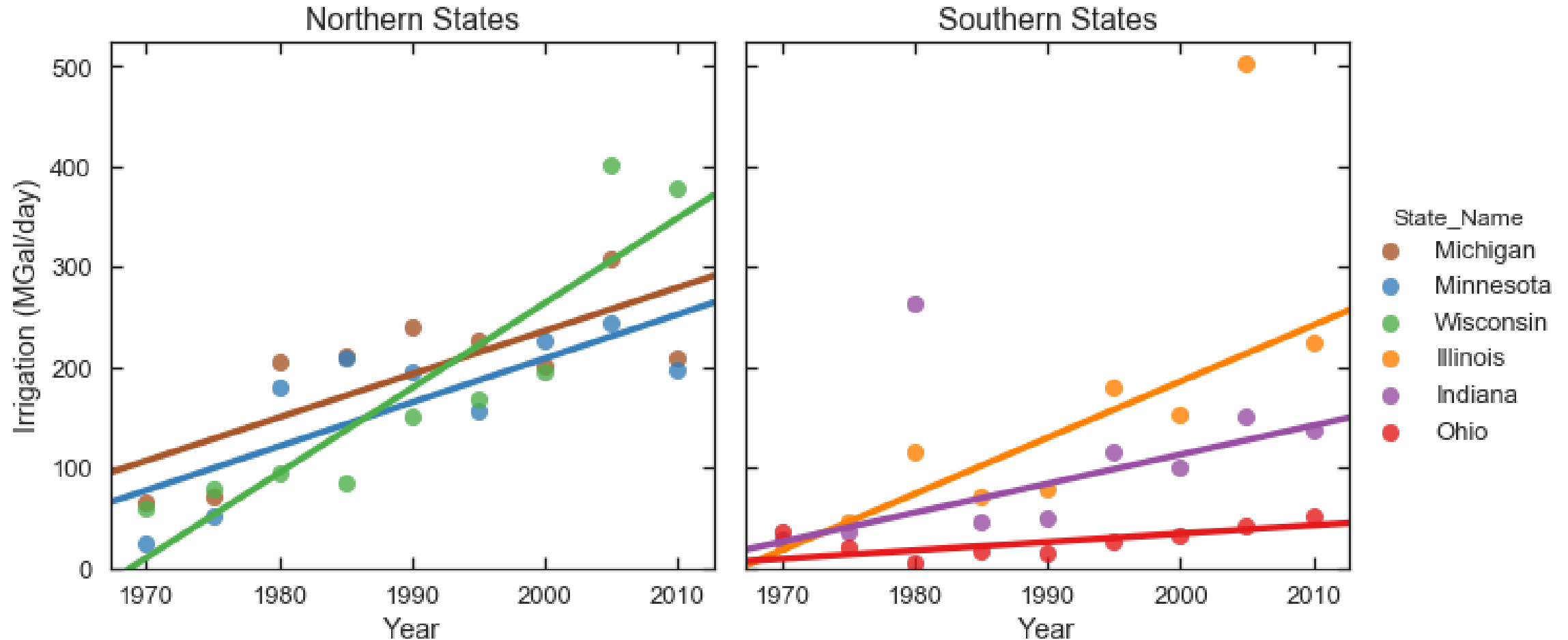
Data from USDA Cropland Data Layers (CDL)

Irrigation across the CONUS



Data from USGS MiRAD Dataset

Great Lakes irrigation water use is increasing



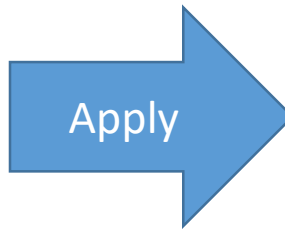
Data from USGS Water Use Estimates

Satellite remote sensing of irrigation

Southwest Kansas

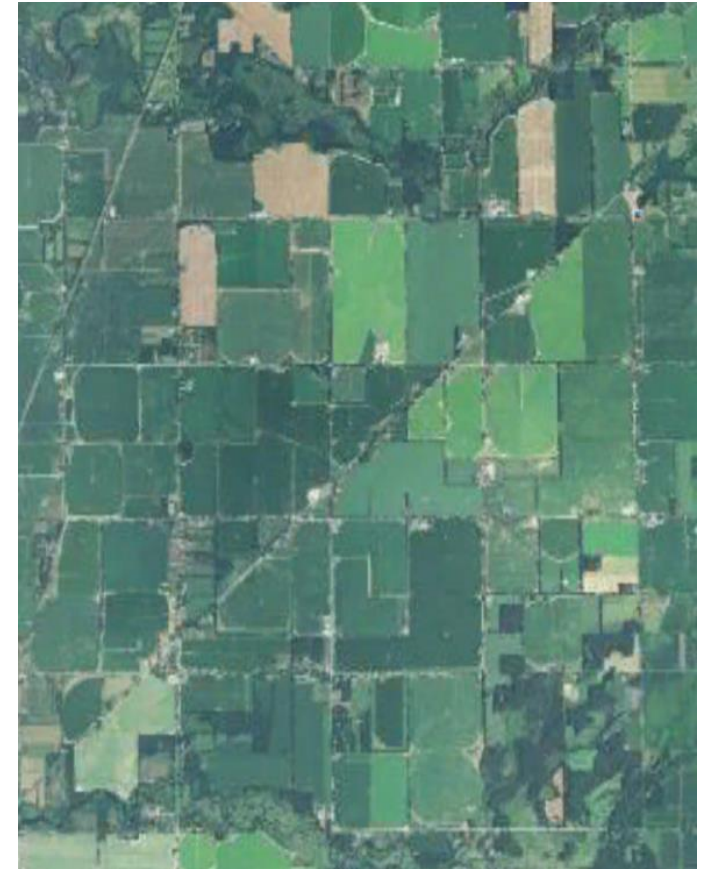


Develop
Methods



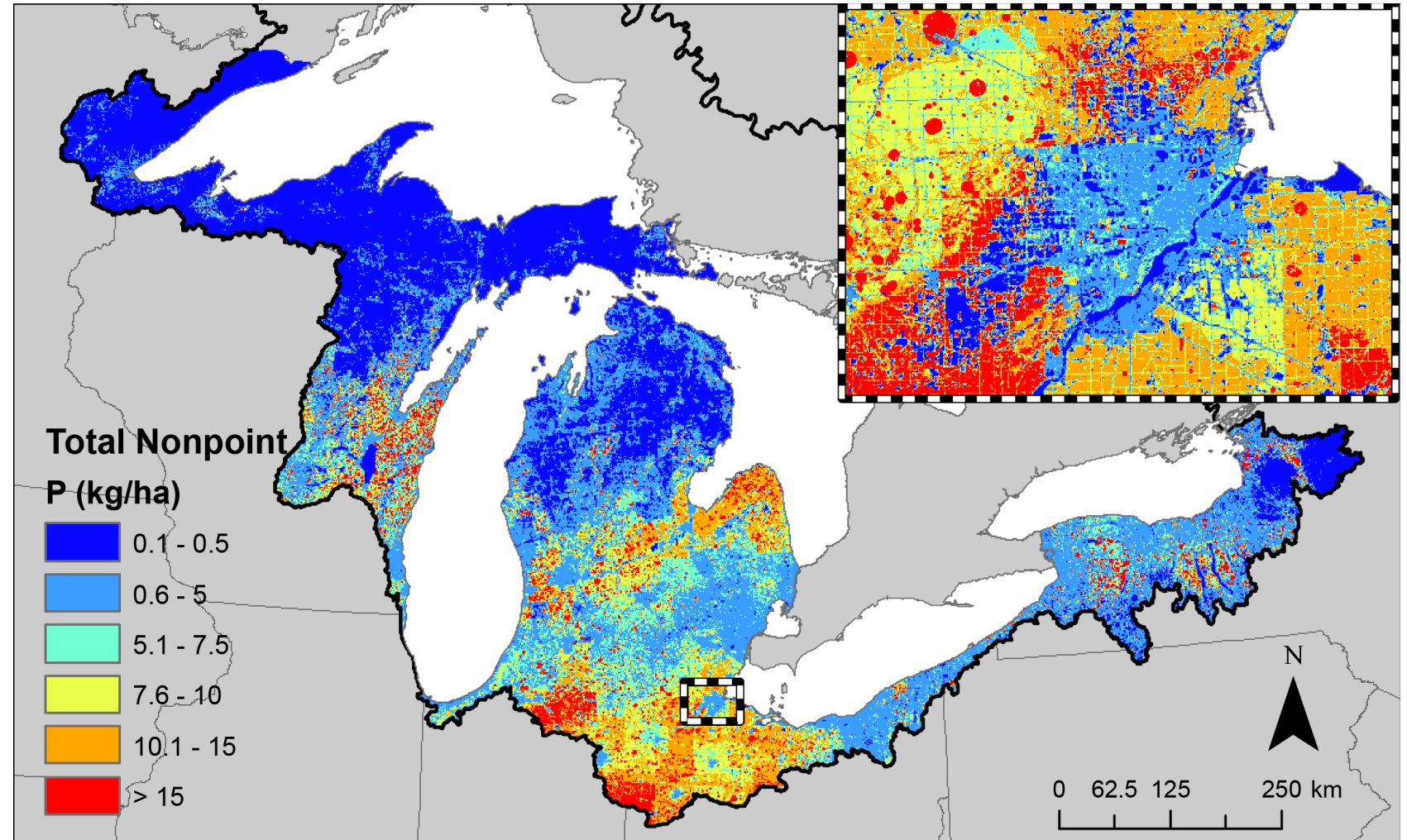
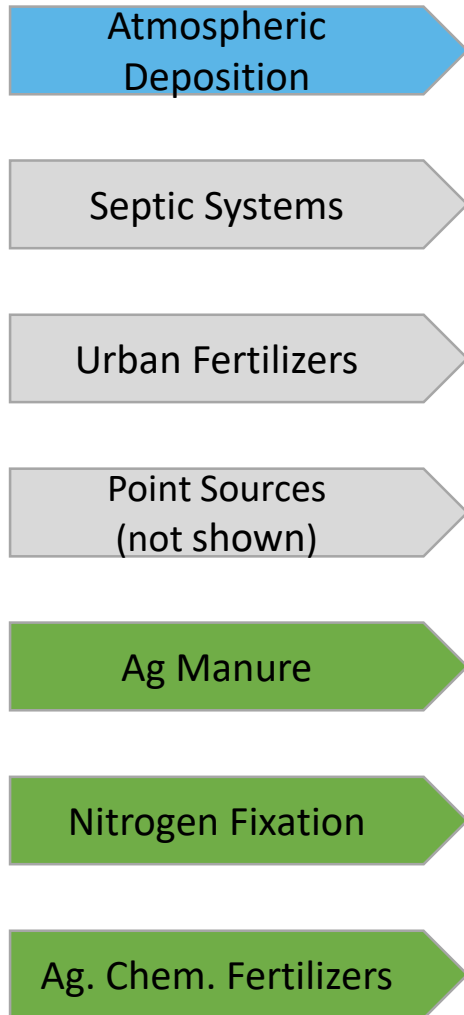
Research
Challenges

Southwest Michigan

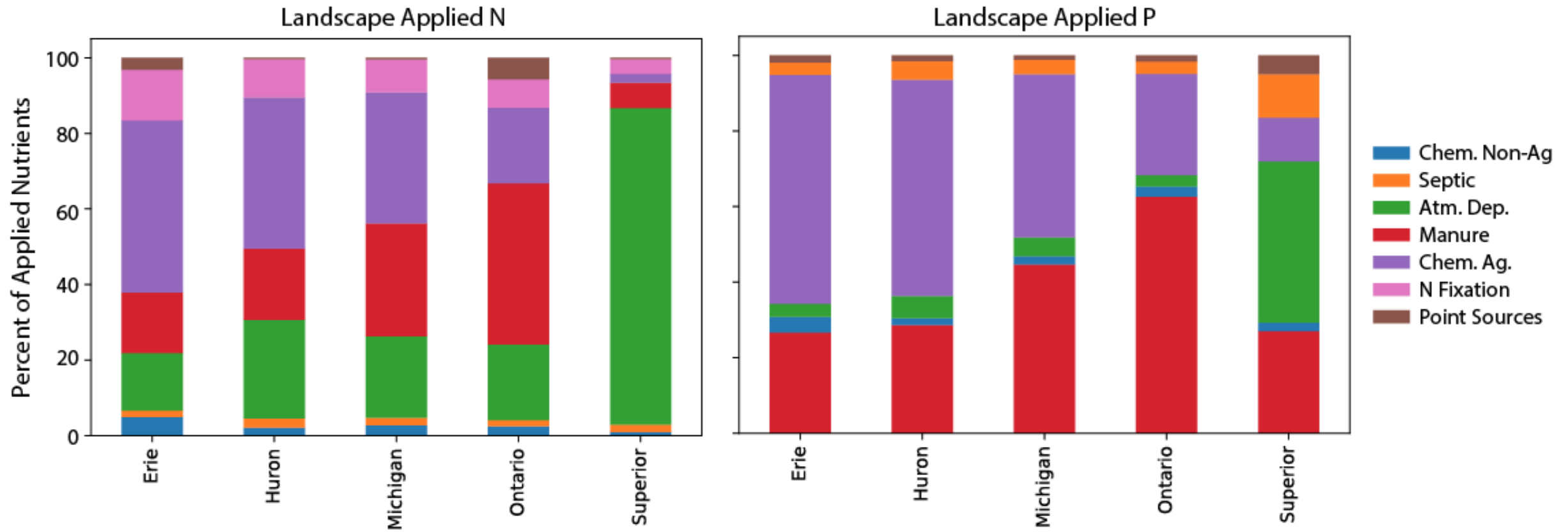


Images from the USDA National Aerial Imagery Program (NAIP)

Nutrient source maps for N and P



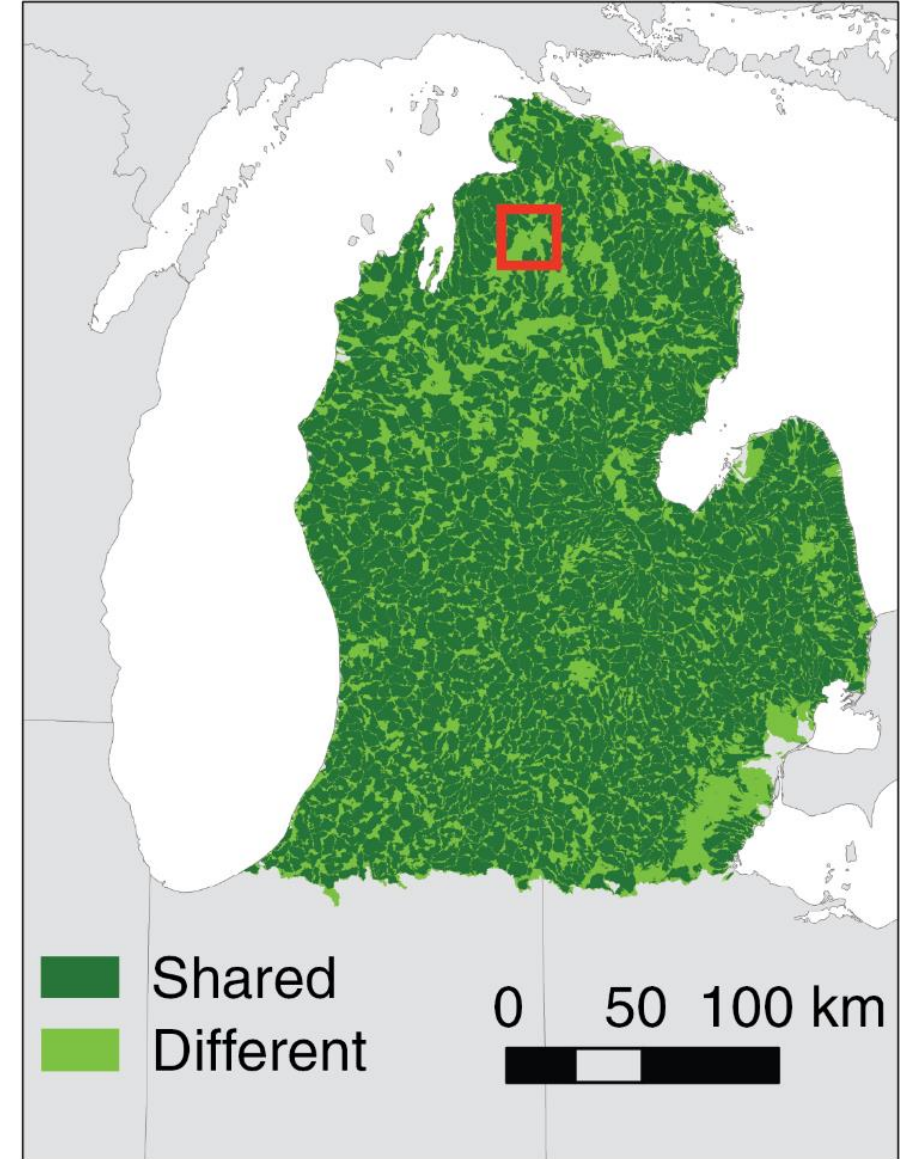
Breakdown of nutrient sources by lake basin



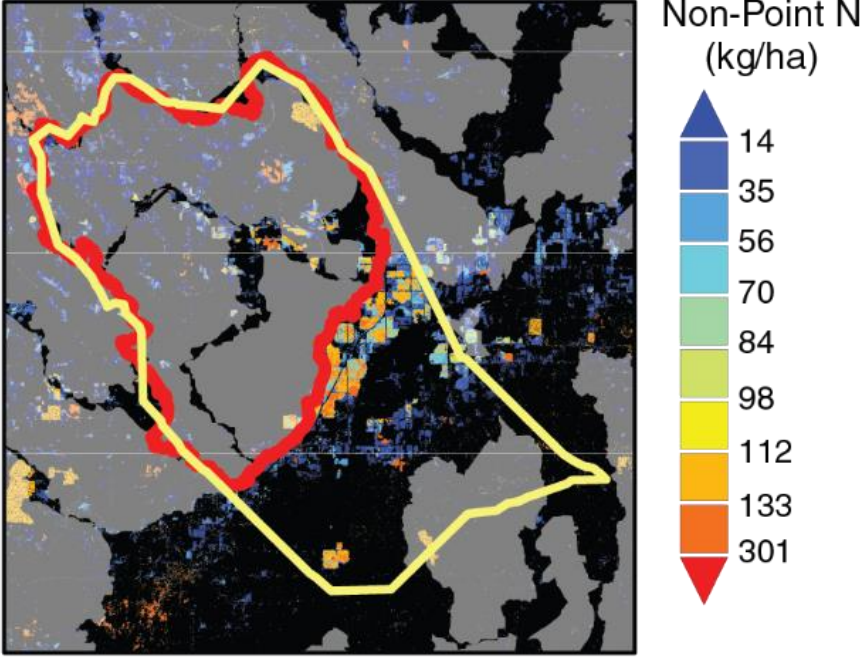
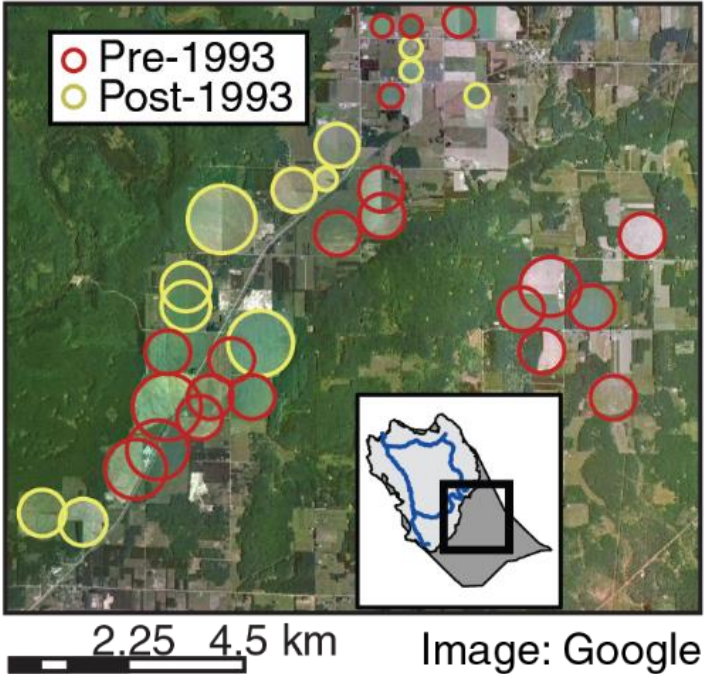
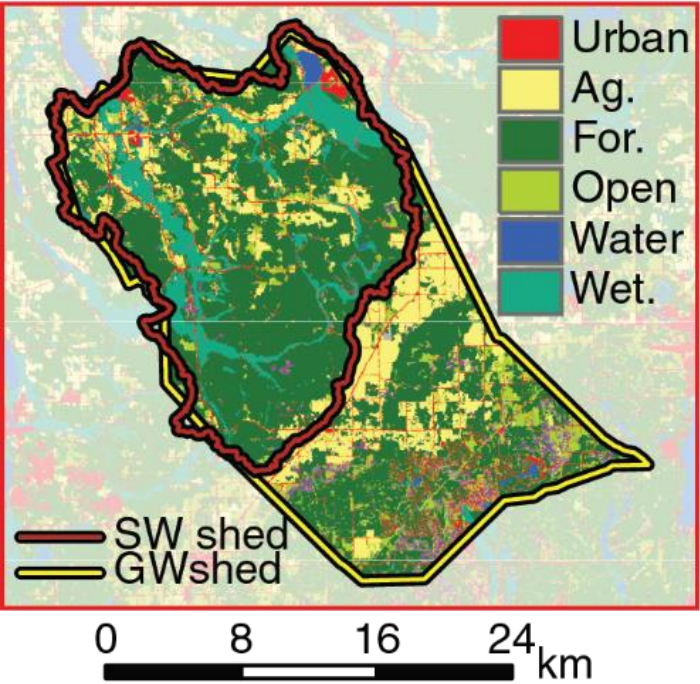
Groundwatersheds

- Groundwatershed: analog to surface watershed → groundwater input to a stream system
- Surface watershed and groundwatershed are often quite different

HUC 12

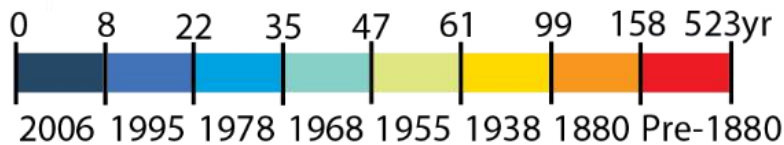
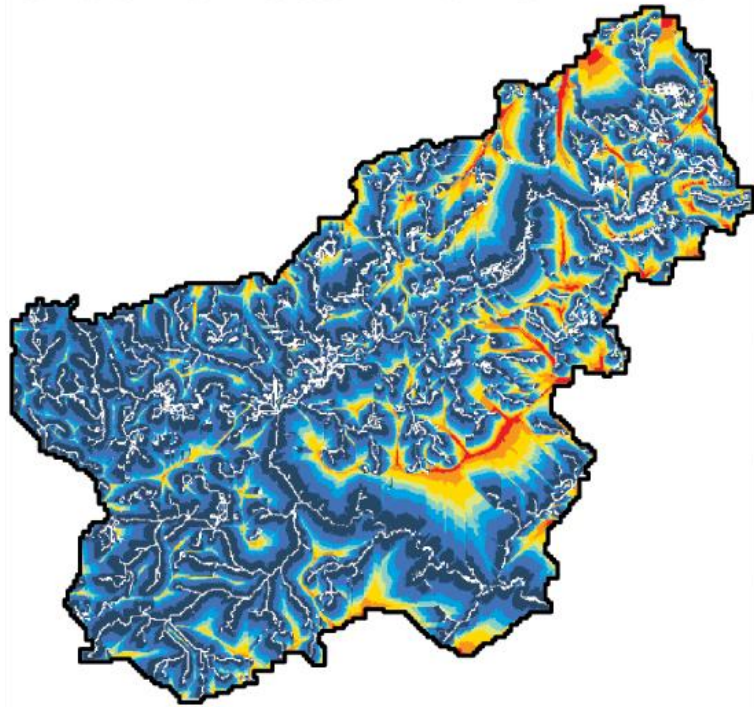


Jordan River Groundwatershed

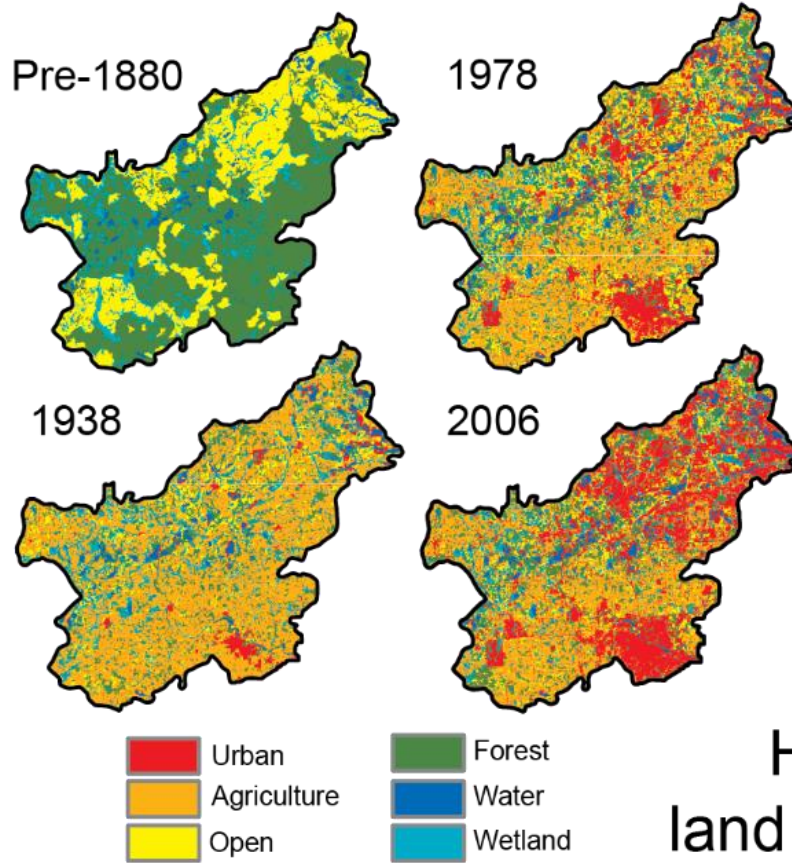


Landuse Legacies

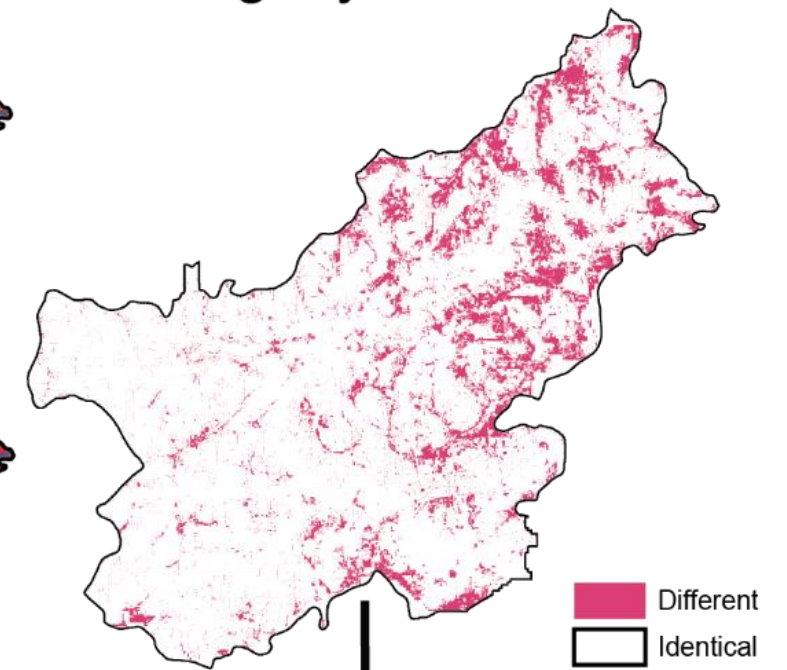
Groundwater Travel Time



+ Historical LULC

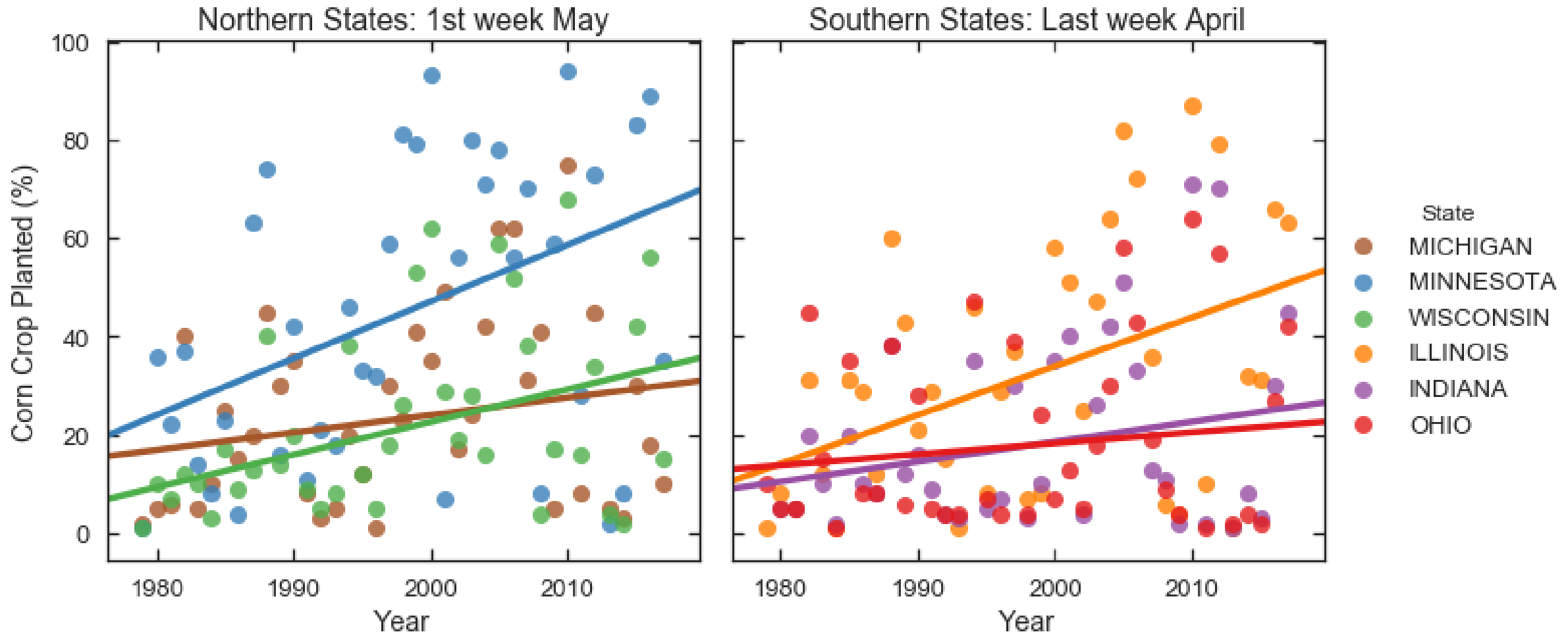


Legacy Differences



How important is legacy land use/cover to water quality?

Farmers are planting their crops earlier



Data from USDA National Agricultural Statistics Service (NASS)

Policy implications for the Great Lakes

- **Agriculture is:**

- Dominant source of nutrients
- Rapidly growing consumptive water user

- **Groundwater is:**

- Primary means of nutrient movement
- Slow to respond to surface change
- Not the same as surface water → groundwatersheds

- **Now is the time:**

- Landuse legacies: sometimes decades from policy to full effects
- Farmers are responding to changes in climate
- Shifting consumer and biofuels → different practices and crops

- **Science-driven regulation:**

- Water Assessment Tool in MI to pre-screen large-volume withdrawal permits
- Regulations need more flexibility to incorporate robust new science

tippingpointplanner.org



- Decision Support Tool for watershed planning
 - Nutrient reduction
 - Non-point sources
- Backed by research from MSU, UofM, Purdue, and others
- Used by local planners
 - Training by IL/IN Sea Grant